

★  
NATIONAL  
**Electric Light**  
ASSOCIATION

---

TWENTY-SEVENTH CONVENTION

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VOLUME II  
**Question Box *and* Wrinkles**

BOSTON, MASSACHUSETTS  
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# Question Box

H. T. HARTMAN, *Editor*

*"Seldom was ever knowledge given to keep, but to impart."*

HALL

## INTRODUCTION

---

*I feel that the association is to be congratulated on the interest so generally manifested and so generously expressed by the gentlemen who have taken the time and trouble to reply to the many inquiries comprising the Question Box for 1904.*

*Few of the many advantages offered to central-station men by this association are of such general and far-reaching benefit as is the Question Box, to which every member can contribute his part, either in the form of a question or an answer on some point involved in his own particular line of work. There is too great a tendency in such organizations as this to depend on others for results, and all the labor generally falls upon a devoted few who are willing to sacrifice their scanty leisure for the benefit of others. In the case of the central-station man who is in a chronic state of overwork, there is some justification for his claim that he can not find time to do much for the association; but practically no time or thought is required to answer a question concerning his daily work, on which his life has been concentrated, and where experience has crystallized into conclusions on most problems of central-station operation and management. The Question Box is not limited to any special field of inquiry, nor to any one class of workers. Every man in a member company, from the general manager to the fireman, can give and obtain information of the highest value. Both question and answer being from specialists, in every section of the country and operating under every possible condition, they possess a value that is unique in electrical literature. Some one has very aptly said that knowledge is of two kinds; we know a subject ourselves, or we know where we can find information upon it. Progress in all branches of electrical work has been so rapid and the changes so radical that it is impossible for the text-books to keep pace with the art. From what library could one draw such a store of information regarding electric lighting in all its phases as is embraced in such an association as this? The Question Box not only saves you the trouble of looking up the data on the subject, but places before you a full discussion upon it in all its phases by men who have tried the experiment you*

may have in view and can advise you authoritatively as to the results that may be expected.

*The interchange of ideas and the helpful spirit engendered are, in the highest degree, broadening and uplifting. The day is past when manufacturers and station men hugged to their bosoms and cherished with jealous secrecy every scrap of information they might chance to obtain. The mystery is all gone now, and in its stead has come a realization that every one is benefited more or less directly by his neighbor's success. The manufacturer and the station man are coming closer together every day, each profiting by the other's experience and both working toward the same end. The Question Box furnishes an excellent example of the many ways in which they may reach a common basis.*

*In conclusion, I desire to express my appreciation of the ready and efficient assistance of Miss Harriet Billings, the assistant secretary of the association. I also wish to acknowledge the courtesy of Mr. E. G. Wendle in permitting the use of thirty questions prepared for a similar publication for the Pennsylvania Street Railway Association.*

H. T. HARTMAN, Editor.

May, 1904.

# Question Box

OF THE

## Twenty-seventh Convention of the National Electric Light Association

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### BUILDINGS

#### A

*No. 1.—What is the best method of constructing a "valley" between two pitch roofs?*

Assuming that the information desired is in regard to keeping such a valley water-tight, would say: We have found that the most satisfactory results will be obtained if the valley is covered with metal. If the building is to be permanent, should advise using sheet copper, this metal to be soldered at the joints and brought up on each pitch roof to a point above that which the water from melting snow will reach.

WILLIAM R. GARDENER.

I assume that the roof is either shingle or slate. The usual method of construction of a "valley" is to lay board up the rafters 12 to 18 inches and cover with tin painted both sides, with shingles or slate to cover it, leaving about four inches from centre of valley to edge of shingles. On an electric station I would run two feet up rafters and use copper instead of tin. I would avoid valley on such station if possible, as it is apt to leak. I have known the heat in such a building to melt snow on the roof, causing the valley to fill up and flow over the flashing, as the weather was so cold that at the leader it was frozen solid.

H. A. C., N. Y. ED. CO.

Sheet copper, long lap, no solder.

AUGUSTA RY. AND ELEC. CO.

*No. 2.—What is the life of a good pine-shingle roof?*

The writer is well acquainted with two white-pine shingle roofs; one put on 21 years ago, which to-day is still weatherproof; the other put on 28 years ago. The latter now leaks badly, but

it was water-tight up to three years ago. We can not obtain a good quality of pine shingles nowadays, as the supply was exhausted years ago. Washington red-cedar shingles have taken their place and are giving good service. I know of several such roofs put on 10 or 12 years ago that are apparently as good to-day as ever. Do not use wire nails in shingle roofs for barns or any place where there is much ammonia. Use the old-fashioned galvanized-iron cut nails, or, better yet, use copper nails.

WILLIAM R. GARDENER.

Life of pine shingles varies. A 24-inch will last from 20 to 25 years and an 18-inch from 10 to 15 years, and may be patched up at small expense to last some years longer.

H. A. C., N. Y. ED. CO.

*No. 3.—What kind of cement and proportions of cement, sand and stones for concrete dams have been found to stand successfully where same have been put on rock bottom, and how wide in proportion to height should the dam be?*

Atlas, Star, Lehigh, Vulcanite and Giant cements are all good.

One part cement, two parts sand, three parts stone, to be especially impervious to water.

One part cement, two and a half parts sand, five parts stone (small), for average good work.

One part cement, three parts sand, six parts stone, for ordinary work.

One part cement, three parts sand, nine parts stone, for ballast.

Much depends on the thoroughness of mixing, and much on the ramming into place.

Upstream side of dam and spillways should be impervious to water. The centre and toes of large dams can be more in the nature of ballast.

One part cement to six parts clean gravel (stones up to four or five inches—no loam) make a strong, cheap concrete, avoiding the necessity of screening.

No dam should be built by the rule-of-thumb relation of width to height. This relation depends on the cross section of the dam, the height of water above the crest in floods, and the

bonding of the masonry with the bed rock. These determining factors should be obtained for each case.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

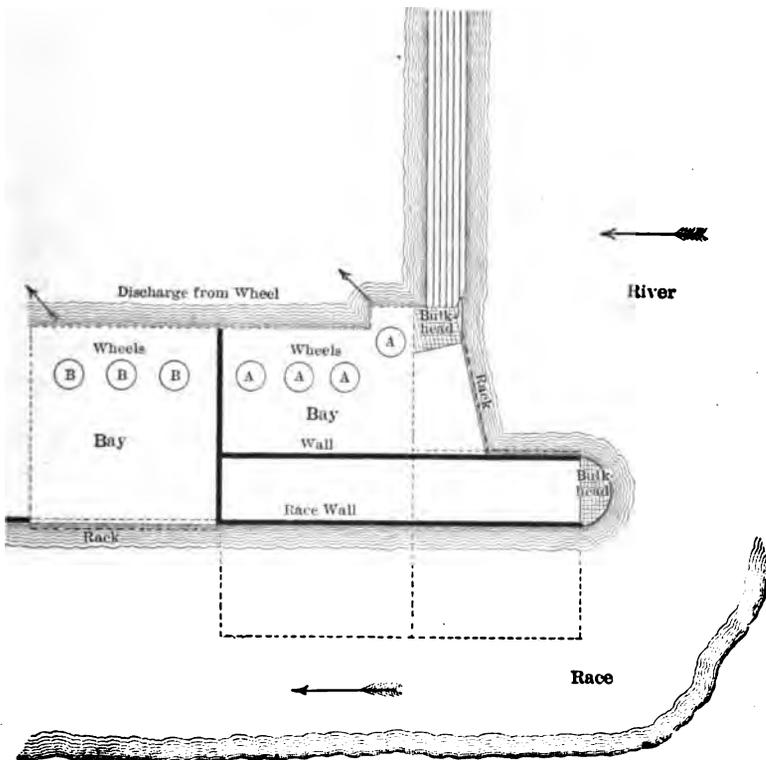
## STATION OPERATION

### B

WATER-WHEELS, WATER-POWER, ETC.

*No. 1.—How is ice handled in water-power plants, and what method is used to prevent it from interfering with the power service? Is the ice worked through the racks, removed from the river entirely, or passed over the dam?*

We have four wheels, marked *A* (see diagram), that take water direct from the end of the dam, and three wheels, marked *B*



B-1

*B*, that take water from the race. If we wish to clean rack number one, we shut down the wheels marked *A*, and open and carry the load with wheels *B, B, B*. As soon as the wheels are closed the suction stops and the ice or drift comes up to the surface of the water and is carried over the dam. If we wish to clean rack number two, we close wheels *B, B, B*, and open and carry the load with wheels *A, A, A*; then we push the ice down below up in the race, and the drift we fish out. Working it in this way, we clean them very easily and quickly.

ED. P. MAXWELL.

We consider it best to leave the ice in the dam and river, both on account of the expense and for the prevention of anchor ice, letting it freeze up as close to the rack as it will, and leaving only room for a rake to work up and down on the rack to remove any small particles of ice or other material that may clog there. A river, pond or canal once solidly frozen over, prevents any further trouble from anchor ice.

THE UNION ELEC. LT. AND PR. CO.

We endeavor to keep floating ice out of our canal until it becomes rotten, when we throw it over our waste weir. Our aim is, however, to keep our canal covered with ice as long as possible, thereby getting rid of slush. We consider it very bad practice to work it through the racks.

L. E. WATSON.

A convenient way of preventing floating ice, sticks, etc., from interfering with the service is to string a boom across the flume or forebay some distance above the racks. Preferably, the boom should be at an angle with the direction of the flow of the stream, so that the ice and brush go automatically toward the spillway. It is preferable to remove all debris entirely.

CALVIN W. RICE.

The floating ice is usually passed over the dam, but if it is not possible to do this, and the ice is present in large quantities, it must be taken from the water and removed entirely from the plant. It is not possible to work the ice through the racks unless it is reduced to slush, and even then it will seriously interfere with the operation of the turbines, often stopping them entirely. This difficulty is more easily prevented than cured,

by arranging head-gates outside the racks and placing the entire gate openings under water. The bulkhead in which the gates are located will then act as a skimmer, and all floating matter can be floated over the dam or through an ice sluice. If this arrangement is not possible, a cheap substitute is found in a glance boom of the pattern known as a stiff boom. This can be built either of logs or square timber and set across in front of the head-gates at an angle with the current; the smaller the angle, the more efficient will be the boom. It is advisable to have the boom two tiers high, so that it will float low in the water.

C. H. HOLLINGSWORTH.

We have about one mile of steel pipe line ranging in size from 18 inches at lower end to 36 inches at the intake, with a total head of 700 feet, or 303 pounds pressure. We run continually, 23 hours per day, and at no time is there less than 250 cubic feet per minute pouring through the pipe. In January the ice began to gather upon the inside of the pipe, and it continued to grow thicker each day until the head was reduced 65 or 70 pounds by friction. Other pipes in the county had frozen solid and the plants closed down. We could not afford to close down, and as a last resort we put a 25-hp steam boiler about 20 feet from the intake and put steam in the water at that point just as fast as that boiler could make it. The temperature of the water in the tail-race before we began using the steam was 30 degrees. After a continual flow of steam in the pipe line for five days and a half, we raised the temperature to 32 degrees, which soon cut the ice from the pipe.

C. L. HOON.

The only satisfactory way to prevent difficulty from anchor ice is to prevent its formation by arranging a large mill-pond or forebay so that the water will remain comparatively quiet and readily freeze over.

E. H. MATHER.

For a 1500-hp plant fed by a power canal, we use a number of booms placed 50 feet apart for a distance of a quarter mile above the intake. This arrangement calms the water and facilitates freezing. Our greatest trouble is with thin ice that forms in patches on the canal surface, and gradually thickens while floating down the two-mile level. The booms hold this back for

some time till it works under and crowds down along the racks. It is then necessary to employ men with rakes to keep the racks clear. Part is worked through and part is removed entirely—an operation of considerable difficulty and expense.

THE EASTON POWER CO.

Ice may sometimes be removed from forebay before getting into wheels by having side outlet to drain surface water from the forebay.

AUGUSTA RY. AND ELEC. CO.

We find the cheapest and most effective method of dealing with anchor ice to consist in the maintenance of a boom of logs across the head-race and, at exceptional times, a continual raking of the racks. This last winter we have had no trouble, as the river and raceways have been frozen solid continuously.

FRED B. HUBBELL.

European practice in disposing of ice is to build in the intake canal special ice-breakers or deflectors and to provide a collecting basin at the end of the canal in which such ice as passes the deflector and the breaker is collected and discharged to the river by means of a sluice-gate or ice-trap, which is lowered, allowing the ice to pass over it. The deflector for floating ice is triangular in plan, located at one side of the intake canal, and built so as to extend above the water level, so that the ice, traveling at a high velocity, is forced against it, its direction of flow is changed, and it is shot over the overflow dam.

FRANZ KÖSTER.

*No. 2.—What methods have been successfully employed to obtain relief from slush or anchor ice?*

There are different kinds of anchor ice: one kind that will go readily through the racks and will clog in the wheels and stop them; and another kind that will gather at the racks and clog, but by means of vigorous raking can be worked through any ordinary rack, and, once through the rack, will pass readily through the wheel. In the former case the very best thing to do is to shut down until the ice stops running, for when it gets clogged in the wheels it takes a long time to thaw out. In the latter case it is usually advisable to keep running and keep the

racks clear by raking. However, as anchor ice usually comes on the first cold nights of the season, we find it best to shut down completely and allow the canal to freeze over solidly, which it will do faster than if the current were running swiftly, and when once frozen over there is no further trouble from anchor ice.

THE UNION ELEC. LT. AND PR. CO.

Thus far we have not been able to do away with slush ice entirely, but we are not troubled now nearly as much as we have been heretofore. Our main desire is to keep our still bay frozen as long as possible. To this end we have put in boom logs, which quiet the water and allow early freezing. At times when slush is expected we endeavor to have at least three inches going over our waste weir. We have a long boom placed at an angle with the weir, so that it tends to throw over all floating slush. We find that it is necessary at such times to keep a man cleaning this weir from the adhering slush. We have also lowered our racks so that the upper end is below the surface of the water. This tends to keep the iron at the same temperature as the lower water.

L. E. WATSON.

I know of no method of successfully obtaining relief from anchor ice, but recommend that provision be made for an inclosed flume for a considerable distance previous to entering the penstock, and where this is impossible, to have a wide and smooth channel to keep down the rate of flow. This works in two ways; first, there are no sharp points at which the anchor ice seems to form; and, second, the choking of the stream is prevented.

CALVIN W. RICE.

The only positive method of obtaining relief from slush or anchor ice is having a sufficiently large mill-pond above the power plant to allow such ice either to melt or come to the surface. This ice is formed in rapids, and if the approach to the turbines is swift water it is a difficult matter to get rid of it. The length of still water required to dispose of it is governed by the character of the stream above the penstock and the velocity of the current, and may be a distance of two miles or more.

C. H. HOLLINGSWORTH.

With an experience of 17 years in the operation of water-power plants, we have not yet been able to find a method for

getting rid of anchor ice. There is a vast difference on this river, (the Mississippi), between slush and anchor ice. The slush ice is on top of the water, and can be taken care of by men at the head-gates, by either removing it entirely from the water with scoops, or by breaking it up and letting it pass through the wheels. The anchor ice, with which we are occasionally troubled, is a very small, diamond-shaped icicle, which is usually carried down by the current from three to five feet below the surface of the water and in such a mass that it clogs up the head-racks, and with three men on the 10-foot rack we have been unable to keep the rack clean. When we have been troubled with anchor ice, it has come down the river immediately after the first freeze-up and interferes with our operation for not over 24 hours; after the river is once frozen over the trouble ceases.

#### LITTLE FALLS WATER PR. CO. OF MINNESOTA.

Slush or anchor ice will usually go through the wheels without difficulty, except in the most severe weather. We have had only one instance of a water-wheel clogging and freezing while running—a 51-inch McCormick turbine, which was afterward thawed out by fires built inside the turbine chamber.

#### THE EASTON POWER CO.

With a plant where the anchor ice floats near the surface, relief can sometimes be obtained by constructing floating guides in front of the rack, leading diagonally to a side sluiceway through which the anchor ice will run off and not pass through the rack. In a plant where the water passes through the rack with much force, it is doubtful if there is a device that will give any more relief than the common hand-rake.

E. H. MATHER.

For disposing of anchor or slush ice, a barrier a few feet high is built across the bottom of the intake canal before it reaches the collecting basin. This barrier is curved, and one end terminates at a sluice-gate built in the overflow wall of the canal. To discharge the ice, this gate is operated from above, either electrically or by hand. It is also common practice to deepen the intake canal before reaching the barrier, and thus reduce the speed of the water and collect all the ice at this point.

FRANZ KÖSTER.

I believe rafts placed in the forebay or pond, so that the water will pass under cover for some distance before reaching the racks, will cure the trouble in many cases. We ran for nine years in connection with a sawmill. During this time the pond for a distance of 500 feet above our racks was covered with logs, and we never experienced any trouble with ice. For the past four years, we have had trouble every year until a coating of ice is formed over the pond, when it ceases, but frequently troubles us again in the spring during cold snaps after the ice has gone out.

E. S. KING.

*No. 3.—A pine-stave, five-foot trunk, taking water from dam to water-wheel a distance of 1000 feet, is bound with steel hoops, uncovered, which are resting on and in the earth. This trunk is always filled with water. Is there any danger from lightning?*

The penstock described in this question is in no more danger from lightning than any other structure in the vicinity. Cases of water-works standpipes being struck by lightning are extremely rare, though they are invariably on high ground, in most cases built of steel, and always full of water.

C. H. HOLLINGSWORTH.

The pine-stave flume bound with steel hoops is not in any particular danger of being injured by lightning on account of its construction, while if there are tall trees near by and overhanging the flume, there is even less danger from lightning.

E. H. MATHER.

We see no reason why there should be any special danger from lightning, unless trunk is raised very high above the ground or otherwise much exposed.

AUGUSTA RY. AND ELEC. CO.

*No. 4.—What is the best method of cleaning racks in a water-power plant?*

As far as possible, lift things up to the top of rack and remove them. Avoid pushing obstructions to the bottom, as they will probably remain there and form a network to collect more. Where possible, sluiceways with gates can be carried to advantage under power-house and into tail-race. The water rushing

through sluiceways will carry off deposits of silt, etc., and the racks may be cleaned by pushing the obstructions down and allowing them to pass through sluiceways. It is difficult to apply this to stations already built. GEO. B. LAUDER.

We have found a rake made of a hickory head-piece and power plants is by means of hand-rakes.

THE UNION ELEC. LT. AND PR. CO.

We have found a rake made of a hickory head-piece and 40d wire spikes for teeth, placed so as to fit between the grates of the rack, attached to a strong wooden handle, to answer very well for cleaning the racks. A large-sized barley fork covered with wire netting, one-inch mesh, is also a useful tool with which to remove floating trash from our still bay.

L. E. WATSON.

The method now usually employed in cleaning racks in a water-power plant is the use of a long-handled rake, which, by moving up and down over the racks, will have the effect of cleaning them for the time, but this must be repeated as often as seems necessary. As it is usually impossible to see down the racks for any distance, their condition is largely a matter of conjecture and can only be guessed at by the flow. The writer has reason to believe from his own experience that accumulations of dead leaves and other matter may remain at the bottom of the racks for years. A remedy for the trouble suggested is to build the racks in narrow, full-depth sections, placing same inside the head-gates. They can then be lifted in sections and cleaned during any time of partial shut-down.

C. H. HOLLINGSWORTH.

Racks are cleaned by two methods: First, such material as will float is raked to the surface of the water and run off through a side sluiceway; second, such material as will sink is drawn off through a sluiceway opening from the bottom of the canal or forebay.

E. H. MATHER.

We have seen no better method than large, heavy hand-rakes. On account of unevenness of the racks, mechanical methods would probably fail if tried on a large scale.

AUGUSTA RY. AND ELEC. CO.

The racks are built in three sections which overlap each other in different planes, the sections sliding in structural-steel guides. Where possible, they are cleaned by the use of a rake, and where this can not be done, the upper rack may be lowered to replace the bottom section while the bottom section is withdrawn for cleaning. Thus, any one section may be removed and two lower sections still remain in place.

FRANZ KÖSTER.

Construct the racks so that they will be practically self-clearing, which can be done in most cases by a reconstruction of the racks with reference to the current of the stream. A number of years' experience in the operation of water-power electric plants has convinced me that there should be but one rack and that at the point of diversion of the water from the stream. The rack should be constructed of steel plates one-quarter to three-eighths inch in thickness and from two to two and a half inches in width, the distance between the plates to be governed by the character of the *débris* running in the stream; ordinarily about three-fourths inch apart.

The rack should be perpendicular and should stand parallel with the current of the stream, and the aggregate area of the openings between the plates should be of sufficient area to pass the maximum amount of water required without any perceptible agitation. By this construction, the *débris* is carried past the racks and over the dam. The forebay should be amply large and tightly covered over, and if timbers are fastened across the inside of the forebay about 12 to 18 inches apart and at the level of the water, the ice in forming will adhere to the timbers, and if the water is afterward drawn below the timbers the ice will remain suspended and will not fall down and clog up the forebay. If booms are placed diagonally across the stream so that the up-stream end is above the intake with the down-stream end pointing away from it, there will be a tendency to pass the floating *débris* along toward the dam and away from the racks.

At one dam of which I had charge, the intake to the forebay was at right angles to the stream, with a short rack across it. In the fall of the year when leaves were running and in the spring when driftwood was coming down the stream, we were obliged to keep a man raking the rack during the night run (no day circuit), and we occasionally lost the lights through the inability of the man to keep the rack free enough to pass the required

amount of water. I enlarged the forebay, changed the intake so as to have it parallel with the current of the stream, and quadrupled the area of the rack surface. This was three years ago, and we have not been troubled once since with a clogged rack, nor have we spent an hour's time, in all of the three years, in raking the rack.

E. D. BLACKWELL.

*No. 5.—What is the usual price paid for water-power where the party owning the water-power furnishes building and water-wheels?*

Price for water-power varies very materially in different locations and under different conditions. Leases made from 50 to 70 years ago for permanent water are as low sometimes as \$10 or \$11 per horse-power of water used per year for 24-hour privilege. A fair price to-day would be from \$20 to \$25 per horse-power of water per year for 24-hour privilege.

THE UNION ELEC. LT. AND PR. CO.

The price for water-power under the conditions described is very elastic, and ranges from \$10 to \$60 per horse-power per annum. It is governed by the amount of power used, conditions under which it is developed, number of hours used per day, and several other conditions.

C. H. HOLLINGSWORTH.

There is no "usual" price paid for water-power where the owners furnish building and water-wheels, as this depends on the cost of the development and the demands for such power. We have known of power being delivered on the water-wheel shaft at \$10 to \$12 per hp-year.

E. H. MATHER.

This city furnishes the water in the canal and a tail-race at \$5.50 per year per theoretical horse-power.

AUGUSTA RY. AND ELEC. CO.

*No. 6.—When a water-power plant has been designed with large units, and, the day load being small, gives very low water-wheel efficiency for a large part of the 24 hours, supposing economy of water to be a great consideration at certain periods, what means can be used to secure better efficiency of operation?*

Kind of wheel not given; if horizontal, with two or more runners on shaft, all but one runner might be closed against the

water and the remaining runner operated by gate more nearly open, giving more efficient operation. The end thrust would probably be troublesome, as the pressure of water would not be balanced.

GEO. B. LAUDER.

It is hard to recommend a specific remedy for the conditions described without fuller details, but in general I would suggest that if a number of wheels are in use driving one unit, considerable economy could be secured during periods of light loads by cutting off some of the wheels, leaving only enough wheels on to do the work at most economical gate-opening

JAS. B. FOOTE.

In the plant described in this question, the best results would be obtained by so arranging the gate mechanism of the turbines (provided there are more than one for each unit) that the wheels can be thrown on or off independently. For instance, with two wheels that develop 1500 horse-power at 400 r.p.m., if one were shut off you would obtain 750 horse-power at 400 r.p.m. minus the power required to revolve the dead wheel.

C. H. HOLLINGSWORTH.

The load factor of the power plant may be improved by so shaping the charges for current as regards time of using that you will actually secure customers for unusual hours. For instance, I understand that in Montreal, the working day in a great many mills begins at five o'clock in the morning and ends at three in the afternoon, thus avoiding the peak at five p. m.

CALVIN W. RICE.

The installation of a small wheel of desired capacity would probably be the most economical means of securing better efficiency, if the local conditions are such as to permit of the additional installation.

E. H. MATHER.

Day motor load at very low rates, or the use of storage batteries, if the interest and depreciation justify it.

AUGUSTA RY. AND ELEC. CO.

*No. 7.—What success have you had in the operation of a steam plant connected in parallel with a hydraulic plant where*

*the load fluctuates 50 per cent. as would be the case if such a combination of plants were supplying current for railway purposes in addition to having a considerable lighting load?*

We have been successfully operating a water-power plant, supplying current from the same generators for both lighting and street-railway load. Two units of 450-kw each, 2400 volts, were the two-phase, are belt-driven from McCormick turbines. At the substations there are motor-generator sets, supplying current at 575 volts to the trolley system. Until lately, this system was operated with the help of a small storage battery on the trolley system. This being insufficient to take care of more than three-fourths of the total variation in load beyond generator capacity, steam-driven direct-current generators were run in parallel with the motor-driven sets, an 800-hp. double-tandem compound McAlister and Seymour and a 400-hp. high-speed Armstrong and Sumner being used. The load fluctuations were then taken up partly by the water-wheels, the steam engines and the storage battery. This service was found very severe, necessitating constant expense and attention to gate brackets and governing apparatus of water-wheel, and to part of steam engine.

When a larger storage battery was installed, making an average of 100 ampere-hours at 550 volts. Since then steam has been practically eliminated, as we find the water all-sufficient to operate under winter conditions of heaviest load. By allowing a net discharge from the battery during the 20 hours of the day and charging up at night, we have obtained an average of 400 kilowatts for the 24 hours from a 450-kw generator. The net load varies from 100 to 700 kilowatts. The alternating-current voltage never varies more than two per cent. and the motor generators as simple shunt machines, the generator load remains constant. Under these conditions, we have run the water-wheel governors and have run them at constant speed, charging the battery—floated without the boosters—keeping the generator and the change in alternating-current voltage very well controlled by a voltage regulator. Using the water-power resources, the generator load shows a slight variation, but not enough to cause variation beyond two per cent in the alternating-current lighting voltage.

THE EASTON POWER CO.

Some three years ago I was connected with the installation of a steam-driven plant and a water-driven plant, the steam-driven plant consisting of a Corliss steam engine belted to a three-phase, 60-cycle, alternating-current generator. In the same station was located a high-speed Ball engine, which in turn was belted to a three-phase, 60-cycle, alternating-current generator. Three-quarters of a mile away was located our water-power station, which consisted of a McCormick turbine direct-connected to a three-phase alternating-current generator. All of the machines generated direct at 2300 volts, which was stepped up to 10,000 volts by means of transformers. The transformers were all located in the steam-driven station, and the output of the water-driven station was transmitted to the steam-driven at 2300 volts. All three of the machines were worked in parallel and their output stepped up through three transformers. The current was transmitted some five miles and was utilized principally in operating mine hoists, which show much greater variations than are usually encountered in railroad practice. The station was operated to our entire satisfaction in this manner.

THOMAS B. WHITTED.

We have not experienced any difficulties in operating steam-driven alternating generators in parallel with hydraulic-driven alternating generators when railway generators were also connected to steam plant. In our case the railway generators are of somewhat less capacity than the engine.

E. W. CRAWFORD.

We operate our electric plant very successfully by combined steam and hydraulic power. The fluctuation in load is fully 50 per cent, and is made up during the daytime almost entirely of motor loads ranging from .5 to 100 horse-power, and driving all manner of machinery and manufacturing industries. Our day load of motors is almost equal to the lighting load at night.

W. F. KINGAN.

In operating a water-power plant of medium head, I believe it will be necessary to have the engine take the variable load where street-car service is on the same line shaft as the lighting generator.

GEO. S. CARSON.

*No. 8.—What method of regulation do you use to accomplish commercial results with such a load?*

We have found that the most satisfactory method of regulation under such a load is to operate the hydraulic plant with wheel gates wide open, and to adjust the speed of the governors on these wheels so that it is slightly in excess of the normal speed of the engine. In this way the engine does the regulating, unless the load drops to such an extent that the engine is doing no work, when the wheels will then take the regulation. We also use a storage battery on the railway circuit, which tends to equalize the load.

E. W. CRAWFORD.

We find that all the regulation necessary is accomplished by the inertia governor of our steam engine supplemented by water-wheel governors set to move a little less sensitively and finally regulated by hand, changing the speed when the load fluctuation is very heavy. This rarely occurs.

W. F. KINGAN.

*No. 9.—Are voltmeter readings from a generator driven by a water-wheel a correct measure of the variations of speed of the water-wheel?*

Voltmeter readings are not a correct measure of speed variation. The variations of voltage will be greater than speed variation, on account of dynamo regulation.

GEO. S. CARSON.

No. This would be a correct measure only in the case of constant load and constant-field excitation of the generator; conditions not obtainable in commercial operation.

THE EASTON POWER CO.

*No. 10.—What determines the degree of possible speed regulation of a water-wheel?*

Our experience with water-wheel regulation has been that two factors are absolutely necessary for good results; namely, a good governor and plenty of flywheel capacity.

E. W. CRAWFORD.

This question is somewhat ambiguous, but, as I understand it, I should say that the Lombard governor regulation of a water-wheel is very close to fair steam-governing, particularly where the waterways to and from the wheels are very large. The limit of time to change the speed in any water-wheel is governed solely by mechanical reasons; namely, the wear and tear on the rack and pinion of the governor, as well as the moving parts of the gate mechanism.

W. F. KINGAN.

*No. 11.—What is the average depreciation of the different parts of a water-power generating plant?*

This question is a very broad one and depends largely on the style of installation. With modern direct-connected, horizontal water-wheel units and generators, with dams, buildings, etc., of concrete and steel on good rock formation, it should not exceed five per cent. This covers building and machinery; and, classifying, would state that, with the best-conducted modern power plants, the depreciation on buildings and dams should not exceed three per cent, water-wheels six per cent, revolving field alternator five per cent, governor and electrical apparatus ten per cent.

W. F. KINGAN.

*No. 12.—What are average operating expenses per hp-year of water-power plants of different sizes?*

Our water-power plant consists of two 150-kw alternating-current generators, each connected to turbine; two 60-kw arc-light machines on one wheel; two 100-kw, 500-volt generators on one wheel. Total capacity of electrical machinery, 620 kilowatts. Flume of wood, three miles long, supplying, at maximum, water enough to develop 500 kilowatts at switchboard. This plant feeds into trunk-lines connecting to two steam plants. The average annual output of water-power plant for two years was 1,700,000 kw-hours; average electrical load, 194 kilowatts. The flume had been in service 10 years, the water-wheels and generators six years, and the repairs to flume and machinery were unusually high for these reasons. The following are in round

figures the operating expenses per kw-hour, not including any depreciation, superintendence, taxes or general expense:

Repairs to building.....	0.007	Cents
Repairs to dam and conduits.....	0.097	"
Repairs to turbine and electrical machinery	0.102	"
Labor, dynamo tenders.....	0.242	"
Labor, flume tender.....	0.053	"
Sundry supplies.....	0.014	"
Total.....	0.515	Cents

The flume was practically gone in 12 years.

HERBERT McNULTA.

A modern water-power plant of about 1500-hp capacity can be operated for \$3.00 to \$4.00 per hp-year, which includes only labor and material used at the power station.

E. H. MATHER.

## C

### FEED WATER, PURIFYING COMPOUNDS, ETC.

*No. 1.—What effect does soda ash, used for purifying boiler-feed water, have on cylinder lubrication?*

Soda ash, when used in a boiler, should be first dissolved in a tank and then pumped into the boiler, so that it will be entirely dissolved. A separator should be used, so that no water can get to the cylinder from the boiler, or some other means should be used to obtain commercially dry steam. Under these conditions soda ash will have no effect on the cylinder, but otherwise it is liable to get into the cylinder and cut the oil.

D. KENNEDY.

It has a tendency to dry the cylinder walls if used in large quantities, and to increase the amount of oil necessary for lubrication.

### STEUBENVILLE TRACTION AND LT. CO.

It depends upon circumstances. If a small quantity is used on boilers that make fairly dry saturated steam, no evil results to engine cylinders will be seen. If boilers are apt to foam or work wet steam, it will seriously affect lubrication.

W. BLOXHAM.

Soda ash, if used in proper quantity for purifying boiler-feed water, has no effect whatever upon cylinder lubrication.

J. D. A., N. Y. ED. CO.

Soda ash used in boilers necessitates the use of more cylinder oil in engines.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Necessitates more oil.

AUGUSTA RY. AND ELEC. CO.

It is claimed by the agents for the different boiler compounds that soda ash will pit the boilers and engine cylinders. However, all boiler compounds contain more or less soda ash. Soda ash should be so used as to precipitate the impurities in a tank before the feed water enters the boiler.

C. S. JOHNSON.

We used 10 pounds per day of 24 hours on 1200-hp boiler without visible effect on lubrication.

G. R. W., MALDEN ELECTRIC CO.

Soda ash has no injurious effect on cylinder lubrication if properly used.

S. B. RICHEY.

If enough soda ash is used to take off all the scale in boilers, it will cut the very best grade of cylinder oil, leaving the cylinder dry and sticky.

E. S. ASPNES.

*No. 2.—What is the object of placing zinc in a steam boiler? Does it prevent scale or corrosion, and what impurities in the water make its use desirable?*

With regard to use of pig zinc in steam boilers, I would say that in actual experience I have found the results highly satisfactory. As a practical illustration: In the year 1893 the tubes in a boiler of one of the United States Government dredges began to become useless through pitting and leaking. Pig zinc was immediately suspended in the boiler, but a new set of tubes was ordered, in order to have them on hand, ready to replace the old ones as fast as they gave out. After putting in three or four new ones no more were needed, the zinc having stopped the pitting of the old ones. Eleven years after that time, the zinc

having been kept continuously in the boiler, the old tubes were removed, their ends having been burned off by action of the fire, and not because they were disabled by the corrosive influence of the water. I could give you other instances of a similar character, but I think this one will convince you of the advantage of using zinc in boilers.

Internal corrosion of pipes and boilers presents itself in various forms, each having a peculiar character of its own, though only sometimes strongly marked; these are designated as uniform corrosion, wasting, pitting, honeycombing and grooving. It has been proven by practice that zinc and kerosene oil are the best known ingredients to prevent the above corrosion.

In modern engines where high-pressure steam is used, decomposition of the cylinder lubricant (if of an animal or vegetable nature) used for the internal parts takes place at or about 235 degrees Fahrenheit. The acids of the oil ultimately come into the boiler, where they proceed to attack the iron. To prevent the acids from damaging the tubes and boilers, plates of zinc (pig zinc) are suspended in the boiler water, forming an exciting fluid of the acids and water, and directly a metallic contact is established between the zinc and iron, a galvanic current is set up, and, according to the usual laws of electricity, the negative pole (in this case the iron of the boiler) is preserved at the expense of the positive or zinc pole.

The customary amount of zinc used is about 50 pounds to every 100 horse-power of boiler; if kerosene is used, about one pint to every 100 horse-power of boiler is used for about 12 hours. The kerosene is often used, as it is one of the best known substances for the prevention of pitting, etc., of heater tubes and pipe systems. Common washing-soda is also good to neutralize the acids, using two pounds for every 100 horse-power per 12 hours.

REID WHITFORD.

Zinc is largely used in marine boilers for the prevention of both incrustation and corrosion. The scale may acquire thickness and hardness, but can be easily removed from the plates. It is supposed that the zinc in connection with the iron of the plates keeps up a feeble galvanic action, and that the hydrogen liberated at the surface of the plates by this action prevents the incrustation from adhering to it.

D. KENNEDY.

Zinc is used to prevent corrosion in a boiler. In boilers using water containing acids or alkalies there is a galvanic action going on, in which parts of the boiler are positive and other parts negative, and the negative parts will be attacked. By placing zinc in the boiler, the zinc becomes negative and sets up galvanic action enough to make all other parts of the boiler positive and the zinc becomes the object of attack by the acids.

STEUBENVILLE TRACTION AND LT. CO.

I have used zinc in boilers to prevent galvanic action with very good results if placed near the water line. I have never noticed any results from use of zinc with reference to scale prevention.

W. BLOXHAM.

The object in placing zinc plates in a steam boiler is to prevent pitting and corrosive action on the iron shell of the boiler. They do not prevent the formation of scale in boilers.

G. WILBUR HUBLEY.

Zinc is used to prevent galvanic action in the boiler, the zinc being eaten away instead of the boiler.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Prevents pitting, in certain kinds of water.

AUGUSTA RY. AND ELEC. CO.

The object of placing zinc in steam boilers is to arrest the corrosive action of saline or other active agents in the water. Zinc is sometimes suspended in boilers of ocean-going vessels, as the saline solution acts as an electrolyte, the zinc as the positive element, and the steel as the negative. According to the law of primary batteries, the greatest action takes place at the positive element, which in this case would be the zinc, or negative pole.

CHAS. H. PETERS.

If acids are present in the water there is a galvanic action which tends to the corrosion of the iron. When zinc is introduced in the boiler, as it is electro-positive with respect to iron, the result is the wasting of the zinc rather than the iron. It also prevents the scale from adhering to the iron if there are solutions of chalk or lime in the water.

LOUIS I. PORTER.

*No. 3.—Is there any means of removing magnesia coating from the inside of hot-water pipes and meters?*

If it is practicable to use kerosene of fire test of 300 degrees Fahrenheit, I think it will have the desired effect.

W. BLOXHAM.

Have cleaned driven wells and horizontal runs of pipe from magnesia with turbine boiler cleaner on end of hose. This was three-inch pipe, or larger. For small pipe and meters, the use of some scale solvent or diluted muriatic acid would be successful.

J. A. MALONEY.

We take pipe and meter down and remove magnesia coating by knocking it out.

GEO. B. TRIPP.

*No. 4.—What results have been obtained in measuring hot boiler-feed water with the Venturi meter? What precautions must be taken in placing meter? Will this meter work accurately where feed pumps are ordinary duplex type with air chamber?*

There is a manufacturing plant in the writer's neighborhood where a four-inch Venturi meter has been used in the feed line for a number of years. The temperature of the water passing it is usually from 200 to 210 degrees Fahrenheit at a pressure of about 90 pounds gauge. On account of the varying demand for steam, the velocity in the line (controlled by a pump governor) varies through quite a wide range. Checking against scale weights shows it to be very accurate. It is equipped with the usual registering mechanism, and, beyond an occasional inspection and adjustment of that device, has required no attention.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Hot boiler-feed water has been measured with the Venturi meter to within about one per cent of absolute accuracy. The meter should be placed either in the section of the pump, or in the discharge, as far from the pump as possible, to avoid surging. If these precautions are taken, the meter will work accurately with a duplex-feed pump.

J. D. A., N. Y. ED. CO.

*No. 5.—What is the best method of feeding purifying compound into a boiler in order to be sure that the amount supplied is proportional to the amount of water evaporated?*

The best method of feeding purifying compound into boilers is probably through the boiler-feed pump or injector. I believe there is a Lee injector manufactured, provided with a receptacle for the purifying compound, so that it may be delivered into the boiler proportionately to the amount of water evaporated. Another plan is to erect a standpipe of sufficient size (with a valve at its bottom) on the water-feed pipe, thus releasing the compound at will.

REID WHITFORD.

By using a sight-feed lubricator.

D. KENNEDY.

The best method of feeding purifying compound into a boiler in order to be sure that the amount supplied is proportionate to the amount of water evaporated, is to use a small pump direct-connected to the feed pump, the capacity of this pump being correctly proportioned to the capacity of the feed pump.

J. D. A., N. Y. ED. CO.

I have found that the best method is to use excessive quantities of compound or kerosene for five or six days, with a very slow fire, blowing the boiler down every 24 hours as low as the grates and pouring in one or one and one-half gallons of kerosene, after which use a mechanical cleaner, and the boiler will be thoroughly clean. At least, this has been my experience with a very hard scale composed mostly of sulphate of lime and silica and with a softer scale composed of the carbonates and sulphates mixed. A good compound fed with lubricator ought to do the work fairly well, but not thoroughly.

W. BLOXHAM.

Feed determined amount of compound at intervals automatically controlled by the speed of the boiler-feed pump.

TOLEDO RYS. AND LT. CO.

Feed the compound in a liquid form by a small ratchet-driven pump operated from the piston or valve link of the boiler-feed pump.

STEBENVILLE TRACTION AND LT. CO.

By small pumps driven from main feed pumps.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

The best and only correct method is to treat the feed water and remove scale-forming impurities before entering the boiler.  
G. WILBUR HUBLEY.

Measuring and feeding through a barrel, with a special inlet into the boiler through the injector.  
AUGUSTA RY. AND ELEC. CO.

Connect small direct-connected feed pump to cross-head of boiler-feed pump, feeding the desired amount continuously.  
G. R. W., MALDEN ELECTRIC CO.

Have a tank placed above the pump and connected to the suction pipe by a small pipe in which there is a gate valve and feed the required amount daily rather than weekly.  
S. B. RICHEY.

• Keep record on daily station report sheet of the number of hours each boiler is actually under fire, and feed purifying compound to individual boilers through feed-water injector in proper quantities.  
PAUL LUPKE.

*No. 6.—Is there any hot-water meter that can be run continuously and that will maintain reasonable accuracy?*

Yes. The American District Steam Heating Company's condensation meter measures to the fraction of a pound.  
D. KENNEDY.

The Venturi meter and a hot-water meter built by the Union Meter Company, of Worcester, Massachusetts, are both reasonably correct for constant use with hot water.  
J. D. A., N. Y. ED. CO.

I have used a Worthington hot-water meter, which varies very little from the city meter.  
W. BLOXHAM.

There are hot-water meters up to two inches that will work continuously with reasonable accuracy with the temperature up to about 211 degrees Fahrenheit.  
C. L. DAVIDSON.

The Worthington special hot-water meter gives very satisfactory results.  
S. B. RICHEY.

*No. 7.—Will any one who has had experience with hot-water meters of one and one half-inch or two-inch size, used individually to record the amount of water evaporated by each boiler, please state the average accuracy of these meters in constant service, the frequency of tests required, and the amount of repairs necessary for the maintenance of this accuracy?*

Experience with impulse meters shows that some makes of these meters will run in continuous service for several months and retain their accuracy. Some trouble has been experienced on account of pivot bearings, and particularly the counters, wearing out.  
W. L. ABBOTT.

In an instance where 16 meters are measuring boiler-feed water of an average temperature of 190 degrees Fahrenheit, the meters were tested for accuracy after four months' service. The meters are of the rotating-disc type, specially built for hot water. There are two sizes: 1.5-inch on 500-hp boilers and two-inch on 800-hp boilers.

Each meter was tested at three rates corresponding to a full load on the boiler, to 66 per cent of full load and to 33 per cent overload. The average accuracy of the 16 meters was as follows:

At 66 per cent of full load, meters were 10.2 per cent slow.

At full load, meters were 5.7 per cent slow.

At 33 per cent overload, meters were 4 per cent slow.

The average of all readings showed the meters to be 6.6 per cent slow. Under small loads the meters can not be depended upon, but if run steadily at the full evaporative rate of the boiler they give good results. As the feed varies constantly from nothing to maximum, the indications of the meters as a whole are probably about 10 per cent slow. This can not be determined exactly from the tests.  
ROBERT LINDSAY.

Seven hot-water meters of two-inch size used under 170 pounds pressure at 150 to 200 degrees feed got from 12 to 15 per cent slow in six months.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

## D

## FUEL

*No. 1.—Describe an effective method of treating bituminous coal at the time of storage, to prevent spontaneous combustion when coal is lying in bins 15 or 18 feet deep.*

Keep coal dry and exclude all air.

D. KENNEDY.

Reduce the quantity of coal by partitions, and provide for quick dumping in case of fire.

CALVIN W. RICE.

Where bituminous coal is piled in bins 16 or 18 feet in depth, spontaneous combustion may be avoided by using a number of two-inch pipes placed in a vertical position in the coal at different depths, the ends being allowed to project above the pile in order to carry away gas formations, besides acting as ventilators.

SAMUEL KAHN.

For treating bituminous coal to prevent spontaneous combustion, few ways are better than to keep it moving, and this is best done by using from the bottom of the bin. The bin should slope enough so that there will naturally be a movement of the entire mass when chutes at bottom are opened.

C. H. HOLLINGSWORTH.

A solution of salt and water (about a quarter of a pound of salt to one gallon of water) has been found effective. Spread the coal in layers of from two to three feet in thickness and wet down with this solution, using about 40 gallons to a ton of coal.

W. F. SIMS.

Make sure that the coal is not wet when put into storage, and do not drop it any great distance in handling it.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 2.—What is the approximate percentage of deterioration in soft coal from exposure? Is it proportional to the period of exposure?*

Our experience has been that soft coal in a pile is improved by exposure to the weather. Repeated tests, extending over a

number of years, of coal just from the car and from the pile—both from the same mine—have invariably shown higher evaporative power in the coal after exposure in the pile.

WILLIAM R. GARDENER.

Soft-coal lignite will slack more in the first five than the next ten days if kept in dry place where wind or sun can not reach it. In my estimation it will lose in five days 150 pounds to the ton.

D. KENNEDY.

The percentage of deterioration of soft coal from exposure can not be estimated, as it is proportional not only to the period of exposure, but to the percentage of volatile matter contained in the coal.

J. D. A., N. Y. ED. CO.

The percentage of deterioration of soft coal from exposure varies with the kind of coal. The percentage is not proportional to the period of exposure, as the coal on the outside of the pile protects that further in.

C. H. HOLLINGSWORTH.

It depends a great deal on the climate, and is not proportional to the period of exposure.

W. BLOXHAM.

Some of the large gas companies find that their coal deterioration averages about 10 per cent per year for six to seven years.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

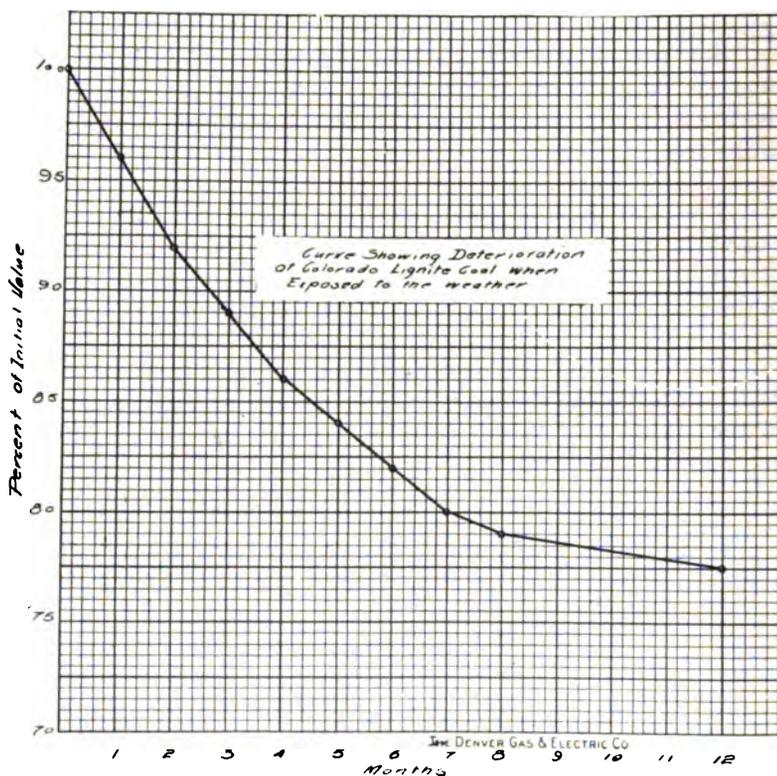
The deterioration of soft coal from exposure can not in any case exceed the percentage of volatile matter that it contains. This runs in general from 20 per cent to 35 per cent, but analyses made on coal after a year's exposure show no apparent change in the amount of volatile matter. Any deterioration that takes place, unless the coal heats, is due solely to the coal crumbling on account of the action of the weather. The deterioration is physical, and not chemical.

W. L. ABBOTT.

The writer has noted that the deterioration in soft coal from exposure follows no law. The outside layer, say to the depth of two inches, may deteriorate considerably in a very short time, but there is little change in the coal below this depth for long periods of exposure.

JAMES MILNE.

Tests made by the Denver Gas and Electric Company on Colorado lignite coal show that the deterioration is very rapid



for the first six months. The results are shown in the accompanying curve.

J. F. DOSTAL.

Six per cent in first six months.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No. 3.—Is there any commercially successful system of making briquets of anthracite culm?

No; they are not a commercial success.

D. KENNEDY.

There are some systems of making briquets from pulverized coal or culm, but the writer does not know of any plants using any of these systems. There is, however, one successful system of burning the coal in a pulverized state.

C. H. HOLLINGSWORTH.

There is a system of briquetting anthracite culm by mixing it with a small percentage of coking coal and then pressing it into a briquet. When these briquets are burned, the coking coal serves as a bond to cement the mass of the briquet firmly together.

W. L. ABBOTT.

*No. 4.—In a station burning 20 tons of coal per day, what is the general practice for checking up coal consumption daily?*

Our way is to take the total number of tons received during the month, then take bin measure in cubic feet at the end of the month, allow 45 pounds per cubic foot of coal, lignite, nut and slack mixed, and deduct the same from the total amount received.

D. KENNEDY.

I recommend corresponding with the makers of coal-handling machinery, who will undoubtedly be pleased to answer this question in detail. (This also answers questions Nos. 6 and 7.)

CALVIN W. RICE.

In a station burning 20 tons of coal per day, the general practice is to weigh the coal on a platform scale.

J. D. A., N. Y. ED. CO.

A simple way to check up the coal consumption is to use charging cars holding a fixed number of cubic feet. The weight of the various coals per cubic foot can be ascertained within a very small percentage by a few experiments. By tallying the number of cars used the weight is easily arrived at. Cars can be filled from the bunkers and run along in front of the boilers.

C. H. HOLLINGSWORTH.

I have found that it is the general practice in plants of this size to be looking for a cheap man and to keep no account of coal.

W. BLOXHAM.

## Weighing.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The installation of a scale, with daily report from each watch showing the kw-hours per ton of coal, would be justified.

AUGUSTA RY. AND ELEC. CO.

Weigh the working stock on scales, as used.

G. WILBUR HUBLEY.

A power station burning 20 tons of coal per day should be furnished with overhead scales if the coal is on the level of the boiler-room floor. Either plan is comparatively inexpensive, and the record of daily consumption is kept with ease and accuracy.

C. W. HUNT CO.

Coal should be weighed and put on the floor for the day's run, and the amount left over measured and credited to day's run. With coal bunker and scales for each boiler, the fireman weighs the amount of coal he uses.

G. R. W., MALDEN ELECTRIC CO.

*No. 5.—What are the relative evaporative values of run-of-mine bituminous and Nos. 1, 2 and 3 anthracite buckwheat coal?*

I recommend Kent's handbook.

CALVIN W. RICE.

Our running log shows a relative value of about seven to nine in favor of run-of-mine bituminous.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

With proper care and intelligent firing, No. 3 buckwheat is equal to the best-quality run-of-mine bituminous. With the same conditions, No. 2 buckwheat is 10 per cent better and No. 1 buckwheat 15 per cent better.

GEO. L. COLGATE.

If the various kinds of fuel are burned under the conditions best suited to each, approximately the same amount of water can be evaporated by 100 pounds No. 3, 85-90 pounds No. 2, or 75-80 pounds No. 1 clean buckwheat coal, or by 65-70 pounds of the better grades of low volatile semi-bituminous coal sold in the New York market.

W. F. W., N. Y. ED. CO.

*No. 6.—Is it easier for the fireman to handle coal from the floor with a long-handled shovel or from a charging car with a short-handled shovel?*

In both cases short-handled shovels should be used.

D. KENNEDY.

It is easier for the fireman to handle the coal from a charging barrow than from the floor, as it is a question of foot-pounds in raising the coal from the floor to the furnace.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

The charging car, with a short-handled shovel.

GEO. L. COLGATE.

It is easier for firemen to handle coal from the floor with a shovel of the standard-length handle.

J. D. A., N. Y. ED. CO.

In the judgment of the writer, it is easier for the fireman to handle coal from a car with a short-handled shovel, than from the floor with a long-handled shovel, as with the short shovel from the car there is less stooping and less strain on the muscles generally, and the work is consequently less tiresome.

C. H. HOLLINGSWORTH.

From the floor.

W. BLOXHAM.

We use a short-handled shovel in both cases.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Firemen will handle coal more easily with short-handled scoop shovel from floor, with room enough for a good swing, and do more work.

G. R. W., MALDEN ELECTRIC CO.

From charging car, with ordinary scoop.

S. B. RICHEY.

The question of whether it is easier to shovel coal from the floor with a long-handled shovel or from a charging car with

a short-handled one, was a subject that received a great deal of attention from gas engineers about 30 years ago. At that time, gas was made in retorts and the coal was shoveled in from the floor or a hand-wagon. Many engineers made careful experiments as to the height of the charging wagon that would cause the least physical work for the men. The result of the various trials in many places and covering many years was that the floor of the charging wagon should be 17 inches above the floor, and the centre of the wagon be placed not less than seven or more than eight feet away from the retorts. This height of car makes it easy for the workmen to force the shovel into the coal by pressing against the handle of the shovel, and as the coal is not lifted vertically the mechanical work done is of translation, which requires the least number of foot-pounds of work. Our experience in steam-boiler firing confirms this conclusion.

C. W. HUNT CO.

I find it is easier to handle coal from a charging cart with a short-handled shovel, because you have a better control of your shovel and coal.

PERCY H. SKILLMAN.

*No. 7.—What is the cost per ton, exclusive of fixed charges on equipment, of handling coal from car to boiler-room bins with modern coal and ash-conveying machinery, assuming an annual coal consumption of 6000 to 10,000 tons?*

The modern coal-handling machinery for a power station using from 6000 to 10,000 tons of coal per annum can almost eliminate the labor item. There is no difficulty in arranging coal and ash-handling machinery in a station of this size to do the entire work with one man, provided the coal is received in cars that dump the entire contents into a conveyor beneath. The coal would be drawn from an overhead storage bin directly to stokers or to the charging floor.

C. W. HUNT CO.

Six cents per ton.

G. WILBUR HUBLEY.

The writer has at hand figures obtained in May, 1901, from the chief engineer in one of the large plants in New York. For handling coal from barges in the river to the bunkers at power-

house, the coal was taken from the barges with a clam-shell bucket, elevated about 80 feet and conveyed an average distance of 600 feet, at a cost of three cents per ton. The output of this station at peak was about 20,000 horse-power. The same coal handled from cars would cost less, as it would be dumped directly into a truck bin and then into the conveyor. However, with small plants the cost ought not to be above five cents per ton, provided all coal cars delivered at plant have hopper bottom.

C. H. HOLLINGSWORTH.

About three cents per ton to handle all coal and ashes.

D. KENNEDY.

*No. 8.—What are the results on grates and draft of burning a mixture of bituminous coal and hard-coal screenings, where formerly bituminous coal alone was used?*

It will not affect grate or draft, but more boilers will be needed to do the same work.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Have found the burning of hard-coal screenings with the bituminous coal to be pretty hard on the grates. The mixed coal will require at least 50 per cent stronger draught to get the same capacity from the boiler.

JAS. E. PYLE.

*No. 9.—How many tons of coal should a fireman and passer handle per day?*

A good fireman can fire 10 tons of good coal in a day, and take care of his ashes. A coal-passer can unload from 40 to 50 tons of coal from a car in a day.

W. L. ABBOTT.

One ton per hour, and tend to water.

G. R. W., MALDEN ELECTRIC CO.

A good fireman can handle 1900 to 2000 pounds of soft coal per hour for an eight-hour day on flat grates. A passer can handle 50 tons of coal in eight hours and weigh it also if the haul is not over 100 feet.

THE EDISON ELEC. ILL'G-CO. OF BOSTON.

About 10 tons.

F. ELLWOOD SMITH.

A fireman can handle 10 tons per day of eight hours, and a passer can handle 40 tons. GEO. B. TRIPP.

*No. 10.—In hand-firing bituminous coal, what is considered good average results in percentage of free oxygen and carbon dioxide on tests of from 12 to 24 hours?*

Ten per cent of carbon dioxide in fuel gases would be considered very good average work on tests.

W. L. ABBOTT.

Nine per cent CO and 11 per cent O<sub>2</sub>  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

## E

### BOILERS

*No. 1.—What results in efficiency and durability have been obtained by the use of a fire-brick coking arch over the grates of an ordinary hand-fired boiler?*

I only know from hearsay, but should say that there would be a gain in efficiency, but not in durability. In fact, there should be some extra expense in upkeep of brick arch. This expense would vary considerably with the intensity of the draft.

W. BLOXHAM.

The efficiency of the boiler is not altered by the use of a fire-brick coking arch. If the draft is insufficient, a long arch may reduce the capacity of the boiler. With a good draft no difference can be observed. A well-built arch fails through the gradual burning out of the fire-brick at the back edge. In this respect it has about the same durability as a bridge-wall. If it is made too flat or is insufficiently braced it may fail through the bricks loosening as a result of expansion and contraction.

PENINSULAR ELEC. LT. CO.

I could never see any difference in efficiency, but maintenance is considerably higher for the fire-brick coking arch.

D. KENNEDY.

About six months ago, we installed water-tube boilers with a fire-brick coking arch over the grates and have noticed a decided gain in efficiency. These boilers are used for intermittent service, and it is necessary for us to get up steam very quickly and to force the fires during operation. The one noticeable feature has been the fact that the gases from the coal ignite at the end of the arch before being condensed by striking the tubes, thus making an unquestionable gain in efficiency. The weak point about this style of furnace is, of course, the arch, but during construction we were especially careful not to have any quantity of fire-clay in the joints, the tile being merely dipped in a solution of fire-clay and laid brick to brick. When built in this manner, I have no doubt that the arch will be fully as durable as the rest of the setting.

E. P. COLEMAN.

*No. 2.—To what extent does such construction abate the smoke nuisance?*

There would be less smoke, but I can not give the percentage.

W. BLOXHAM.

The fire-brick coking arch over the grates of an ordinary hand-fired boiler, if made sufficiently long and given air above the fire as well as below it, will abate the smoke nuisance entirely. The coal must be coked on the front grates and pushed back and spread with the hoe before fresh coal is put in. If there are two or more doors to the furnace, only one door should be fed at a time. The work is harder on the firemen than ordinary firing, and if there is a poor draft it will be impossible to get the same output from the boiler.

PENINSULAR ELEC. LT. CO.

Probable good effect.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

I find that the fire-brick arch cuts down the volume of smoke very materially; it is hard to say to what extent, but I can give an illustration that will convey a very fair idea of the same. We have at our power station a battery of two 304-hp (nominal) water-tube boilers with fire-brick arches, dis-

charging the flue gases into a brick chimney 125 feet in height and six feet internal diameter, and, even when being pushed, comparatively little smoke is seen at the top of the chimney, and that of a light color, even this being absent except at the moment of firing. We also have connected with the same flue a 36-inch vertical heating boiler without arch, which is used at times when no steam is on the main boilers, and we have noticed that the total volume of smoke from the large boilers is not over 25 per cent of the volume discharged by the small heating boiler and is very much lighter in color.

E. P. COLEMAN.

It abates it to a slight extent.

D. KENNEDY.

*No. 3.—Which is the best practice: to put such a furnace in front of the boiler, or beneath it in the usual position?*

In front.

W. BLOXHAM.

Furnace as described should be placed in front of the boiler.

GEO. L. COLGATE.

The best place for such a furnace is wholly or partly in front of the boiler. Care must be taken that the flame from the arch does not strike on one spot on the boiler shell, or it will burn out that spot. If the boiler can not be set high enough to let the flame die out before it reaches the shell, it is a good plan to let the grates slope downward toward the back and to build a hearth of fire-brick on which the flame will impinge and be broken before it turns upwards toward the boiler shell.

PENINSULAR ELEC. LT. CO.

In front:

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In my judgment it would be best in front of the boiler.

D. KENNEDY.

Putting a furnace in front of a boiler exposes the user to the danger of losing heat by radiation, but also gives him the chance of having double walls, and drawing the air in through the hollow wall, thus using hot air instead of cold.

AUGUSTA RY. AND ELEC. CO.

A furnace beneath the boiler, in the usual manner, will give better results than in front of it.

S. B. RICHEY.

*No. 4.—What should be the minimum distance between the grate surface and the crown of the arch for use with Ohio or Indiana run-of-mine coal?*

From two feet six inches to two feet eight inches.

STEUBENVILLE TRACTION AND LT. CO.

There is no fixed minimum distance. A short arch must be set lower to do the work. A long arch may with advantage be set higher. The low arch will burn out sooner. If there is a high combustion chamber behind the arch, the arch may be shortened. The requirements are that the arch shall be near enough to the coal to ignite it by radiant heat and long enough to secure the complete combination of the gases rising from the fuel with the air admitted above the grates. The air is best admitted through louvres in the fire-doors so that it will mix immediately with the gases rising from the coal that is coking. If the air is admitted in this way, the arch over the front of the grate should come immediately above the fire-door openings and should be higher over the back of the grate. The arches of the Babcock and Wilcox chain-grate stokers as now built are good examples. They are now about four feet long. The crown of the arch is 18 inches above the grate at front and 24 inches at the back end of the arch. They used to build these arches only two feet long. Four feet is much better, and five or even six feet would increase the security against smoke.

PENINSULAR ELEC. LT. CO.

The long-flame cannel coals of Ohio and Indiana should be burned in Dutch ovens, and the minimum height of arch above bed of coals should be four feet. The theoretical minimum would vary with the draft, as may be seen by the following calculation:

Assuming a combustion of 25 pounds of coal per square foot of grate surface per hour, or .0066 pound per second, and assuming 30 per cent of volatile matter with the average formula of  $\text{CH}_4$ , and taking the atomic weight of carbon as 12, we have 7.5 per cent by weight of hydrogen to be reduced

by eight times its weight of oxygen, which constitutes about one-fifth of the incoming air.

$$.0066 \times .075 \times 8 \times 5 = .0198 \text{ pound of air per second required for the hydrogen alone.}$$

Assuming one-sixth refuse we have

$$.0066 \times .759 \times 32/12 \times 5 = .0665 \text{ pound of air required for carbon.}$$

Total pounds of air required per second per square foot of grate surface equals .0863, which at a temperature of 2500 degrees equals about seven cubic feet per second. Now, a draft of .25 inch water above grate is equivalent to a velocity of 43 feet per second, and the gases will travel to the crown of a four-foot-high furnace in about one-tenth of a second, providing 4.3 cubic feet of air, an insufficient quantity to burn the volatile matter before it can escape. The action of the arch in baffling the products of combustion, and shunting them into boiler, retards them sufficiently to give a furnace efficiency that is practically all that can be obtained under any circumstances.

J. W. BRASSINGTON.

*No. 5.—What form of grate bar is preferable for use with run-of-mine soft coal?*

For lignite coal, mine-run, use herringbone grate with one-quarter-inch mesh.

D. KENNEDY.

A good shaking flat grate.

STEBENVILLE TRACTION AND LT. CO.

A stationary grate with large air space, and it is necessary that the surface of the bars should be even, to prevent obstruction of slice-bar.

W. T. D., N. Y. ED. CO.

A good shaking and dumping grate, for any coal.

W. BLOXHAM.

Will depend upon the amount of work to be done. For continuous run would recommend a good chopping grate with at least 60 per cent air space.

G. R. W., MALDEN ELECTRIC CO.

One with 50 per cent or more air space.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 6.—Can a boiler be forced as hard with automatic stokers as with hand-firing?*

No; you can not force the boiler with mechanical stoker as you can with hand-firing. D. KENNEDY.

The boiler can be forced much harder with the automatic stoker than by hand-firing under ordinary conditions, if the stoker is a good one.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

A good stoker should be able to force boiler harder than hand-fire. This depends greatly on the grate surface, draft, etc., in either case. TOLEDO RYS. AND LT. CO.

It can with some kinds of stokers, when slack coal is used with a very strong draft.

STEUBENVILLE TRACTION AND LT. CO.

The average stoker is much more difficult to force than a hand-fired furnace and is generally not so elastic; that is, a low fire or a banked fire is not as quickly gotten into service as with a hand-fired boiler. W. BLOXHAM.

A boiler can be forced just as hard with an automatic stoker adapted to the kind of fuel that it is burning, as it can with a hand-fired furnace. J. D. A., N. Y. ED. CO.

Yes; a large overload can be handled with stokers with induced draft.

G. R. W., MALDEN ELECTRIC CO.

A boiler can not be forced so hard with automatic stokers as with hand-firing. S. B. RICHEY.

With the same draft conditions, a boiler can be forced harder with hand-firing than with automatic stoking, unless the stokers are so arranged that the fire can be readily raked and stirred.

W. L. ABBOTT.

Experience has taught me that boilers can be forced harder with hand-firing than with any mechanical stoker, with one exception, and that is the Jones underfeed.

JAMES MILNE.

A boiler can be forced much higher by hand-firing. European practice has shown that mechanical stokers are far less efficient than hand-firing.

FRANZ KÖSTER.

A boiler with any one of the modern automatic stokers can be "forced" as much as by hand-firing. The fire can not be "brought up" as rapidly as by hand-firing.

C. S. JOHNSON.

It depends on the type of stoker and the conditions of draft.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

It can seldom be forced as much with automatic stokers as with hand-firing, unless the design of the stoker is such as to permit it and yet avoid getting the fire too close to the boiler.

AUGUSTA RY. AND ELEC. CO.

Yes; depending on the type of stoker, grade of coal and so forth.

G. WILBUR HUBLEY.

*No. 7.—Is there any one stoker that will efficiently handle both hard and soft coal?*

No mechanical stoker will successfully handle both hard and soft coal.

D. KENNEDY.

We believe that there is a stoker that will efficiently handle both hard and soft coal, but we have no occasion to advertise the stoker.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

There is no stoker that will satisfactorily handle both hard and soft coal.

J. D. A., N. Y. ED. CO.

I have never heard of one, and will say here that I think a weak point in the stoker is its inability to burn different coals.

A good shaking and dumping grate will burn bituminous, anthracite, or anything that will burn at all.

W. BLOXHAM.

I believe not; the type of stoker should be adapted to the grade of coal to be used, or *vice versa*.

G. WILBUR HUBLEY.

Yes, the "Roney."

G. R. W., MALDEN ELECTRIC CO.

We do not think there is any stoker on the market that is eminently suitable for both kinds of coal. Some stoker manufacturers may say so, but experience says no. What is designed for one kind of coal is unsuitable for the other, and any one stoker said to be good for both is, in our opinion, inefficient for both kinds.

JAMES MILNE.

*No. 8.—How should the blow-off pipes of a boiler be protected?*

If they are tapped in the rear head or in the shell near the rear end, blow-off pipes for tubular boilers can be protected from the intense heat at this point by an outer casing of a larger-sized pipe, say about four inches, and the space filled in with asbestos, sand or fire-clay. Even then they are liable to give trouble, especially if there is a deposit of lime or other solids in the feed water, necessitating frequent renewals. Extra double-thick pipe two inches in size has given us the least trouble. We find the difficulty can be remedied to a great extent by either feeding through the blow-off or by tapping the shell on top and in the rear head above the setting, connecting a continuation of this pipe so as to produce constant circulation. This extension pipe should be connected outside the boiler setting, as close as possible to the blow-off valve. This allows free circulation in the fire space, but any solids given up by the feed water will settle between the blow-off valve and the point where this pipe leaves off. It is a good plan in this case to make connection to the feed and use it a portion of each day, if you do not care to feed regularly through this place, so as to keep the valve clear. With occasional feeding, the best arrangement is to have

two blow-off valves and the feed tapped in between them. We had our boilers tapped for the blow-off pipe in the shell at the back six or eight inches from the head, and also in the head in the front, our boiler water being very bad. We had a great deal of trouble with blow-off pipes in the back until we connected them up as above described.

S. S. INGMAN.

By building a fire-brick covering around same, entirely covering all parts of the pipe.

W. H. BANES.

By keeping outside moisture away, protecting against mechanical injury and keeping them clean by blowing out frequently.

D. KENNEDY.

Protect with a coating of fire-clay cement.

GEO. L. COLGATE.

If it runs straight from the boiler through the brick-work, incase it in a piece of cast-iron pipe of sufficient size to allow an air space around the blow-off pipe, so that if the latter should become filled with sediment it will not get red-hot and burst. If the blow-off pipe runs straight down to the ground it should be built in a brick pier.

STEBENVILLE TRACTION AND LT. CO.

On a horizontal tubular boiler the blow-off pipe should have a pier built around it.

W. BLOXHAM.

When blow-off pipes are directly in the path of furnace gases of high temperature, a split tile, preferably of fire-clay and with an inside diameter sufficiently large to allow an air space between pipe and covering, gives the necessary protection.

The practice of using extra heavy annealed brass piping between boiler and blow-off valve usually renders exterior protection unnecessary, and is a guarantee of freedom from interior corrosion.

J. P. S., N. Y. ED. CO.

The blow-off pipe of a boiler should be protected by a larger pipe acting as a sleeve. Where the pipe comes in contact with the hot gases an extra protection of fire-brick should be added.

G. H. CUSHMAN.

Blow-off pipes should be protected all around, so as to keep brick-work from coming into contact with them during expansion and contraction of the boiler or its setting. If possible, allow plenty of room for expansion where the blow-off pipes are connected to the common header, as this may cause trouble very quickly.

AUGUSTA RY. AND ELEC. CO.

The blow-off pipe should be protected by means of a globe valve and asbestos-packed cock in addition.

FRANZ KÖSTER.

By a pipe sleeve slipped on over pipe.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Should be protected from the direct flame by a cast-iron sleeve or a brick pier.

G. R. W., MALDEN ELECTRIC CO.

The best way in which to protect the blow-off pipes of a boiler is to keep a circulation of water through them. This is best accomplished by feeding the boilers through them.

S. B. RICHEY.

The blow-off pipe of a boiler may be protected by an asbestos covering, fire-brick, or piping. The last mentioned is the best and most durable. The blow-off pipe is fitted with a pipe of sufficient diameter to give about .25-inch air space. The pipe may be bent to avoid elbows. If an elbow be used, it should be below the fire-wall, for protection from the hot gases.

E. E. LEE.

We have a horizontal tubular boiler with a two-inch blow-off pipe, which we have protected by a three-inch pipe slipped over it. The three-inch pipe extends through the brick wall of the boiler setting and is plugged with cement except a very small hole that allows just enough air to enter to keep the blow-off from being burned. We consider that the extra life of the blow-off pipe more than balances the loss due to the leakage of air into the furnace.

FRED B. HUBBELL.

Blow off the boiler often enough to make sure that no pieces of scale are clogging the blow-off pipes, and the heat will not injure them.

E. A. ASPNES.

*No. 9.—Is the advantage of a surface blow-off sufficient to overcome the disadvantages of the additional joints, piping, etc., where they are necessarily exposed to the fire?*

We believe this depends entirely upon the character of the feed water, but the pipes should not be exposed to the fire. Rather tap the top of the shell and run down on the inside to the water level, and put on a tee and a short piece of pipe both fore and aft. Where the water contains anything of a soapy or oily nature, the use of this blow-off several times a day may be a cure for foaming.

S. S. INGMAN.

Under certain conditions, with impure water, the advantage gained may be enough to overcome the disadvantages mentioned.

D. KENNEDY.

In localities where the boiler-feed water is at all good, the disadvantages of a surface blow-off overcome its advantages, but in certain localities the surface blow is indispensable.

J. D. A., N. Y. ED. CO.

This depends upon feed water, but if they are exposed to the fire they need a very strong reason to justify their installation.

AUGUSTA RY. AND ELEG. CO.

In our experience the use of the surface blow-off is fully warranted, notwithstanding the cost of maintaining the piping, joints, and so forth.

EDGAR B. GREENE.

In most cases, yes.

W. BLOXHAM.

No.

G. R. W., MALDEN ELECTRIC CO.

*No. 10.—How and where should the feed water be introduced into a boiler of the horizontal tubular type?*

We prefer to feed in the top of a horizontal tubular boiler, carrying the pipe about half the length of the boiler just above the flue, on a support that rests on top of the flues, then drop down to about six or eight inches from the bottom of the shell where the water is discharged. We are not aware, however, of any particular virtue in this arrangement, and have used all manner

of means of delivering feed water into the boiler with no perceptible advantage one way over the other.

S. S. INGMAN.

A prominent authority recommends the introduction of the feed pipe at the front head, just above the upper row of tubes, and extending along the side of the boiler nearly to the back head. It then crosses to the opposite side of the shell and, turning downward, discharges between the shell and the tubes. If pipe is too large it will fill with scale until force of water is sufficient to prevent its further formation. In any case, the comparatively cool feed water should not be allowed to come in contact with the hottest part of the shell, that is, over the fire.

WILLIAM R. GARDENER.

The water should be fed into the boiler under the surface of the water directly over the crown sheet.

STEUBENVILLE TRACTION AND LT. CO.

By entering water-feed pipe in the front end of boiler and running it along above the tubes the length of the boilers, and spraying into the back end.

D. KENNEDY.

I believe the feed water should be introduced through the blow-off pipe in rear end of boiler, although the boiler insurance companies prefer the front feed. By introducing the water at the rear, we are always certain of blow-off being kept clear. The circulation of the water prevents the burning of the blow-off connections, and the water, being heated by passing through feed-water heater, does not set up any strains.

A. PETERS.

Very good results have been obtained by feeding the feed water into the horizontal tubular boiler through the front head above the upper row of tubes, just below the water line, with the pipe extended on the inside about one-half the length of the boiler and well perforated with holes in order that the water may be distributed and not delivered at any one point.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Over the top of tubes near rear head, the pipe passing through water from front head in which it should enter, or on top near front head.

W. BLOXHAM.

A good way to introduce feed water into a horizontal tubular boiler is through the head, just above the tubes, thence by a pipe nearly the length of the boiler, an elbow, a short piece of pipe carrying to the centre line, another elbow and a discharge pipe extending down between the tubes. As there is nearly 20 feet of pipe inside the boiler below the water line, the feed water is heated considerably before discharged, and when discharged there is little chance of unequal strains.

FRED B. HUBBELL.

I believe the proper place for feed water to enter a horizontal tubular boiler is to be sprayed in the top of boiler near the back end. I have had no trouble with a feed of this kind. To be sure, the mud and some scale will form on top of the tubes under this feed, but it is easily gotten at. With feed pipes in the bottom of either end, the scale will form near the end, and also *inside* of the *feed pipe*, and it is hard to get at it in the bottom of the boiler.

W. S. NEWMAN.

Feed pipe should enter boiler in front head over tubes, and extend back three-fourths of the length of the boiler, cross over boiler, and discharge into closed part of boiler.

G. R. W., MALDEN ELECTRIC CO.

Feed water should be pumped into a horizontal tubular through the blow-off pipe at the same rate at which it is being evaporated.

S. B. RICHEY.

The feed-water pipe of a horizontal tubular boiler should enter through the top of the second sheet and extend toward the back, being on a level with the water line and central horizontally. The horizontal pipe should be provided with enough small holes to equal the cross section of the pipe. It should extend to within 18 inches of the rear head and should be capped.

E. E. LEE.

Feed-water pipes entering through the front head over the top row of flues and on one side, running back in the boiler to within from two to four feet from rear end, then crossing over the flues with a nipple pointing down between the third or fourth flue from the opposite side, have proved very successful.

E. A. ASPNES.

Feed water should be introduced at some point where the feed pipe will not be affected by expansion and contraction of the boiler, and through a pipe that extends some distance through the water in the boiler, thus preventing the very cold water (when such is used) from striking any part of the heated metal.

AUGUSTA RY. AND ELEC. CO.

Through the front head above tubes with internal feed pipe to near the rear head, where it turns and delivers downward.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 11.—Is the water-tube boiler more efficient in every-day operation than the horizontal tubular boiler? If so, to what extent?*

For small units, it is not.

D. KENNEDY.

We have not found the water-tube boiler, in every-day operation, better than the horizontal tubular boiler when considered from the point of view of fuel economy. The main point in favor of the water-tube boiler is economy in space.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Conditions being equal, I should say that the water-tube boiler is not more efficient than the horizontal tubular boiler.

W. BLOXHAM.

With a proper setting, a horizontal tubular boiler should be just as efficient as a water-tube boiler. In my estimation, the question of space is the only one to be considered.

GEO. L. COLGATE.

Yes; since it steams more rapidly, can be forced with less possibility of damage by burning, has minimum danger of explosion, and is more readily cleaned and kept in repair than a horizontal tubular boiler.

W. T. D., N. Y. ED. CO.

A water-tube boiler, if kept clean inside and outside, is more economical.

AUGUSTA RY. AND ELEC. CO.

No difference.

G. R. W., MAJ DEN ELECTRIC CO.

A large number of tests made by reputable engineers show that the tubular boiler can hold its own with any other boiler on the market so far as economy is concerned, and on page 118 of Bryan Donkin's "Heat Efficiency of Steam Boilers" it is shown that out of 11 tests there is an average efficiency of 68.7 per cent with a maximum of 81.2 per cent and a minimum of 56.6 per cent with horizontal tubular boilers against 64.9 per cent average efficiency on water-tube boilers, maximum 77.5 and minimum 50 per cent.

My own opinion is that properly proportioned return tubular boilers, well set and carefully fired, will show as high evaporative results as any other type of boiler operating under the same conditions.

JAMES MILNE.

*No. 12.—What is the comparative cost of repairs between the water-tube and the horizontal tubular boiler?*

If there is any difference it is slight, and in favor of the tubular boilers.

D. KENNEDY.

Repairs should not be needed on either for at least five years if water and attendance are what they should be, but when the time comes for repairs the repairs on fire-tube should greatly exceed repairs on water-tube boilers.

W. BLOXHAM.

If the repairs are figured with regard to the horse-power, they are less in water-tube boilers than in return tubular boilers.

STEUBENVILLE TRACTION AND LT. CO.

About the same. AUGUSTA RY. AND ELEC. CO.

Ten per cent more for a water-tube.

G. R. W., MALDEN ELECTRIC CO.

This all depends on the care that has been given them. So far as the repairs on the brick-work are concerned, there is no difference. The percentage of repairs on a return tubular boiler is higher than that of a water-tube operated under similar conditions and with the same care; but if interest on the investment is taken into account, there is very little difference between the two types. As an example, take a 150-hp boiler.

The approximate cost of the return tubular, including the setting and foundation, would be, say, \$1500, while the water-tube for the same size would be at least \$2500.

	Return Tubular	Water-tube
1. Cost, including setting.....	\$1500	\$2500
2. Repairs on grates.....	(same in each case)	
3. Repairs on the boiler.....	\$120 = 8 per cent	\$100 = 4 per cent
4. Depreciation (first year, say).....	150 = 10 "	125 = 5 "
5. Interest on investment.....	90 = 6 "	150 = 6 "
Total of 3, 4, 5.....	\$360	\$375

In the case of the return tubular boiler I have taken the repairs at \$120 per annum, or 8 per cent, which includes renewals of tubes and general repairs. I have also taken the depreciation for the first year on the return tubular boiler at 10 per cent. This is the amount usually allowed, but in many cases it is too high, as return tubular boilers have a life varying from 15 to 30 years, depending on the usage.

In the water-tube boiler I have taken the repairs at four per cent, which might by some be considered high, but still a conservative estimate. The depreciation I have placed at five per cent, which certainly can not be reduced. Interest on the investment I have in each case taken at 6 per cent.

The total cost and depreciation in one case (return tubular) would be \$270 against \$225, but by adding interest we have \$360 against \$375. Omitting interest on the investment, the repairs and depreciation on the return tubular boiler are highest.

JAMES MILNE.

*No. 13.—What is the comparative cost of cleaning between the water-tube and the horizontal tubular boiler?*

The cost of cleaning the water-tube boiler is considerably greater than that of cleaning the return tubular boiler.

D. KENNEDY.

Have found the comparative cost of cleaning water-tube boilers to be somewhat higher than that of horizontal tubular boilers.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

The cleaning of horizontal tubular boilers should be the cheaper under most conditions.

W. BLOXHAM.

If the cost of cleaning is charged per horse-power, it will be found much less with water-tube boilers, and the cleaning can be more effectually done.

STEUBENVILLE TRACTION AND LT. CO.

Water-tube cleaning costs more and takes longer time.

AUGUSTA RY. AND ELEC. CO.

Taking the same horse-power capacity in boilers, using the same kind of water, and with similar hours of service, the cost of cleaning the water-tube boilers will be at least 40 per cent in excess of that for the horizontal tubular. This cost is made up mainly of labor, as it will take twice the time to take off and replace all the caps over the tubes of the water-tube boiler as is required to clean a horizontal tubular boiler. The joints must be cleaned, a large proportion of the gaskets must be replaced, and where scale is deposited from impure water the cleaning inside the long tubes is a tedious job. A water-tube boiler must be out of service at least 24 hours to be opened, cleaned, and again made ready for steaming. The horizontal tubular boiler is quickly opened by removing the manhole covers, a cleaner can get inside, and the boiler can readily be cleaned and closed ready for service in from 10 to 12 hours.

J. H. VAIL.

Fifty per cent more for a water-tube boiler.

G. R. W., MALDEN ELECTRIC CO.

*No. 14.—What type of mechanical cleaner has been found most satisfactory for the tubes of water-tube boilers?*

When water is sold by meter, the steam knocker is the cheapest. The cost of maintenance is far greater in the water turbine.

D. KENNEDY.

I find the Wienland mechanical cleaner a very efficient machine.

W. BLOXHAM.

Wienland power cleaner, or one of similar construction.

TOLEDO RYS. AND LT. CO.

Steam-turbine tube cleaner.

G. WILBUR HUBLEY.

Have not found any that is satisfactory.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Water turbine. G. R. W., MALDEN ELECTRIC CO.

The best type of cleaner for water tubes is the water-turbine type.  
W. L. ABBOTT.

*No. 15.—Would it be the better policy for an electric-light company doing a business calling for 300 indicated horse-power with a minimum of 70 indicated horse-power, using compound engines with a ratio of 1:3.48 between the cylinders, driving a line of shafting and belting to the various machines, to install high-pressure boilers with superheaters (with the idea of a steam turbine later), or to continue with the present arrangement of boilers carrying 100 pounds pressure, and giving about two and a half per cent moisture in the steam? Engines of the type used at present have been run successfully at 150 pounds pressure, with 100 degrees superheat, the company being obliged to put in new boilers on account of the age of the old ones. The plant is already equipped with an economizer that would take up extra heat going to chimney from superheater.*

I would install high-pressure boilers with superheater of moderate capacity contained in boiler for either turbine or engine. The turbine is, I believe, not yet out of the experimental stage, although for electric lighting where the load varies a great deal I should say the turbine is superior to the small engine.

W. BLOXHAM.

Install the high-pressure boilers with superheaters.

GEO. L. COLGATE.

It would be to the company's advantage to install high-pressure boilers and superheaters.

J. D. A., N. Y. ED. CO.

Put in high-pressure boilers and a first-class condensing system, and put in the superheater when the turbine is installed.

STEUBENVILLE TRACTION AND LT. CO.

Two water-tube boilers to be run at 150 pounds pressure, with flue-fired superheaters.

G. R. W., MALDEN ELECTRIC CO.

It would pay to install high-pressure boilers with superheat, because, eliminating all practical sources of leakage of power, we should have a theoretical gain of over 50 per cent in efficiency of power-generating apparatus. Taking our load as 200 horse-power on the average for 10 hours, we have:

(1) Loss due to 2.5 per cent moisture at 30 pounds of steam per horse-power equals  $200 \times 300 \times .025$ , or 1500 pounds of water for 10 hours. Assuming the feed-water temperature at 100 degrees, there is a loss of about 17.5 pounds coal, neglecting losses at engine.

(2) Available heat at 100 pounds gauge pressure (no superheat) equals 39 B. T. Us.

Available heat at 150 pounds gauge pressure (160 degrees superheat) equals 124 B. T. Us.

(3) Assuming four pounds of coal per horse-power, original cost in coal of 200 horse-power equals 800 pounds per hour, and a loss of 60 degrees superheat between boiler and engine, we should be able to reduce our coal bill about 160 pounds coal per hour.

(4) Total gain for 10 hours equals 1617.5 pounds of coal per day.

J. W. BRASSINGTON.

Under conditions specified, continue present arrangement.

G. WILBUR HUBLEY.

Put in high-pressure boilers and superheater.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

As most plants will increase their capacity fully up to the limit of their present expectation, it is generally wiser to purchase such apparatus as will permit of the greatest possible future increase.

AUGUSTA RY. AND ELEC. CO.

*No. 16.—Which is preferable for a small electric-light plant—say 250 horse-power—a water-tube or a return tubular boiler? Coal \$2.25 per ton. Good water (no lime in it).*

A water-tube boiler.

STEBENVILLE TRACTION AND LT. CO.

Water-tube, when it is erected properly and cleaned thoroughly and regularly.

W. H. BANES.

The return tubular boiler is preferable.

D. KENNEDY.

A good water-tube boiler, to enable one to carry high pressure.

W. BLOXHAM.

Tubular boiler.

GEO. L. COLGATE.

If only one boiler is to be installed, you are practically limited to the water-tube type; but the better plan would be to use two horizontal tubular boilers.

EDITOR.

A water-tube boiler would be preferable.

J. D. A., N. Y. ED. CO.

Instead of one boiler, it would be preferable to have two of about 150 horse-power each, and the greatest return for the money invested would be obtained by the installation of return tubular boilers properly designed and well set.

JAMES MILNE.

Water-tube.

G. R. W., MALDEN ELECTRIC CO.

A horizontal return tubular boiler.

S. B. RICHEY.

In my experience a return tubular boiler has been found to be preferable for a small electric-light plant, as it is easy to take care of and the repairs amount to very little and can be made by any engineer; that is, of course, provided the boiler is of good make and is kept clean and well cared for. We should say, always install a high-pressure boiler, safe at 150 pounds working pressure and with no dome, even if only 100 pounds of steam is needed, as the slight increase in cost of the high-pressure boiler will increase the safety and length of life of the boiler considerably.

E. S. ALDRICH.

A small plant of 250 horse-power should have at least three boilers. Water-tube boilers of 100-hp capacity or less are very expensive, and not so convenient to manage as tubular boilers, which would be preferred with steam pressure of 125 pounds or less.

W. L. ABBOTT.

In my opinion the return tubular boiler is preferable to a water-tube boiler for a small plant. First, the water-tube boiler must be watched closer than the other; second, it takes more time to clean it, and costs more for gaskets; third, it costs much more for repairs on the boiler itself than the return tubular boiler.

W. S. NEWMAN.

Water-tube boiler.

G. WILBUR HUBLEY.

A water-tube boiler is preferable to a return tubular boiler.

C. S. JOHNSON.

In a plant of 250 horse-power we should prefer the water-tube boiler, as it is more efficient and safer to operate.

E. H. MATHER.

For small plants, where price is important and attendance might not be of the best, the simplest would be the cheapest, and as a return tubular needs less attention, it would be preferred.

AUGUSTA RY. AND ELEC. CO.

Return tubular boiler.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

For a 250-hp electric-light plant, with good water, and coal at \$2.25 per ton, the horizontal tubular boilers will cost the least to install, will be the simplest to operate, and will be fully as economical as water-tube boilers. Every plant should have duplicate units, and two 72-inch by 16-foot boilers properly set will make an efficient outfit. Actual results from operating under similar normal conditions show as high evaporation obtained from the horizontal tubular boiler as from the water-tube type. But when long life, under continuous high pressure and forcing under peak-load conditions must be considered, the odds are in favor of water-tube boilers.

J. H. VAIL.

*No. 17.—What is the average useful life of a horizontal tubular boiler?*

We had two horizontal tubular boilers in almost continuous operation for 12 years, running them the last four years at 125

pounds pressure, previous to which the pressure was 100 pounds. They began to show signs of weakness and we replaced them.

WILLIAM R. GARDENER.

Ten years.

D. KENNEDY.

The useful life of the horizontal return tubular boiler depends largely upon the care taken and the kind of water used in them. If the water is clean, the boilers carefully handled, kept in almost constant use and not allowed to stand cold for long periods, they will be good for about 15 years.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

It depends altogether on conditions, such as the care taken, quality of water, and climate. For instance, the life of the boiler, other things being equal, would be 30 per cent greater on the Great Lakes than it would be at the sea level in the tropics.

W. BLOXHAM.

Twelve years.

GEO. L. COLGATE.

From 10 to 12 years.

STEUBENVILLE TRACTION AND LT. CO.

Ten years.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Dependent on conditions; probably 12 to 15 years.

G. WILBUR HUBLEY.

The life depends not only on the water, care and service, but also on the material. The depreciation is usually figured from eight to ten per cent.

AUGUSTA RY. AND ELEC. CO.

About 10 years with good care.

G. R. W., MALDEN ELECTRIC CO.

From 12 to 15 years. It depends largely on their use. I have seen boilers with 10 years of service that were in very poor condition.

E. W. LLOYD.

This depends entirely on the usage the boiler has been given. If the boiler has been forced and little pains taken with it,

the life would perhaps run from 10 to 15 years; but where good care has been taken, I have known this type of boiler to run for 25 years and still be in good repair.

JAMES MILNE.

*No. 18.—Which of the methods in use for covering the tube-hole openings in water-tube boilers do you consider the best for the economical operation of a plant; that is, as regards breaking and renewal of the joints when cleaning?*

Use a first-class rubber or asbestos gasket.

W. H. BANES.

The distinction between external and internal covers is that the latter are held and tightened in position by the boiler pressure, while with the former the joint is made by drawing up a bolt on an inside guard, and the tendency is for the cover to loosen with increased pressure. With internal covers, a gasket is used to assist in making the joint steam-tight, while external covers use a ground joint—metal to metal—which becomes rusty and dirty, and it is necessary to regrind it before renewing or you have leaky joints after you get up pressure again. The pressure often has to be taken off a boiler having the external covers, several times, because, after apparently having the joints tight, leaks develop when the pressure is renewed. I know of plants using each of the above methods, and the external type takes many times as long to renew the joints as the internal takes. The cost of gaskets does not offset the saving in labor if the proper precaution be used in their selection, with regard to the service they have to perform, together with the proper placing.

A friend of mine operates two types of boilers: one with oval internal covers, using gaskets, having 75 tubes; the other with external covers, using ground joints and having 126 tubes. The covers on the former type of boiler can be replaced and made steam-tight by two men in about three hours; the latter type using external covers, takes two men anywhere from three to five days to renew the joints and make them steam-tight.

REGINALD CONSTABLE.

Ground joint.

D. KENNEDY.

The plate should be on inside of boiler.

W. BLOXHAM.

Unquestionably the ground joint for all caps applied externally. For internal covers a composite gasket of copper wire and some of the zinc or lead alloys has proved efficient and economical where the joint surfaces would allow their use; some surfaces prohibit the use of any gasket but one having rubber as a base and wire insertion to strengthen.

J. P. S., N. Y. ED. CO.

I consider the use of external caps with ground joints the most economical way of covering the tube handholes in water-tube boilers.

J. D. A., N. Y. ED. CO.

For low cost of making joints and reliability of having them tight after once made, the gasket is far preferable to the ground-joint pattern. The rubber and canvas gasket placed on the inside of handhole plate with a little graphite and oil does not stick solidly to plate or shell and is easily removed, and when once drawn into position will hold tight for a year. The old gasket can be removed, leaving clean surfaces, in very much less time than necessary to clean and scour the ground joint. The latter are not so sure in operation, as they often leak in starting up, requiring the emptying of the boiler to allow making the joint, which is never the case with the inside gasket. In many cases where ground joints are furnished by builders, the purchaser substitutes gaskets after one or two experiences of this kind. The cost of the rubber gasket is less than the cost of time cleaning the ground joints, and if lead is used is still cheaper.

H. M. LYMAN.

Ground joints.

G. WILBUR HUBLEY.

Outside caps; ground joints.

G. R. W., MALDEN ELECTRIC CO.

As regards breaking and renewing of joints, it is best to use Guillot gaskets on the front water-leg and McKim on the rear. The Guillot gasket can be used at most three times, and then a rebate can be obtained for the old metal. The McKim gasket should be opened up only twice a year, and there is no rebate.

C. G. Y. KING.

*No. 19.—What advantage is there, if any, in the use of oval internal handhole covers opposite each tube in a water-tube boiler, over one provided, mainly, with round internal covers?*

They can be removed entirely from boiler without disturbing a single other place.  
W. H. BANES.

Oval internal covers throughout are far better than any other type for economical operation. They are independently removable, and no time is lost putting them into position or taking them out, since they can be entered or removed through their own openings. The round internal cover has to be moved from its opening, either horizontally or vertically, by hand or some awkward method, until you can remove it from an oval hole provided expressly for the purpose. In replacing this cover the same operation has to be gone over; therefore it is easily seen that with oval holes throughout much time can be saved, and the boiler placed in service much quicker.

The compensation is not only the time saved in breaking and making the joints for internal-tube cleaning, but also in the economy gained by a cleaner boiler, since the oval cover makes it possible to clean the boiler many times where with the round covers it would be impossible, for lack of time.

As an illustration that time is often limited, during the Spanish-American war a United States torpedo boat did not get into the action off Cienfuegos because, as the commander stated in his report, of lack of time to clean the boilers. The time required for cleaning is a vital factor.

REGINALD CONSTABLE.

The advantage is in oval covers, because of the ease in removing and putting them in again.  
D. KENNEDY.

The oval internal handhole covers can be easily taken out and cleaned when they become leaky.

STEUBENVILLE TRACTION AND LT. CO.

The advantage of oval internal handholes over round internal handholes lies in the fact that, with oval holes, any hole can be opened without disturbing any other.

J. D. A., N. Y. ED. CO.

The oval handhole cover requires the tubes to be placed farther apart than the round, which increases the ratio of gas area to the heating surface, producing short-circuiting and loss of economy. Practice shows that, if the tubes are not spaced wider, too much metal of the water-leg plates is cut away to allow large hollow stay-bolts, the result being that the stay-bolts are either omitted where they are needed or if furnished they are almost all solid, and the solid stay-bolt is never desirable. The round handhole allows sufficient metal and proper spacing to get the best economy and larger factor of safety in water-leg construction with large stay-bolts with seven-eighths-inch holes between every tube. The oval cover may be removed and replaced somewhat more quickly, but what is gained here is very much offset by the inability to use the soot-blower in the hollow stay-bolts and the manifestly weaker construction. Oval handholes can not be properly reamed nor the oval caps accurately faced.

H. M. LYMAN.

With oval caps the boiler can be closed more quickly, as each cap is put in its place without having to be passed up the inside from hole to hole.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Oval covers are better, on account of being more easily removed, and with the use of both round and oval there would be only two kinds of covers. This should not cause any great confusion.

AUGUSTA RY. AND ELEC. CO.

*No. 20.—Is it necessary when cleaning a horizontal water-tube boiler to remove any of the covers in the rear section, or do you depend solely upon the blow-off to remove all sediment?*

Yes; remove all the covers if you want to do a good job. Don't depend on the blow-off at all. You will be surprised at what stays in the boiler after you "think" you have blown down.

W. H. BANES.

It is usual when cleaning to remove the covers in the bottom row, so as not to allow any large pieces of scale, etc., to enter the blow-off. By removing the covers in one row it is possible to tell in a general way the condition of the rear headers and whether it is necessary to clean them as well as the tubes.

REGINALD CONSTABLE.

Remove all covers and get at all accessible parts.

D. KENNEDY.

In cleaning horizontal water-tube boilers, it is absolutely necessary to remove the handhole covers in the rear section, to insure a positively clean boiler. Otherwise the boiler-cleaner depends on his sense of touch at the end of an 18-foot rod, rather than upon his eyesight.

J. D. A., N. Y. ED. CO.

If the boiler is to be cleaned thoroughly, all the handhole covers should be taken off.

STEUBENVILLE TRACTION AND LT. CO

With boilers of the water-leg construction it is necessary to remove the rear caps only here and there if large pieces of scale are liable to slide down the tube and lodge in the leg or blow-off pipe. Removing a few will allow the operator to insert his arm and remove any obstruction. With the sectional header boilers it is necessary to remove the bottom cap of every header and inspect for pieces of scale, and it is generally necessary to remove about one-half of the upper caps or enough so that the back end of each tube can be examined with the hand.

H. M. LYMAN.

We remove part of the handhole plates in lower row in rear water-leg to remove sediment, etc.

TOLEDO RYS. AND LT. CO.

Yes; remove every second cover on the lower line of tubes.

C. G. Y. KING.

Leave all caps on rear headers when cleaning tubes with turbine. Water to run turbine will be sufficient to wash out all scale. When through, take off a part of caps, handhole plates and mud drums.

G. R. W., MALDEN ELECTRIC CO.

When cleaning horizontal water-tube boilers it is always best to remove the covers on all the lower rows of tubes to such extent as will afford a clear indication of the condition of the inside of the tubes. The engineer should know beyond question that the tubes are clean, as instances have occurred where the blow-off

was freely used, and yet scale formed and sediment collected in lower tubes, reaching a dangerous condition.

J. H. VAIL.

If there is a mud drum, it certainly would be wiser to remove the manhole covers on it.

AUGUSTA RY. AND ELEC. CO.

We always take off back caps as well as front caps.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

Not necessary except at long intervals.

G. WILBUR HUBLEY.

*No. 21.—Do you remove all the covers in the front heads of a water-tube boiler when cleaning?*

Yes; every one should be removed, in order to inspect every part.

W. H. BANES.

Usually it is necessary to remove all the covers only in the two or three bottom rows, since experience has shown that scale forms more rapidly in these rows, due to the intense heat with which they come in contact. After these rows are examined and cleaned, a cover is removed from each succeeding row to the top, and if it is found necessary these rows are also cleaned. But, except in cases where the water is very bad or the boiler has been left for a long time without cleaning, it is not necessary.

REGINALD CONSTABLE.

No.

D. KENNEDY.

Not unless for examination or to scale tubes.

W. BLOXHAM.

All of the covers in the front end of a water-tube boiler should be removed when cleaning.

J. D. A., N. Y. ED. CO.

In a water-leg boiler we remove only one in five or six.

H. M. LYMAN.

Not usually, but if condition of test tubes warrants it all are removed.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Yes.

G. WILBUR HUBLEY.

If the design does not permit reaching two tubes from one opening, and if they are so dirty that they must be thoroughly cleaned, it certainly is necessary to remove all covers.

AUGUSTA RY. AND ELEC. CO.

Every third row is sufficient in Heine boilers. One tube on each side of the handhole plate removed can be cleaned with hose from this handhole.

TOLEDO RYS. AND LT. CO.

Yes.

C. G. Y. KING.

Yes.

G. R. W., MALDEN ELECTRIC CO.

*No. 22.—In replacing the handhole covers in a horizontal water-tube boiler, do you replace them regardless of the position they held before removal, when re-using the gaskets?*

No; number your holes and covers.

W. H. BANES.

When removing the covers, expecting to re-use the gaskets, always make a mark on the cover so that you will be able to replace it in the exact position it held before removal. Each cover should have its same position, because if any part of the gasket sticks to the tube plate when the cover is removed, by this method of replacing, each portion fits into its original position and no trouble is experienced in making the joint tight.

The usual scheme to enable the proper replacement is to mark the top of each cover, lettering the vertical and numbering the horizontal rows.

REGINALD CONSTABLE.

Mark and replace them as they came out.

D. KENNEDY.

Always try to put them back in the same position that they were in before.

W. BLOXHAM.

No; they should all be marked before removing.

STEBENVILLE TRACTION AND LT. CO.

No; put them back in same place.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

It lessens the chances of leaks, and takes little time, to centre-punch each cover before removing it, and laying them in proper order when removed will insure their being properly replaced.

AUGUSTA RY. AND ELEC. CO.

*No. 23.—Do you think that a tube-hole cover should be on the outside of its section, or on the inside; that is, should the arrangement be such that the handhole cover tends to tighten under pressure?*

The latter arrangement is always preferable.

W. H. BANES.

A tube-hole cover should be on the inside rather than on the outside, for in the former method, if anything should happen to the guard or bolt holding the cover, the pressure would hold the cover to its seat, but in the latter the cover would be blown off, thereby letting the water and steam out, which would probably kill any one close by. The stud of the external cover may be strained nearly to breaking by a wrench, so that the added load of the steam pressure carries it beyond the danger point; whereas the stud of the internal cover may be strained quite to the breaking point without material detriment, since the strain is relieved by the steam pressure on the cover. The external cover relies on the strength of the stud for safety, while the internal cover relies on the strength of the cover itself. Also, in replacing the covers it takes far less time with the internal cover to make the joint steam-tight.

REGINALD CONSTABLE.

Yes; they should be so arranged that the pressure should tighten from the inside.

D. KENNEDY.

On the inside.

W. BLOXHAM.

With a properly constructed handhole cover, made of proper material, there is no objection to its being on the outside of the header.

J. D. A., N. Y. ED. CO.

The handhole cover should be on the inside, by all means, and the joint made with a rubber or lead gasket soft enough so that one man with a short wrench can pull it tight when cold. It will always hold when warmed up with pressure on it and will relieve the bolt of strain. The outside cap needs to be pulled up with a long wrench and generally by two men, and it needs tightening again when warmed up; and the higher the pressure, the greater the strain under which the bolt and plates must be placed to resist a leak. The inside plate is far preferable for convenience and safety. Inside handhole plates with a gasket, if in order, can always be drawn tight either hot or cold by one man with an 18-inch wrench. If one man can not draw it tight he has either forgotten the gasket or something is under the seat, and he should put it in order at once and not exert more force, as this is liable to break something.

H. M. LYMAN.

The handhole covers should be on the inside, so that if a new gasket squeezes up when it gets hot the pressure tends to hold it taut, otherwise it would blow out.

STEUBENVILLE TRACTION AND LT. CO.

A gasket is difficult to place and make tight on inside plate, whereas the outside plate can have ground joint.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Using an inside cover permits the use of a gasket, prevents any possibility of being able to regrind, and also interferes with the cleaning of the seat on which the gasket rests.

AUGUSTA RY. AND ELEC. CO.

Tube-hole covers on outside have proven satisfactory.

G. WILBUR HUBLEY.

Tube-hole covers should always be on the inside so that the pressure tends to tighten the joint. This practice obviates the danger of broken bolts or stripped threads. A certain company manufacturing water-tube boilers has changed from outside covers to inside.

S. B. RICHEY.

On the inside.

C. G. Y. KING.

I believe that all handhole covers should be on the inside of plates so that they will tighten under pressure, and that they are safer on inside than they can be made on outside.

W. S. NEWMAN.

*No. 24.—Can you give an idea, from your experience, of the relative time it takes to replace external and internal handhole covers, and make them steam-tight on water-tube boilers of practically the same number of tubes?*

You can put on the inside plates about twice as fast as you can the external plates.

D. KENNEDY.

It takes longer to replace internal covers, but we can not give comparative figures.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 25.—How do you tell, in any of the various types of boilers, when a tube needs removal?*

A leak develops, which soon makes itself apparent; or you may observe a blister or a sagging of the tube.

REGINALD CONSTABLE.

By sound, by bulging, or by outside corrossions.

D. KENNEDY.

A tube never needs renewing until it shows a leak—or a blister which will soon develop a leak—and a leak may be known by hearing it hiss or by the appearance of water near it. The foregoing refers to fairly clean tubes; if they are so covered with scale that they will not steam, or can not be cleaned, they need to be removed, of course.

H. M. LYMAN.

By a close inspection for blisters, or if it can be gotten at, test for thin places with the hammer, or if the tube has been burned it will show by the color of the iron.

STEUBENVILLE TRACTION AND LT. CO.

By examination and by the hammer test.

W. T. D., N. Y. ED. CO.

In water-tube boilers the tubes will get thin and show distress. Slight leaks should be watched and repaired at once. In tubular boilers the tubes show leaks at end of tubes.

G. R. W., MALDEN ELECTRIC CO.

Inspect your tubes thoroughly at periodic intervals.

C. G. Y. KING.

A tube needs removal when it can be seen to be badly pitted on the inside or outside, or when it blisters, or tends to pull out of shape. All these causes will show possible trouble before any leaking commences.

AUGUSTA RY. AND ELEC. CO.

By inspection or evidence of leak. In case of very old tubes, tapping with hammer will sometimes indicate defective tubes.

G. WILBUR HUBLEY.

*No. 26.—What is a practical method of keeping a boiler in service when a leak develops in the tubes, either fire-tube or water-tube?*

Should the leak develop in the body of the tube, away from the tube sheet in the water-tube type of boiler, a wooden plug can be driven into the tube end; or in the fire-tube type of boiler by using iron plugs and drawing them tightly into the tube end by through bolts.

REGINALD CONSTABLE.

For a fire-tube you can slug both ends of the tube; for a water-tube, you will have to shut down and renew tube or plug it.

D. KENNEDY.

In a fire-tube boiler a leak may be stopped temporarily by driving in a pine plug, the end of which should snugly fit the tube, the centre being turned to a smaller diameter. Drive the plug into the tube until the leak stops; then drive it a little distance farther—some two or three inches—until the leak is opposite the turned-down part of the plug, which will then be held in place by the boiler pressure.

F. W. BULLOCK.

There is no practical method of keeping a water-tube boiler in service after a leak has developed in the tubes. With a fire-

tube boiler, however, it is possible to plug the tube and thus keep the boiler going until such time as the tube can be replaced or repaired.

J. D. A., N. Y. ED. CO.

If leak is slight, keep on running till load allows a shut-down of boiler. If leak is bad, shut down as soon as possible.

C. G. Y. KING.

Tubular boiler tube leaks can be stopped by plugging the leaky tube with plugs for that purpose, and the boilers kept in service. With leaky tubes of water-tube boilers clamps can be put on and the boilers will run for a short time. Most leaks in tubes of these boilers are caused by sediment in same, and the tubes will bag and split. Tubes in this condition can be kept in service by hot fires, not allowing tubes to contract.

G. R. W., MALDEN ELECTRIC CO.

If the leak in water-tube boilers is not bad enough to put out the fires, let it squirt; if in a fire-tube boiler, the tube may be plugged at both ends with pine plugs, though squirting will not damage much here either.

H. M. LYMAN.

I have had very good success in temporarily repairing leaking boiler tubes, where the trouble was in either end, by driving into the tube a ferrule coated with red lead.

EDGAR B. GREENE.

A fire-tube boiler that develops a leak in one of its tubes may be kept in service by placing two corks in leaking tube and drawing them together with a long threaded bolt extending through the tube. A bolted patch similar to that used in making a new tap on a water pipe might be of service in an accessible point in a water-tube boiler leaking at one of the tubes, but hammering should be done very sparingly on account of the vibration it produces.

AUGUSTA RY. AND ELEC. CO.

*No. 27.—Describe methods of patching headers or shells that are exposed to the products of combustion, and also when they are not exposed.*

Those that are exposed to the products of combustion should have a hard patch, namely, a steel plate riveted over the injured

part and caulked. Those unexposed may have a soft patch, namely, a steel plate bolted over the injured part, with white lead and iron filings between the patch and the original plate. The patch plate should be crimped at least an eighth of an inch.

REGINALD CONSTABLE.

Headers must be renewed. For shells, on the bottom plates the taps must be put on the inside. For other places on the shell it does not matter whether it is on the outside or inside.

D. KENNEDY.

In the shell, cut out the bad spot and rivet a patch on the inside. In the headers a soft patch may be riveted on the outside, care being taken to cut away around the burned section so that the water may come in contact with the patch and protect it from the effects of the fire. This patch should be placed on the outside to permit calking.

W. T. D., N. Y. ED. CO.

Patches that are exposed to the products of combustion should be made as large as possible, in order to avoid seams in contact with very hot gas. Any great variation in the thickness of metal should be avoided when it can be, in order to prevent possible buckling in parts of the patch or boiler where exposed to the flames.

AUGUSTA RY. AND ELEC. CO.

*No. 28.—Describe what you consider to be the proper method of blowing down a boiler.*

Do not have too high a furnace temperature nor too high steam temperature; open valve slowly.

D. KENNEDY.

It is preferable to let all steam condense before letting water out of boiler.

W. BLOXHAM.

For a short time before blowing off, the fire under the boiler should be slacked down, as much as possible, to allow the sediment to settle, and then the blow-off valve should be opened gradually, and just as gradually closed again.

STEUBENVILLE TRACTION AND LT. CO.

The blow-off cock should be opened very slowly and allowed to remain open until the water has been lowered two or three

inches in the glass, then slowly closed. This should be done just after the fires have been started and water begins to circulate freely.

S. B. RICHEY.

A boiler should be cooled off as slowly as possible. Steam should be let off gradually for about half an hour or more. Then the damper should be opened slightly, and if time is no object the boiler should be left until the water has cooled to the temperature of the air. You can blow off the boiler while still hot and then wash out with hot water, if absolutely necessary, but the more slowly the blowing down is done, the better for the boiler.

FRED B. HUBBELL.

The proper method of blowing down a boiler after it has been shut down is as follows: About two hours or more after boiler has been cut out and fires banked, the blow-off cock should be opened full, and left open until the boiler has been blown down about two gauges, after which blow-off cock should be closed. This may also be done before starting up the boiler for a new run. In any event, sufficient time should elapse after shut-down of boiler and before blowing down, to give the sediment a chance to settle.

W. F. SIMS.

Valve should always be used instead of a cock, and in blowing off boiler the valve should be opened very gradually and slowly until piping is heated and has taken its new position due to its expansion. Blow down two gauges, *e. g.*, to the first gauge. The frequency of blowing off boiler is to be determined by local conditions, *e. g.*, quality of feed water and service of boilers, etc.

G. WILBUR HUBLEY.

First let the steam down to 20 or 30 pounds, in order to avoid the great heat that may be produced in the blow-off pipe, or surroundings, thus causing trouble.

AUGUSTA RY. AND ELEC. CO.

*No. 29.—Is the use of high and low-water alarms advisable, or do they tend to make the firemen careless? What are their advantages and disadvantages?*

Were it not for the fact that an alarm column makes the attendant feel that it is unnecessary to watch his gauge, their

adoption would be universal. Accidents have occurred through such carelessness where the alarm failed to notify the attendant. The advantage of carrying a fixed water line is beyond dispute. The above-named disadvantage can be obviated by the management requiring a limited number of whistle blows each day.

(UNSIGNED.)

The tendency is to make firemen careless, but the advantage is to let the operating engineer know where his water stands.

D. KENNEDY.

I should prefer not to use them.

W. BLOXHAM.

I have found the use of high and low-water alarms to be a great safeguard, particularly with water-tube boilers. Would not have any installation without them. I do not think they make a good fireman careless. The advantages are greater safety from low water in boilers and from high water coming over into engines or causing wet steam. Several years' experience with them has not developed any particular disadvantage.

J. A. MALONEY.

High and low-water alarms must be used in Ohio, to conform to law.

TOLEDO RYS. AND LT. CO.

High and low-water alarms are an advantage, inasmuch as they let every one within hearing distance know that the fireman has allowed the water to get either too high or too low, and if properly looked after they have a tendency to make firemen more careful.

STEUBENVILLE TRACTION AND LT. CO.

The high and low-water alarm is very desirable when the feed water is regulated by an automatic feed-water regulator. When the feed water is regulated by hand a good water-tender is all that is necessary.

C. S. JOHNSON.

No. The one disadvantage of a fireman depending on an automatic device which can not be permanently reliable outweighs any advantages that may be claimed.

G. WILBUR HUBLEY.

We do not use them. We prefer to make the water-tender responsible.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Some states require them by law, and though they may make the firemen careless, they are in many cases more reliable than the fireman alone.

AUGUSTA RY. AND ELEC. CO.

Prefer only the low-water alarm. They have a tendency to make the firemen and water-tender more careful and watchful when on duty, as the blowing of these whistles can be heard for a long distance.

G. R. W., MALDEN ELECTRIC CO.

We favor the use of both high and low-water alarms, as they tend to make the firemen more careful.

S. S. INGMAN.

*No. 30.—What is a short, practical method of determining whether or not the boiler is using the available heat generated within the furnace?*

The best ready method is to take the temperature of the gases as they leave the boiler, and should they show a temperature higher than 600 degrees something should be done to reduce them.

REGINALD CONSTABLE.

A very fair knowledge of the operation of the boiler can be determined by taking frequent readings of the temperature in the flue between the boiler and the chimney. Should the temperature be too high the boiler is not what it should be.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Examine your fires and take temperature of flue gases.

W. BLOXHAM.

Use suitable thermometer in breeching or chimney base. If temperature is high and there are no air leaks in boiler setting that might have cooled gases, it would be an indication that boiler did not absorb as much of the heat as it should.

J. A. MALONEY.

A good estimate can be made from temperature of flue gases.

TOLEDO RYS. AND LT. CO.

Take the temperature of the flue gases. This temperature should not be over 150-200 degrees Fahrenheit above the temperature of the steam in the boiler. G. H. CUSHMAN.

By observing the evaporation of the water.  
W. T. D., N. Y. ED. CO.

Analysis of flue gas and temperature of flue.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

Test flue gases. G. WILBUR HUBLEY.

First test a fair sample of coal to get its heating value in B. T. Us. Then by putting a meter on the feed pump the weight of water evaporated in a given time can be determined. The weight of coal burned in the same time should be determined, and from these results the amount of water evaporated per pound of coal or combustible can be determined. Reducing this to the standard, *viz.*, number of pounds of water evaporated into dry steam from and at 212 degrees, we can compare this with the theoretical heating value of the coal. The temperature and analysis of the flue gases will show the amount of heat going to waste in this way. IRVING E. BROOKS.

Measurement of the flue temperature near the boiler, and examination of the boiler setting, showing where cold air may be leaking in, will quickly determine if any heat is being wasted. AUGUSTA RY. AND ELEC. CO.

*No. 31.—What are the advantages of shaking grates as compared with ordinary Tupper grates? What percentage of fuel is lost through shaking grates? Are the maintenance costs of shaking grates greater than those of stationary grates?*

With coking coal or anthracite, the shaking grate is the best. D. KENNEDY.

The advantage of the shaking grate over the Tupper grate depends on the fuel used. If the coal used is anthracite and bituminous mixed, the shaking grate has an advantage over the Tupper grate, provided the coal does not produce hard clinkers. There need be very little fuel lost by the shaking grates

if they are handled by skilful firemen, and the maintenance of the grates will depend very largely on the management in either case; but we believe the Tupper to be the least expensive to maintain.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

They are available for any kind of coal, and air can always be admitted to the furnace without opening furnace doors. The percentage of fuel lost depends on the class of fireman. A careless man will waste more coal with shaking than with plain grates. I have found maintenance about the same in both cases.

W. BLOXHAM.

The principal advantage of shaking grates is that the fire can be broken up and ashes shaken out without keeping the fire-doors open long enough to use pokers and scrapers. There is no fuel wasted if properly used. No.

STEUBENVILLE TRACTION AND LT. CO.

With a good shaking or chopping grate, the fire can be kept clean without opening fire-doors, and fires can be kept in better condition without cold air getting at the boiler, which is very essential to economy in the modern water-tube boiler. The cost of maintenance of shaking grates will be slightly higher than a stationary grate, but they will not waste any more fuel.

G. R. W., MALDEN ELECTRIC CO.

(1) The stationary grate makes it necessary to open the furnace doors in cleaning fires, thereby causing heat losses through cooling of furnace. The use of shaking grates removes these losses. (2) Fuel losses depend upon the method of handling. (3) Slight increase as compared with the stationary grate.

W. T. D., N. Y. ED. CO.

*No. 32.—In plants using No. 3 buckwheat or rice anthracite coal, is it more economical to use ample grate area and moderate rates of combustion, or the usual grate area and high rates of combustion with forced draft?*

Standard grate area with forced draft.

GEO. L. COLGATE.

It is more economical to use a moderate rate of combustion with large grate, medium thin fire and moderate draft. The high rate means stronger draft, which blows much fuel off the grate and tends to burn faster where the fuel is thin, which results in still faster burning in spots, soon making a hole where cold air blows through, cutting down the economy. Small grates generally mean small passages for products of combustion which require rapid travel over the heating surface, greater pressure in the settings, more escape of heat through the settings to the room and considerably reduced economy from the causes named, besides a burnt boiler front and a hot firing-room.

H. M. LYMAN.

Ample grate surface and moderate rate of combustion.  
STEUBENVILLE TRACTION AND LT. CO.

Ample grate and moderate rate of combustion.  
G. R. W., MALDEN ELECTRIC CO.

*No. 33.—In setting boilers, is it advisable to leave an air space in the division and side walls?*

Solid wall is best, because it is impossible to obtain and keep tight a dead-air space between two walls. D. KENNEDY.

It is a good idea, but is seldom done.  
W. BLOXHAM.

No; make boiler walls solid and flush.  
GEO. L. COLGATE.

Boiler walls built with an air space should be much better if properly constructed, since allowance is made for expansion of the walls next the fire. Walls thus arranged should not crack.  
REGINALD CONSTABLE.

A boiler wall is almost certain to crack more or less, and the danger of air leakage is doubled by leaving an air space which will provide a passage-way between any cracks that may occur in the inner and outer walls.  
EDITOR.

In setting a boiler, it is advisable to leave an air space in the division and side wall.  
J. D. A., N. Y. ED. CO.

A setting wall with air space is far preferable to a solid one having the same masonry, the air space allowing the inner walls to expand and contract easily with the heat without cracking and without shoving or cracking the outer walls, thus maintaining a better setting than can be had with a solid wall. The hollow air space can also be used to deliver heated air into the furnace, returning the heat that otherwise would be radiated to the room. The hollow walls are just as permanent and easily repaired as the solid ones if properly constructed.

H. M. LYMAN.

The walls are more apt to crack with the air space in them than without an air space.

STEUBENVILLE TRACTION AND LT. CO.

Yes. G. R. W., MALDEN ELECTRIC CO.

Yes, if it is properly made and the walls are thick enough so that the space does not weaken them too much.

C. L. DAVIDSON.

We have found the air space in side walls an objection, causing more leaks than when set solid.

S. S. INGMAN.

When setting boilers, an air space should always be allowed between the furnace wall and exterior wall. This allows for expansion and contraction, and the dead-air space tends not only to reduce the temperature of the wall surface exposed to radiating effect in the boiler-room, but the furnace walls are also less affected by external temperatures. (UNSIGNED.)

As the conductivity of air is less than that of bricks, and as it gives, to some extent, two independent brick walls, thus avoiding part of the chance of cracking, it is advisable to leave an air space in the division and side walls. This is a good method, too, of getting air into the furnace under the grate or behind the bridge wall.

AUGUSTA RY. AND ELEC. CO.

*No. 34.—What has been the experience as to the relative cost of cleaning scale from drums of water-tube boilers using rounded-*

*nose chisel operated by compressed air as compared with hand-chipping?*

I should say there would be a difference of 50 per cent in favor of mechanical cleaner.  
W. BLOXHAM.

The use of a round-nose chisel operated by compressed air, as compared with hand-chipping in boiler-cleaning, reduces the cost fully 50 per cent.  
J. D. A., N. Y. ED. CO.

The use of compressed-air tools in place of hand-chipping for cleaning boilers is dangerous in the hands of any but the most intelligent and careful men, as a little carelessness may concentrate several blows on one weak spot and develop an opportunity for future trouble.  
AUGUSTA RY. AND ELEC. CO.

*No. 35.—What is the cheapest and best method of feeding coal into stokers where no conveying system is used and coal is dumped on fire-room floor?*

Labor. G. R. W., MALDEN ELECTRIC CO.

Large, short-handled shovels are about the cheapest thing that can be used, but this method lacks much of the saving possible with stokers. Raising the whole boiler-room floor, so as to permit the coal being shoveled along the floor directly into the stokers, would greatly reduce the labor cost.

AUGUSTA RY. AND ELEC. CO.

*No. 36.—Is there any cheap method of treating the brickwork of boilers to reduce air leakage to a minimum?*

Asbestos fibre is a good material with which to fill up cracks in boiler walls.  
D. KENNEDY.

Keep cracks closed with light coating of Portland cement and lime.  
W. BLOXHAM.

By applying a thin coating of fire-clay over the entire surface of the brickwork, practically making an unbroken wall.

W. T. D., N. Y. ED. CO.

Independent brick walls, with a sheet of asbestos soaked in silicate of soda between them, will produce a solid, air-tight wall.  
AUGUSTA RY. AND ELEC. CO.

Plaster with fire-clay. G. WILBUR HUBLEY.

An effective way to reduce air leakage in brickwork of boilers to the minimum, is to point carefully all joints on the interior of the setting. W. F. SIMS.

*No. 37.—How do you test for leaks in boiler setting?*

By blowing the tubes with high-pressure steam.  
D. KENNEDY.

Build a fire with oily waste; close the damper and observe the leakage of smoke. W. T. D., N. Y. ED. CO.

Go around all the cracks in boiler settings with a candle. The flame will be sucked toward crack if it is leaking.  
A. PETERS.

To test leaks in boiler settings, get a good smoking fire and close the damper tight.  
AUGUSTA RY. AND ELEC. CO.

Test by lighted torch around the outside of setting.  
G. WILBUR HUBLEY.

The most reliable test for leaks in boiler settings is to analyze the flue gases in order to determine the amount of nitrogen present. If the facilities for this analysis are not at hand, a simple method is to hold a lighted candle close to the joints in the brickwork while the boiler is in operation. Any decided deflection of the flame toward the joint will indicate the presence of a leak. W. F. SIMS.

By holding an open flame near suspected crack.  
S. B. RICHEY.

Leaks in a boiler setting may be tested by throwing fresh coal on the fire and closing the damper. Smoke will show up on the outside very quickly.

FRED B. HUBBELL.

A smoky streak on the walls of the setting indicates a leak.  
S. S. INGMAN.

*No. 38.—Has your experience shown you that there is any difference in the economy of the cross-pass setting known as the Babcock and Wilcox pass and the horizontal-pass setting known as the Heine pass? What are the relative advantages and disadvantages aside from the question of efficiency?*

A case came under my notice where a boiler using the horizontal or Heine pass was changed so as to have the cross or Babcock and Wilcox pass, and by actual test there was an increase in economy of between 10 and 11 per cent when running under exactly similar conditions.

Another point in favor of the cross pass is that any soot that lodges on top of the tubes falls down into the combustion or fire chamber when the boiler is being cleaned. With the horizontal pass the soot that is blown from the tubes simply falls to the bottom row of tile, lodges there, and keeps increasing each time the boiler is blown. It is said that this soot can be blown out of the open end where the gases enter the tube bank, and probably it can with most careful attention, but that is just what a boiler does not get. I know of cases where fully one-third of the heating surface was cut off from this cause, thus cutting down the normal boiler capacity, which was maintained only by increased firing and consequent decrease in economy.

REGINALD CONSTABLE.

The Heine parallel pass known as horizontal is preferable to the cross pass because experiments have shown that it is from six per cent to ten per cent more efficient in the absorption of heat. Besides, the baffles are close-fitting and when broken or burned out can be easily renewed, the latter being impossible with some cross-pass settings. The horizontal pass allows cleaning from front to rear through the water-legs by which every square inch of the surface can be reached with the blower, which is not possible with the cross pass, thus resulting in better economy. The weight of the baffle tile in the parallel pass has never been known to spring the tubes, while the cross baffles have been known to break and become displaced from settling

on the bridge wall. Clean surfaces and good baffles are necessary for good steaming. Mr. Geo. H. Barrus, of Boston, found six per cent better efficiency for the parallel pass over the cross pass in the same boiler, which he tested with both baffles, and published these results in the *Boston Journal of Commerce*.

H. M. LYMAN.

My experience leads me to believe that there is no difference in the economy, provided both types of boilers are operated under similar conditions.

Theoretically, the gases striking at right angles may appear to be the better plan of the two, but practically we have no difference. In fact the return tubular boiler will show as good economy as either of these types operating under conditions suitable for same. This shows that where boilers are properly designed and properly operated, the heating surface of one type of boiler is just as efficient as that of the other.

JAMES MILNE.

The two passes apparently have the same efficiency, provided the length of the gas travel is the same in each case.

W. L. ABBOTT.

*No. 39.—Which of the following methods of supporting a boiler has your experience proved to be the better; or do you think that advantages gained by one method are offset by disadvantages in the other? First, supporting in a gallows frame with straps around the drum, which hangs the boiler entirely free of the brickwork (with no support beneath). Second, supporting by carrying the load on the front end on columns and the load of the rear on rollers supported by a brick pier.*

Hanging by straps is the best.

D. KENNEDY.

Different boilers require different settings, but they should all be supported on columns.

W. BLOXHAM.

I believe that all boilers should be supported entirely independent of brickwork, as there is less liability of undue strains when brickwork requires renewal.

J. A. MALONEY.

Sectional boilers should be swung from the drum, as that is their strongest point, while water-leg boilers should stand on their legs, thus distributing the weight over a much larger foundation area, bringing the supports very much nearer the foundation and resulting in better construction and entire freedom from vibration. Practice has never shown any objection to supporting the front on columns and the rear on a low brick pier. This pier is much larger than the footings for the overhead columns and less trouble occurs from settlement. The fire-brick linings can be renewed throughout for boilers set on their water-legs without disturbing the supports of the settings, though we have no record of replacing the linings of the rear brick piers.

H. M. LYMAN.

We favor suspending boilers from supports above the setting. We think the setting keeps in better shape when the boiler is hung in this way.

S. S. INGMAN.

Supporting in a gallows frame with rods and plates is a better method than either of those mentioned. The second method mentioned in the question should only be used in setting small boilers, say 40 inches in diameter by 12 feet long, and smaller.

S. B. RICHEY.

The second method is usually cheaper and, if substantially built, the rollers should provide for expansion if too much soot is not allowed to accumulate.

AUGUSTA RY. AND ELEC. CO.

The method of supporting boiler from gallows frame, entirely free from under supports of any nature, is preferable.

G. WILBUR HUBLEY.

*No. 40.—Is there a recognized standard of boiler efficiency, expressed in percentage of available heat transferred to the water in the boiler?*

The usually recognized standard of efficiency is 70 per cent of the theoretical water evaporation per pound of coal when the latter is of fair quality.

REGINALD CONSTABLE.

The standard code for steam-boiler trials adopted by the American Society of Mechanical Engineers a few years ago provides two efficiencies that are recognized standards.

1. Efficiency of boiler = 
$$\frac{\text{Heat absorbed per pound of combustible}}{\text{Calorific value of 1 pound of combustible}}$$
2. Efficiency of boiler and grate = 
$$\frac{\text{Heat absorbed per pound of coal}}{\text{Calorific value per pound of coal}}$$

The first is recommended as a standard of comparison for all tests, and is the one that is understood to be referred to when the word "efficiency" alone is used without qualification.

G. A. O., N. Y. ED. CO.

See American Society of Mechanical Engineers' code for boiler tests.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 41.—Should not the steam required to produce draft or combustion be credited to the boiler and debited to the furnace, that is, over and above that required for a plain hand-fired type of grate?*

It should be credited to the boiler and debited to the furnace.

D. KENNEDY.

The steam required to operate the furnace certainly should be charged to the furnace, as the boiler should not be charged with work that belongs to the chimney.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

There is nothing in it for the company financially either way.

W. BLOXHAM.

If the *boiler* efficiency is to be determined, the steam required to produce draft should be credited to the boiler and debited to the furnace.

J. D. A., N. Y. ED. CO.

In our opinion, it should be credited and debited as you state.

TOLEDO RYS. AND LIGHT CO.

Yes, when analyzing results of furnace and heating surface.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

Yes. G. WILBUR HUBLEY.

*No. 42.—In an electric-light station, having the usual winter peak, are the total annual fuel and operating costs less with a boiler plant of rated capacity equal to the peak load, or with a smaller boiler plant using forced draft under peak conditions?*

Cheaper on smaller boiler plant. D. KENNEDY.

Boiler plant should have full rated capacity.  
GEO. L. COLGATE.

In the electric-light station referred to in this question, a smaller boiler plant, using forced draft, would undoubtedly be the cheaper.  
J. D. A., N. Y. ED. CO.

They should be less with a smaller boiler plant with forced draft.  
AUGUSTA RY. AND ELEC. CO.

Allow about 60 per cent of peak load as boiler capacity. Expenses will prove less with smaller boiler capacity than maximum load would call for.  
G. WILBUR HUBLEY.

Small boiler plant within limits, and use forced draft for peak of load.  
G. R. W., MALDEN ELECTRIC CO.

*No. 43.—Has moderate superheating of steam by fuel oil or other fuel, just before the steam enters the engine cylinders, been tried? If so, what type of heater was used and what was the cost of same and the resulting economy?*

Yes. In 1886, the Pioneer Iron Works installed a superheater in the tugboat *Glen Iris*. The heater was shell construction, with top and bottom heads into which tubes were expanded. The heater was placed in the uptake for the boiler, and steam entered the bottom and emerged from top to the engine. It was

impossible to obtain dry steam, owing to too rapid evaporation. The fuel used was anthracite pea coal, and tests were made with fuel oil. No satisfactory results obtained.

W. T. D., N. Y. ED. CO.

*No. 44.—Has the open water-leg of the Heine-type boiler, forming a common inlet for all the tubes of a water-tube boiler, any advantage over the arrangement of separate headers such as used in the Babcock and Wilcox, the National, and others?*

Open-leg Heine-type boiler has a decided advantage for circulation.

D. KENNEDY.

The former has the advantage that the total area of the connection between the headers and drums is much larger, giving large areas and thereby less restriction to the circulation of the water, which has the following important advantages:

*First*—It certainly should increase the life, since it does away with strains due to contraction and expansion, caused by the uneven temperature of the water in different parts of the boiler.

*Second*—The steam should be much better, since with large areas there is an undisturbed flow of the water from the headers to the drums. Where the areas are contracted the water is forced through the openings with great velocity, causing unnatural ebullition and therefore certain entrainment of water with the steam.

*Third*—It is a well-known fact that the forcing of a boiler beyond its normal capacity often causes the burning out of the tubes, especially in the upper rows. This is due to the fact that the areas at the heads of sections, or where entrance is made to the drums from a box type of header, are not large enough to allow the water and steam to pass. When this occurs the water and steam in the upper rows back down these tubes, until lack of circulation causes the tubes to burn out.

Another advantage is that all boilers of the Heine type are of steel construction, which has more elasticity and allows for the necessary expansion and contraction without danger of rupture.

REGINALD CONSTABLE.

The Heine type of water-leg has a great advantage over the sectional, on account of the larger area allowing free circulation from drum to tubes and to drum again. The throat at junction of drum and water-leg generally has from 60 per cent to 85 per cent of the tube area and, being all one body of water, has a carrying capacity equal to the tubes, which never fails to supply the tubes with sufficient water to maintain a rapid circulation and keep water in the tubes at all times. In some other types of boiler each header, sometimes double and triple deck, comprising from five to fifteen tubes, is connected to main drum and supplied by a single tube or nipple which does not afford nearly enough area to supply water in sufficient quantities for rapid circulation, the bottom tubes especially having a very slow flow, resulting in the water turning largely or almost wholly into steam and passing up the front headers as steam. Steam in a tube has not nearly the absorbing capacity for heat that water has, which results in the tube being overheated or unduly expanded, resulting in rupture or leakage and loss in economy by reason of the water not being able to traverse the heated surface. Experiment has established the law that the absorption of heat by water running through hot tubes increases as the cube of the velocity of flow, so that every decrease of the circulation decreases the economy. If the water flashes into steam in the top drum, where it should on account of that being the point of least pressure, it does not deposit scale in the tubes, as the scale adheres where liberated. This also keeps a more even temperature throughout the boiler structure, which is conducive to long life and freedom from bent tubes and chewed-off connecting nipples. The water-leg has less clogging from scale and dirt, because the passages are large enough to keep themselves clear.

H. M. LYMAN.

No; from a standpoint for quick repairs. In the Heine type of boiler if a crack develops in the water-leg the boiler must be taken out of service until a new section is put in; whereas, with the Babcock and Wilcox type of boiler the cracked section can be temporarily cut out by cutting the nipples and plugging the openings, and the boiler can be restored to service until the cracked section is replaced by a new one.

W. T. D., N. Y. ED. CO.

The single water-leg may permit cleaning more than one tube at a time with a hose, and thus avoid the need of always taking off all the handhole covers.

AUGUSTA RY. AND ELEC. CO.

It has, as there are fewer joints, and the water-leg of the Heine being flanged and riveted to drum, the joint is more easily kept tight.

S. B. RICHEY.

The Heine open water-leg allows the free and unrestricted circulation of water through all tubes. The Babcock and Wilcox separate header restricts the flow through the 7, 8, or 12 tubes, because of its small cross section. The circulation through the upper tubes is also retarded, because the water from the lower tubes has a higher velocity, due to head and more intense heat. Hence the advantage of the Heine over the Babcock and Wilcox arrangement.

E. E. LEE.

*No. 45.—Please describe the tests applied by the boiler insurance companies, and the character and scope of the periodical inspection?*

Insurance companies give a good internal and external inspection at intervals, according to circumstances.

D. KENNEDY.

The boiler is emptied, all handhole and manhole plates off, and must be thoroughly cleaned internally and externally. The steam-gauge is removed for test, and the ironwork is tested with a hammer and scrapers.

W. T. D., N. Y. ED. CO.

Boiler insurance companies make internal and external inspections at periodical intervals; usually twice annually. The scope of the inspection is sufficient to indicate thoroughly the general condition of the boiler, but the value and thoroughness of each inspection are due greatly to personal equation of the inspector in charge. From experience, I have found such tests and inspections of much practical value.

G. WILBUR HUBLEY.

*No. 46.—In setting horizontal tubular boilers, what is the best method of supporting the weight and allowing for expansion?*

By hanging by the two ends, making front end stationary and allowing rear end to expand. D. KENNEDY.

Build the regular setting, but instead of using the iron plates sent out by builders, run two lengths of railroad iron side by side along each wall. Rest the boiler lugs on these, the rear lug having rollers placed between it and the rails. The weight of the boiler is thus equally divided on the whole of the wall, and not on two points as is the case when plates are used under lugs. The expansion is also taken care of by the rollers, but as the surface on which rollers rest is the same as that on which front lugs rest, there is no end-racking of walls as is the case with the setting when rails are not used.

A. PETERS.

I prefer boiler supported on columns, but boiler resting on rollers or iron plates is very satisfactory.

W. BLOXHAM.

In setting horizontal tubular boilers, a good method of supporting the weight and allowing for expansion is to use rollers resting on cast-iron plates underneath the lugs, which are riveted to the boiler, the cast-iron plates under the rollers being imbedded in the boiler setting.

J. D. A., N. Y. ED. CO.

If the front end is supported solidly and the back end is hung on long links or supported on a non-corrosive plate, leaving the blow-off pipe free, there will usually be little trouble from expansion. Three points of support avoids racking caused by one of four points getting low.

AUGUSTA RY. AND ELEC. CO.

A horizontal tubular boiler should be supported in a gallows frame by rods and plates under the ordinary lugs and placed in position on solid foundation before brickwork is commenced.

S. B. RICHEY.

Horizontal tubular boilers are best supported by being hung on steel framing in such a way that the brickwork is relieved from all weight. This makes it much easier on the setting and greatly facilitates work in case of needed repairs. Such an arrangement, properly designed, allows freedom for expansion without cracking brickwork.

C. C. GARTLAND.

Let weight rest on brickwork, with rollers under back lugs.  
G. R. W., MALDEN ELECTRIC CO.

*No. 47.—Which is the most satisfactory in practical operation: the pop safety valve or the lever-and-weight type?*

Pop safety valve.

D. KENNEDY.

Pop safety valves are undoubtedly the most satisfactory in practical operation.

J. D. A., N. Y. ED. CO.

The pop safety valve is more satisfactory, because of being adjusted by boiler inspector and tested at will. The lever-and-weight type is too easily changed by any of the boiler-room laborers, thereby introducing an element of danger.

G. H. CUSHMAN.

The pop safety valve.

G. WILBUR HUBLEY.

Pop valve.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The pop safety valve is more satisfactory, because of being less easily tampered with.

AUGUSTA RY. AND ELEC. CO.

Pop safety valve.

G. R. W., MALDEN ELECTRIC CO.

The pop safety valve.

S. B. RICHEY.

The pop safety valve is the only kind to use, and is very satisfactory in operation.

FRED B. HUBBELL.

In a salty atmosphere the spring of the pop safety valve is liable to become weakened from rust. Gradually tightening it to keep up the pressure contracts the area of relief so that it may become dangerous. The lever valve is not subject to this objection.

S. S. INGMAN.

*No. 48.—What are the comparative merits of charcoal-iron and steel boiler tubes, including first cost, liability to cracking at the ends in expanding, liability to corrosion, and general reliability under severe conditions of service?*

Charcoal iron is the best.

D. KENNEDY.

Up to about 10 years ago charcoal-iron tubes were made of charcoal iron and gave excellent results in every way. To-day only the name survives, as the "charcoal-iron" tube of commerce is not made of charcoal iron. An examination of the scrap pile from which the skelp is made at any tube-mill will convince any unbiased observer of this.

No scrap can be bought anywhere whose constituent parts can be guaranteed as charcoal iron. Steel is now so cheap and so universally used that most wrought scrap is a conglomerate mass of borings, clippings, turnings, etc., of every kind of steel, good, bad and indifferent, with occasional lots of second-hand iron which may be old charcoal iron but as likely is not. The puddling and working of this scrap into skelp is more expensive than making skelp by the Bessemer process. Steel skelp and tubes made from it will be guaranteed by the tube companies as to chemical and physical properties and, from the fact of having been melted and blown in a converter, is more homogeneous than puddled-iron steel tubes, and therefore cheaper and purer than so-called charcoal-iron tubes. The latter masquerade under the prestige of the real charcoal-iron tubes of 10 and 20 years ago.

Steel tubes will stand all physical tests and the operations of expanding, flaring and beading much better than charcoal-iron tubes. In water-tube boilers where the internal pressure has to be withstood by the transverse strength of the tubes, it is a grave mistake to use charcoal-iron tubes, for their transverse tensile strength is only one-half that of steel tubes. The only excuse for using charcoal-iron tubes at all is found in

boilers of deficient circulation, for corrosion can take place only during stagnation, and it is well known that the scale or impurities of iron resist corrosion better than pure metal. But a steel tube may be half corroded through before it is as weak as a charcoal-iron tube in its original condition and thickness. Finally, under severe conditions of service charcoal-iron tubes are liable to form blisters, since from the process of manufacture they are naturally composed of a number of laminations more or less imperfectly welded during squeezing and rolling of the skelp, and with patches of scale between the laminae. An engineer who now specifies charcoal-iron tubes assumes a grave responsibility.

H. M. LYMAN.

In 21 years' experience with boiler tubes, both return tubular and water-tube boilers, I have found the charcoal-iron tube to last longer and to require less attention in service.

EDGAR B. GREENE.

Charcoal-iron boiler tubes are preferable, on account of less liability to cracking and splitting, and because they can be re-rolled in case of leaks at headers. They have longer life, and are more economical, considering the first cost, service and maintenance.

G. WILBUR HUBLEY.

*No. 49.—In setting horizontal tubular boilers, what is the best method of constructing the arch at the rear end where the gases pass from the combustion chamber into the flues?*

Have your mason build a "self-supporting" arch; that is, don't depend on iron or other material than the fire-brick itself. The bricks should be especially selected and of the very best grade.

W. H. BANES.

A good way of constructing the rear arch is to use the usual iron, set slightly up; in other words, do not try to get a perfect quarter of circle. Set the end resting on boiler rib so as to form a part of an oval. Then, after setting fire-brick in between ribs, coat the whole with asbestos cement. This has been found to make a good, lasting arch.

A. PETERS.

A very good method is to procure arch fire-brick tile about four inches longer than the space between the rear boiler head and the rear wall and turn the arch immediately about the flue, having the tile rest on the fire-brick lining of the rear wall. We have had arches of this character to run under severe conditions for eight and ten years without repairs.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Use cast-iron arch bars, protected by fire-brick.

W. BLOXHAM.

The Hartford Steam Boiler Inspection and Insurance Company has an excellent design for a cast-iron ribbed clamp into which the arch-brick are laid and which rests on the side walls, the axis of arch being parallel to that of boiler instead of at right angles to it as in the usual construction. Ordinary fire-brick may be used instead of special arch-brick or tile, and cracking or breaking down is practically impossible.

EDITOR.

An arch bar that answers its purpose exceedingly well consists of an arch of cast iron, the walls being about an inch in thickness and strengthened by a rib on top. Fire-bricks are placed on the under side of arch. These bricks come in contact with the hot gases, thereby protecting the metal part from the extreme heat which sometimes melts the iron, causing the wall to cave in.

G. H. CUSHMAN.

A satisfactory "arch" for back of tubular boiler setting can be made by using two-inch pipe for the supports for fire-brick, the open ends of the pipe being left clear for the free circulation of air through the pipe.

S. S. INGMAN.

Wrought-iron T-beams, inverted and placed across from one side wall to the other at a distance apart equal to the length of a fire-brick. After the channel thus formed has been filled with fire-brick a layer of common brick is laid in asbestos.

S. B. RICHEY.

This arch is best constructed as follows: Use cast-iron T-sections set bottom up, spaced the length of a brick apart, and supported on suitable walls at the ends; lay a course of fire-brick on edge between the bars, with the joints made of fire-clay mortar. It will be better if the ends of the fire-bricks are notched out to allow the face of the brick to project say one inch below the lower face of the bar, thus, 

When the fire-bricks are laid, cover with mortar and finish with a course of red brick laid in joints flushed with mortar. Give the whole outside surface a good coat of mortar one inch thick.

J. H. VAIL.

*No. 50.—What is the cost of boiler-room labor per ton of coal for firing coal and handling ashes?*

In a boiler-room equipped with coal conveyers and automatic stokers and burning about 400 tons of coal a day, the costs of boiler-room operating labor, including unloading of coal, handling ashes and boiler-room foreman, run from 16 to 20 cents per ton of coal.

W. L. ABBOTT.

\$0.368 per ton. 20 tons per day, hand-fired.

G. R. W., MALDEN ELECTRIC CO.

It varies entirely with local conditions, such as wages and boiler-room arrangements.

D. KENNEDY.

Cost of handling coal and ashes eight and one-half cents, and cost of firing attendance five cents per ton of coal fired to boilers, under the conditions that coal and ash conveyor and automatic stoker are used.

G. WILBUR HUBLEY.

Fifty cents.

F. ELLWOOD SMITH.

*No. 51.—What has been the experience with water-cooled noses on bridge walls on the water-tube boiler?*

Water-cooled noses save the bridge wall, but are liable to be burned out if the water supply is not ample and reliable.

W. L. ABBOTT.

*No. 52.—What is the best construction of furnaces for firing poor grades of bituminous coal that is high in volatile matter?*

Undoubtedly the best construction for a furnace using coals high in volatile matter is of the "Dutch oven" type, or a construction using the same principle, which brings the gases in contact with incandescent arches.

REGINALD CONSTABLE.

Chain-grate furnaces with liberal grate and igniting arch area.

TOLEDO RYS. AND LT. CO.

## F

### FORCED DRAFT, BLOWERS, STACKS, ETC.

*No. 1.—How much steam is consumed by the so-called argand jet blower, so largely used throughout the anthracite regions for forced draft?*

From five per cent, under favorable conditions, to ten and fifteen per cent.

EDITOR.

*No. 2.—What amount of chimney draft is necessary for the efficient consumption of Ohio and Indiana run-of-the-mine coal?*

About 13 pounds of air to 1 pound of coal.

AUGUSTA RY. AND ELEC. CO.

Draft should not be less than .5 inch.

G. WILBUR HUBLEY.

*No. 3.—What type of pyrometer is most satisfactory for use in determining chimney temperatures?*

A mercury column pyrometer is the most reliable, and can be purchased reading up to 900 degrees and over. Barring actual breakage, a mercury thermometer will always read fairly accurately.

A Siemens pyrometer is reliable, but involves labor and some skill and judgment.

A thermostat pyrometer with mechanical connections to a gauge is too liable to get out of order.

J. W. BRASSINGTON.

Stack mercurial pyrometer reading to 800 degrees Fahrenheit.

G. WILBUR HUBLEY.

*No. 4.—There seems to be considerable variation between the tables of relative height and cross section of chimneys; which is the most reliable?*

The cause of the variation between the various tables of capacity, height and cross section of chimneys is the different assumptions regarding coal per horse-power and the empirical constant used in the general formula for chimneys.

All chimney formulæ may be reduced to the following form:

$$C = aA \sqrt{H}$$

Where  $C$  = coal consumption in pounds per hour.

$A$  = area of cross section in square feet.

$H$  = height above grates in feet.

$a$  = a constant.

The height of the chimney is usually determined by other than theoretical considerations, the height of adjoining buildings, avoiding a nuisance, hills or other natural obstructions making necessary a higher chimney than would be required to furnish sufficient draft to burn the particular grade of coal used. Where no such obstructions exist the height may be found from the draft requirements by the following:

$$H = 135.87 D.$$

Where  $D$  = the draft pressure in inches of water.

The constant  $a$  depends on the amount of air passing into the furnace and varies between 5 and 20, the value of 5 being deduced from metallurgical practice, where three or four times the air theoretically necessary for combustion is supplied to the furnaces. The value 9.3 given by Professor Ser is based on twice the amount of air necessary for perfect combustion, while the average large stack in electric stations figures about 12 (equaling an excess of one-half the theoretical amount). Kent's formula gives a constant of 16.65, using the effective area instead of the actual area.

Now, having the height fixed by conditions or draft required, the coal consumption fixed by the horse-power required and the known efficiency of the boilers, the formula becomes:

$$A = \frac{C}{a \sqrt{H}}$$

In which  $A$  and  $a$  are the only unknown quantities. The quality of the coal and type of grate are all that is needed to determine  $a$ —thus leaving only the area to be calculated by the formula.

G. A. O., N. Y. ED. CO.

The best known formulæ for obtaining heights and cross sections of chimneys are as follows:

Smith	Kent	Gale.
$A = \frac{0.0825 F}{\sqrt{h}}$	$A = \frac{0.06 F}{\sqrt{h}}$	$A = 0.07 F^{\frac{2}{3}}$
$H = \left( \frac{0.0825 F}{A} \right)^2$	$H = \left( \frac{0.06 F}{A} \right)^2$	$H = \left( \frac{180}{t} \left( \frac{F}{G} \right) \right)^2$

in which  $A$  represents area;  $H$ , height of stack in feet;  $F$ , pounds of coal burned per hour;  $t$ , the stack temperature, and  $G$ , grate area; but in Kent's formula  $A$  represents the effective area only, and he adds a ring two inches wide all around to allow for chimney friction. Thus, if the formula gives a chimney 41 inches in diameter on 36 inches square, its actual size must be 45 inches diameter or 40 inches square. For stacks 100 feet high Kent's formula gives a total area 11 per cent larger than Smith's for 250 pounds of coal per hour (50 horse-power); exactly the same for 500 pounds of coal (100 horse-power); 18 per cent smaller for 1000 pounds of coal (200 horse-power); 24 per cent smaller for 5000 pounds of coal (1000 horse-power), etc. The five pounds of coal per horse-power is merely a convenient assumption and is based on an evaporation of seven pounds of water per pound of coal.

Kent's formula has the advantage of recognizing the practical fact that for the larger power the area of chimney required per horse-power becomes less. Gale's formula is more promising, but as his constants are based on observed data much smaller than those of best modern practice, they lead to rather too large results; but making the height depend only on the stack temperature and the rate of combustion is much more

in accord with facts than making ordinary height and area interdependent, as the other two formulæ do. With Gale's constants modified so that

$$\left( H = \frac{127}{t} \left( \frac{F}{G} \right)^2 \right)$$

the heights can be fixed and then Kent's formulæ for area applied. The interdependence of height and area exists only in limits defined by practical observation.

WM. R. PAGE.

The capacity varies as the square root of the height and as the square of the diameter.

D. KENNEDY.

Kent's tables and formula are accepted.

G. WILBUR HUBLEY.

*No. 5.—Describe a ready method of increasing the intensity of draft exclusive of increased height of stack or mechanical blower.*

Connect a small pipe (say half-inch) to the steam main and run it into the bottom of the stack. Place an expansion cone on the end of this pipe and let the steam pass through, and you will find that the draft is greatly increased.

REGINALD CONSTABLE.

Small steam jet.

W. BLOXHAM.

Install a steam jet in stack, and if possible flush the ash-pan with water.

W. G. D., N. Y. ED. CO.

Introduce a steam jet into the uptake flue.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 6.—How do you overcome back-draft in starting the fire in a boiler connected to a flue and stack that have been out of service for some time?*

Place some saturated oil waste in the bottom of the stack, and thereby heat up the air inside, which will at once promote the draft in the proper direction.

REGINALD CONSTABLE.

If you have trouble with a back-draft in starting a cold boiler setting and stack, start a little fire in the base of the chimney a few minutes before starting fire on the grates.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Prevent too much air from going through grates.  
W. BLOXHAM.

By building a fire in the base of the chimney. A small bunch of oily waste, bundle of papers or straw, will be sufficient.  
E. W. FURBUSH.

By building an auxiliary fire in the bottom of the flue and then starting the fire in the boiler.  
W. J. C., N. Y. ED. CO.

A small fire in the base of stack of easily burning stuff will usually start the draft in the right direction.  
AUGUSTA RY. AND ELEC. CO.

Build fire in flue at base of stack.  
G. WILBUR HUBLEY.

Make a very little fire at first, closing the fire-doors gradually.  
S. S. INGMAN.

Build a fire in the bottom of the chimney and dry it out.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 7.—What draft is required to obtain the rated capacity of boilers fired with No. 3 buckwheat coal? What percentage of the total steam generated is usually required to operate the fan supplying forced draft?*

With a ratio of 57:1 between heating surface and grate surface, an average pressure in the ash-pit of one inch will burn sufficient No. 3 coal to give the rated capacity on a water-tube boiler. From two per cent to five per cent of the steam generated will be required to operate the fan.

W. F. W., N. Y. ED. CO.

*No. 8.—Is there any economy in lining steel stacks with brick? If so, to what height should lining be carried and what kind of brick used?*

I should say, yes; not over 25 feet on a 150 foot stack.

W. BLOXHAM.

There is no economy in lining small steel stacks, and frequently such lining is an impossibility as well. Above five feet in diameter a brick lining will pay, especially where only natural draft is used, as the unlined steel stack will radiate heat much faster than the lined stack. The kind of brick required depends on the temperature of the flue gases. If this temperature does not exceed 600 degrees Fahrenheit red brick may be used, but when the temperature runs higher second or third quality fire-brick should be used for about half the height of the stack and good fire-brick in the neighborhood of the flue entrance. The lining where used should be carried to the top of the stack and both shell and lining covered with a water-tight cap. A properly constructed lining will add largely to the life of a thin steel stack. Stacks larger than 10 feet diameter should have the lining built in sections and supported on metallic rings riveted to the shell, and the individual sections may be backed solid with cement mortar. It does not pay to use linings thicker than eight inches in a steel stack.

G. A. O., N. Y. ED. CO.

Brick lining prevents the gas from attacking the steel, and should be carried up about one-half the height of the stack.

D. KENNEDY.

A large or moderate-sized steel stack should be lined throughout its entire height with hard radial fire-tile curved to conform with stack. The thickness of the lining should depend on the temperature at which the gases are admitted. Ordinarily use 13-inch lining at the base and 4.5-inch at the top with about two-inch air space between fire-tile and stack metal. The radial tile should be corbelled out to stiffen lining with one tile about every four feet centres.

C. A. KELLER.

311321

Lining steel stacks will undoubtedly prolong their life. Lining should preferably be carried to the top and should consist of a good quality of fire-brick for the lower part with a cheap brick above.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 9.—What is the relative cost of regular brick, special Custodis, and self-supporting, brick-lined steel stacks from 160 to 200 feet high?*

The best way to find the relative cost between the two classes of stacks would be to get bids from people constructing stacks. The location has frequently very much to do in the matter. Custodis stacks are sometimes the cheaper of the two in the first construction, and we believe very much cheaper in the long run.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

At the present time, the steel stack properly designed with an eight-inch brick lining, and foundations on good bottom, is about 10 per cent cheaper than any of the radial brick stacks. The steel stack with its lining will be about 50 per cent as heavy as the brick stack, and the bulk of the saving is in the cost of the foundation. Where rock bottom can be secured the stacks would be approximately equal in price. The item of freight is a very heavy one for the brick stack, and the above is based on the net price of the erected stack exclusive of freight. A well-designed common brick stack is at least 20 per cent more costly than the radial brick stack.

G. A. O., N. Y. ED. CO.

The self-supporting brick-lined steel stack will be a little cheaper in first cost. At the end of say 10 years, the Custodis chimney would probably be cheaper, especially if on the sea coast and exposed to salt atmosphere.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The approximate cost of a brick stack about 200 feet high above foundations, with 18-foot core, will be about \$22,000; a

Custodis stack of the same size, about \$17,000; a similar steel stack, \$20,000.

C. G. Y. KING.

*No. 10.—Is there any simple and practical method of chimney-gas analysis that will enable one to determine relative economy of combustion?*

After a little practice, a sample of flue gas may be analyzed with the apparatus devised by Orsat in five or ten minutes. This apparatus, which is described in Stillman's "Engineering Chemistry," can be obtained from any dealer in chemical apparatus.

W. F. W., N. Y. ED. CO.

*No. 11.—Is there any reliable method of testing soils in order to insure brick chimneys against cracks or other defects due to irregular settling of foundation?*

A very good method of testing soils for chimney foundations is to apply a test load after excavation has been made.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Sinking test pipes is the surest way.

AUGUSTA RY. AND ELEC. CO.

The most reliable method of testing soils in order to insure brick chimneys against defects due to settling, is to make test borings on the site upon which the chimney is to be built in order to determine the character of the underlying strata. From the data thus obtained the foundation of the chimney can be designed so that the soil will not be overloaded, thus reducing the chances of settling.

W. F. SIMS.

*No. 12.—Which is the better or more economical method of increasing boiler capacity during heavy peak loads—forced or induced draft?*

We favor induced draft.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

I should prefer induced draft if conditions were such that I could use it.

W. BLOXHAM.

Forced draft is the better and more economical method of increasing boiler capacity.  
J. D. A., N. Y. ED. CO.

Opinions differ. Mine is that the induced draft is the best.  
D. KENNEDY.

Forced draft is preferable, as it is more economical.  
G. WILBUR HUBLEY.

*No. 13.—Is there any way to protect the interior of brick stacks against cracking and disintegration when boilers are forced and stack temperature is approximately 650 degrees Fahrenheit?*

By building an inner lining of fire-brick with a three-inch air space between that and the stack shell, with openings at the bottom of chimney, thus admitting cold air. This lining should extend up about one-quarter the height of the stack.  
W. T. D., N. Y. ED. CO.

The best way to protect the interior of a brick stack is by using the best quality of radial fire-tile for the lining. The lining should be brought up in three concentric stages, starting each one from the bottom with an air space of one inch between each stage. The inner stage should be brought up about one-third the height of the stack, the middle about two-thirds, and the outer stage all the way up, with a two-inch space between it and the brick stack. The lining should be stiffened by cor-belling out one radial tile every four feet centres.

C. A. KELLER.

*No. 14.—What is the proper area to allow per boiler horse-power in a flue in plants of from 500 to 1000 horse-power, from 1000 to 2000 horse-power, and from 2000 to 3000 horse-power?*

Flues having a cross-sectional area of from one-fourth to one-sixth of the grate area of the boiler should give good results, the larger size being adopted in the case of the smaller plant and the smaller area for the larger one.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Fifty to 100 horse-power with stack 100 feet high, area 20 to 35 square feet; 1000 to 2000 horse-power with stack 125 feet high, area 35 to 65 square feet; 2000 to 3000 horse-power with stack 150 feet high, area 55 to 80 square feet.

G. WILBUR HUBLEY.

Assuming that by "flue" is meant chimney or stack, I give below a few well-known rules for finding the area of chimneys in general, thinking this is perhaps the best way to answer this question:

*First*—Multiply the number of square feet of grate surface by 120, and divide the product by the square root of the height, and the quotient will be the required cross section in square inches.

*Second*—Divide the horse-power by three and one-third times the square root of the height, and the quotient will be the required area in square feet. To the diameter or length of side required to give this area, add four inches to compensate for friction.

*Third*—In stationary boilers the chimney should be one-fifth greater than the combined area of all the tubes.

*Fourth*—For marine boilers the rule is to allow 14 square inches of chimney area for each nominal horse-power.

*Fifth*—The *Locomotive* gives the following: "The unit for chimney construction should be a flue, 81 feet high above the level of the grates, having an area equal to the collective area of the tubes of all the boilers leading to it, the boilers being of the ordinary horizontal return tubular type."

*Sixth*—Tully gives the following table of sizes of chimneys:

Height	DIAMETER AND NOMINAL HORSE-POWER			
	60 Inches	64 Inches	72 Inches	78 Inches
100 feet	500 Hp	600 Hp	750 Hp	930 Hp
110 "	550 "	650 "	825 "	990 "
120 "	600 "	700 "	900 "	1050 "

WILLIAM R. GARDENER.

*No. 15.—What is considered good practice in flue temperatures?*

The tests that we have made show a much higher economy with the flue temperature below 400 degrees than above 500 degrees. A number of tests have shown as much as 15 per cent more water evaporated with the flue temperature ranging from 350 degrees to 400 degrees than was obtained with the flue temperature running from 500 degrees to 600 degrees. Would consider 450 degrees good practice where economizers are not in use.

JAS. E. PYLE.

Five hundred to 540 degrees Fahrenheit.

THE B. F. GOODRICH CO.

Between 500 and 550 degrees Fahrenheit.

G. WILBUR HUBLEY.

*No. 16.—In installing damper regulators for a battery of boilers, why would it not be better to let one or two fires do the regulating and allow the others to work at maximum furnace efficiency, rather than place damper in stack or main flue and cut air from all the furnaces?*

In installing damper regulator to control the main damper at the chimney base, the trouble of changing the regulator from one boiler damper to another when the boilers are cut in or out will be obviated. Second, boilers that are allowed to work under strong draught at their maximum furnace capacity are very apt to show a much lower economy than when they are cut back by a damper. We should therefore expect to find considerable gain in fuel economy by having the damper regulator control the main damper instead of regulating independent dampers on part of the boilers.

JAS. E. PYLE.

It would be better to damper one or two boilers rather than the whole battery, because your remaining fires will then be in good condition to take care of increased loads.

THE B. F. GOODRICH CO.

In very large stations, or in small stations with steady load, this is possible. With large fluctuations in load, however, the scheme would be undesirable, as the boiler on the damper could not vary the rate of work quickly enough to give a good steam line.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 17.—Is there any simple and practical method of chimney-gas analysis that will enable one to determine relative economy of combustion?*

I know of none that is reliable. . . . W. BLOXHAM.

One of the simplest and most practical methods for analyzing flue gases to determine the economy of combustion is the use of the Orsat apparatus, which can be obtained from any chemical supply dealer and can be used by anybody of a reasonable degree of intelligence. . . . J. D. A., N. Y. ED. CO.

A simple, practical method of flue-gas analysis to any degree of accuracy is by the use of the Orsat apparatus. The gas is drawn from the stack by means of a pipe, perforated with many holes and connected by a rubber hose to a small tank filled with water. On the tank there are two cocks, one being attached to a rubber hose leading from the perforated pipe and the other being open to the atmosphere. When the cocks are opened the water flows out, allowing an equal volume of gas to flow in its place. It may be well to state that two tanks should be used, the first being used to draw out any air that is in the hose and pipe, and the second tank is for the sample of gas. One hundred cubic centimeters of the sample gas at atmospheric pressure is drawn into the graduated tube of the Orsat apparatus and is consecutively forced into the following solutions: potassium hydroxide, pyrogallic acid and cuprous chloride, which removes the carbon dioxide, oxygen and carbon monoxide respectively. Knowing what the relative quantities of the gases should be under good conditions, we can readily judge whether or not we are getting perfect combustion. If conditions are unsatisfactory, they may be remedied by the adjusting of the drafts. Our tests were conducted on boilers

that used oil as fuel, and the results were quite reliable, as the fire-doors were not opened every few minutes as in the case where coal is burned. The following percentages of gases were found under the best conditions:

CO <sub>2</sub> .....	11.0	per cent
O <sub>2</sub> .....	5.9	"
CO .....	.1	"
Other gases .....	83.0	"
	100.00 per cent	

SAMUEL KAHN.

By the use of a pyrometer.

D. KENNEDY.

A Hempel apparatus is a simple and practical instrument for gas analysis, and requires very little practice to enable operator to obtain reliable results so as to determine relative economy of combustion.

J. W. BRASSINGTON.

Orsat's apparatus. However, the method is not entirely simple or practicable for daily use.

G. WILBUR HUBLEY.

The analysis of chimney gases may be determined by means of an econometer, which gives a continuous indication of the amount of carbon dioxide in the gases; or the percentage of this gas may be determined by means of a portable Orsat instrument. The determination of the percentage of this gas is a very good indication of the condition of combustion in the furnace.

W. L. ABBOTT.

## G

### ENGINES

*No. 1.—What is understood by the indicated horse-power of a steam turbine, and what is the approved method of obtaining it?*

By use of the Prony brake.

D. KENNEDY.

It is generally figured in electrical horse-power or kilowatts. I know of no mechanical method of obtaining indicated horse-power.

W. BLOXHAM.

The indicated horse-power of a steam turbine may be defined as the shaft-horse-power plus the power required to overcome the friction of the wheels in the steam under the existing conditions of pressure and temperature. It is customary to assume that these rotation losses are independent of the amount of steam passing through the buckets; they can therefore be determined by driving the turbine with an electric motor, using the proper conditions of pressure and temperature within the casings and measuring the power delivered to the motor.

A. R. DODGE.

There is no method of getting the indicated horse-power of a turbine.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The term "indicated horse-power," as applied to the steam turbine, is strictly a *misnomer*, and no definite idea of the internal working of steam may be conveyed by its use. It is frequently desired to draw a direct comparison of the performance of the turbine with a certain reciprocating engine, in which case it is necessary to assume arbitrarily for the turbine a mechanical efficiency that is applicable to the engine. Thus, in <sup>electrical horse-power</sup> indicated horse-power comparisons, 85 per cent is frequently used as representing the full-load overall efficiency of a generating unit. With engine-type units of large capacity and possessing modern refinement in construction, this total efficiency may rise as high as 90 per cent, but infrequently rather than otherwise. Assuming, for instance, a maximum water rate of 13 pounds per i.hp-hour for the engine and 15 pounds per e.hp-hour for the turbine, the so-called "indicated water rate" of the latter would be 12.75, or practically the same as the engine. With a turbine water rate of 13 pounds per e.hp-hour, the "indicated water rate" would be 11 pounds. The comparison is evidently legitimate as a comparison, but it contributes no further knowledge to the internal action of the turbine.

An interesting point occurs in applying this comparison at light loads. Under the assumption of constant mechanical and electrical losses in both engine and turbine, which has been proven in the case of the former to be an approximately cor-

rect one, the water rate of the turbine appears to startling advantage. In a recently published test, by applying the above combined efficiency of 85 per cent to the water-rate curve of the turbine under the assumption just noted, the "indicated water rate" is 11.3 pounds and is constant at all loads. This, of course, could not take place in actual practice, but, nevertheless, represents the performance that a reciprocating engine must meet in order to equal the actual performance of the turbine.

FRANCIS HODGKINSON.

*No. 2.—What results have been obtained commercially as to the amount of steam consumed per hp-hour by a modern turbine operating non-condensing?*

About 33 pounds is the best of which I have heard.

W. BLOXHAM.

A turbine designed to operate condensing requires about twice as much steam per horse-power when operating non-condensing as when running with 95 per cent vacuum.

A. R. DODGE.

The operation of a steam turbine when running condensing or non-condensing is similar to the behavior of a reciprocating engine under like conditions. An engine with high cylinder ratio, designed for operation under vacuum, will give but indifferent results when operating non-condensing. Experience with Westinghouse-Parsons turbines shows that a turbine designed for high vacuum and that will show a steam consumption of 16 pounds per e.hp-hour under vacuum, will show a corresponding consumption of about 34 pounds per e.hp-hour running non-condensing. If, however, it is designed for operating without vacuum, much better results will be obtained; for instance, a 150-kw turbine has shown a steam consumption of 30 pounds per brake hp-hour, and a 600-kw turbine about 25 pounds per brake hp-hour, non-condensing.

FRANCIS HODGKINSON.

*No. 3.—What overload can be carried by a steam turbine under the control of the governor and without opening by-pass or turning on additional nozzles by hand?*

The Curtis turbine will automatically take care of from 90 per cent to 100 per cent momentary overload without adjustment.

A. R. DODGE.

Twenty-five per cent with the Westinghouse-Parsons turbine.  
THE B. F. GOODRICH CO.

The overload that may be carried by a steam turbine without the use of devices intended to increase its capacity, depends entirely upon the design of the individual machine and upon its rating determined by the character of the load that must be sustained. For instance, if a steady load of motor-driven pumps were to be sustained by a turbine generating outfit, the turbine might naturally be rated much higher than if a widely fluctuating railway load were to be provided for.

Westinghouse-Parsons turbines may readily be designed so as to carry continuous overloads far beyond the capacity of the generator, still maintaining close control by the governor. As a turbine, however, always gives its highest economy when operating normally at its maximum load, it is somewhat more advantageous to employ an auxiliary or secondary valve on widely fluctuating loads, in order to provide large overload capacity of the turbine and still maintain its best economy at or near the point of rated load. Overloads of 80 to 100 per cent may be carried if the exigencies of service prescribe such capacity.

FRANCIS HODGKINSON.

*No. 4.—Does a steam turbine require a special condensing equipment or one more expensive than required by reciprocating engines?*

The steam turbine does not necessarily require a special condensing equipment or one essentially more expensive than would be required by reciprocating engines. The feature of excellence in the steam turbine is that in it one is able to take advantage of the economies due to high vacua, namely, 28 or 29 inches,

which do not obtain in the reciprocating engine, and for that reason the most efficient condensing apparatus is recommended. The turbine will work on a poorer vacuum, but of course with less efficiency.

CALVIN W. RICE.

Yes; requires more condensing capacity.

W. BLOXHAM.

As it is necessary to provide from two to three times the amount of cooling water for a high vacuum, it is desirable to use a larger condenser than customary for a reciprocating engine. There is some gain due to the use of a valveless pump in place of the usual type of pump. If the pump used to remove the condensed steam is not designed to remove the air also, an auxiliary dry vacuum pump must be provided.

A. R. DODGE.

The answer to this question depends upon the quantity and quality of the supply of condensing water and also on the type of condenser used. If the jet condenser is used and the supply of cold condensing water is practically unlimited, the same condensing outfit would do for the turbine or engine, although the turbine outfit would use about 50 per cent more power in the auxiliary machinery, and this ratio would hold even with a warmer restricted water supply for equal economies with large-sized units.

If surface condensers are used, most manufacturers consider that the turbine with 28 inches of vacuum requires a much larger and more costly condenser than an engine using only 25 inches of vacuum. Other manufacturers consider this a mistaken idea and claim that the additional vacuum can be obtained by increasing the capacity of the air and circulating pumps. With plenty of cold condensing water the additional three inches of vacuum can readily be obtained at slight expense for power without increasing the cooling surface; but with a warm or restricted water supply, more surface is needed, and with intake water at 80 degrees Fahrenheit 28 inches of vacuum is almost impossible of attainment.

It may be safely stated that, taking into account a dry air pump for use with the turbine, the net excess cost of con-

densing apparatus for turbines will not exceed \$1.00 per horsepower over that for engines, and for ordinary conditions the excess cost will be much lower.

G. A. O., N. Y. ED. CO.

The turbine does not require a more expensive condensing system than an engine, but it will be so much more economical with the better vacuum that it pays to increase the size of the condensing plant.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

A steam turbine does not require a special condensing equipment, or one more expensive than required by reciprocating engine, but a high vacuum counts so very much more in economy with the turbine than with reciprocating engine that it is economy to install the more efficient condensing apparatus for a turbine unit.

W. F. KINGAN.

Steam turbines do not necessarily require a more expensive condensing equipment than do reciprocating engines, but the possibility of thus improving the performance of steam turbines is greater than with reciprocating engines. The improved economy and additional capacity possible to secure in a steam turbine will, under most conditions, justify the investment in high-grade condensing equipment.

P. JUNKERSFELD.

The higher the vacuum, the better the steam economy on a steam turbine. For that reason a more refined and expensive condensing apparatus is desirable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

More expensive, because a higher vacuum should be carried.

THE B. F. GOODRICH CO.

A steam turbine does not require a more expensive condensing equipment than a reciprocating engine, but it is, nevertheless, a paying investment to furnish an equipment of the highest grade obtainable, for the reason that the turbine can readily avail itself of a higher ratio of expansion than is found

practicable or expedient with reciprocating engines. It is found that with Westinghouse-Parsons turbines every inch of vacuum above 25 inches obtainable in the exhaust pipe will improve its economy three or four per cent. A little arithmetic will show the effect of this saving on the station economy, bearing in mind the fact that the cost of operating condensers designed for high vacua is but slightly greater than for low vacua. For instance, assume two power stations operating continuously on 25 pounds of steam per kw-hour through a life of 15 years, with the cost of coal at \$2.00 per ton and gross evaporation of 7.5 pounds. Suppose, then, that one station increased its working vacuum from 26 inches to 28 inches, resulting in a reduction of average daily steam consumption of two pounds per kw-hour. At the end of the assumed life of the equipment, the saving resulting from the use of this higher vacuum has amounted to \$35 per kilowatt capacity of equipment. The new condenser has, however, necessitated an extra investment of \$2.65 per kilowatt, so that a net saving of \$32.35 per kilowatt results, which is 12 times the cost of the increased vacuum.

The only real item of cost besides that of initial investment in higher-grade condensing apparatus is that due to handling the greater amount of cooling water necessitated by the decreased temperature range in the condenser. This may mean much or little, according to the location of the power plant with reference to available water. With balanced suction and discharge water columns, the power required for circulating becomes very small.

FRANCIS HODGKINSON.

*No. 5.—What economy is there in the use of compound as compared with single-expansion engines at pressure of 100 pounds or less?*

About 18 to 20 per cent.

D. KENNEDY.

We do not believe there is any economy in running a compound engine with 100 pounds boiler pressure unless it can be run condensing.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

About 10 per cent.

W. BLOXHAM.

It is extremely doubtful whether there would be any saving in steam consumption, even at full load, while at partial loads it is certain that the economy of a compound engine at so low a pressure would be much less than that of a simple engine. Furthermore, as the number of wearing parts is greater in a compound engine, the cost of oil and repairs would be greater.

EDITOR.

We should say that the economy obtained on the compound engines in comparison with single-expansion engines would all depend on the load carried and whether or not a condenser could be used. If a compound engine is run at less than half load and non-condensing at 100 pounds steam, we should think it would not be any more economical than a good simple engine; but in case the compound can be run at full load and non-condensing we find that saving in fuel will amount to from 10 to 15 per cent, while if a condenser could be used the saving over simple engine might be 20 per cent. The above is based on engines of say 100 to 150 horse-power. For a small electric-light plant, where the peak load is on for only about four hours and the rest of the time the engine is run at half load or even less, we should advise either putting in two simple engines or a single medium-speed engine for best all-around results. In the first case use both engines during the peak load and cut one out at the time when the other engine can handle the load. The saving in fuel should be considerable over a compound running all the time.

E. S. ALDRICH.

One hundred pounds is too low a pressure to make compound engines advisable, unless circumstances necessitate their use, when condensers will be of great assistance.

AUGUSTA RY. AND ELEC. CO.

About 10 per cent or 15 per cent better under favorable conditions.

D. W. ROPER.

The compound, non-condensing engine will show increased economy over the simple engine of about 18 per cent to 20 per cent with 100 pounds initial steam pressure, but this only when operating at full rated load, as when operating under lighter

loads the steam consumption in the case of the compound increases much more rapidly than in the case of the simple engine.

S. S. SMITH.

*No. 6.—How is the capacity in horse-power of a compound engine computed from its cylinder dimensions and speed?*

Take the indicated horse-power of each cylinder.

D. KENNEDY.

By the engine constant, if I understand the question.

W. BLOXHAM.

The capacity in horse-power of a compound engine may be found by figuring each card separately and adding the results together; or the steam may be considered to be expanded in either cylinder, preferably the low-pressure. By dividing the mean effective pressure of the high pressure by the ratio of the cylinders and adding the result to the mean effective pressure of the low-pressure cylinder, we have a m.e.p. the same as if the steam had been expanded in the low-pressure cylinder alone.

We will suppose that we have a compound engine with cylinders 18-inch high-pressure, 36-inch low-pressure, with a stroke common to both of 36 inches, and 100 r.p.m. The ratio of the cylinders is 1:4. Considering the m.e.p. of the high-pressure cylinder to be 40 pounds and of the low-pressure to be 10 pounds, we have  $40 \div 4 = 10$ .  $10 + 10 = 20$  pounds m.e.p. if the steam had been expanded in the low-pressure cylinder alone. The horse-power constant would be 4.626 for the high-pressure cylinder and for the low-pressure 18.5. Figuring the cylinders separately we have  $4.626 \times 40 = 185$  horse-power.  $185 + 185 = 370$ , total horse-power for the engine. By the second method we have  $18.5 \times 20 = 370$  horse-power.

E. W. FURBUSH.

Assume that the entire work to be done and the expansions all take place in the low-pressure cylinder.

Then  $1 + \text{hyp. log.}$  of the total number of the expansions multiplied by the terminal pressure due to the expansions; this product multiplied by the area of the low-pressure cylinder

piston and by the piston speed in feet per minute; this product divided by 33,000 will give the approximate horse-power of the engine.

Formula:

HP = horse-power of compound engine.

H = 1 hyp. log. of total number of expansions.

T = terminal pressure low-pressure cylinder.

E = average m.e.p. due to number of expansions.

S = piston speed in feet per minute.

A = area of piston.

E = T H.

$$\text{Then HP} = \frac{A S E}{33,000}$$

C. C. GARTLAND.

Assume ratio of expansion in high-pressure cylinder. Multiply by ratio of piston areas to get total expansion in both cylinders. Then assume that total expansion occurs in low-pressure cylinder and figure horse-power as for a simple engine.

D. W. ROPER.

A compound engine may be considered as two simple engines, and if we find the power developed in each cylinder or simple engine and then take the sum of these two, we get the total output of the compound engine. This may be calculated as follows:

For each cylinder.

Let D = diameter of cylinder in inches.

Let A = area of cylinder in square inches.

Then  $A = \frac{1}{4} \pi D^2$  (1).

Let L = length of stroke of piston in feet.

Let N = number of strokes per minute of piston, or r.p.m.  $\times 2$ .

Let P = mean effective pressure of steam in pounds per square inch, which must of course be accurately obtained from indicator card.

Then the horse-power developed in that cylinder will be

$$\text{HP} = \frac{P L A N}{33,000} (2),$$

which is very easily remembered by the familiar sequence of the letters.

Remembering that  $A = \frac{\pi D^2}{4}$ , and substituting in (2), we get

$$\text{HP} = \frac{P L A N}{33,000} = \frac{P L N}{33,000} \times \frac{\pi D^2}{4} = \frac{P L N D \times .7854}{33,000} =$$

$$P L N D \times .000238 \text{ (exact).}$$

Having obtained the HP for each cylinder, add the two, and we have the total horse-power of the engine.

As the dimensions of the engine are constant and the speed in most cases nearly so, we may easily obtain for any engine what is known as the engine constant, or

$K = L N D \times .0000238$ , which being known has only to be multiplied by the m.e.p. to give the horse-power at any given pressure.

Or  $HP = KP$ .

M. C. T.

Having given the cylinder dimensions and speed of a compound engine, it is also necessary to know the initial steam pressure for which the engine parts are designed in order to determine the horse-power of the engine. In the case of the high-class condensing engine operating with a vacuum of 26 inches, the economical load will be that resulting in a terminal pressure of about eight pounds absolute in the low-pressure cylinder, and this divided into the initial pressure absolute gives the number of expansions ( $r$ ) of the steam, neglecting clearance, etc. Knowing this, the mean effective pressure reduced to the low-pressure cylinder can readily be obtained from the well-formula

$$P_{em} = \frac{P_i (1 + \log_e r)}{r} P_b$$

in which  $P_{em}$  stands for mean effective pressure,  $P_i$  stands for initial pressure absolute,  $\log_e r$  stands for the hyperbolic log. of the expansions and  $P_b$  represents the back pressure. The value of  $P_{em}$  obtained from this must be multiplied by an amount less than unity to correct for wire-drawing, clearance, etc., termed the diagram factor and equal to about 84 to 88 per cent. The resulting  $P_{em}$  being substituted for  $P$  in the formula

$$HP = \frac{P \times L \times A \times N}{33,000}$$

will give the horse-power of the engine,  $A$  being the area of the low-pressure cylinder.

S. S. SMITH.

Assuming a certain m.e.p. for low-pressure cylinder, figuring it the same as a single engine. Manufacturers and engineers differ on their bases of calculation of horse-power of compound engines.

G. WILBUR HUBLEY.

It is necessary to assume a mean effective pressure for both the high and low-pressure cylinders either from the boiler pressure and exhaust from high pressure into the low-pressure cylinder, or making a theoretical estimate based on the proposed pressure and estimated pressure of exhaust from high-pressure cylinder. Then follow the fixed formula for estimating the horse-power of engines for each cylinder, and add the results together:

$$\frac{A \times S \times P}{33,000}$$

A = mean area of piston in inches.

S = mean speed of piston in feet per minute.

P = mean effective pressure in pounds on each square inch of piston.

33,000 = conventional number of foot-pounds in one horse-power.

E. W. LLOYD.

Let P represent the m.e.p. in pounds per square inch.

" A " " area of piston in square inches.

" L " " length of the stroke in feet.

" N " " number of strokes per minute.

Then the work done per minute = P L A N foot-pounds.

One HP = 33,000 foot-pounds per minute.

the indicated horse-power of a compound engine is found from the formula

$$\text{I. HP in H. P. cylinder} = \frac{P L A N}{33,000};$$

$$\text{I. HP in L. P. cylinder} = \frac{P L A N}{33,000}.$$

W. J. C., N. Y., ED. CO.

*No. 7.—What is the maintenance cost, including oil, attendance and repairs, of modern Corliss engines, 500-hp to 600-hp, single or compound, when run at 100 r.p.m., as compared with similar engines run at 120 to 130 r.p.m.; both with steady and with variable load?*

The attendance would be the same in both cases, but the oil and maintenance charges would be higher in the case of the high-speed engine.

D. KENNEDY.

The Corliss valve gear does not give satisfactory service at speeds much above 100 r.p.m., and few makers recommend its use at such speeds as 120 to 130.

EDITOR.

We have not been able to find any appreciable difference in the maintenance cost between Corliss engines running at 100 r.p.m. and others running at 120 to 130 r.p.m.

E. H. MATHER.

The cost of maintenance would be no more for 120 r.p.m. if engine is properly proportioned.

G. R. W., MALDEN ELECTRIC CO.

*No. 8.—Does the use of superheated steam require a different ratio of high and low-pressure cylinders than for saturated steam?*

The use of superheated steam does not require a different ratio of cylinders than saturated steam, but I see no reason why they should not have a higher ratio with good economical results.

C. L. DAVIDSON.

In European practice with superheated steam the ratio of the high and low-pressure cylinders is considerably higher than when saturated steam is used.

FRANZ KÖSTER.

It does not.

D. KENNEDY.

Some authorities claim that superheated steam has an efficiency of from 10 to 15 per cent greater than saturated steam, and while theoretically the cylinder required would be smaller with superheated steam, in practice no difference is usually made.

The principal economy in the use of superheated steam is in the saving in fuel. Below will be found the results of test made in 1877 by chief engineers Loring, Baker and Farmer, of the United States Government, on the small Corliss engine of the Institute of Technology.

The boiler pressure throughout the tests was kept uniform. Three different rates of expansion were taken, and one test with each was run with saturated and one with superheated steam, the degree of superheat being adjusted to the rate of

expansion. The total steam used was condensed and weighed, and the loss by cylinder condensation thus accurately determined.

TESTS OF CORLISS ENGINES, 8-INCH BY 24-INCH—MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Pounds Boiler Pressure	Rate of Expansion	Superheat	POUNDS STEAM PER HP PER HOUR		Loss by Moisture when using Saturated Steam
			First Test Superheated	Second Test Saturated	
50.4	4.05	279° F.	10.39	27.66	42.6 per cent
50.1	2.16	194° F.	21.75	29.14	33.9 "
50.2	1.44	129° F.	26.48	33.54	26.6 "

WILLIAM R. GARDENER.

*No. 9.—Are steam-actuated dashpots entirely reliable and satisfactory in connection with Corliss valve gear when operated at speeds as high as 150 r.p.m.? What advantage, if any, do they have over the usual vacuum type?*

We have had two 500-hp Corliss engines running for the past year at a speed of 164 r.p.m., using steam dashpots. They have proven very reliable and satisfactory. Their advantage over the usual air dashpot is that they are working at boiler pressure and are consequently instantaneous in operation.

WILLIAM R. GARDENER.

Steam-actuated dashpots have not proven reliable or satisfactory at an engine speed of 150 r.p.m. for Corliss valve gear, as the increased inertia and wear in the multiplicity of moving parts at this speed is excessive. This does not apply to a Corliss gear with direct positive connection between wrist-plate and valve-stem rock arm.

S. S. SMITH.

Five-years' service has shown that steam dashpots are entirely reliable on Corliss valve gear, running 150 r.p.m. The advantage is in the positive closing of valves and faster closing than with a vacuum dashpot.

G. R. W., MALDEN ELECTRIC CO.

*No. 10.—With a variable power load, what is the highest speed at which poppet valves, with detaching valve gear, can be operated with reliable and smooth action and without pounding or injury to valves or seats?*

I have run them at 100 r.p.m., and should say that was high enough practically for a 2000-hp engine.

W. BLOXHAM.

*No. 11.—What are the relative economies and maintenance costs of the Corliss and poppet-valve systems?*

*No. 12.—How do modern four-valve high and moderate-speed engines compare in economy, maintenance and depreciation with standard Corliss engines?*

Largely in favor of the Corliss engine.

D. KENNEDY.

From tests on our Corliss medium-speed engines of 750 horse-power at 150 r.p.m., after about a year of service, an economy of 13.2 pounds with 150 pounds initial and 26-inch vacuum places this type in the same class as the best slow-speed Corliss. With others of the same capacity and under the same conditions in another plant the station records showed 300 watts per pound of buckwheat anthracite coal being developed month in and month out with a mixed incandescent, arc and railway service, and this some years after installation. An examination of the repairs on these engines, which have now been in service some seven or eight years, shows an exceedingly small percentage on the first cost, while the engines themselves show very little wear, requiring only occasional taking up in the working parts, even in the case of some engines running at much higher speeds than stated above. These results in economy and operation show how well this type of engine maintains its high efficiency after years of service.

S. S. SMITH.

*No. 13.—What results have been obtained by the use of metallic packing for Corliss valve stems? What metal and*

*method of construction has proved most satisfactory for this service?*

The Ideal metallic packing has proved very satisfactory.

D. KENNEDY.

Very good results.

W. BLOXHAM.

Various types of metallic packing have been used for Corliss valve stems, but with the exception of packing made by Cooke, of Louisville, none of them have given satisfaction. In Cooke's packing, babbitt is the metal that comes in contact with the stem. The method of construction can be learned from the manufacturer.

J. D. A., N. Y. ED. CO.

Good results are obtainable from the use of metallic packing on Corliss valves. The composition of the metal is not given out by the manufacturers, but the construction varies with each make of packing. There are at least two or three on the market that are considered exceptionally good.

C. L. DAVIDSON.

Metallic Corliss valve-stem packing has been found by us to be cheaper than fibre packing, for we have had metallic packing in service for seven months' wear, while a good quality of fibre packing formerly used lasted only two weeks. Metallic packing costs a dollar per pound; fibre packing costs 36 cents. The metallic used is manufactured by the American Metallic Packing Company, Cleveland, Ohio.

THE B. F. GOODRICH CO.

*No. 14.—Which is preferable for a small electric-light plant—say 250 horse-power—a direct-connected, high-speed unit, or a slow-speed Corliss engine belted to the generator? Coal \$2.25 per ton.*

A slow-speed, simple Corliss engine belted to generator. Engine built to withstand 20 per cent overload for three hours at a time.

W. H. BANES.

A Corliss slow-speed engine, belted to the generator, would be the more economical.  
D. KENNEDY.

I should say a direct-connected, high-speed unit. The first cost is less, and a compound high-speed engine will not use at full load and 125 pounds pressure over 23.5 pounds of steam per hp-hour. When using a Corliss engine and belted generator, more room is necessary, the noise is greater, and I doubt if, after belt-slip is taken into consideration, the simple Corliss is any more economical in operation than the high-speed compound engine direct-connected to generator. A high-speed, inclosed, self-oiling engine uses an exceedingly small amount of engine oil, the valve oil being about the same in proportion to size as with other slow-speed engines, and if well looked after during periods of rest is practically as automatic during operation as an electric motor.  
A. PETERS.

I should prefer the Corliss. W. BLOXHAM.

The slow-speed Corliss engine is preferable from an economical standpoint.  
J. D. A., N. Y. ED. CO.

We prefer two engines to one of 250 horse-power, as this allows the engineer to take advantage of the load to get the best results from the engines.  
S. S. INGMAN.

Under conditions usually found in plants of this size, a low-speed belted Corliss unit is preferable.  
S. D. S., N. Y. ED. CO.

The slow-speed unit will probably cost more, but should last longer and be more economical in coal and wear and tear on boilers.  
AUGUSTA RY. AND ELEC. CO.

We should consider a direct-connected unit of about 225 r.p.m. more desirable for a 250-hp plant, as the first cost would be less, the building smaller and the operating expenses probably less than with the Corliss equipment.

E. H. MATHER.

Assume, of course, simple engines, an evaporation of nine pounds, and that the average load is about one-half the rated load for 10 hours per day. The difference in economy per electrical horse-power per hour delivered at the switchboard, on account of the higher mechanical efficiency of the direct-connected single-valve set, would be about only two pounds in favor of the slow-speed Corliss engine belted to the generator of about 250-hp capacity. This would represent a difference in the course of the year of about 50 tons of coal, costing \$113, and to this should be added in favor of the Corliss engine the slightly smaller boiler required, though this advantage would be small. On the other hand, there is a saving in first cost of the high-speed unit, in belting, foundations, floor space and building, to which must be added the less cost of upkeep of the high-speed unit, the elimination of the noise due to the belt, and the danger ever present in a belted unit, leaving no doubt as to the more desirable one.

S. S. SMITH.

Slow-speed Corliss engine.

G. R. W., MALDEN ELECTRIC CO.

From tests taken on direct-connected, high-speed engines of good design, the results indicate a very high steam consumption per kw-hour at the switchboard. Where the electric plant runs 24 hours with an average load of 35 per cent of the maximum, a Corliss engine shows much better efficiency.

E. M. LLOYD.

Slow-speed Corliss engine, belted, will be more economical.

G. WILBUR HUBLEY.

*No. 15.—What experience have you had in operating gas engines?*

*No. 16.—What is the percentage of repairs on gas engines to the total cost per kw-hour?*

*No. 17.—Are you manufacturing gas from producers, and if so what are the results obtained in comparison with its use over manufactured or natural gas?*

The several gases mentioned have approximately the following heating values: Natural gas, 1000 B. T. Us. per cubic

foot; manufactured coal gas, 625 B. T. Us. per cubic foot; producer gas, 125 B. T. Us. per cubic foot. With a gas engine requiring 12,500 B. T. Us. per brake-hp-hour, the following quantities of gas would be required per hp-hour: With natural gas, 12.5 cubic feet; with manufactured gas, 20 cubic feet; with producer gas, 80 cubic feet, from which the cost per horse-power for the first two kinds can be easily determined when the cost per thousand feet for gas is known. The manufacturers of producer-gas apparatus claim to be able to furnish one brake-horse-power per pound of coal used in the producer. Probably a safer estimate for plants of medium to large size would be 1.5 pounds of coal per horse-power. With this information one can easily determine the cost per hp-hour when the cost of coal is known. To the cost of producer-gas power, as shown above, there should be added the cost of operating labor and maintenance of plant, which, however, would be comparatively small items.

S. J. GLASS.

*No. 18.—Is not the inertia governor better adapted for steam turbines than the purely centrifugal governor?*

*No. 19.—Do you know of any difficulty having been experienced in controlling steam turbines, due to racing when adjusting their speed preparatory to synchronizing, or racing when the load is suddenly increased or released?*

*No. 20.—What is the average coal consumption per hp-hour on slide-valve, high-speed automatic and Corliss engines?*

Slide-valve engine, about 45 pounds of steam; high-speed automatic engine from 30 to 35, and simple Corliss engines 27 pounds.

D. KENNEDY.

The average coal consumption per hp-hour for a tandem compound condensing engine of about 150 horse-power is five pounds of Ohio coal per hp-hour.

W. F. KINGAN.

Assuming the case of two 300-hp engines, one being a slow-speed Corliss and the other the higher-speed automatic Corliss, we find that there is practically no difference in the

average coal consumption per hp-hour, as each of them would show an economy, condensing with 150 pounds steam pressure, of about 14.5 pounds.

S. S. SMITH.

*No. 21.—What is the average coal consumption per kw-hour at the wattmeter on the switchboard when the installation consists of a tubular boiler and high-speed, direct-connected engine and dynamo, steam pressure 100 pounds, non-condensing?*

Seven and one-half pounds of coal.

G. R. W., MALDEN ELECTRIC CO.

This will vary according to local conditions. Average commercial practice would probably show between eight and ten pounds per kw-hour.

G. WILBUR HUBLEY.

Runs all the way from 12 to 20 pounds.

D. KENNEDY.

The consumption of good coal per kw-hour at the switchboard in small plants using tubular boilers and high-speed, non-condensing engine direct-connected to dynamo, has been in plants that have come under our observation, from nine to twelve pounds.

E. H. MATHER.

With the units so divided up as to obtain practically full load for each, we are obtaining one kilowatt at the switchboard for 3.75 to four pounds coal with a non-condensing, single-valve, tandem compound engine, operating under about 100 pounds pressure.

S. S. SMITH.

*No. 22.—What is the average gas consumption per hp-hour of the average gas engine at one-quarter, one-half, three-quarters and full load?*

*No. 23.—What practical difficulties attend the use of steam turbines in power-plant operation?*

None.

THE B. F. GOODRICH CO.

*No. 24.—In what percentage does the degree of vacuum and superheating affect the economy of turbines?*

*No. 25.—How do mechanical-feed cylinder lubricators compare with those of the ordinary hydrostatic type in first cost, economy, ease of regulation, and efficiency?*

First cost greater, greater economy and better regulation.  
D. KENNEDY.

Superior in all respects, especially as to reliability.  
G. WILBUR HUBLEY.

*No. 26.—How should mechanical-feed lubricators be driven, and how should they be piped so as to avoid localization of feed on certain parts of the valve chest or cylinder?*

Connected and driven from cross-head or valve rods or any part of engine giving a reciprocating motion. It starts and stops with the engine. Should be piped to enter between throttle valve and cylinder and the pipe extended within the steam pipe to about the centre of steam pipe, in order to cause the spraying effect, giving uniform distribution of the oil and avoiding its localization.  
G. WILBUR HUBLEY.

*No. 27.—Why is a Corliss engine more economical than a high-speed engine, all conditions being equal?*

We will not allow that the slow-speed Corliss engine is more economical than the higher-speed Corliss valve engine, such as we build, all conditions being equal. We are obtaining just as good economy from them as is obtained from the slow-speed, with the added advantages of less cost of foundation, less floor space, and so forth.  
S. S. SMITH.

## H

### PIPING

*No. 1.—What is the formula for loss by radiation in uncovered steam pipes?*

In order to appreciate the value of a good pipe covering, we must understand something about the amount of steam that will

be condensed in an unprotected pipe. Careful experiments have given somewhat different results. Taking the average of four that are reported by the same number of very good authorities, we find that one four hundred and twentieth part of a pound of steam was condensed for each square foot of surface per hour for each degree difference of temperature, hence this rule:

Multiply the number of square feet exposed to air by the difference between the temperature of the air and steam, and divide the product by 420, the quotient being the number of pounds condensed.

D. KENNEDY.

Approximate formulæ are found in a number of the engineering handbooks.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Loss in steam flowing in pipes is due to both radiation and to friction, and a formula that gives the loss due to radiation in heat units is

$$H = .262 r \times l \times d.$$

Where  $l$  = length of pipe in feet,

"  $d$  = diameter of pipe in inches,

"  $r$  = the coefficient of radiation and depends on the absolute pressure. The following values may be used for " $r$ ," for uncovered pipes:

Pressure/	" $r$ "
40	437
65	555
90	620
115	684

M. C. T.

*No. 2.—What is the formula for finding the dimensions of steam piping to engines?*

The area of steam pipe to an engine is directly proportional to (1) the area of the cylinder, and (2) to the frequency with which it is filled (it being assumed in these calculations that the cylinder is filled with steam at each stroke), and inversely proportional to the mean velocity of the steam, which is generally taken to be not over 6000 feet per minute for live steam and 4000 feet per minute for exhaust steam. So

$$\text{Area of pipe} = \frac{\text{area of cylinder} \times \text{piston speed}}{\text{mean velocity of steam}}$$

$$\text{Area of cylinder} = \frac{\pi D^2}{4}$$

Let  $V$  = area of pipe.

*No. 3.—In which direction should a steam-piping system slope; toward the boiler, or from it?*

Boiler piping should slope toward the engine.

D. KENNEDY.

Toward the separator, if there is one, or set level if there is no separator.

W. BLOXHAM.

The pipe should slope toward the engine, as what condensation there is will flow along with the steam and the pipe will be free from water. The steam should be shut off when the pipe is not in use, or a drip should be provided at the lower end, connected to trap, to keep the line free from water.

E. W. FURBUSH.

From the boiler, under ordinary conditions. While steam is being used entrained water can be separated from it quicker if pipe slopes from the boiler. When boiler steam valve is shut and a drip is opened at engine or at lowest point in pipe line, there can be no dangerous accumulation of water.

J. A. MALONEY.

Toward the engine, in order to drain in that direction and not against the current of steam.

W. H. BANES.

A steam-pipe system should slope in the direction of the flow of steam.

J. D. A., N. Y. ED. CO.

Between the boiler and stop-valve the pipe should slope toward the boiler; after passing the stop-valve, pipe should slope away from the boiler.

THE B. F. GOODRICH CO.

The piping system should slope in the direction in which the steam is traveling. In European central heating plants—for instance, in Dresden and Berlin, where the pipe lines are one mile in length—the pipe is stepped in long sections and drained at each low point.

FRANZ KÖSTER.

Slope away from the boilers, and thereby keep steam and condensation flowing in same direction.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

From the boiler. Put a tee on the main line of pipe near the engine, with the outlet looking up, and pipe from this tee to the engine. Tap a hole in the under side of the tee and pipe the condensation to a trap.

P. E. COWLES.

Provision should be made for draining the water of condensation from the pipes at the lowest point practicable. This water will travel with the steam, no matter which way the pipes slope. From the boiler to the header we advocate sloping toward the boiler, so that while the boiler is under pressure but not in service the water condensing in the pipes will drain back into the boiler.

S. S. INGMAN.

A steam-piping system should slope away from the boilers.

S. B. RICHEY.

Steam piping should preferably slope from the boiler.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In low-pressure steam piping (steam heating, etc.), the slope is usually toward the boiler. In all higher-pressure work, however, the slope should be away from the boiler, and ample provision made in the way of separators and drains for getting rid of the condensation, which may be returned to the boiler by other means if required. If the slope is toward the boiler, the steam and water are flowing normally in opposite directions, with a constant tendency on the part of the steam to retard the water and accumulate it in the pipe. A sudden rush of steam might pick it up and carry it over with a rush, even through a separator. But, if the slope is the other way, there is not likely to be any accumulation, as the pipe is kept naturally drained by both the slope of the pipe and the steam, working together instead of in opposition.

F. M. FARMER.

*No. 4.—What disc material and form of seat give the greatest durability in globe valves for regulating the feed supply of boilers?*

We do not believe that any material and form of seat have yet been made that will give satisfaction when the valves are opened with a screw, allowing the water under pressure to be forced between the seat and the valve for the purpose named. Excellent results can be obtained by using a good angle valve for a master valve on a feed-water pipe with a leader gate for regulating the flow of water to the boiler to supply the same while in operation. As this valve will not hold tightly, but will serve for regulating the flow of water to the boiler, it can be used for this purpose. The angle valve should be closed at such a time as is necessary to shut off the feed water entirely from the water, but it should be used at no other time.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Use gate valves. W. BLOXHAM.

Have had the best success with gate valves with metallic seats; preferably a make in which the discs are renewable.  
E. W. FURBUSH.

Hard brass, crown pattern.  
W. T. D., N. Y. ED. CO.

Bronze seats and discs.  
THE B. F. GOODRICH CO.

Brass seats and discs. JOHN A. WILSON.

Asbestos or a babbitt-filled disc.  
G. R. W., MALDEN ELECTRIC CO.

*No. 5.—What are the relative installation costs and operating expenses of the Holly system of handling drips, as compared with the automatic tank and pump system?*

The Holly system is somewhat more expensive to install for first cost, but, including operating expenses, it would be the cheapest system at the end of a period of three or four years.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

There is little or no loss in the Holly system when the bleeder can be discharged into an open heater.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 6.—In covering steam lines carrying superheated steam, with plastic or sectional coverings arranged in layers, is it the best practice to provide an air space between the pipe and the first layer and between successive layers of covering?*

I think one air space next to pipe sufficient.

W. BLOXHAM.

In covering steam lines with non-conducting material it is not good practice to use an air space, because it is practically impossible to make this air space tight, and, unless it is so, it acts as a flue to circulate air and carry away heat.

J. D. A., N. Y. ED. CO.

It is much better to have an air space next to the pipe, and also between layers, as by this method it has been found that condensation is not as great.

W. J. C., N. Y. ED. CO.

Air is not a first-class heat insulator, and the covering will stand up much better if it is firmly put on so that it can not work loose on account of vibration.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Pipe covering on superheated steam lines is subject to more or less jar, vibration and rough usage, the same as on any other steam line. Coverings, whether plastic or sectional, must therefore, under these circumstances, be built to withstand same. If air space or spaces be provided, the stability of the covering is at once impaired, it being easily cracked or broken, consequently it soon jars loose. The application of the covering direct, without any air spaces, makes it substantial and cheaper in first cost, and it is just as efficient if the best quality of covering is used.

E. E. LEE.

*No. 7.—What is the best type of atmospheric exhaust valve for use in condensing plants?*

A Lunkenheimer regrinding seat metal valve.

D. KENNEDY.

The best type of atmospheric exhaust valve for use in condensing plants is a plain, weight-loaded globe valve, similar to those built by Edward P. Allis Company for the Ninety-sixth street engines of the Metropolitan Street Railroad, New York city.

J. D. A., N. Y. ED. CO.

Vertical atmospheric exhaust valves that have a water seal.

THE B. F. GOODRICH CO.

The Worthington spring type.

AUGUSTA RY. AND ELEC. CO.

The best type of atmospheric exhaust valve for use in condensing plants is a single-seated, piston-balanced, water-sealed valve, provided with dashpot to prevent chattering.

E. E. LEE.

For an atmospheric exhaust valve in connection with a condensing plant, one of the first desiderata is that it be absolutely tight. These valves are generally large, and if they have metal seat and discs it is difficult to maintain absolute tightness.

In connection with steam-turbine installations, a very satisfactory valve consists of a metal seat, the valve disc having a groove into which is inserted a soft-rubber ring. The valve is bare of mechanism beyond a lever to open the valve wide when desired. Such a simple valve as this would probably knock itself to pieces if used in connection with reciprocating engines, because of the intermittence of the exhaust, but with turbines they have been found to be entirely satisfactory. The absence of internal lubrication permits india rubber to be used, which would otherwise be decomposed by the oil in the exhaust steam.

FRANCIS HODGKINSON.

*No. 8.—Is there any type of steam trap that can be depended upon for high-pressure steam lines?*

The steam trap of the bowl type for moderately high pressure, with the seat high above the bottom of the trap, away from dirt and scale, will give good results if the seat and point are made of good phosphor bronze and a feed-pipe drip that is tapped from the engine supply below the lubricator is carried into the feed pipe of the trap in order that the small amount of cylinder oil may go through it and lubricate the point and seat slightly. We have had traps working under these conditions for several years without repairs, and they are still tight. Have tried it also on traps of more recent installation with similar success with steam pressure of 125 pounds.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

I find no trouble with the Nason if it is kept clean.  
W. BLOXHAM.

The Dinkle trap is being used successfully on steam pressure of 200 pounds.  
W. T. D., N. Y. ED. CO.

Wright emergency steam traps have given very good satisfaction on 150 pounds pressure.

THE B. F. GOODRICH CO.

The Nelson.

AUGUSTA RY. AND ELEC. CO.

We have found the Bundy high-pressure steam traps very reliable on steam lines operating at 120 to 140 pounds.

PENINSULAR ELEC. LT. CO.

As reliable as any steam trap on the market for high-pressure steam lines, is a type that is provided with three separate valves, one taking care of the condensation under normal conditions, the other two acting as reserves. The combined outlet area of the three valves is equal to the area of the inlet pipe; it is therefore good for any emergency.

E. E. LEE.

*No. 9.—What is the most economical and reliable method of handling drips and condensation from various classes of steam piping?*

I should say, the Holly system. W. BLOXHAM.

Carry the condensation from the mains to steam traps discharging into a tank and return water to the boiler by pumps.

W. T. D., N. Y. ED. CO.

Any first-class reliable trap returning drips and condensation to feed-water heater.

THE B. F. GOODRICH CO.

• Holly system for high-pressure steam and good traps for heating systems and other low pressures.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

With high pressure, use a sufficiently high degree of superheat and thus avoid all drip except at the engine.

FRANZ KÖSTER.

Holly system for high-pressure drips.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Holly system.

AUGUSTA RY. AND ELEC. CO.

Holly system for high-pressure bleeders, and traps on low-pressure in connection with a tank and pump system.

G. WILBUR HUBLEY.

*No. 10.—What causes the "water-hammer" in steam-heating pipes, and what will stop it?*

Water-hammer is caused in steam-heating pipes by not having the pipes so graded that the water will run ahead of the steam. If the pipes are level or drain toward the steam supply, water-hammer must be expected.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Water-hammering in steam-heating pipes is caused by the pressure of water and steam in a partial vacuum. It can be stopped by properly draining the system.

J. D. A., N. Y. ED. CO.

Either poor drainage or water-pocket in the pipes. Can be stopped by relieving the above-named conditions.

THE B. F. GOODRICH CO.

Water in the pipe. Proper drainage will eliminate this.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Water-hammer is caused by condensation being picked up by a rush of steam and hurled against an abrupt turn or closed end of pipe. The remedy is proper drainage.

S. B. RICHEY.

This is caused by the condensation of the saturated steam, and by using superheated steam it will be avoided.

FRANZ KÖSTER.

By being airbound. Placing an air valve will stop it.

D. KENNEDY.

The sudden admission of steam to a pipe containing water, or into a cold-water pipe. Steam-pockets are formed between the plugs of water, and the condensation of steam leaving a vacuum causes what is known as "water-hammer." There are, however, other causes that might result in water-hammer. The slow and gradual admission of steam, allowing piping to heat up gradually, will prevent water-hammer from the cause noted. It is important that steam pipe be always properly and thoroughly drained.

G. WILBUR HUBLEY.

The condensed water becomes pocketed in the pipe, and the incoming steam striking it, becomes condensed, thereby forming a vacuum. The water rushes ahead to fill up this vacuum, and the velocity thus acquired is dissipated by the water striking against the fittings where the pipe changes its course. Steam in the pipe offers very little resistance to the movement of this

water. All pipes should be pitched away from the boiler and the condensed water dripped back to the boiler or hot well.

R. H. THURSTON.

When steam is delivered into one end of an inclined pipe filled with water it may work in either of two ways; if the pressure is high and is let in suddenly it may drive the column of water against the end of the pipe, or owing to difference of gravity the steam may rise to the top of the pipe in the form of a bubble. When the steam condenses, the bubble will break and into the vacuum thus formed the water underneath will rush with a bang directly against the side of the pipe. The steam continuing to come in, the water recedes farther and the bubbles get larger and move farther up the pipe and, condensation still going on, the blows gain in rapidity and strength, owing to the steam passing a larger amount of water.

Now, if there were no water in the pipe there could be no water-hammer, hence the remedy is plain. The pipes should be installed in such a way as to drain themselves, or have drip-cocks so located as to do the work.

The writer was greatly annoyed by excessive water-hammer in a new heating installation in his home, but raising one end of several radiators and providing suitable drips soon remedied the trouble.

WILLIAM R. GARDENFR.

*No. 11.—Should a globe valve be so placed as to close against the pressure or with it?*

A valve should be so placed as to close against pressure, as it can be packed, and in case of breakage of valve stem it can be opened, without any trouble.

W. H. BANES.

A globe valve should close against the pressure, not only for convenience in placing but so that the thread on the valve stem will not be stripped or the valve disc shell be pulled from the stem.

E. W. FURBUSH.

A globe valve should close against the pressure, so that the valve stem may be packed when the valve is closed.

DAVID W. BEAMAN.

If used as a regulating valve in line of feed pipe to boilers, always place a globe valve so that it closes against the feed pumps or other source of supply. Under any other conditions it should be placed so that the stem may be packed when pressure is off top of valve.  
J. A. MALONEY.

The method of placing a globe valve is to a great extent dependent on the service for which it is intended. If it is placed so that it closes against the pressure, the stem can be packed when the valve is closed.  
J. D. A., N. Y. ED. CO.

Against the pressure, as this prevents foreign matter from being forced into the seat under the disc.  
AUGUSTA RY. AND ELEC. CO.

A globe valve should be so placed as to close against the pressure.  
S. B. RICHEY.

A globe valve should be placed to close against the pressure.  
FRED B. HUBBELL.

Both ways have their good and bad points. Practically it does not seem to make much difference.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

A globe valve should be placed so as to close against the pressure. This aids ease of opening and also ease of packing.  
S. J. LISBERGER.

Globe valves should be placed so as to close against the pressure.  
THE B. F. GOODRICH CO.

*No. 12.—Should a globe valve be placed with its stem in a vertical or in a horizontal position?*

We do not believe that it makes any difference with a well-constructed valve whether it is placed in a vertical or a horizontal position.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

In a steam line the stem of a globe valve should always be placed horizontally, to avoid trapping water in pipes. In general, it is best to place them horizontally, if possible, for the same reason.  
J. A. MALONEY.

If the valve body is drained properly the position of the stem is immaterial.  
J. D. A., N. Y. ED. CO.

Globe valves should be placed with stem in a horizontal position.  
THE B. F. GOODRICH CO.

It does not make any difference with a good valve in good condition.  
AUGUSTA RY. AND ELEC. CO.

Vertical.  
F. ELLWOOD SMITH.

It is impossible to give a rule that would fit all cases.  
S. B. RICHEY.

In a horizontal position.  
FRED B. HUBBELL.

No special choice.  
THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 13.—Is brass a suitable material for blow-off pipes for boilers?*

Yes.  
W. BLOXHAM.

Brass is a very good material for blow-off pipes for boilers.  
J. D. A., N. Y. ED. CO.

Brass pipe is suitable for blow-off pipe only when protected from the fire.  
JOHN A. WILSON.

Brass blow-off piping has been used in one plant carrying 160 pounds boiler pressure for 12 years with little or no trouble of any kind.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No; not reliable.  
G. WILBUR HUBLEY.

*No. 14.—What cement would make a suitable screw pipe joint for a steam pipe where there is an excess of alkali (carbonate of soda) in the water; one that would resist the action of water carried in the steam in eating out the threads?*

*No. 15.—What has been the experience with ground joints on high-pressure steam piping, after, say, at least two years of service?*

After two years of service the pressure of the steam pipes would be forgotten.

FRANZ KOSTER.

## I

### HEATERS AND HEATING SYSTEMS

*No. 1.—What are the advantages, if any, of an open over a closed heater?*

An open heater will heat water hotter, and has a tendency to put water into the boiler more free from scale-forming substances, provided heater is regularly cleaned. It is not so good as a closed heater as to oil, as more or less oil will find its way to the boiler.

D. KENNEDY.

With an open heater there is practically no back pressure. A proportion of the exhaust is returned to the boilers. Those minerals that become insoluble at 210 degrees are deposited on the plates or trays of heater, and are easily removed; in other words, an open heater acts as a purifier.

A. PETERS.

The advantages in favor of open heaters are: (1) The feed-water temperature is raised higher than in a closed heater. (2) Purification of water is better. (3) The back pressure on the engine is practically nothing, while with closed heaters it is often considerable.

S. J. LISBERGER.

An open heater is a better feed-water purifier than a closed heater and, besides being more readily closed, returns the condensed exhaust steam to the boilers.

S. B. RICHEY.

The open heater is a little more efficient because it mixes the exhaust steam with the feed water, thus utilizing the heat in the exhaust after it has been condensed, and it does not fall off in efficiency, due to the heat-transmitting surface being coated with grease or scale. It has no pressure parts, but has the disadvantage of requiring some method of eliminating the oil in the exhaust.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

A higher feed-water temperature and the saving of the heating steam.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The open heater has the advantage over the closed heater in that it is less expensive in first cost, will raise feed water to higher temperature with same amount of steam, is easier to clean, eliminates the greater part of the oil, and removes the greater part of the scale-forming matter from the feed water.

THE B. F. GOODRICH CO.

When an open feed-water heater is used there is no danger of increasing the back pressure on the auxiliaries or of flooding the auxiliaries by water backing up through the exhaust.

C. S. JOHNSON.

Feed-water heaters of the open type are preferable for water that will precipitate solid matter at temperatures near the boiling point. Well-constructed heaters of this type intercept large quantities of scale-making matter, which is an especial advantage with certain waters. The exhaust, mingling with the feed water, partially condenses, and part of the oil used for cylinder lubrication mixes with the boiler-feed water. The mixing of the oil carried over with exhaust steam, and the further disadvantage of pumping hot water, do not obtain with closed heaters; but as both of these so-called difficulties are readily overcome, open heaters are really very much in vogue, for the reasons given.

C. C. GARTLAND.

*No. 2.—What are the comparative advantages and disadvantages of steam and hot-water systems, as operated by central stations?*

A complete answer to this would involve a treatise of not less than 50,000 words. Briefly summarized, however, hot water may be considered to have the following advantages over steam as a method of distributing heat from a central station:

By the use of exhaust steam in connection with a hot-water heating system, back pressure on the generating engine is entirely eliminated. Back pressure is necessarily objectionable, because it either increases the steam consumption per hp-hour of the engine or it decreases the amount of power that the engine can turn out, thus necessitating additional investment in engine capacity. With the hot-water system all of the exhaust steam is condensed at the power-house and the condensation saved and returned to the boilers clean and hot. With steam plants the problem of disposing of the condensation is a serious one and is usually solved by throwing the condensation into the sewer. This means that of the exhaust steam not only the water is lost, but the heat that is in the water. With a hot-water system there is from eight to thirteen per cent more exhaust steam available for heating purposes than with a steam system where the condensation is thrown away.

In heating practice, not only in individual plants, but in large groups of buildings, it has long been recognized that hot water makes an annual heat demand on the generating stations of but 50 or 60 per cent of that required by a steam system. This is due to the fact that the water may be circulated at any temperature desired to accomplish the desired heating; whereas with the steam-heating system the steam must be kept at a certain stated temperature throughout the entire season. Hot-water heating plants, then, can carry a great deal more business with a given amount of exhaust steam than can a steam-heating plant.

The life of hot-water pipes is practically indefinite, whereas the life of a steam pipe is limited because of the condensation that runs along the bottom of the pipe, it being well known that newly condensed steam is particularly active in dissolving iron. In the hot-water heating system the same water is used over and

over again, and is practically inert as far as any chemical action on the pipes is concerned. Hot-water heating is also a more satisfactory method to the customers of the company, and is, from the customer's standpoint, far more desirable than steam.

D. F. MCGEE.

*No. 3.—What relation does the heating of the feed water bear to the capacity of a boiler?*

By heating the feed water you may increase the boiler capacity with exactly the same amount of fuel burned per hour as when not heating it; for when the water is fed cold a great amount of heat is used up in heating the water to the boiling point, which heat could be used in evaporating more water and thereby increasing the capacity.

REGINALD CONSTABLE.

A feed-water heater increases capacity of a boiler, also saves the heat units required to bring water from original temperature to whatever temperature it has when it leaves the heater.

D. KENNEDY.

The heating of feed water increases the capacity of a boiler in the proportion of the heat units added to the water, to the heat units in the steam delivered by the boiler.

J. D. A., N. Y. ED. CO.

The heating of the feed water increases the capacity of the boiler. A boiler horse-power is the evaporation of 30 pounds of water per hour from 100 degrees Fahrenheit into steam at 70 pounds pressure, 1110.2 B. T. Us. being expended per pound of water in completing this change. If the feed water is supplied at a higher temperature than 100 degrees Fahrenheit, a less number of heat units are expended in converting water to steam; therefore, for the same amount of fuel, more boiler horse-power is developed.

SAMUEL KAHN.

The increased capacity of boiler due to heating of feed water depends upon the steam pressure at which boiler is working and range of temperature through which feed water is heated, but an

average value used in practice is one per cent increase for every 10 degrees rise in feed-water temperature.

S. O. SWENSON.

By increasing the feed-water temperature from 60 to 210 degrees the capacity of a boiler at 100 pounds pressure is increased 10 per cent.

THE B. F. GOODRICH CO.

*No. 4.—When should an economizer be used in preference to a feed-water heater, and when can an economizer be used to advantage with a feed heater?*

An economizer should be used when the engine runs condensing. Both economizer and heater can be used to advantage when running non-condensing and the temperature of the escaping gases is high.

REGINALD CONSTABLE.

Wherever you have exhaust steam from an engine, heater and feed pump should be used.

D. KENNEDY.

An economizer can be used with a feed heater when there are carbonate and sulphate of lime in the water. The temperature at which carbonate of lime becomes insoluble is about 212 degrees, and that at which the sulphate becomes insoluble is about 290 degrees. As a feed-water heater rarely raises the feed water above 210 degrees, an economizer is useful in getting rid of the above minerals.

A. PETERS.

I do not know of any case where an economizer can be used to advantage, or in preference to a feed-water heater, unless it be in a plant where there is absolutely no exhaust steam with which to heat feed water, in which case it may be cheaper to use an economizer than to feed cold water to the boiler.

J. D. A., N. Y. ED. CO.

An economizer should be used instead of a feed-water heater when the exhaust steam is to be used for heating or some such purpose, and can be used with the feed-water heater in a large plant where the exhaust steam is not used and where the cost

of the fuel saved will be great enough to warrant the expense of installing and operating an economizer.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

*No. 5.—What economy evolves from feed-heating, aside from increased boiler capacity?*

Aside from increased boiler capacity, reduced cost of maintenance of boilers results from the heating of feed water.

J. D. A., N. Y. ED. CO.

Feed-water heating means a saving in fuel of about one per cent in fuel for each increase of 11 degrees Fahrenheit in the feed-water temperature.

S. J. LISBERGER.

For every 11 degrees that the temperature of the feed water is raised, there is a saving of one per cent of fuel.

A. PETERS.

The gain from heating feed water where the exhaust is not used, the engines running non-condensing, will amount to about 14 per cent in fuel bills as well as in increased boiler capacity.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Not only is the boiler capacity increased by heating the feed water, but its life is prolonged, as the hotter the water fed to the boiler, the less liability there is to trouble from unequal expansion. Where cold water is fed to boilers it contracts the plates in the vicinity of the feed discharge outlet. Less coal will also be required. For instance, we will suppose that a pound of good coal contains on the average 14,000 heat units; that the boiler will use 10,000 of them, and that the feed water is 65 degrees Fahrenheit in one case and 212 degrees Fahrenheit in another; the boiler pressure in both cases being 100 pounds by gauge. The total heat in each pound of steam is 1217 B. T. Us., which means that each pound of water will require 1217 heat units, less the temperature of the water. to evaporate

it into steam at 100 pounds pressure. In the first case, with feed at 65 degrees Fahrenheit, the heat required will be  $1217 - 65 = 1152$  units of heat required to evaporate each pound of water. As we have 10,000 units available in each pound of coal, it will evaporate  $10,000 \div 1152 = 8.68$  pounds water per pound of coal.

In the second case we have  $1217 - 212 = 1005$  units of heat to be supplied to each pound of water, or  $10,000 \div 1005 = 9.95$  pounds water evaporated per pound of coal; or 14.6 per cent more water evaporated per pound of coal with the feed at 212 degrees than when it is at 65 degrees. A very close estimate is one pound saving for each 10 degrees the water is raised in temperature.

Supposing the coal bill to be \$10,000 with the feed at 65 degrees, it would be only \$8,540 with the feed at 212 degrees. This is, of course, assuming that the heat used in heating the feed water would be wasted, as in the case of the exhaust from a non-condensing engine or where a large amount of heat is escaping at a high temperature up the chimney; in which case an economizer might be of benefit.

E. W. FURBUSH.

Economy in heating feed water (aside from increase of boiler capacity) is utilization of waste heat energy; the life of boiler is increased and boiler repairs are diminished. Many of the impurities in the water are deposited in the feed-water heater, and the boiler does not have to be cleaned or blown down as often. If the steam plant is large, there will be a saving in coal and ash-handling and possibly coal-storage.

S. O. SWENSON.

Decrease of scale and of repairs on boilers.

THE B. F. GOODRICH CO.

Every increase of 11 degrees in temperature of feed water means one per cent less work for the boiler and one per cent saving in the coal pile when the heating is done from waste products.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

There is less danger of chilling parts of the boiler.  
AUGUSTA RY. AND ELEC. CO.

Feeding hot water into a boiler lessens the strains, due to unequal expansion, that would be produced by feeding cold water.  
S. B. RICHEY.

Less strain on boiler due to expansion and contraction caused by feeding cold water in boiler; therefore decreased cost of maintenance and increased life of boiler.  
G. WILBUR HUBLEY.

*No. 6.—Where open heaters are used, is there any economical method of keeping oil out of the boilers?*

I have found the Mississippi steamboat doctor the very best.  
D. KENNEDY.

Every good open heater has an oil-separating arrangement, which, if connected according to builder's instructions, works perfectly.  
A. PETERS.

In all modern open heaters the oil separators remove so much oil that there is no harm in the small amount remaining.  
THE B. F. GOODRICH CO.

An oil separator in the exhaust pipe will eliminate nearly or quite all the oil. If the feed water is then passed through a filter of straw or excelsior there should be no trouble from oil in the boilers.  
S. S. INGMAN.

All first-class open heaters are provided with efficient oil separators.  
S. B. RICHEY.

In one plant of 10,000-kw capacity running at 160 pounds steam pressure, open heaters have been in use for some four years without any trouble from the oil being carried over into the boilers.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

There are separators made with removable strainers.  
AUGUSTA RY. AND ELEC. CO.

*No. 7.—Would the returns from a steam-heating plant in a town of 5000 population, where a non-condensing plant is located three-quarters of a mile from the business centre, be sufficient to warrant the installation of such a system?*

No. W. BLOXHAM.

They would. D. F. MCGEE.

Such an installation is certain to yield only loss and disappointment. Theoretically, the proposition is an attractive one and fairly bristles with "selling points." Practically, a station has sufficient waste exhaust steam to supply such a system at peak load only, or say two hours or so per day. During the rest of the 24 hours, live steam must be used or the back pressure on the engines must be increased. Both plans mean excessive fuel consumption in comparison with the results, while the latter also involves a reduction in available capacity of engine. In the case cited in question, the amount of business available is very small in comparison with the radiating surface of the street mains and services required, making the efficiency very low, while the cost of installation would be out of all proportion to the possible receipts. EDITOR.

No. F. ELLWOOD SMITH.

## J

### PUMPS

*No. 1.—What is the reason why there is greater difficulty in pumping hot than cold water?*

Because the vapor from the hot water fills the vacuum as fast as it is made by the piston, and destroys its force. The pump is yet to be made that will lift hot water satisfactorily.

WILLIAM R. GARDENER.

Because the decreased pressure due to partial vacuum caused by piston of pump causes the water to boil (the temperature at which water boils being dependent upon the pressure), and the steam thus generated fills the space that would otherwise be filled with water if it were cold. This steam acts as a pressure against the column of water to be lifted, for the reason that very hot water must flow into the pump. Usually about four feet head is ample.

A. PETERS.

When the plunger of the pump moves forward, a vacuum is created in the suction pipe, and the cylinder fills with steam or vapor instead of water.

To obviate this difficulty, the pump must be placed below the level of the water supply.

G. H. CUSHMAN.

A pump that has to handle hot water is working at a disadvantage from the fact that water in a vacuum boils at a low temperature, so the height to which a pump will raise water depends upon the temperature. For instance, with a 15-inch vacuum (corresponding to about 15 feet lift) water would boil at 177 degrees Fahrenheit. The vapor thrown off would be drawn into the pump cylinder, where it would be alternately expanded and compressed as the piston moved back and forth, and so would produce no vacuum in the pump cylinder, which would prevent the pump from drawing water. If the water is at or near the boiling point, the pump must be placed below the source of supply.

E. W. FURBUSH.

Hot water vaporizes much more quickly than cold. Especially is this true when the pressure on the water is reduced, as it is when you pump it. Vapor in the suction pipe would destroy the tendency to a vacuum, and thus prevent drawing water to the pump.

DAVID W. BEAMAN.

The reason for the difficulty in pumping hot water is because the vapor or steam from the hot water fills the vacuum as fast as it is made by the piston and impairs its force so that it will not lift hot water. The best way to pump hot water is to place the pump below the source of supply so that the water will flow into the valve chambers.

F. W. BULLOCK.

The difficulty is owing to the fact that the movement of the pump piston causes a reduction of the pressure on the suction side. It is a well-known fact that water will boil and give off a vapor at a lower temperature than 212 degrees Fahrenheit, if the pressure is reduced below that of the atmosphere. Consequently the pump piston will, so to speak, run away from the water and the partial vacuum thus created will immediately fill with steam, thus reducing the capacity of the pump. On the return stroke the piston, having no solid water to contend with, will compress the vapors entrained in this vacuous space and come up against the water with great shock and jar, thus causing possible damage and erratic action of the pump. With small valve openings and high piston speed, this trouble is very much aggravated. The difficulty may be overcome by giving the pump large, free passages and very slow piston speed, or else arranging it so that the water will flow to the pump under pressure, or a head, which will tend to make the water hug the piston closely on the suction side. This also explains the reason why it is impossible to raise hot water by suction.

KNOWLES STEAM PUMP WORKS.

The reason why it is more difficult to pump hot than cold water is that the vapor arising from the hot water fills the space above the water and thus destroys the vacuum, and makes that much additional head or pressure for the pump to work against. From this we see that when it is desired to pump hot water it should be so arranged that the water will flow into the pump by gravity.

M. C. T.

Because water evaporates at lower temperature as the pressure on it is reduced.

AUGUSTA RY. AND ELEC. CO.

Unless there is a head of water on pump suction, hot water is liable to vaporize behind the pump plunger, due to lack of pressure. Hot water also softens the valves of pumps not especially designed for this service.

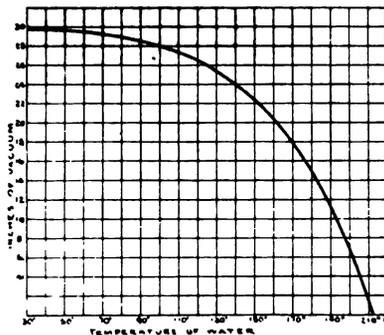
W. F. SIMS.

If there is a good head on the supply pipe to the pump, there will be no difficulty in pumping either hot or cold water.

By a good head is meant a head large enough to overcome the friction of the piping and pump valves and to quickly impart motion to the water. Do not underestimate these resistances. It takes head to start the water and give it the velocity needed to cause it to rush in and fill the cylinders instantly as soon as the valves open, and it takes head to overcome all the friction of pipe, elbows and valves at this velocity.

If the water is cold the pump will form a vacuum in the cylinders at each suction stroke. If the water is warm a vacuum will form, but not so good a one. If the water is hot, boiling hot, no vacuum at all will be formed. Many hot-water pumps operate very well if the water is not too hot, but if the temperature runs high they begin to hammer and make trouble. This is because they have not enough head on the suction. The vacuum helps them out when the water is only warm, but when it becomes hot there is no vacuum to help; the water comes in too slowly. Before the cylinders are filled the plungers reverse their motion and jump until brought up short by striking the water.

The diagram shows the vacuum in inches of mercury at which water of different temperatures will flash into steam, or, in other words, the amount of vacuum that it is theoretically possible to get in the cylinders with water at different temperatures. For example, with the water at 170 degrees Fahrenheit



it is not possible to get any higher vacuum than 18 inches; in practice it would be less than 18 inches. Practically, the pumps should be set so as to have ample head, and this difficulty will disappear.

ROBERT LINDSAY.

The vapor from hot water destroys the vacuum, the difficulty being in proportion to the temperature. Locating the pump far enough below the source of supply will remedy the difficulty, generally.

S. S. INGMAN.

There is not much difference, provided there is sufficient suction head to positively and surely operate the valves. Hot water can not be conveniently lifted on account of the vapor from the water partly filling the pump passages.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

On account of the vapor given off by hot water not allowing the cylinder to completely fill with water. This can be obviated to a large extent by putting a tee in the suction pipe higher up than the supply in the heater, which will allow the vapor to escape.

S. B. RICHEY.

*No. 2.—Is there a really effective and satisfactory automatic boiler-feed water controller on the market?*

The Geo. F. Blake Manufacturing Company build a controller which has given satisfactory results. It consists of a small tank or receiver, built specially strong to withstand the boiler pressure. This receiver is located at about the normal water level of the boiler, and the upper side is piped to the steam space and the lower side to the water space in the boiler. The receiver contains a cast-iron float, fitted with a counter-balance weight placed outside of the receiver. Any variation of the water level will raise or lower this float, which by means of outside connections, controls a balanced steam valve placed in the steam supply to the boiler-feed pump.

(UNSIGNED.)

Have never found any.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 3.—Considering the variability of service required, are motor-driven boiler-feed pumps in a non-condensing plant more economical in total annual costs than the ordinary duplex steam pumps?*

In a plant of the type referred to, motor-driven boiler-feed pumps would undoubtedly be the more economical.

J. D. A., N. Y. ED. CO.

This is a broad question, and depends very much on the capacity of the plant. In a large plant where there is a continuous and steady demand for feed water, it is no doubt more economical to install an electric or power-driven boiler-feed pump. For smaller plants, however, where the demand for feed water is variable, it is necessary at times to curtail or cut off the supply of feed water entirely. To accomplish this result with a motor-driven pump it would be necessary to arrange a by-pass back to the suction, and as an electrically operated pump must run at a stated speed, there would be more or less waste of electrical energy. An ordinary duplex steam pump can be operated at any speed to conform to the demands for feed water. If the exhaust steam from the pump is utilized in an auxiliary feed-water heater, or other method of economizing the waste heat in the exhaust, it will be found that considerable saving can be accomplished; and taking this fact into consideration, together with the first cost, the ordinary duplex pump would be more economical than the motor-driven pump for plants of small and moderate size.

DEANE OF HOLYOKE.

Direct-driven or belted power pumps are much more economical (in small units particularly) than duplex steam pumps.

E. W. LLOYD.

Steam-driven auxiliaries are more economical up to the point where all the exhaust can be condensed in heating feed water. Beyond this point the motor-driven auxiliaries would be cheaper to operate.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In some places we have found them satisfactory.

AUGUSTA RY. AND ELEC. CO.

The ordinary duplex steam pump requires from 100 to 200 pounds of steam per hp-hour. With a non-condensing engine there is a surplus of exhaust steam available for heating feed water, therefore the exhaust of the pumps is of no value for this purpose, and the steam used to drive the pumps is fairly a direct charge against the cost of feeding water into

the boilers. If we assume that the non-condensing engine uses 30 pounds of steam per hp-hour, we should then have the following comparative economy:

Steam consumption in engine per hp-hour.....	30	pounds
Efficiency to generator, loss 10 per cent.....	<u>3</u>	"
	33	"
Add 40 per cent for conversion to electrical horse-power..	<u>13.2</u>	"
	46.2	"
20 per cent loss through motor of 80 per cent efficiency....	<u>9.24</u>	"
	55.44	"
Loss through friction of geared pump, 30 per cent.....	<u>16.63</u>	"
Total steam per horse-power on motor-driven pump..	72.07	"

J. H. VAIL.

Yes. A motor-driven boiler-feed pump should be installed with a capacity sufficient to take care of the ordinary load, supplemented by a steam-driven pump sufficient to take care of the entire capacity and used only in case of repair to the motor pump or during peak loads.

R. H. THURSTON.

*No. 4.—What conditions should determine the adoption of feed pumps as against an injector for boiler feed?*

A feed pump is preferable to an injector in cases where a feed-water heater can be used.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

This would be governed largely by local conditions. If there is no way of heating the feed water the injector would be the more economical, not only in fuel, but in the increased life and safety of the boilers. The injector has a very high efficiency when considered as a pump and feed-water heater combined, but is not a very economical way of feeding boilers, as all the heat put into the feed must be taken from the boilers, and where the exhaust steam from pumps or engines is available a pump is to be preferred. If an injector is to be used in connection with a feed-water heater, the one using the least amount of steam to move the water should be used, as this leaves a larger amount of heat to be absorbed from the exhaust steam or the waste gases if an economizer is used.

E. W. FURBUSH.

The temperature of feed water and size of the plant would determine the adoption of a feed pump against an injector. Injectors are desirable where the boilers are small and there is no other means of heating the feed water.

J. D. A., N. Y. ED. CO.

As a rule, a boiler-feed pump is preferable to an injector for the following reasons: a pump can be controlled to operate at any speed to suit the demand of feed water, and it is preferable to supply the boiler with a steady continuous feed, which is not possible with the injector. An injector can only handle cold water, whereas a pump can handle water at any temperature. If the exhaust steam of the boiler-feed pump is utilized in a feed-water heater all the waste heat is saved, and the economy is thus greater than with an injector.

SNOW STEAM PUMP WORKS.

It depends on whether you have a feed-water heater or not.  
THE B. F. GOODRICH CO.

An injector should never be used as a boiler feed in a plant of any size, as a pump is more easily regulated and in connection with a good heater is more economical.

S. B. RICHEY.

When there is little or no heater capacity the injector is preferable to the pump. We believe both are desirable, however, one being retained for emergencies.

S. S. INGMAN.

The feed pump, especially in combination with feed-water heater, is a much more efficient machine than the injector. The injector is useful as a relay, and also where it is highly important to save weight and space.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The number of boilers, for one thing.

AUGUSTA RY. AND ELEC. CO.

Reliability of service.

G. WILBUR HUBLEY.

*No. 5.—In boiler-feed pumps for handling hot water, 200 degrees Fahrenheit and hotter, what results have been obtained*

*by using ball valves instead of usual flat valves, composition or otherwise?*

For handling water at 200 degrees Fahrenheit in a boiler-feed pump, it is usually preferable to fit the pump with flat valves made of composition, or preferably hard vulcanized rubber. A ball valve would operate perfectly satisfactorily under these conditions, provided the pump were operated at a slow piston speed, otherwise the ball valves would be liable to batter the seats out of shape owing to the frequent and quick reversals of the pump pistons. The only advantage of a ball valve is in handling very gritty or viscous liquids containing more or less solid matter, which, of course, is not a consideration in a boiler-feed pump.

#### KNOWLES STEAM PUMP WORKS.

*No. 6.—What types of boiler-feed pumps have given the most satisfactory service with water at 200 to 210 degrees Fahrenheit? What is the minimum head of hot-water supply above pump suction for reliable pumping service?*

Vertical marine type with bronze-ring water-packing.

W. BLOXHAM.

A boiler-feed pump of the piston pattern is usually most satisfactory for pumping hot water at a temperature of 200 to 210 degrees Fahrenheit. The piston should be packed with a square canvas packing made especially for this service, the packing being very hard and not liable to shred away, due to the action of the hot water. With water that is absolutely free from grit, a pump piston packed with babbitt rings has given eminent satisfaction. The water valves should be either of composition, or preferably hard vulcanized rubber. An outside packed plunger pump is also a satisfactory pump for hot-water service, especially where the boiler pressures are quite high. The pumps can be of the single or duplex type.

As regards the minimum head of hot-water supply above the pump suction for reliable pumping service, this depends upon several conditions. A large pump operating at extremely low piston speed and arranged with large valve area, will pump

hot water satisfactorily and with a low head on the suction of about three to four feet. If, however, the pump is run at a high piston speed so that the pistons have a tendency to run away from the water, and produce a partial vacuum on the suction side, then it is necessary to have considerable head on the suction so as to force the water through the suction valves, and keep it in close touch with the pump pistons at all points of the stroke; sometimes with a head of 30 to 40 feet, especially for marine service, boiler-feed pumps have given unsatisfactory service owing to the fact that they were of too small capacity, necessitating high piston speed. This is often the cause of breakage of the pump, owing to the fact that the piston, having a partial vacuum on the suction side filled with steam, will on the return stroke have no load to contend with and will thus strike the inflowing water with great force, often causing destruction of the working parts and pump chambers.

THE GEO. F. BLAKE MFG. CO.

Brass-lined, outside-packed, duplex pumps have given very good service in pumping water at temperatures up to 210 degrees Fahrenheit with eight feet head on suction valves of pump.

THE B. F. GOODRICH CO.

Any good type of plunger pump with from four to six feet head on the suction should give satisfactory service.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

A vertical, outside-packed, motor-driven plunger pump has been handling water of this temperature very satisfactorily for over a year, and any plunger pump so constructed that the plunger can not get out of line will do the same.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Outside-packed plunger pumps. Where the hot well is close to the pump and there is ample suction capacity, two feet has been found sufficient; but where the hot well is located at a distance from the pump, friction in the pipe is the controlling factor.

R. H. THURSTON.

## K

## CONDENSERS

*No. 1.—Are water-cooling towers for condensing purposes satisfactory in service and economical in operation?*

Under many conditions, yes; under others, no. An ample supply of circulating water is, of course, always preferable. The capacity of a condensing equipment with water-cooling towers is more largely dependent on weather conditions and consequently is reduced during the summer months.

P. JUNKERSFELD.

We have a cooling tower for cooling condenser water, which is found very satisfactory and economical. A 22-inch vacuum is maintained by expenditure of steam sufficient to raise the water to a height of 28 feet.

C. W. HUMPHREY.

Yes, if auxiliaries are steam-driven and steam used for heating feed water, or motor-driven auxiliaries.

G. R. W., MALDEN ELECTRIC CO.

A water-cooling tower which will give 23 to 24-inch vacuum under natural draft during the greater part of the day and the same during peak load under forced draft, has been in satisfactory service for a number of years.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Water towers are used to a very large extent in Europe, and where the water supply is sufficient are very economical.

FRANZ KÖSTER.

Yes, but not so good as if there were plenty of water.

F. ELLWOOD SMITH.

The many cooling towers that have been and are being installed are the best evidence that they give satisfactory results. Where a natural water supply is not available, or the character of the water is injurious to piping and condensing apparatus,

there is no question but that cooling towers of the proper size and type will give satisfactory and economical results.

(UNSIGNED.)

*No. 2.—Other things being equal, what is the comparative efficiency of the surface and the jet condenser?*

Jet condensers should be a trifle more efficient as machines, and the first cost and repairs should be somewhat less.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Where the condensed water contains too much oil to be used in the boilers the jet condenser is superior to the surface condenser, as one less pump is required and the repairs are less.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The efficiency of surface and jet condensers should be the same, provided the same care is exercised in selecting and installing each type.

(UNSIGNED.)

*No. 3.—What is the best type of condensing equipment for steam turbines?*

The best type of condensing equipment for steam turbines is the surface condenser, for the reason that with good water at the outset there need be no impurities introduced into the system, as the steam turbine is free from lubrication and furnishes an ideal steam engine in that regard.

CALVIN W. RICE.

Mechanically, the surface condenser can be better adapted to the turbine.

W. BLOXHAM.

Surface condensers equipped with wet and dry vacuum pumps seem to promise the best results. With turbines of large size requiring immense amount of cooling water, centrifugal pumps promise good results in handling circulating water.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The best type of condensing equipment for steam turbines depends entirely upon local conditions; but generally speaking,

the high-vacuum surface condenser is preferable, and particularly so where it is advisable to use the condensing water for boiler-feed purposes.  
(UNSIGNED.)

So far as the steam turbine is concerned, it is immaterial what type of condenser is employed, so long as it gives the required vacuum. A surface condenser is the most expensive, but has much to recommend it. Its use in conjunction with steam turbines will give boiler feed that is pure and uncontaminated with oil, since no internal lubrication is used in turbines.

It is claimed that with a modern dry vacuum pump and a closed hot-well system, a higher vacuum may be obtained with this than with any other type of condenser, because the water, in its passage from the boiler to the engine and back again to the boiler, does not find an opportunity to become aerated. Notwithstanding this, excellent results are obtained with jet condensers. They are much simpler to operate and are to a less extent affected by the electrolytic troubles that are sometimes experienced with surface condensers.

FRANCIS HODGKINSON.

*No. 4.—What vacuum is regularly obtained at the engine cylinder in plants equipped with central condensing system?*

Twenty-seven inches is maintained under favorable conditions.  
S. D. S., N. Y. ED. CO.

A 10,000-hp station is maintaining between 25 and 26-inch vacuum on a central condensing plant.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Central condensing systems of the more recent and improved types and with properly-designed pipe system are maintaining an average of 26 inches of vacuum at the engine cylinders.

(UNSIGNED.)

The attainment of a high vacuum with a central condensing system requires: First, a continuous flow of a sufficient quantity of water of a temperature low enough to produce the vacuum. Second, the absolute perfection of the pipe-fitting work so that all the connections are airtight.

An engineer may be right on the water supply, and believe the system to be airtight, and yet not get a high vacuum. A good way to prove the system is to close all valves under the highest vacuum for 10 or 12 hours after stopping, and see whether the vacuum holds. Air leaks are best found by going over the joints of the entire system with a lighted candle when under vacuum. An air leak will draw in the flame of the candle. With all joints perfectly tight and the outside surfaces painted over with good asphaltum varnish, and water supply up to the required conditions, a vacuum of 27 inches should be maintained at the exhaust from the low-pressure cylinder.

An engineer should not be satisfied with the vacuum shown at the condenser, but should test it directly at the cylinder.

J. H. VAIL.

*No. 5.—What is the relative cost of fan and natural-draft cooling towers for condensing systems? What vacuum can be obtained with their use?*

Very little difference in first cost. From 16 to 27 inches, according to temperature of water and efficiency of condenser.

W. BLOXHAM.

The cost of fan and natural-draft cooling towers will be the same, taking into consideration the cost of fan-engine foundations, piping for engines, etc. A 26-inch vacuum can be obtained.

G. R. W., MALDEN ELECTRIC CO.

It depends upon conditions. Ordinarily, the natural-draft cooling towers will cost from 50 to 100 per cent more than fan cooling towers. A vacuum of 25 inches with barometer at 29 inches and outside temperature of 80 degrees is not unusual under fair operating conditions.

P. JUNKERSFELD.

The only difference between a natural-draft cooling tower and a forced draft is in first cost and maintenance. The water in each instance must be pumped to the same height. Operating costs show in favor of the natural draft by the amount used

for driving the fan. A natural-draft tower must be somewhat larger, but does not cost any more, because no fans or motors are necessary.

C. W. HUMPHREY.

The natural-draft tower may be expected to cost about 50 per cent more than the fan tower, and a vacuum of from 22 to 26 inches is ordinarily obtained.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The natural-draft cooling tower, under normal conditions and with the average size of installation, will cost about 50 per cent more than the fan-draft tower; in larger units this percentage will be somewhat reduced, while in smaller units it will be increased. The vacuum maintained depends to a great extent upon the condensing equipment, but, everything being properly proportioned, the same results can be obtained.

(UNSIGN'D.)

## L

### DYNAMOS AND MOTORS

*No. 1.—What objection, if any, is there to the use of motor-driven exciters for alternators that are to be operated in parallel?*

Short-circuit on line, suddenly dropping station voltage, will "kill" motor driving exciter, and station will shut down. An additional exciter, driven by means independent of alternator voltage, will be necessary to start after a complete shut-down.

GEO. B. LAUDER.

More complicated. Can not get as steady voltage as when driven from shafts of alternators.

B. A. SCHAK.

We are operating alternators in multiple, virtually excited by motor-driven exciter, and experience no inconvenience from the practice. However, if alternators are to be excited entirely by motor-driven exciters, it is as well to have an auxiliary battery to call on in event of interruption to the alternating circuits, which would naturally shut down the motor-driven exciter.

E. P. DILLON.

One objection to the use of motor-driven exciters is that any fluctuation in the speed of the alternators has a direct effect on the voltage generated by the exciter-dynamos. This in turn increases the variation in voltage on the main generators. It would also be necessary to have a steam-driven exciter or some exterior source of supply in order to start the system. All objections to motor-driven exciters are overcome by always having a battery of sufficient size running in parallel on the exciter 'bus.

W. F. W., N. Y. ED. CO.

A motor driving an exciter, especially a synchronous motor, will drop its load and stop if the voltage supplied to the motor becomes sufficiently low. As the voltage supplied depends in turn on the excitation, a motor-generator exciter set makes a sensitive combination that is liable to shut down an entire plant through some disturbance in the power circuits due to momentary heavy load or to the surging between generators in paralleling. An induction motor is preferable to a synchronous motor since it is not so sensitive to such disturbances and it is also not necessary that it remain in synchronism with the generators. A heavy flywheel effect is sometimes a benefit to a motor-generator exciter set, enabling it to maintain its speed for short intervals, regardless of the voltage supplied to the motor.

E. M. TINGLEY.

There are objections to motor-driven exciters for large alternators operating in parallel, and it is not wise to depend upon such sets unless they are backed up by some constant source of supply, such as a storage battery or an engine-driven exciter set. When the motor driving the exciter is of the synchronous type, operating from the common 'bus-bars, there is liability of the motor dropping out of step if the alternating-current 'bus-bar voltage should be momentarily interrupted, as may happen when alternators are cut in without being properly prepared, or in case some of the automatic switches should accidentally open or close prematurely.

J. H. HALLBERG.

The use of motor-driven exciters for alternators in parallel is common practice, but they should be operated in conjunction

with a steam-driven exciter or a storage battery, or both, for additional insurance against failure of excitation.

R. F. SCHUCHARDT.

The objection to using motor-driven exciters for alternators is that if the plant is operated under an overload at times it is possible that with the decreased voltage the motor on the exciter will slow down and the exciter voltage will fall. If this condition continues, the circuit-breakers will go out.

THE B. F. GOODRICH CO.

Objections that may be mentioned are: (1) if the motor is driven from the main 'bus, fluctuations in voltage are accentuated; (2) if the motor breaks down while the generator is in parallel, the generator is short-circuited across the 'bus.

F. M. FARMER.

If induction-motor-driven exciter sets are understood, there is no serious objection to their use. An auxiliary, such as a battery, should furnish an exciting source after a shut-down and a sufficient operating potential for remotely controlled apparatus. Considered by themselves, they should operate to minimize the current effects of a heavy short-circuit on the system, although on a light short-circuit they operate against the sensitive synchronous system by reason of their multiplying the pressure-lowering effect of the short-circuit.

If both alternators and exciter sets are fed from a transmission line, as in the case of frequency-changing sets, the effect of line disturbance is of course multiplied on the generator end of the set, but the induction-motor sets will operate more satisfactorily than a belt-driven set or a direct-connected set for exciting purposes.

B. JAMIESON.

Alternating-current generators should have at least one exciter that does not depend on driving power from main leads of generator or 'bus-bar which said generator supplies. There is no serious objection to motor-driven exciters, provided they are paralleled on both motor and generator ends.

J. MANLEY.

None, beyond the possibility of the engine abnormally increasing or lowering its speed and consequently the frequency, in which cases the motor would either speed up and raise the voltage of exciter abnormally in the first case, or would drop in speed in the second case so that it might lose its load. These cases are rare, however, and it is considered good practice to use motor-driven exciters for alternators running in parallel.

M. C. T.

This is perfectly satisfactory in practice.

E. P. COLES.

*No. 2.—Why is it difficult to run 60-cycle rotaries in parallel on the direct-current end when they are operated from the same engine-driven generator?*

We assume that the 60-cycle rotaries that are difficult to operate with the direct-current ends in parallel on the same generators are also in parallel on the alternating-current ends. In this case, any slight difference in construction, or in the position of the direct-current brushes, may cause circulating currents between the rotaries, thereby greatly increasing the current at the brushes and causing sparking and burning at the commutators.

E. M. TINGLEY.

It will not be difficult to run 60-cycle rotaries in multiple on the direct-current end when proper relations are obtained between rotaries so run, such as correct field strength with equal power factor and correct relative phase relations on the alternating-current side of machines.

A. D. GILMORE.

The tendency to hunt varies directly with the frequency, being higher as the frequency is higher. Sometimes the characteristics of two rotaries of the same make, type and construction differ greatly. This being the case, the machine having the steeper characteristic will carry the most load. Should the load fluctuate very greatly, this machine will start to hunt and will gradually fall out of synchronism. Again, should the leads or bus-bars on the direct-current end be of different conductivity relative to each other, any excess of current in one side will find a return path through the alternating-current end.

This also gives a tendency toward hunting. The above applies to all rotaries in general, but particularly to the higher frequencies, as (as has been said before) the tendency to hunt varies directly with the frequency.

C. F. HAYWOOD.

It is not difficult to operate 60-cycle rotaries under this condition.

E. P. COLES.

With properly designed rotary converters there should be no difficulty, unless it is attempted to run the rotary converters with their alternating-current terminals in parallel; that is, unless it is attempted to run two or more rotary converters from the same transformer secondaries or from the same alternating-current bus-bars. The difficulty that is experienced in running rotary converters with their alternating-current terminals and their direct-current terminals both in parallel is not due to the use of 60-cycle current, but is due to the fact that unless the characteristics of the machines are exactly identical at all loads, there will be large cross currents through the alternating-current and direct-current connections. The same difficulty would be experienced with rotary converters operating on any frequency.

It may happen that the characteristics of the engine driving the generator are sufficiently good as regards momentary pulsations with the load caused by one rotary converter, while with the double load corresponding to two rotary converters they are not so.

If the trouble is of this kind, a single converter of double size would produce the same result.

Trouble of this kind may be had with rotary converters of any frequency, but is more likely to occur with 60 cycles than with lower frequency, since it is more usual to find engines unsuited for their work on higher frequencies than on lower. In the same way the damper capacity of the generator might be sufficient at light loads but insufficient at heavier loads.

CLARENCE RENSHAW.

*No. 3.—Will a rotary converter operated from a three-phase circuit commutate any better if the transformers are so arranged*

*as to furnish six-phase current to the converter? If so, is the improvement great enough to justify the additional expense and complication?*

It will depend on the particular rotary converter whether a change from three-phase to six-phase will make any improvement in the commutation. If there are no cross connections or balancing rings on the rotary armature, it may be benefited by the addition of the extra collector rings, which will act as balancing rings. If there are already three or more balancing rings on the armature, changing to six-phase will make no appreciable change in the commutation. This assumes that the commutation is not influenced by pumping or other conditions that would be modified by the six-phase connection.

E. M. TINGLEY.

A rotary converter will commutate somewhat better if furnished with six-phase current instead of three. The principal benefit, however, is in the decreased heating in the armature conductors and less liability to hunt. It is customary to make all converters on three-phase lines of 500 kilowatts and over, with six-phase connections. It would be only on very small converters that this would not pay. (UNSIGNED.)

The Westinghouse Electric and Manufacturing Company have built rotary converters for both three-phase and six-phase circuits. So far as they have been able to determine, the commutation and general operation of the three-phase rotary converters was in every respect equally satisfactory to that of the six-phase rotary converters. The additional expense and complication of six-phase rotary converters is therefore not warranted, so far as the rotary converters themselves are concerned. In some cases, however, where large units are employed, the subdivision of cables and switches, which would be necessary in any case, makes practically no more complication for six-phase than for three-phase.

CLARENCE RENSHAW.

Yes, a rotary will commutate better when furnished with six-phase current, for the reason that, owing to the extra taps,

the paths of the current through the armature from collector ring to commutator are shorter and more direct, consequently the heating of the armature is materially lessened, and it may be made smaller in size for the same output.

As to the extra expense and complication, would say that this need not be much increased in either case. The only additional expense incurred would be the running of three more cables from the secondaries of the transformers, which in most stations is not a very great distance.

There is very little extra complication of wiring, owing to the fact that the connections can be made with three transformers each having two coils in the secondary. The primaries of these should be connected in delta, while the secondaries may be connected in two or three different ways, which need not be described here except to say that perhaps the most prevalent connection is what is known as the double-delta. This merely consists in connecting one secondary of each into a delta, and the remaining three into another delta; this latter, however, being connected up in the reverse order to the first, and the six wires from the two deltas going direct to the six collector rings of the rotary.

M. C. T.

The improvement of commutation due to changing a three-phase to a six-phase converter would not justify the expense incurred, but the three-phase converter if connected six-phase will give a 45 per cent greater output for the same internal losses.

A. D. GILMORE.

*No. 4.—Is there any simple method of testing a three-phase generator for regulation, using ordinary station instruments?*

The measurement of regulation of alternating-current generators is very difficult. The station instruments will not ordinarily give accurate results. The regulation is greatly affected by small changes in power factor of load, and it is especially difficult to measure accurately when the power factor is high.

E. M. TINGLEY.

A generator may be tested for regulation with ordinary instruments by making the usual test; the accuracy, of course, will only be equal to the accuracy of the instruments employed.

With the generator on open circuit, read terminal volts with different values of field amperes, from rheostat "all in" to rheostat "all out." The field amperes should be varied always in one direction and the speed held constant. With full load on the generator, observe the field amperes and terminal voltage, and from the first test obtain the voltage on open circuit corresponding to the excitation observed with the load. Then

$$\text{Per cent regulation full load} = \frac{\text{no-load volts} - \text{full-load volts}}{\text{full-load volts}}$$

A. M., N. Y. ED. CO.

A simple method of testing the regulation of a three-phase generator with station instruments is either to take the actual regulation with load where this can be done—that is, measure the difference in voltage, keeping the speed and field current the same—or, by making a short-circuit test where the phases of the machines are short-circuited on themselves and the field current is brought up to from one-fourth to one-third its normal value. By the method given by the American Institute of Electrical Engineers the regulation is then calculated by composition of vectors of magneto-motive forces.

(UNSIGNED.)

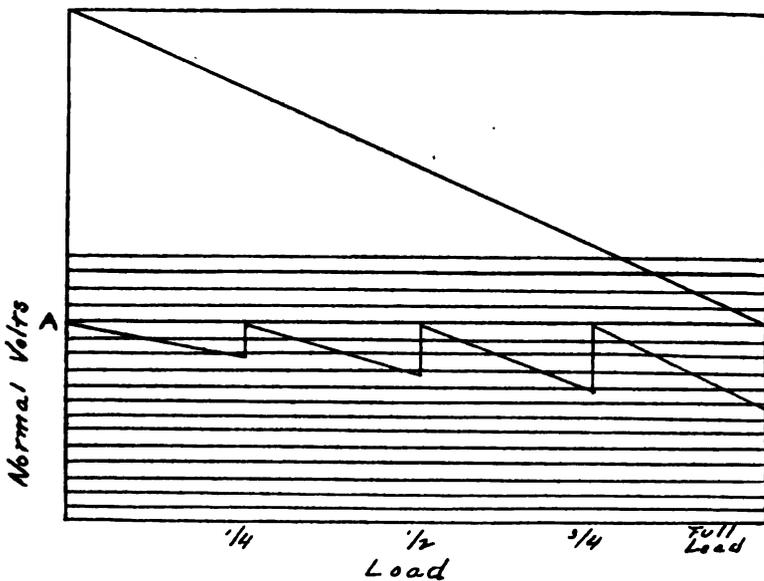
If the load is purely non-inductive, variations in voltage may be read on voltmeter at different loads as read on ammeter, speed remaining constant. If load is inductive, voltmeter and wattmeter readings must be taken.

E. P. COLES.

Measure the field current at any time when the machine is supplying its full-load current to the 'busses. At any subsequent time, when convenient (perhaps just before cutting out the machine preparatory to shutting down), and while the machine is hot, open the main switches and raise the field current to the value previously measured, keeping the generator speed the same as it was at that time. Read the voltage, and the ratio of the two readings will give the regulation.

F. M. FARMER.

Take no-load reading first, then without changing field strength bring machine up to quarter load. Volts will of course drop. Readings should be taken here. Now, holding the load at one-fourth of full load, volts should be brought up to normal (no load). Next, holding this field, bring load to one-half and repeat as before to full load, full voltage. Now, remove entire



load with field at full load, normal voltage. Volts will of course rise considerably above normal no load. The curve of volts will be something like the accompanying sketch. At *A* the volts are normal, no load.

C. F. HAYWOOD.

*No. 5.—Why are shunt-wound dynamos generally used in preference to compound-wound generators for the Edison three-wire system?*

Because of the simpler switching arrangements necessary when throwing machines in multiple, and the ease of so doing as compared with compound-wound generators.

A. PETERS.

Because of simplicity.

GEO. L. COLGATE.

A short-circuit on an Edison system run by compound-wound generators would cause a dangerous overload on the armatures of the machines, whereas a short-circuit on a system operated by shunt-wound generators would cause the voltage to drop rapidly, thus preventing such an overload.

DAVID A. BEAMAN.

It is preferable to use shunt-wound generators for parallel operation, inasmuch as the load for each generator can be predetermined and divided among the generators without the use of the equalizing 'bus which is necessary with compound-wound dynamos, thus simplifying the switchboard and manipulation of switches, etc., when machines are to be cut in and out. Furthermore, it is difficult to compound different-sized generators so that they will automatically take only their proportional part of the load as the demand on the 'bus-bars is increased.

J. H. HALLBERG.

Compound-wound generators are usually employed in plants having wide and numerous load fluctuations, and in small installations having but occasional switchboard attendance. In central lighting stations of the Edison three-wire system, the load is generally steady and increases and decreases gradually and evenly. Loads of this character are easily taken care of by the operator who is in constant attendance. For such work, the shunt-wound machine is much more desirable than the compound-wound dynamo with the accompanying equalizing cables and 'busses, the equipment for which adds to the first cost of the plant and is entirely unnecessary in handling the usual Edison loads. Compound-wound generators bring in the factor of load distortion when paralleling, and in some instances have been known to interchange load to such an extent that another machine connected to the same 'bus has been transformed into a series motor and has been caused to run away.

W. T. D., N. Y. ED. CO.

Shunt-wound dynamos are preferably used on the three-wire system, for the reason that in case of a bad short-circuit on lines compound windings would be just a little too active for pleasant consequences.

CHAS. H. PETERS.

In case of a heavy short-circuit on a shunt machine the current in the fields decreases and the fields lose their magnetism, and the machine drops the load without any injury to the armature.

LOUIS I. PORTER.

*No. 6.—Why do the large Edison stations use two-unit, 125-volt generating sets exclusively in preference to 250-volt single units operated in connection with balancer sets?*

Good modern practice is to use 230-volt machines connected to outside of system with 125-volt balancer that can be thrown to either side of the system and should have enough capacity to take care of the greatest unbalanced load.

J. MANLEY.

Since the perfection of the two-machine balancing sets there should be no advantage in operating two-unit, 125-volt generating sets in place of 250-volt single units operating in connection with balancer sets. As a matter of fact, the 250-volt units with balancer sets should represent a lower first cost, higher efficiency, greater flexibility, lower maintenance cost at brushes, and so forth.

J. H. HALLBERG.

This is not the present practice of the large Edison stations.

LOUIS I. PORTER.

Principally, I believe, because of less damage if a short-circuit takes place between either outer and the neutral. In the case of the two generators the short-circuited one will burn off any cross, the other taking care of the load on its side. If, however, a "short" occurs when a balancer set is used, the "short" cuts out one side of balancer set and allows the full 220 volts to get to the lamps, thus destroying them. To overcome this difficulty a balancer set is usually equipped with a coil connected between the two outers and the centre of coil connected to neutral. In this coil works a plunger, which, when the electromotive force rises to a high value between either outer and the neutral, cuts in circuit a shunt coil which trips circuit-breaker on the 250-volt generator. When using a balancer set a battery is very useful to throw in on the short-circuited side to burn off any obstruction.

A. PETERS.

It is not the practice in the large Edison stations constructed in recent years to install two-unit, 125-volt generating sets, but to use 250-volt single units and operate them in connection with compensator sets and large storage batteries, which are connected to each of the three conductors. Before the use of batteries became general, one objection to a 250-volt unit was that in case of a heavy short-circuit between the positive and neutral conductors, the balancer set might burn out and thus allow the potential of 250 volts to exist between the negative and neutral. With 125-volt units this is impossible.

W. F. W., N. Y. ED. CO.

Balancer sets are not required in stations using the usual Edison outfit, that is, two-unit generating sets. But when high-tension, alternating-current generators are used as the primary source to operate rotary substations supplying 250-volt current to the secondary mains, then balancer or compensating sets are connected in series with the system with the middle point connected to the neutral. The largest Edison company in the world, its capacity being 72,000 kilowatts, uses balancer sets.

WILLIAM R. GARDENER.

The Edison stations use two 125-volt generating sets in preference to 250-volt single units with balancing sets in order to avoid having to run a large balancing set, which is merely equivalent to two large motors running idle. The set has to be very large in order to take care of trouble that may occur on either side of the neutral.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Because there is usually nothing to be gained by making the change.

GEO. L. COLGATE.

*No. 7.—What is likely to cause a direct-current, constant-potential generator to lose its magnetism?*

Open circuit in field magnetizing coils.

WILLIAM R. GARDENER.

A direct-current generator may lose its magnetism or have it reversed from any of the following causes: lightning, reversed connections, the earth's magnetism, or proximity to another dynamo.

L. E. WATSON.

The direct-current, constant-potential generator will lose its magnetism, and sometimes be reversed, if it is set close to another machine that is operated when it is standing idle. If the field of the second machine be of the same polarity as the one that loses its magnetism, the trouble can be remedied by reversing the polarity of the field in either of the machines. Generators sometimes appear to lose their field when such is not the case, and the trouble is likely to be in loose field connections or too much paraffin or other lubricating compound being used on the contact plates of the field rheostat.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Having a heavy load suddenly switched off and the field circuit simultaneously opened when machine is hot from long run.

GEO. L. COLGATE.

There are several things that will make a dynamo lose its magnetism. Residual magnetism weak or destroyed by vibration or jar, proximity of another dynamo, earth's magnetism where machine stands idle for a long time, and the accidental reversing of current through fields, but not enough to completely reverse magnetism.

F. W. BULLOCK.

A constant-potential generator may be demagnetized by a severe jar, which sometimes happens in moving from one location to another. A heavy short-circuit or a large forward lead on the brushes will have a similar effect.

W. T. M., N. Y. ED. CO.

Proximity to other or larger machines, or standing idle for some time. Pounding or jarring the magnet frame.

C. F. HAYWOOD.

Allowing a direct-current, constant-potential generator to stand idle for a long time will sometimes cause it to lose its

magnetism. Starting up or shutting down an Edison three-wire system with both dynamos connected to the circuit will cause one of the machines to lose its magnetism. The main switches should not be closed before the pilot lamps become red when starting up, and should not be opened before they go entirely out when shutting down.

S. B. RICHEY.

*No. 8.—What causes reversal of polarity in direct-current machines?*

Short-circuit; open-circuit; suddenly discharging field and an abnormal armature reaction due to short-circuit or suddenly interrupted circuit. So many features regarding connections, operation, etc., enter into the question that it is hard to assign the exact cause unless all facts are known.

GEO. B. LAUDER.

Reversal of polarity may be caused by lightning discharge, also by wrong plugging at the switchboard; and when running in parallel the dynamo may become reversed while stopping, by the current from other machines at work.

Remedy: Send a current through the field coils in the reverse direction.

WILLIAM R. GARDENER.

The same conditions mentioned in my answer to the preceding question will sometimes cause reversal of polarity.

GEO. L. COLGATE.

Reversal of polarity may be caused in several ways: by field circuit being broken while machine is in operation; by a stroke of lightning; by throwing machine in parallel with another machine when not at the proper voltage, and by mistake in connecting the machine after having it apart for repairs.

F. W. BULLOCK.

A reversal of polarity may be caused by a heavy short-circuit on an armature. This also sometimes happens after the field coils have been separately excited. Such excitation might be necessary in measuring the resistance of the field spools, etc. In fact, anything that demagnetizes the field magnets may cause

a reversal, as the original residual magnetism is destroyed and may reappear with an opposite polarity.

W. T. M., N. Y. ED. CO.

A flash of lightning or a cross with other lines will cause a dynamo to reverse.

S. B. RICHEY.

Reversal of polarity in direct-current machines of the bipolar type is sometimes caused by short-circuit on the line, also by being affected by another machine, the adjacent poles of the machines being of like polarity. Have seen it done in multipolar machines by slowing up in speed or pulling main switch when shutting down.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Failure of source of power of any one generator, when a number are running in parallel.

AUGUSTA RY. AND ELEC. CO.

*No. 9—What is the theory of the Wood arc-dynamo regulator?*

The current on a Wood (Fort Wayne) series arc-light machine is maintained at a constant value by means of an electro-mechanical regulator consisting of a magnet, friction wheels, and a brush-shifting device, all of which are mounted on the frame of machine, on commutator end. The machine is equipped with two sets of brushes, which are placed so that they incline at a slight angle toward, and can be moved to or from, each other.

The main current of the machine passes through the magnet and attracts an armature, which attraction is opposed by a spring. Upon being raised, the armature moves a lever, which in turn engages the friction wheels, which actuate by means of a belted pulley the brush-shifting device, moving brushes to or from each other according as the armature is raised or lowered. If the current exceeds its normal value the lever is moved upward and brushes are nearer together and in a nearly vertical position, thus decreasing the voltage; while if the current

decreases the lever is lowered and the brushes are moved further from each other and in a more nearly horizontal position, and the voltage is consequently decreased. M. C. T.

The normal current in series circuit is used to exactly balance a certain weight with spring adjustment, in which balance position a pair of friction wheels so geared as to produce opposite movement of the brush-holders are held out of frictional contact with a constantly revolving wheel on armature shaft. Current above or below normal brings one or the other of these wheels into contact with the moving wheel on armature shaft, which shifts the rocker arm backward or forward as required. S. D. S., N. Y. ED. CO.

A series magnet geared to the brush yoke that rocks brushes forward or backward as current increases or decreases, cutting more or less active coils into circuit.

J. MANLEY.

*No. 10.—What is the best commutator lubricant?*

The best we have found is the commutator compound made by the K. and W. Company, Pittsfield, Massachusetts.

WILLIAM R. GARDENER.

When a commutator is smooth we have found that the much-desired dark-brown color can be quickly obtained by using a very small amount of common kerosene, applied with a cloth, the commutator being rubbed with a clean finger afterward.

L. E. WATSON.

We have found that a good commutator lubricant for commutators with carbon brushes is a piece of paraffin wax occasionally passed lightly over the commutator.

JAS. B. FOOTE.

Vaseline in small doses.

W. H. BANES.

We have found that a light engine oil occasionally applied on a strong piece of ticking gives the best results on our commutators—being careful not to use too much oil.

E. P. DILLON.

On high-tension machines I have always found vaseline to answer the purpose. W. J. C., N. Y. ED. CO.

Vaseline.

A. PETERS.

I have used equal portions of paraffin and plumbago with good results. GEO. L. COLGATE.

The best commutator lubricant for copper brushes is vaseline. Put a very little on a cloth and rub the commutator frequently; too much will cause sparking, and too little will cause cutting; but the proper amount, which is very little, applied frequently, will give good results.

DAVID W. BEAMAN.

Sperm oil cut with cast-iron borings in the proportion of one pound of cast iron to one gallon of sperm oil has given very good results as a commutator lubricant.

THE B. F. GOODRICH CO.

Vaseline is as good as any lubricant for a commutator; but very little lubricant of any kind should be used, as a commutator needs little or no attention when running properly, after having acquired a good gloss. M. C. T.

The best commutator lubricant is clean engine oil.

S. B. RICHEY.

One of the largest manufacturing companies uses a cloth dipped in red engine oil. This applied once or twice in 24 hours gives excellent results. C. F. HAYWOOD.

The best commutator lubricant we have found is sperm oil, which should be used frequently but in very small quantities.

E. H. MATHER.

*No. 11.—Is it advisable to soak carbon dynamo brushes in oil to prevent wear of brush and commutator? If so, what kind of oil should be used?*

We have found that by soaking carbon brushes in ordinary light dynamo oil excessive wear of both commutator and

brushes is prevented; and we have found it even better to throw away our carbon brushes and use "Graphite" brushes.

L. E. WATSON.

No; if you use vaseline your brushes will soon become well greased.

W. H. BANES.

Soaking carbon brushes in oil will cause them to crumble and deposit a film of carbon and oil on the commutator, resulting in sparking and short-circuits between commutator bars. Carbon brushes will give best results when just enough oil is put on commutator to prevent cutting.

B. A. SCHAK.

Oil should not be used on commutator brushes under any conditions.

GEO. L. COLGATE.

It is a good plan to soak carbon brushes in oil, and we find a light dynamo oil very satisfactory.

DAVID W. BEAMAN.

We do not favor soaking carbon brushes in oil where a brush is used on a reaction, or any type of holder where the brush is required to slip back and forward to adjust itself to the commutator, as the holder will gum and the brush become fastened to the holder, or at least become sluggish in its movement. Should the brush be clamped fast to the holder and the holder itself pressed toward the commutator by a spring, the carbon brush can be improved by being soaked in hot paraffin oil.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

It is advisable to soak carbon brushes in sperm oil heated lukewarm. They should be soaked about half an hour for every two weeks of constant running.

THE B. F. GOODRICH CO.

For the best results carbon brushes should have the lubricating element included in the process of manufacture.

S. D. S., N. Y. ED. CO.

Usually not. In some cases good results are obtained by boiling brushes in paraffin. Soaking brushes in cold oil does more harm than good.

E. P. COLES.

Boiling carbon brushes in paraffin prevents wear of brush and commutator.

J. MANLEY.

Soaking carbon brushes in hot vaseline has given satisfactory results. There are several brands of lubricated brushes on the market, and the price is so low that it hardly pays to lubricate them yourself.

S. B. RICHEY.

Yes. Light cylinder oil.

F. C. S., MALDEN ELECTRIC CO.

We have seen very good results from carbon dynamo brushes that have been soaked in sperm oil before being placed in operation.

E. H. MATHER.

No. The brushes should not be soaked in oil, nor should oil be used on the commutator. Oil tends to soften and disintegrate the insulation between the bars, allowing carbon and copper particles to collect and cause trouble. The less lubricant of any kind, the better. A very slight amount of vaseline, rubbed on the commutator and wiped off again immediately once a day, should be sufficient. Aim to get a hard, dark, glossy finish on the commutator and a good surface on the brushes, and then very little lubricant will be required.

F. M. FARMER.

Yes, if properly treated. Use mineral oil.

G. WILBUR HUBLEY.

Soaking in good machine oil or paraffin will help sometimes, depending on conditions and design of machine.

AUGUSTA RY. AND ELEC. CO.

*No. 12.—Are any combination gas and electric plants operating gas exhausters with electric motors? If so, with what results?*

*No. 13.—To what extent is the speed of a compound-wound motor affected under a widely varying load, say from one-eighth load to 20 per cent overload, while the voltage of supply remains practically constant? What change of speed would there be with a variation of from two to five per cent in the voltage?*

Compound-wound motors vary in speed from five to ten per cent under these conditions if cumulatively connected, but would run at very nearly constant speed if differentially connected. Much variation in voltage would cause a similar reduction in speed up to a certain limit, but speed would drop very quickly if the pressure dropped to 20 per cent of line voltage.

J. MANLEY.

Speed of motors with 80 per cent shunt and 20 per cent series winding varies 12 to 18 per cent with change from one-eighth load to 20 per cent overload. Variation in speed will be in same direction as variation in voltage and of slightly less magnitude.

E. P. COLES.

The amount of speed variation on a compound-wound motor due to changes in load varies greatly according to the motor field winding. If it has a heavy series and a slight shunt winding the change in speed under different loads is considerable, as the characteristics of the motor approach those of a series motor. On the other hand, if a motor has a slight series and a heavy shunt field winding, the change in speed under different loads is slight, as its characteristics approach those of a shunt machine. However, on a motor having 20 per cent series and 80 per cent shunt winding (the ratio generally used on standard compound-wound motors) the change in speed from one-eighth load to 20 per cent overload would be 12 to 15 per cent, provided the line potential remained constant. If the voltage, however, dropped, say, five per cent as the load comes on, the total variation in speed from one-eighth load to 20 per cent overload would be 14 to 17.5 per cent, but should the voltage increase five per cent as the load came on, the total variation would be only 10 to 13 per cent. In other words, with a constant load and a change in voltage of five per cent the speed would be affected from two to 2.5 per cent.

H. B. EMERSON.

It depends very much on how well the machine is designed. If the motor is differentially wound (that is, series coils opposing the shunt coils, as is inferred from the question) and the series coils are properly proportioned to the shunt characteristic, it should run pretty nearly at constant speed, just as a compound-wound generator gives constant potential.

With a given load at normal voltage, the speed will vary approximately as the voltage. The deviation from exactly the same variation will be due to the kind of load and the manner in which the current will vary in the armature and fields with change of voltage, for the speed is directly proportionate to the counter-electromotive force, which in turn depends on the drop in the armature and the field strength. If the load is such that increase in speed increases the current drawn from the line, an increase in voltage will cause the series coils to weaken the field, the shunt coils to strengthen it and the armature drop to increase. The first effect tends to increase the speed, the last two effects to decrease the speed. The net result would probably be slight, especially if the fields are near saturation.

F. M. FARMER.

*No. 14.—In a small plant, which can not afford a laboratory equipment, what is the best method of locating short-circuits or grounds in armature or fields of a direct-current generator or motor?*

With one voltmeter and a source of current, all of the ground tests may be performed. If a voltmeter is not available, a magneto may be used, especially in connection with a telephone receiver, although of course quantitative results can not be obtained by this method.

In bar-to-bar tests on armatures, for open or short-circuit, a galvanometer or low-reading voltmeter is desirable, but this test may be performed very satisfactorily with a telephone receiver in place of the galvanometer.

A. M., N. Y. ED. CO.

Use a magneto; or even better, connect 500-volt circuit in series with five 110-volt lamps, and use this to test out. A ground will be indicated by the lights becoming bright.

L. J. LISBERGER.

To find short-circuits in armature coils a very simple method is to connect two wires to a 110-volt circuit, connecting a 110-volt, 16-cp lamp in series and a low-reading voltmeter in parallel. By applying loose ends of wires to adjacent pairs of commutator segments, from the least deflection of meter needle it is found that the short-circuited coils are connected to these segments.

J. MANLEY.

Short-circuits may be detected by measuring resistance by means of volt and ammeter reading; grounds by means of test lamp or voltmeter.

E. P. COLES.

A small magnet made from the pole piece of a street-railway motor, excited by alternating current, is cheap and yet very handy.

AUGUSTA RY. AND ELEC. CO.

The simplest way to locate a short-circuit in the armature of a generator or motor is to drive the machine as a generator, separately exciting the fields, beginning with a low excitation and increasing same until you can smell heated conductors, then shutting down and ascertaining by feeling the coils where the short-circuits are. The trouble may be in the commutator, two bars of which may be short-circuited or grounded to the core, and it may be necessary either to disconnect the commutator from the armature winding and ring commutator to core or between bars to locate grounds or short-circuits. It could be also ascertained, as stated before, by driving the apparatus separately excited and noting the bars that are burned. These bars will lie adjacent to the burned commutator bars.

W. F. KINGAN.

Connect fields to be tested in series with direct current, using ammeter and voltmeter, and calculate resistance from indications. The drop around each coil can be measured in similar manner and a coil with short-circuited winding can be readily located. The test for a ground can be made by the use of a voltmeter to measure the leakage current between winding and core of fields or armature, and the location of ground can be determined by testing section by section.

Short-circuits in an armature in service will be indicated

by heating or burning of coils where trouble exists, or a test can be made by charging field from a direct-current source with armature circuit open; for example, remove brushes, and holding a piece of iron in hand, pass it around the armature in the magnetic field. The location of the short-circuit will be indicated by the pull on the piece of iron.

These simple methods of testing are fairly reliable where proper facilities for the test are not available.

G. WILBUR HUBLEY.

Short-circuits in the fields or armature can be located by the drop-of-potential method. Place a known resistance in series with the coils to be tested and pass a current through them. Take voltmeter readings across the different coils, and as the resistances are proportional to the deflections the short-circuit can be located. For locating a ground in armature, wrap a wire around the commutator and pass a current through this wire and the armature core. The ground can be located by a compass needle, as it is the place of greatest magnetization. For ground in field coil, connect source of current to ground and one terminal of field coil and take voltmeter readings between splices of field coils.

LOUIS I. PORTER.

*No. 15.—Why should a 125-cycle, single-phase dynamo on a one-mile transmission line give a better light than a 133-cycle machine operating over the same line and transformers with precisely the same voltage and conditions?*

Assuming that machines of 125 and 133 cycles generate precisely the same voltage, there will be greater loss in transmission at 133 cycles both in line loss and transformer loss, due to the inductance component of electromotive force being greater with higher frequency.

E. P. DILLON.

The transmission line will have less inductive drop with 125 cycles than with 133 cycles and consequently will give a higher terminal voltage with the lower frequency, the initial voltage being the same in both cases. Possibly the station voltmeter in question is affected by frequency or wave form in such a way

that the actual initial voltage is higher with 125 cycles than with 133 cycles, although the voltmeter indication is the same in both cases.

E. M. TINGLEY.

The lower frequency current produces less inductive drop in line and transformers.

M. P. R., N. Y. ED. CO.

The reactive drop of transformers and line increases directly with the frequency, other factors remaining the same. Therefore the voltage at 133 cycles would be lower than at 125, and consequently the light would be poorer.

M. C. T.

Reactive drop in line and transformers is less at 125 cycles than at 133.

E. P. COLES.

Because the inductive effect on lines is less on the lower frequency.

CHAS. H. PETERS.

*No. 16.—How is the capacity of a three-phase alternator computed from its current and voltage?*

Each leg of a three-phase generator feeds two phases, but the rating in current is given as the amount that will flow in each leg when generator is loaded. The amount of current in each leg is not, however, the sum of the current of the two phases that the leg feeds; it is 1.73 times the current in one phase. Call  $C$  the rating in amperes (which is current in one leg), divide  $C$  by 1.73, and you get the full-load current in one phase. Multiply the quotient by the voltage rating, and you get the capacity of one phase. Multiply this last result by three, and you get the capacity of three phases, or the total capacity. Let  $C$  equal rating in current and  $E$  the rating in voltage; then

$$\frac{C}{1.73} \times E \times 3 = \text{capacity.}$$

The capacity thus obtained is for a purely non-inductive load.

GEO. B. LAUDER.

If the amperes and volts of a three-phase generator are given, the watt capacity can be computed by multiplying the

two together, and the product thus obtained by the square root of three, which it is usual to take roughly as 1.73.

JAS. B. FOOTE.

$KW = \sqrt{3} EC$ .  $C$ , the current in each of the three legs, and  $E$ , the voltage across any two.

C. F. HAYWOOD.

According to Foster's "Electrical Engineer's Pocket Book," page 233, "In any balanced three-phase system the energy is equal to the product of the electromotive force between any pair of mains and the current in one main, by  $\sqrt{3}$ ; the result being multiplied by the cosine of the angle of lag; that is, the power factor.

WILLIAM R. GARDENER.

In a three-phase Y-connected generator: Current per phase by voltage  $\times \sqrt{3} \div 1000$  will give kilowatt capacity of  $\times$  generator.

J. MANLEY.

Let us consider a three-phase alternator to be composed of three single-phase machines, then its output will be equal to the sum of the outputs of the three phases.

In a Y-connected armature:

Let  $e$  = e.m.f. per phase.

Let  $i$  = current per phase.

Let  $w$  = energy per phase.

Let  $E$  = e.m.f. between the mains.

Let  $W$  = energy of generator.

Then, energy of each phase =  $ei$ .

(1) Total energy of generator =  $W = 3ei$  (1).

But  $E = \sqrt{3} \times e$  or  $e = \frac{E}{\sqrt{3}}$ .

So that (1) becomes  $W = 3ei = \frac{3 \times E \times i}{\sqrt{3}} = E \times i \times \sqrt{3}$ .

Similarly in a delta-connected armature:

Using the same symbols as before we have:

$w = ei$ , and  $W = 3ei$  (1), but  $E = e$  and  $I = \sqrt{3}i$  or  $i = \frac{I}{\sqrt{3}}$ .

So that (1) becomes  $W = 3ei = \frac{3EI}{\sqrt{3}} = EI\sqrt{3}$ .

Thus we see that, irrespective of whether the armature is connected Y or  $\Delta$ , the output of the generator is found by taking the product of (1) the volts between mains, (2) the current in one main, and (3) the square root of 3. This is, however, assuming that the load of the generator is entirely non-inductive or that the power factor is unity, which is very rarely the case in actual practice. To correct for this, the result obtained by above formula should be multiplied by the power factor of the load, which is expressed in per cent and generally designated as  $\cos. \phi$ ,  $\phi$  being the angle of lag of current behind voltage. So that our final formula becomes

$$W = E \times I \times \sqrt{3} \times \cos. \phi.$$

M. C. T.

Capacity in kilowatts for three-phase generator, either delta or star-connected, is

$$KW = \frac{V \times C \sqrt{3}}{1000} \times PF.$$

V = volts as indicated by voltmeter.

C = current as indicated by ammeter.

PF = power factor in per cent (that is, expressed as a fraction of 1).

F. M. FARMER.

The capacity in watts of a three-phase alternator, computed from the full-load current and voltage for which the machine is designed, is based on the alternator operating at 100 per cent power factor; that is, the watts = volts  $\times$  amperes  $\times$  1.73. To compute watts generated by a three-phase alternator, it is necessary to know definitely the power factor and to introduce this into the equation; that is, watts = volts  $\times$  amperes  $\times$  power factor  $\times$  1.73.

E. P. DILLON.

A simple way to remember the current output of the three-phase generator is that the current per terminal is 15 per cent greater than in a two-phase generator of the same capacity and voltage. A 200-kw, 1000-volt, two-phase generator will have a current of 100 amperes at each of the four terminals, while the same generator wound for three-phase will have 115 amperes at each of the three terminals. Therefore, to compute the

capacity of the three-phase generator in watts from current and voltage, divide the current per terminal by 1.15 and multiply the result by twice the voltage.

E. M. TINGLEY.

The capacity in kilowatts =  $C \times V \times \sqrt{3}$ .

W. T. M., N. Y. ED. CO.

*No. 17.—In case of a damaged coil in the armature of an alternating-current generator, should the wire be removed entirely, or is it sufficient merely to cut it out and bridge the adjoining coils?*

If coil is damaged so that the convolutions are in electrical contact, it should be removed, to prevent local currents from circulating in the coil itself.

GEO. B. LAUDER.

The damaged coil should be removed if possible; if not removed it should be carefully insulated so that it is not short-circuited on itself, or excessive heat will be generated.

L. E. WATSON.

Cut out coil and bridge the adjoining coils. Removing coil will not only do no good, but will unbalance armature.

B. A. SCHAK.

Cut damaged coil out, bridging the adjoining coils. If the damaged coil is injured so that there is a local circuit in it, it will have to be cut out entirely and the vacant space filled with something to balance armature.

A. PETERS.

A damaged coil in an alternating-current generator armature in which all the coils are in series may be cut out by bridging. As to whether or not the defective coil is to be removed depends upon circumstances. If the coil contains a short-circuit the coil should be removed and cleared of the short-circuit. In the two-circuit or continuous type of armature winding, one coil supports another at the ends of the armature, and in this case it is best to leave the injured coil in place if possible. In an armature having two or more circuits in parallel, the

effect of cutting out one or more coils on unequal heating of the armature winding should be closely noted.

E. M. TINGLEY.

The coils could be left in provided they are clear from short-circuited turns, otherwise they must be removed.

W. T. M., N. Y. ED. CO.

The wire of a damaged coil in an alternating-current armature should be removed entirely, as it would act as a coil short-circuited on itself.

EDW. NEUMANN.

To make quick repair, disconnect coil and bridge adjoining coils. It would be better practice to remove coil entirely.

J. MANLEY.

We have run one of our alternators with parts of the coils cut out, the dead wires remaining in place.

S. S. INGMAN.

The damaged coil should be removed, as it is liable to heat and injure the good coils adjoining it.

JOHN A. WILSON.

At least one large company specifies that it is sufficient to cut out, remove and bridge the damaged coil.

AUGUSTA RY. AND ELEC. CO.

Temporarily it is sufficient to merely cut it out. Coil must be left entirely open-circuited.

E. P. COLES.

*No. 18.—Why does the commutator of a Wood dynamo tend to burn at the bars opposite the armature spider arms?*

I have not observed this to be the case. It is probably due to some local defects.

G. WILBUR HUBLEY.

*No. 19.—Are 60-cycle, double-current generators commercially satisfactory for lighting service where load is reasonably uniform?*

We have been using 60-cycle, double-current generators for seven years and have obtained very satisfactory results for

lighting and power work on the direct-current side. Have had some motor work on the alternating-current side, which has been operated under steady load. Have not taken on any motors for intermittent power, such as elevator work, on alternating-current circuit.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

It is best to avoid the use of 60-cycle, double-current generators where possible. They will require more care and attention than 60-cycle rotaries, and the commutation will be sensitive to the effect of an alternating-current load.

E. M. TINGLEY.

Yes.

W. F. KINGAN.

Properly-designed 60-cycle, double-current generators having good inherent regulation should be commercially satisfactory under the above conditions. Machines with weak fields and poor inherent regulation will probably not be satisfactory, for the same reasons that ordinary alternators with weak fields and poor inherent regulation would not be satisfactory.

CLARENCE RENSHAW.

No. For 60-cycle service the high speed and large number of poles are such that it results in a very undesirable machine.

P. JUNKERSFELD.

Yes.

E. P. COLES.

We have a 400-kw machine that is satisfactory on a steady load.

AUGUSTA RY. AND ELEC. CO.

*No. 20.—Assuming compound-condensing Corliss, or equally economical engine, and dynamo units of 200 to 300 kilowatts, will the annual operating economy with direct-connected dynamos be sufficient to offset the additional fixed charges over direct-belted units? Hours of service 7000 annually and average load factor 40 per cent.*

If economy in fuel is the only consideration, direct-belted units may have the advantage. If the buildings and space are

very valuable, the direct-connected unit will surely be the proper one to install.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Theoretically, yes; practically, no.

GEO. L. COLGATE.

Assuming the direct-belted unit to be in good condition—no.

G. WILBUR HUBLEY.

In our opinion, the annual operating economy with the direct-connected dynamos will more than offset the additional fixed charges over belted units.

E. H. MATHER.

Yes.

W. F. KINGAN.

Do not think it would.

E. P. DILLON.

*No. 21.—What is the loss in efficiency in using carbon brushes instead of copper gauze on 125-volt, direct-current generators? Is there any modified type of carbon brush or mode of treating carbon brushes that will obviate this loss?*

There is a brush now on the market, made partly of carbon and partly of copper, which will to a great extent increase the efficiency of the carbon brush.

B. A. SCHAK.

Carbon brushes may be made with copper gauze interwoven in the carbon.

AUGUSTA RY. AND ELEC. CO.

*No. 22.—What precautions are necessary in coupling and operating two direct-belted alternators, of same design and make, in multiple?*

Assuming that the generators are somewhere near the same capacity, and are driven by units of somewhere near the same capacity, there ought to be little trouble in paralleling the generators. Care should be taken to have the phasing device prop-

erly connected. If each alternator has its own exciter, the exciters might to advantage be run in parallel, so that each generator will be subject to the same variation in exciter voltage; this does not seem to be necessary.

GEO. B. LAUDER.

Assuming that they are run from different engines: First, the engines must receive the same attention, and must work the same under the same conditions. Second, the ratio of speeds and the slip of the belts must be equal. Then with a good synchronizing instrument or outfit there should not be any further trouble. I should recommend that the generators be excited from same exciter.

W. J. C., N. Y. ED. CO.

Assuming that the questioner means that both alternators are to be coupled to the same prime mover, care should be taken to have like phase conductors of the two machines occupying exactly the same position with respect to the field poles in each machine, so that the alternating waves of the two machines will be exactly in phase with each other. The phases must be connected so as to have the same rotation in each machine.

R. F. SCHUCHARDT.

The great trouble in multiple operation of direct-connected or direct-belted alternators is a tendency to an oscillation in their relative motions. If belted to the same source of power, good operation depends essentially upon the *exact* adjustment of pulleys and belts and the belt tension and friction. Even where pulleys are of exactly the same dimensions a slight difference in belt thickness may cause heavy cross-currents. If machines are run from a jack shaft energized by two or more engines, great attention should be paid to the correct design of the flywheels. Too small a flywheel will give a fluctuation that might amount to serious trouble if synchronous apparatus were on the line, while too large a wheel might cause the engines to act independently so far as the angular variations are concerned. The best thing to do is to synchronize the engines themselves, so that the impulses may come together. The amount of angular variation should not exceed two and one-half degrees of phase variation. The angle of circumference that corresponds to this

variation can be found by dividing two and a half by one-half the number of poles; thus, in a 20-pole machine the maximum variation from the *mean* would be  $\frac{2.5}{10}$  of one degree.

C. F. HAYWOOD.

Each machine must deliver its proportion of current to the line, and in order to do this they must work together in synchronism. The voltage of both machines must be the same all the time. If this is not the case, the moment that one machine falls in voltage the other machine will send current through it, with the possibility of turning it into a motor. The speed of machines should be adjustable while in motion. This is usually accomplished by an adjustable weight attached to the engine governor. With similar generators the engines must run at the same speed and have equal regulation. As a general thing, high-speed engines will run generators in parallel more successfully than slow-speed engines will.

WILLIAM R. GARDENER.

Get voltages, phase relations and frequency the same.

E. P. COLES.

Provide good, wide belts and good dynamo foundations, be sure of good engine regulation and use care in synchronizing. Good belts will withstand the exchange of synchronizing effort between machines, and for machines of moderate size base rails are advisable. Good engine regulation is necessary under varying load conditions, in order to reduce cross-currents.

It is understood, of course, that when all electrical construction work has been completed correct electrical rotation must be proven and synchronism must be secured before machines are paralleled. A lamp test is sufficient for testing rotation, but a dial synchronizer is preferable to lamps for synchronizing.

B. JAMIESON.

*No. 23.—To what extent will a three-wire dynamo, equipped with one commutator and balancing coil, stand unbalancing of load on the two sides of the system?*

Twenty-five per cent.

GEO. L. COLGATE.

The machine should be balanced exactly, but as this is an impossibility in practice I have seen them operating with a difference of 25 per cent. It frequently has a tendency to raise the voltage of one of the machines above its normal rating, with consequent danger from that source. W. F. KINGAN.

*No. 24.—Have alternating-current motors been used satisfactorily for crane and hoist work when supplied from lighting circuits?*

Cranes or hoists of any considerable capacity can not be operated without causing voltage to fluctuate. If they are liable to be used frequently in lighting hours they will not be found desirable loads for lighting circuits. GEO. B. LAUDER.

Alternating-current motors in large hoists, in sizes of from 25-hp up, are very liable to materially affect the voltage regulation on lighting circuits fed by the same system. E. P. DILLON.

The use of motors on lighting circuits is unsatisfactory. Not because of the design of the motor, or whether alternating current or direct current, but simply because of the variable load that is thrown on and off on a circuit not having sufficient copper or sufficient generating capacity. Where conditions are favorable for throwing on and off suddenly, then not only alternating-current motors, but direct-current motors, have been used satisfactorily for crane and hoist work. CALVIN W. RICE.

Yes, even on small generators, from 300-kw to 400-kw capacity, provided that all motors of 10-hp and over have a proper resistance in the armatures. Automatic generator and feeder regulators will make considerable improvement. W. T. M., N. Y. ED. CO.

No. Crane service means a constant starting and stopping of motors, which means a disturbing of the regulation of the

line and jumping of the lights. Friction clutches with a constant-running motor will help conditions. J. MANLEY.

When alternating-current motors used for crane and hoist work are connected to a lighting circuit, the heavy starting currents used cause serious trouble in the regulation of these circuits, unless copper in lines and capacity of station are comparatively very large. W. F. SIMS.

It is a very difficult matter to operate alternating-current motors for crane and hoist work from a lighting circuit and prevent a fluctuating voltage at the lamp terminals. E. H. MATHER.

Yes; when station is equipped with Tirrell regulator. E. P. COLES.

*No. 25.—How can compound-wound, direct-current generators of different types and sizes running in parallel be made to divide the load automatically?*

If the difference is small, it may be compensated by means of the hand regulator, but if large, then German silver or copper-ribbon resistance should be inserted in series with the series coils of the dynamos. The work done by each machine may then be increased or diminished by varying the resistance and each machine be made to take only its own share of the load. WILLIAM R. GARDENER.

The series winding of all machines must have the same drop to bus-bars when the current for which each machine is rated is passing through the series coils of that machine. A. PETERS.

My experience has been that with 75-kw General Electric compound-wound, multipolar, 125-volt, direct-current machines operating in parallel with 33-kw Thomson-Houston bipolar, compound-wound, 110-volt, direct-current machines, the larger machines have a tendency to carry more than their share of the load. To make them divide the load automatically I remove the

shunts of the smaller machines so that their series coils compound at full strength, and, then by increasing or decreasing the resistance of the shunts to the series coils on the larger machines, make them divide the load automatically with the smaller machines.

F. W. BULLOCK.

By making their *percentages* of over-compounding the same, by arranging shunt across series field.

C. F. HAYWOOD.

Compound-wound machines of different size and make can be made to divide the load automatically by using shunts of proper capacity and resistance across the series winding.

JOHN A. WILSON.

Put machines in parallel under full load and adjust rheostat until they divide the load equally and the voltage is right at the centre of distribution. This means the pressure at 'bus-bar. Call this *A*; next, run one dynamo without any load and adjust rheostat until voltage equals voltage of lamps. Put on full load and adjust shunt in field winding until 'bus pressure equals *A*. This must be done without moving field rheostat. Do the same with other machines, and they will divide load equally.

J. MANLEY.

By adjustment of shunts on series fields, and maintaining correct speeds.

E. P. COLES.

When the voltage curve from no load to full load of both machines is the same, they will divide the load automatically if speed is kept constant.

AUGUSTA RY. AND ELEC. CO.

By first adjusting all the machines individually for the same degree of compounding, either "flat" or "over" as desired, and then adjusting the resistance of each series field circuit (by inserting cable in series if necessary) inversely as the capacity of the machine. That is, with one machine as a standard and requiring no change, another machine with half the capacity should have twice as much resistance in its series circuit.

F. M. FARMER.

By shunting some of the current from series field winding of stronger machine through a resistance connected in parallel with it; or, by adding turns to series field winding of weaker machine.

M. P. R., N. Y. ED. CO.

Compound generators can be made to operate in parallel, dividing the load proportionally and automatically, by using the usual equalizer connection.

The generators will most probably have different characteristic curves, but can be regulated as a rule through the medium of the shunt field. Often good results can be effected by the removal or addition, as the case may demand, of some of the resistance of the shunt across the series field.

L. J. LISBERGER.

*No. 26.—Is it advisable to connect in multiple both the alternating-current and the direct-current sides of rotaries in substations?*

It is not advisable to connect both the alternating-current and the direct-current ends of rotaries operating in parallel, on account of the liability of currents between the rotaries. The alternating-current ends should be fed from separate transformers, or from transformers having separate secondaries.

E. M. TINGLEY.

It is seldom good policy to put all your eggs in one basket. A substation consisting of a number of units should be sectionalized on the alternating end and be fed by two, or perhaps three, transmission lines, depending upon the number of units in the substation and the importance of the substation. Each line should feed a group of the units, and the switching arrangement should be made flexible so that any or all of the units can be operated from any of the lines entering the substation.

On the direct-current side the rotaries generally feed into a common system and are thus in parallel with each other.

R. F. SCHUCHARDT.

They should operate satisfactorily connected this way.

E. P. DILLON.

It is advisable to operate rotaries with both alternating-current and direct-current sides in parallel. Have operated several successfully in this manner for several years.

R. W. ROLLINS.

See answer to Question L—2.

C. F. HAYWOOD.

Yes.

E. P. COLES.

No. Rotary converters have been and are still operated satisfactorily in this way, but it is no longer considered good practice. When rotary converters are thus connected there are likely to be large cross-currents through the alternating-current and direct-current connections, unless the characteristics of the machines are identical at all loads.

CLARENCE RENSHAW.

There can be no objection to coupling rotaries in substations in multiple on both alternating-current and direct-current 'busses. As a matter of insurance, however, it would be preferable to subdivide rotaries into groups in a substation, operating the groups from separate sources of supply as much as possible, as in this way troubles with individual lines or machines would not affect such a large part of the substation capacity.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Running rotaries in parallel on the alternating and direct-current sides is advisable for the following reasons:

Economy in units necessary to carry peak load; in feeder capacity and switching to take care of substation; in keeping units at most economical load and in steady running of units, but is *not* advisable in regard to reliability of service.

S. O. SWENSON.

No.

S. D. S., N. Y. ED. CO.

*No. 27.—Have three-phase, 60-cycle, alternating-current motors been successfully applied to passenger-elevator work?*

We have three-phase, 60-cycle, alternating-current motors on elevator service, under both mechanical and electrical control. They are giving good satisfaction on their special kind of service (slow-speed passenger). However, we are supplying alternating-current motors only in places not accessible to our 500-volt, direct-current system. E. P. DILLON.

Yes; if you will kindly address the writer he will give full details. CALVIN W. RICE.

Yes. Three-phase motors operate just as well as two-phase for such purposes. W. T. M., N. Y. ED. CO.

We have several operating on our system, and they are all giving fairly good service. J. MANLEY.

Three-phase, 60-cycle, alternating-current motors have been successfully used for passenger-elevator work. A number of them are now in operation on the system of the Commonwealth Electric Company, Chicago, Ill. W. F. SIMS.

*No. 28.—What is the approximate resistance of the armature and of the field of a 75-hp street-railway motor? What is the resistance of the rheostat used in starting same?*

*No. 29.—What is the best method of operating passenger elevators from a three-phase, alternating-current system?*

If you will address the writer he will be pleased to give detailed information regarding this.

CALVIN W. RICE.

We presume that a lighting system with comparatively small generators is referred to. Experience leads us to believe that elevator motors of over 10 horse-power should never be installed without a resistance in the armature; that tests should be made on all new installations of 10 horse-power and over

to see that the controllers work properly and that the motors do not take abnormal currents in starting. Regular inspections are also necessary to see that the regulating devices have not changed. Ampere readings should be made on all inspections. The condition of all parts of the controller should be carefully investigated. Owners should be notified as to what changes in adjustment are required; also what repair parts should be kept on hand. It has often been necessary to improve the regulating devices on controllers. This has been done by tests and supervision, getting the elevator company to make such changes as may be necessary to get the best effects on lighting circuits when starting.

W. T. M., N. Y. ED. CO.

From the central-station point of view, the most satisfactory way of operating passenger elevators from a three-phase system is to install the motor with clutch or shifting pulley, so that the motor can acquire full speed before the elevator load is thrown on.

E. H. MATHER.

Perhaps the most reliable, but not cheapest in first cost, is the method of using a motor with rheostatic control and geared to drum.

E. P. DILLON.

Alternating-current motors having the same characteristics as direct-current series motors are now on the market, and such motors offer the best means of operating elevators from alternating-current systems.

Elevators may be operated by induction motors if desired. If this is done, the motors should be connected to separate transformers. The effects on the secondary circuit that are caused by the inductance of the transformer and the drop in the secondary leads will then be limited to the motors only. Even with series alternating-current motors it is better to use separate transformers.

CLARENCE RENSHAW.

Magnetic or mechanical clutch interposed between armature shaft and worm.

W. F. KINGAN.

*No. 30.—In economic operation of a unit in the central station where for a considerable number of hours the generating*

*apparatus is operated with but one-sixth to one-fourth of full load, would it not result in a large saving of fuel and wear and tear to install a unit of one-fourth capacity, with the same steam supply, to carry the small load? Is it not considered good practice, therefore, in the small station to have two units in this proportion; and what is found to be the comparative cost of operation?*

Generally speaking, we would recommend it, but it depends greatly on local conditions.

TOLEDO RYS. AND LT. CO.

It would result in a large saving of fuel and wear and tear to install a unit of capacity sufficient to carry the smaller load without crowding.

THE B. F. GOODRICH CO.

A compound Corliss condensing engine of medium size will consume about 18 pounds of steam per horse-power at full load, while at quarter load the consumption will be between 45 and 50 pounds of steam. If a small engine were used to carry the light loads, the steam consumption would be in the neighborhood of about 22 pounds per horse-power. Therefore it is much more economical to have two units running, each as near full load as possible, and the cost of operation is about one-half as great; cost of operation including only the variable generating expense, such as coal.

C. W. HUMPHREY.

Yes; it is more economical to provide two units under the conditions of variable load as noted. The small unit to take care of the light load over the greater part of the day and the larger unit to be used for peak-load period. The generator should be loaded under maximum-load conditions to at least 50 to 75 per cent of its capacity.

G. WILBUR HUBLEY.

It is good practice in any station to have two or three units, and in most cases it is desirable to have the units of the same size, so as to maintain uniformity of station design

and minimize the supplies and repair parts. Under this plan the station can operate with fair economy under light load, and in case of breakdown in one unit a portion, if not the whole of the load, can be carried by the balance of the equipment.

E. H. MATHER.

It certainly is good practice to have flexibility in a plant and to be able to adapt units in service to load demand. The cost of operation in such a plant should be greatly reduced.

E. P. DILLON.

*No. 31.—When motors are operating continually for refrigerator or pumping stations, what is the most practical safety device to use in connection with three-phase motors to protect them from burnouts from single-phase current in case a fuse blows?*

Use a circuit-breaker that opens the circuit upon failure of current upon any phase.

GEO. L. COLGATE.

The simplest and best way to prevent three-phase induction motors, operating under continuous service, from burning out on account of fuse blowing so that the motor runs single-phase, is to make the capacity of the fuses so small that they will blow for any considerable increase in current over full load. The only cause of the burning out of the motor is excessive current in its winding, regardless of whether that current is three-phase or single-phase, and if fuse is properly proportioned the motor can never carry excessive current long enough to be injured. This can easily be arranged where motors are operated under continuous service, since a motor with resistance in its armature will not take sufficient current in starting to blow the fuses, and a motor with squirrel-cage armature can be arranged so that the fuses are in circuit only after it has reached full speed and not during the time that the starting compensator switch is in its starting position.

(UNSIGNED.)

Where three-phase motors are operating continuously without an attendant, two sets of inclosed fuses can be installed in parallel and both used in starting the motor, but one set only

left in circuit after the motor acquires full speed. The capacity of the fuses left continuously in circuit should be only sufficient to carry the motor at normal load. The blowing of one fuse would then result in throwing an excessive amount of current on the remaining two, which would open either one or both and shut the motor down.

E. H. MATHER.

*No. 32.—What is the relative cost of maintenance of induction motors and of direct-current motors in general city service?*

It is impossible to give actual figures on cost of maintenance of motors, since this item varies so much under different conditions. In general, it may be said that where proper care is taken of the motor practically the only cost of maintenance in induction motors with squirrel-cage armatures is a very occasional renewal of the bearings. In most motors having resistances in their armatures in starting, an occasional renewal of contact pieces for the resistance short-circuiting switch is necessary. These contact pieces are used, however, only when the motor is being started, whereas with the direct-current motor the brush and commutator are in use, not only during the process of starting, but all the time that the motor is running. For this reason, and also since there is always danger of dirt and moisture collecting in the armature winding, the potential of which is always greater than that of an induction motor, the cost of maintenance in direct-current motors is found to be at least several times that of induction motors.

(UNSIGNED.)

We have about 600 horse-power in induction motors, most of them having been in use for the past three years, and have yet to hear of any of our customers or of ourselves expending any money for repairs.

F. C. S., MALDEN ELECTRIC CO.

Induction motors with cage-wound secondaries should cost less to maintain than motors of any other type, either direct or alternating-current. Induction motors with movable contacts and starting devices incorporated in them should be no more expensive to maintain than direct-current motors. The expense

of maintaining such motors will usually be greater for the starting devices than for the motor itself.

CLARENCE RENSHAW.

The relative maintenance cost of induction motors having outside resistance to direct-current motors, is as about four to one in favor of the former.

W. F. KINGAN.

Cost of maintenance of induction motors under average conditions will be about 25 per cent less than of direct-current motors.

G. WILBUR HUBLEY.

Two years' experience with a large capacity in induction motors in use in customers' premises has resulted in practically no repairs being required. Up to date, a comparison of the repairs on both direct and alternating-current motors would be in the ratio of 100 to 1 in favor of the alternating-current motors.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 33.—In starting the direct-current side of a double delta or a diametrically connected rotary converter that has the transformer and regulator permanently connected, the transformer and regulator windings act as a short-circuit on the direct-current brushes. What is the best method of reducing the current at the instant of starting? What results are obtained in practice by the method described?*

We would recommend that switches be installed in alternating-current conductors between rotary, transformer, regulators, etc., and left open until rotary is up to speed, or nearly so.

TOLEDO RYS. AND LT. CO.

Switches should be placed between the low-tension side of the transformers and the rotary converter, in order to avoid the trouble here mentioned. This means synchronizing on the low-tension side, which is the standard practice of our manufacturers.

(UNSIGNED.)

*No. 34.—What are the objections to grounding the neutral of a high-tension, three-phase, star-connected generator?*

The objections to the grounding of a neutral high-tension, three-phase, star-connected generator are principally because of

the fact that a ground on the system is the same as a short-circuit.  
(UNSIGNED.)

One objection to grounding the neutral of a high-tension, three-phase, star-connected generator is the liability of damage from lightning.  
E. H. MATHER.

We operate our 4000 and 2300-volt, four-wire, three-phase system with ground on the neutral at the station.  
TOLEDO RYS. AND LT. CO.

*No. 35.—Two star-connected, three-phase generators of same capacity running in parallel with grounded neutral show a neutral current proportional to the difference in load on the two machines. This current does not appear in the ammeters on the phase wires of the machines. What is the nature of this neutral current, and what is its course through the winding of the two machines?*

This current is probably caused by a distortion of the wave form and the appearance of harmonics, and is a short-circuit through the windings of the two machines.  
(UNSIGNED.)

*No. 36.—How do currents in the grounded neutrals of star-wound generators affect operating conditions? How can they be eliminated?*

Unless these currents are excessive, they will probably have little or no effect on the operating conditions. They can be eliminated by using the generator that gives a perfect sine wave and that remains undistorted throughout the operation, something very hard to obtain.  
(UNSIGNED.)

*No. 37.—Can two generators driven by rope drives from the same shaft be synchronized independently?*

*No. 38.—What has been your experience with alternating-current induction motors in connection with derrick hoists; are*

*they efficient, and can loads requiring careful lifting, such as flasks in a moulding shop, be lifted without damage?*

The most common type of induction motor used in derrick hoisting is that with collector rings and external armature resistance, which is short-circuited by means of a controller. With a reasonable amount of resistance and number of controller points, it becomes possible to handle with most extreme delicacy any load that the motor may be required to lift. The efficiency is low at low speeds, but since it operates at low speed during only a small portion of the time, this objection is seldom appreciable.

(UNSIGNED.)

Comparisons have been made with hoists equipped with both alternating and direct-current motors, which have shown results slightly in favor of the alternating-current motors. In no case where direct-current equipments have been changed to alternating-current have any results been obtained that tend to show that the alternating-current motors were less efficient than the direct-current. Equipments furnished with drums and band brakes have been able to do careful work successfully.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 39.—Have you any installations of air-compressors direct-belted to alternating-current three-phase motors with automatic starter and stopper? If so, has the customer had any trouble with such installations? Are they efficient and reliable?*

It is never considered good practice to install induction motors for operating air-compressors where the air pressure is regulated by starting and stopping the motor automatically. All manufacturers of air-compressors now supply an automatic by-pass attachment, which relieves the pressure in the cylinder by opening certain valves when the pressure in the reservoir reaches a certain limit, and in this way the compressor and motor can be operated continuously with much better satisfaction and higher efficiency than if required to start and stop with variations of pressure.

(UNSIGNED.)

*No. 40.—How does the efficiency of induction motor speed control compare with the efficiency of direct-current motor control?*

Where variation in speed of induction motors is obtained by inserting resistances in the armature circuit, the efficiency is practically the same at all speeds, as in the case of shunt-wound, direct-current motors with resistance in their armature circuits, and the efficiency varies practically in proportion to the speed for a given torque development. Where speed control is obtained by the use of high-resistance armature winding and variation of potential applied to the field, the efficiency at various speeds is slightly less than in motors with variable resistance in the armature circuit. Where variation in speed is obtained by changing the number of poles or the frequency of the circuit, the efficiency is practically the same at reduced speeds as at full speeds. (UNSIGNED.)

For constant-speed work the efficiency of control during starting and acceleration of the induction motor is practically the same as that of the direct-current shunt motor. For variable-speed work, the direct-current shunt motor can be controlled by varying the field current, and speed control obtained in this way is much more economical than speed control of the induction motor. Speed control of the induction motor during starting and acceleration is comparable with the direct-current shunt motor, and is therefore less economical than that of the direct-current series motor. In general, the speed control of an induction motor is similar in efficiency to the speed control of a direct-current shunt motor by means of resistance in its armature circuit. CLARENCE RENSHAW.

*No. 41.—Is it a fact that the air-gap at the top between armature and frame of large engine-type generators is considerably greater when machine is not running? If so, what is the explanation?*

I do not know that this is a fact of general application, but can give an instance of one particular case where it was a fact and my conclusions at that time regarding the explanation.

Several years ago circumstances rendered it advisable for me to direct-connect a 264-kw revolving-field, three-phase generator, with an air-gap of approximately five-thirty-seconds of an inch, to a centre-crank engine, designed for belting, and operating at a speed of 225 rpm. To do this, the stationary armature was set up on an extension of the brick engine foundation, the belt pulley was removed from the engine, and the fields, which were of practically the same weight and outside diameter, were substituted therefor. As the general opinion seemed to be that this arrangement would be rather hard on the main bearings of the engine, owing to the fact that there was no out-board bearing, we started with the boxes on this side a trifle loose and the fields set slightly above the centre of the armature. Upon starting, the fields promptly jammed over against the upper forward quarter of the armature. We shut down the engine, raised the armature until the fields were in a position slightly lower than the armature centre and set the boxes down considerably harder than we would have done for a belt drive. With this arrangement we had no trouble with the set, and the fields appeared to come into their proper position in the centre of the armature; it was necessary, however, to keep the boxes down tight to prevent the fields from lifting. The only explanation that we could give of this tendency to rise on the part of the fields was that the entire push of the engine on the crank shaft came in that direction, as will be seen by tracing out the effects of the push due to the connecting rod acting on the crank pin. With an engine running under, I think that these conditions would have been reversed.

E. P. COLEMAN.

*No. 42.—What is the usual energy consumption of refrigerating machines per ton of refrigerating capacity? Also kw-hour consumption per ton per season in northern states?*

*No. 43.—What is the energy consumption per car-mile of high-speed hydraulic electric-driven elevators?*

*No. 44.—Can an ordinary modern-type, 500-volt, compound-wound, direct-current generator be easily changed to feed into a three-wire system? Can the armature be tapped out to a slip ring, and in this case will the generator work satisfactorily*

*under out-of-balance conditions, and how much out of balance must the system be to cause serious sparking?*

Our only experience in this line has been to operate 500-volt generators on three-wire system by cutting out series coil and separately exciting for 250-volts. With this arrangement we have carried 140 per cent of rated ampere capacity, furnishing current to the outside wires on the three-wire system.

TOLEDO RYS. AND LT. CO.

*No. 45.—In operating two machines in series on the Edison three-wire system, how nearly balanced should the negative and positive be? If unbalanced on either side, would it have a tendency to affect the operation of or injure the machines?*

Two generators in series operating an Edison three-wire system, will not be injured by unbalancing so long as they are not overloaded. The perfect operation of the system is not interfered with by unbalancing so long as the neutral conductors are of sufficient size to properly carry the current represented by the amount of unbalancing.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

My experience in operating two Edison bipolar shunt-wound machines in series on the Edison three-wire system with an unbalanced load has been that a difference in load does not affect the operation of or injure the machines so long as they are not overloaded. In fact, while thawing water-pipes this winter I operated a 60-kw. bipolar Edison for a period of from six to eight hours at a time with 400 amperes on it, while the one in series with it had only about 40 amperes on it, with no bad effect on either machine.

C. J. ABBEY.

*No. 46.—The writer was called to repair a motor that operated a coffee mill. The machine would run and pull the load, but the brushes were throwing fire terrifically, and on one or two occasions the current leaped from brush to brush. Upon examining the armature, it was found to be in perfect condition and the fields were found to be open. The motor was shunt-wound and free from grounds and connected up properly.*

*and would continue to run when the upper half of the frame and one field coil were removed, but would pull no load as it did when these parts were in place. Why did it run with the fields cut out?*

The armature current would induce magnetism in the iron of the fields through the magnetism of the armature core. This magnetism in the iron of the fields would be fairly weak compared with what it would be when excited by shunt winding; consequently, the motor armature having very little counter-electromotive force, the current would be large, causing bad sparking. When the half of field was taken off there was that amount of iron taken away, consequently there was a diminished magnetic field and correspondingly diminished torque. The very low counter-electromotive force will account for the inability to pull the load, as possibly a portion of the resistance had to be left in armature circuit, and this kept the current within limits.

A. PETERS.

Because the armature induced a comparatively weak field of opposite polarity in the field pole or poles, and because of the weak field abnormal armature current was required, which caused the severe sparking at the brushes.

S. D. S., N. Y. ED. CO.

## M

### STORAGE BATTERIES

*No. 1.—How can one tell when a storage battery is fully charged?*

A battery may be considered completely charged when with constant current flowing the voltage reading has remained steady for a period of not less than 15 minutes.

B. A. SCHAK.

When the current is constant and the electromotive force of each cell ceases to rise, also when the specific gravity of electrolyte ceases to rise.

A. PETERS.

*First*—When the specific gravity ceases to rise.

*Second*—When the voltage curve becomes flat.

*Third*—When both oxygen and hydrogen gases are given off when charged at the normal rate. Upon the method of operation depends the use of one or all of the above methods.

S. C. H., N. Y. ED. CO.

The surest way to tell when a storage battery is fully charged is by watching the voltage of a number of cells that have been in circuit during the whole charge. Near the end of charge the voltage rises very quickly until it reaches a point where it rises very little. About 15 minutes after this point is reached the battery will be fully charged. It is necessary, especially for the last half hour, to keep the charging current constant, because otherwise the voltage readings will vary with the current. When recording voltmeters are in use with the battery the point of the end of charge is easily found. If it is possible to take specific gravity reading on pilot cells, the end of charge will be indicated when the density of the acid reaches the same point that it reached at the end of the last preceding charge.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

When the voltage has risen to about 2.5 volts per cell, or ceases to increase after another half hour of charging. Also by vigorous boiling and gassing of the electrolyte, the bubbles giving a sharp explosion if a lighted match is applied to them.

F. M. FARMER.

A storage battery may be considered as fully charged when the voltage and specific gravity of the electrolyte cease rising during a period of one-half hour, the battery being charged at its normal, or eight-hour, rate.

THE ELECTRIC STORAGE BATTERY CO.

Roughly speaking, when electrolyte boils.

CHAS. H. PETERS.

In general, a battery may be said to be fully charged if while the normal charging current is passing through the cells

the specific gravity of the electrolyte ceases to rise. The recording voltmeter curve also furnishes a very reliable means for indicating the time to cut the battery off charge, as the curve ceases to rise and begins to run straight at about the same time that the specific gravity stops rising.

ERNEST LUNN.

After a little experience this may be readily determined by the amount of gassing, the specific gravity of the liquid and the voltage of the cells.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

By indications of voltmeters, testing the specific gravity of the electrolyte, or by noticing when the point of "boiling" of the electrolyte is reached.

G. WILBUR HUBLEY.

*No. 2.—How often must the acid in storage batteries be removed and renewed?*

The acid in storage batteries never needs changing. The addition of pure water is necessary to make up for evaporation, and about once in 18 months or two years it is necessary to replace a little dilute acid to make up for that which has sprayed away.

A. PETERS.

The acid in a battery need never be removed unless impurities are found. Acid must be added from time to time to keep the gravity at its proper height.

S. C. H., N. Y. ED. CO.

When a battery is always kept in good condition, especially when the water used for re-filling the battery is always pure—that is, free from foreign substances such as iron, chlorine, etc.—it will not be necessary to renew the acid. In course of time some sediment accumulates at the bottom of the cells, and by this action the strength of the acid is reduced to a slight degree, so that it will be necessary to add about once a year some new acid amounting to about three per cent of the whole amount of acid in the battery.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The acid in a storage cell removed and renewed. All that once every year, as there is a course of charging, and re-fill proper level of electrolyte.

It is necessary to replace which must be pure. Dis where it can be obtained. approved by the battery of the battery from this or to remove and replace of temperature and vent to replace this evapora

#### THE ELI

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Every records have, as a rule, little to do with the main-  
 cost; but for the sake of working the battery to the best  
 age and with a full knowledge of the behavior of all cells,  
 records should be kept of the ampere hours discharged  
 charged, together with the specific gravity and voltmeter  
 readings of individual cells, which should be taken at least once  
 a week.

ERNEST LUNN.

Q. 5.—*Does the storage battery require any extra or spe-  
 cial labor?*

A. Not necessarily; but a man to look after a battery must be  
 employed to keep records, and ought to be intelligent.

A. PETERS.

For operating a battery no special labor is required except  
 that the cells must be filled up with water about three or four  
 times a week. When some cells are considerably lower in density  
 and voltage than the rest of the battery, separate charging of  
 those cells may be necessary. Repair work on batteries must be  
 done by skilled workmen, but, especially in small plants, such  
 repairs will not happen so often as to require the hiring of such  
 a workman. In many cases it will be possible to train the  
 operator of the station so that he can do small repairs on the  
 batteries.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Yes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Generally speaking, the time of one man for one-half to one  
 hour a day is sufficient labor for a battery, depending upon its  
 size. It is necessary to replace evaporation loss by the addition  
 of water at intervals ranging from once a week to once every  
 two weeks, depending upon the location of the battery. An  
 evaporation loss that would necessitate putting into the battery  
 an amount of water equal in volume to the amount of electrolyte  
 in the cell, during a period of six months, may be considered as  
 a high rate of evaporation.

THE ELECTRIC STORAGE BATTERY CO.

Yes. A battery requires careful attention. It does not require a great deal of labor to keep it in condition, but men especially instructed should be placed in charge, who should make the battery their first and foremost duty.

ERNEST LUNN.

*No. 6.—Is the total line loss lessened or increased by installing a storage battery with booster at the centre of distribution instead of at the generating station?*

It can be shown that whenever the load transmitted to the centre of distribution during the lighter hours is less than the load transmitted during the peak hours, multiplied by the efficiency of the battery plant, the transmission losses can be reduced by the installation of a battery at the centre of distribution. A maximum saving will be effected by such an installation when the load transmitted during the hours of the battery charge (including the current for charging the battery) is equal to the load transmitted during the peak hours (after deducting the battery discharge), multiplied by the efficiency of the battery installation; that is, let  $A$  be the demand at the centre of distribution during the lighter hours,  $B$  the demand during the peak hours, and  $x$  the efficiency of the battery. Then if  $A$  is less than  $Bx$ , a saving in transmission losses can be effected by installing a battery. If  $a$  is the charging current of the battery, and  $b$  is the discharge on the peak, then a maximum saving in transmission losses is effected when  $A + a = (B - b)x$ .

THE ELECTRIC STORAGE BATTERY CO.

Lessened.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The line loss will generally be lessened when the battery and booster are located at the centre of distribution, but exact figures can be given only when the daily load curve, size of battery compared with size of dynamo, distance of centre of distribution from generating station, etc., are given.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Line loss will be lessened.

G. WILBUR HUBLEY.

*No. 7.—Is the investment in storage batteries to be used exclusively for excitation warranted in large and moderate-sized plants?*

In large plants, yes; moderate-sized, no.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

As the exciting current is necessary for continuity of service, and as storage batteries give an absolute insurance against an interruption of this current, the answer to the question as to whether the necessary investment is warranted, depends upon the value placed upon this insurance. The expenditure for storage batteries for this service is a very small percentage of the total expenditure in a plant, and when due consideration is given to the financial and other results that might ensue from interruptions in the exciting current, the premium paid for the insurance afforded by storage batteries may be fairly considered as very small. To secure reliability of service, many lighting companies generating alternating current have spent large sums in reserve units and in storage batteries distributed on their systems. The amount involved in the purchase of exciter batteries is small by comparison with the cost of these other forms of insurance. The entire system depends upon the exciting current, and in comparison with its importance and the service it renders the cost of an exciter battery is less than that of any other form of protection.

Both steam-driven and motor-driven exciters are dependent for operation upon several links in a chain, while the storage battery, being a different species of apparatus, is not subject to those accidents that would disable either or both of the other classes of exciters.

CHAS. BLIZARD.

Plants of the size indicated are generally provided with motor-generators for excitation and one engine-driven dynamo to spare. The addition of a storage battery would be of value only in case of a breakdown of the motor-generator set, to keep up the excitation until the spare dynamo is started. But such a breakdown will happen comparatively seldom, so that the battery would stand idle through the greater part of the year; and it is a fact that a battery under these conditions gives con-

siderably less capacity at the first discharge following such a time of idleness. The installation of a storage battery is therefore not recommended.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

No.

G. WILBUR HUBLEY.

## N

### SWITCHBOARD INSTRUMENTS AND STATION WIRING

*No. 1.—What methods of voltage regulation have proven successful where single-phase lighting circuits are distributed across the phases of three-phase machines, when these machines also serve highly inductive load in motors and arc lamps?*

Under conditions stated we have been successful by using the Tirrill regulator on one phase, and balancing the other phases as closely as possible. This same method is used elsewhere successfully.

GEO. B. LAUDER.

Our system supplies induction motors, arc lamps and incandescent lighting. The lighting circuits are distributed single-phase from three-phase 'bus-bars and balanced on the phases. The general regulation is accomplished by an automatic potential regulator on exciters and alternators; also each single-phase circuit is controlled by an induction regulator adjusted to load according to a chart drawn up to suit individual characteristics of each circuit.

E. P. DILLON.

The voltage can be controlled by a central-station feeder regulator. This regulator is built on the principle of a transformer, the primary being connected across the 'bus-bars and the secondary connected in series with the feeders. The voltage regulation takes place in the secondary where the amount of winding cut in on the feeders can be controlled at will.

SAMUEL KAHN.

To get good regulation from single-phase circuits on three-phase 'bus-bars, a separate regulator must be placed in each single-phase circuit, otherwise good regulation can not be had.

W. J. C., N. Y. ED. CO.

Hand-operated voltage regulators are working satisfactorily with us on two-phase machines, single-phase distribution.  
AUGUSTA RY. AND ELEC. CO.

Feeder regulators connected to each phase of a three-phase system will provide means for properly balancing the single-phase lighting circuits.  
E. H. MATHER.

Regulation by means of Tirrill regulator.  
E. P. COLES.

*No. 2.—How often should such switchboard instruments as ammeters and voltmeters be tested to insure reasonable accuracy?*

We find once a week none too often.  
WILLIAM R. GARDENER.

They should be tested when they are installed, and any troubles developing from shipment or handling should be remedied. After this, recalibration once a year should suffice.  
(UNSIGNED.)

In general, switchboard instruments should be checked monthly, unless very favorably situated with respect to vibration, careless treatment, etc.

A good plan would be to take checks quite frequently for some time, keeping a record of the errors found, if any; and from this determine the necessity for frequent checking in each particular case.  
A. M., N. Y. ED. CO.

At least once a year, and as much oftener as their readings seem unreasonably large or small.  
C. H. CUSHMAN.

Switchboard instruments should be checked every time they receive any severe overload, and it is advisable to test them periodically, say once a week. Most instruments of this sort are liable to be influenced by stray fields from 'busses, etc., and so to change their calibration with change of load on the machines. This effect should be taken into account.

CLAYTON H. SHARP

At least once a week; perhaps oftener. A good method is to check them against good Weston portable ammeters and voltmeters, which are in turn sent to a first-class testing laboratory every month or two to be accurately checked. If the station is too far from such a laboratory, then buy a portable potentiometer and check your own instruments.

F. M. FARMER.

Should be tested when they are installed, and any troubles developing from shipment or handling remedied. After this, recalibration once a year should suffice.

(UNSIGNED.)

This depends upon the make of instruments. About every six months, at the most, should be all that is necessary.

AUGUSTA RY. AND ELEC. CO.

It depends upon conditions. At least once in six months.

IRVING E. BROOKS.

Twice a year.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Twice a year.

F. C. S., MALDEN ELECTRIC CO.

After every short-circuit, and periodically, say once in two weeks, especially if a meter system and incandescent lamps are used. There is a simple potentiometer on the market for accurately checking voltmeters.

WILSON S. HOWELL.

About every six months; have adopted the practice of making such calibrations in April and September.

G. WILBUR HUBLEY.

*No. 3.—Are hot-wire instruments reliable in practical everyday service, and do they give equally accurate results with both direct and alternating currents?*

Our main switchboard, originally equipped with hot-wire instruments, has been practically refitted with a more satisfactory and reliable type of instruments.

E. P. DILLON.

Hot-wire instruments that we have tested from time to time have proved unsatisfactory. They are easily affected by the temperature of the room in which they are installed. As they heat up the deflection increases. Equally accurate results are obtainable from them using either direct or alternating current. If, however, it is desired to use hot-wire voltmeters as transfer instruments in checking alternating-current voltmeters, it may be done in the following manner:

Place the hot-wire meter in multiple with a direct-current standard, bring the standard to the desired voltage, let the hot-wire instrument warm up for five or ten minutes and adjust it to agree with the standard meter. Then by means of a double-pole, double-throw switch, change the hot-wire instrument from the direct to alternating current at the same voltage. It will then be ready for checking the alternating-current voltmeters.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Yes, except on rapidly fluctuating loads. Yes.

S. D. S., N. Y. ED. CO.

We find them perfectly reliable on alternating and direct current, and absolutely dead-beat; at least, those of the Stanley type.

CHAS. H. PETERS.

In my opinion, no.

F. C. S., MALDEN ELECTRIC CO.

The form of hot-wire instrument gotten out by the Stanley Electric Manufacturing Company some five years ago has proven very reliable for station use, and has thus far proven to be the only instrument that is accurate on both direct and alternating current under all conditions of frequency, wave-form and external magnetic field variations.

(UNSIGN'D.)

Hot-wire instruments, if properly constructed, will give equally good results on direct and alternating current. They are, consequently, useful as transfer instruments for checking up alternating-current instruments against direct-current standards. They are liable to change their calibration, and this change is indicated by a change in their zero. The adjustment of the zero of the instrument needs to be looked after every time the instrument is used.

CLAYTON H. SHARP.

*No. 4.—The old Thomson-Houston alternating-current ground detector consisted of a choke coil, with an incandescent lamp shunted across a few of the turns that were of heavier wire than the rest, thus making the combined carrying capacity at this point much greater than that of the rest of the circuit with which it was in series. Why was this necessary?*

The ground detector is not a choke coil but an auto-transformer. Coarse winding corresponds to secondary and fine winding to primary of an ordinary transformer, each carrying a current practically in inverse proportion to the voltage across it.

M. P. R., N. Y. ED. CO.,

*No. 5.—Please describe a simple form of ground detector for use on Edison three-wire system.*

Ground positive wire through two 110-volt lamps in series and ground neutral through one 110-volt lamp. The three lamps should be of equal candle-power and voltage. If the positive becomes grounded the current will flow through one lamp to the neutral, causing it to burn to candle-power. If the neutral becomes grounded, the current will flow through the two lamps in series to the positive, burning two lamps to a dull red. Should the negative become grounded the current will flow through the two lamps in series to the positive, causing them to burn at full candle-power, also through one lamp to the neutral, causing it to burn at full candle-power. Thus the indication will read: no ground on the system, a dull red on all lamps; one lamp burning brightly, positive ground; two lamps burning dimly, neutral ground; three lamps burning to candle-power, negative ground.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

A very simple ground detector may be made by connecting three incandescent lamps in series between the positive and neutral conductors of an Edison system, and making a ground connection between the second and third lamps. If the system is clear all lamps burn at one-third voltage.

If the positive conductor becomes grounded, lamps Nos. 1 and 2 are extinguished and No. 3 burns at full voltage.

If the negative conductor becomes grounded, all lamps burn at full voltage.

If neutral conductor becomes grounded, lamps Nos. 1 and 2 burn at half voltage and No. 3 is extinguished.

W. F. W., N. Y. ED. CO.

To make a simple form of ground detector for use on Edison three-wire system, take a three-point lever switch and connect the three points to the three bus-bars, running a wire from the lever of the switch through two lamps in series to a good ground. If desired, a voltmeter can be so connected as to determine the character of the ground on the line, although this is not essential. If your lines are grounded, begin the test by swinging the lever of the switch to the positive contact. If the lamps light brightly the test will show that the negative side of your system is grounded; if they light dimly it will indicate that the neutral wire is grounded, and if they do not light at all it indicates that the positive wire is grounded. If the lever is shifted to the middle or neutral contact and the lamps light dimly it will indicate that either the positive or negative side is grounded, and if they do not light at all it will show that the neutral wire is grounded. If the lever is shifted to the negative point and the lamps light brightly it indicates a ground on the positive side; if dimly, a ground on the neutral, and if they do not light at all it indicates a ground on the negative side of the system.

C. J. ABBEY.

*No. 6.—With a single-phase six-mile, 5500-volt transmission, how would you turn on and off from the power-house street lights that are located at feeder end?*

It goes without saying that all transmission plants have a private telephone line to power-house. The arrangement used at this plant consists in general of a pole-changing switch at the power-house, which connects our 75-volt exciter circuit to the 1000-ohm bridging Bell telephone circuit for about 10 seconds at the time of throwing street lights on or off, the polarity of the connection determining whether the lights go on or off. In the transformer-house at the centre of distribution, and con-

nected across the telephone circuit, is a polarized bell relay, which closes local circuit through the "on" and "off" solenoids respectively. This polarized relay is an ordinary 1000-ohm ringer, with the bell-tapping rod made stronger and longer and suspended in a vertical position. To the lower end of this rod is fastened a weight hanging in the oil dashpot can. This weight is heavy enough to cause the bell rod to take a vertical position half-way between the contact points when direct current is not on the telephone line. The inertia of this weight and the oil resistance prevent the bell rod from responding to magneto-current. The steady direct-current pull from the exciter circuit will close the contact points as described, throwing 110-volt alternating current through either the opening or closing solenoids as required.

H. A. SPRAGUE.

If it is not desirable to run a separate circuit for the street lights, they could be turned on and off by an automatic time switch located at the distribution end of the feeder circuit.

E. H. MATHER.

We have never been able to devise a scheme for the purpose mentioned, unless the running of a separate circuit for the lights could be so considered.

GEO. B. LAUDER.

We have a reactive-coil street-light system in a small town six miles away, and pay a man to turn the circuit on and have a time switch to turn it off.

WILLIAM R. GARDENER.

*No. 7.—Is there any form of automatic voltage regulator adapted to control an Edison three-wire system, which will not only regulate properly with one pair of machines, but will regulate and insure proper division of the load when several generators are operated in multiple?*

The Tirrill voltage regulator has been successfully applied to many similar conditions.

GEO. B. LAUDER.

Fifteen years ago the Edison United Manufacturing Company devised such a system of regulation, but it was necessary

that the several generators be separately excited by an exciter generator on each side of the three-wire system.

GEO. L. COLGATE.

*No. 8.—What type of time-limit device for circuit-breakers has given the most reliable service; mechanical, electro-mechanical, or electrical?*

In the opinion of the writer, the motor-driven time-limiting device made by the General Incandescent Arc Light Company has given the most satisfactory service, and is the most reliable device now on the market. A very much simpler and cheaper device, which has also given good service, is the pneumatic-diaphragm time-limit relay made by the General Electric Company. The mechanical or spring-driven devices have never given good service.

(UNSIGNED.)

For direct current, electrical, consisting of direct-current circuit-breaker, with instantaneous break. For alternating current, electro-mechanical, consisting of a bellows dashpot, with air valve regulating the flow, determining the closing of contacts, which in turn close the circuit of the tripping coil and operate the breaker.

G. L. THOMPSON.

Two years' experience with the clock-escapement type of time-limit relays has proven them very reliable, but a subsequent experience of six months with relays of the bellows or diaphragm type, in which the time limit is in inverse proportion to the amount of overload, shows that this latter type performs the functions required of a device of this kind in a more satisfactory manner.

W. F. W., N. Y. ED. CO.

*No. 9.—Are compensators for voltmeters on alternating-current circuits satisfactorily taking the place of pressure wires?*

We are using compensators in connection with separate circuit regulators, and they give satisfaction.

WILLIAM R. GARDENER.

Yes.

GEO. L. COLGATE.

The types arranged for inductive as well as ohmic drop would do so, if their advantages were fully realized by station managers. They give perfect service wherever used.

(UNSIGNED.)

Compensating voltmeters are sufficiently accurate to allow of keeping voltage within two per cent of normal under conditions created by supplying motors and arc lamps from the same circuits.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In my opinion, yes.

F. C. S., MALDEN ELECTRIC CO.

Compensators designed to compensate for ohmic and inductive drop of voltage on alternating feeders are being satisfactorily used instead of pressure wires. They have recently been applied to four-wire, three-phase feeders by placing a compensator in each wire. In this way such feeders may be operated with unbalanced loads with perfect success. It is also practicable to run a four-wire feeder to a central point, taking single phase subfeeders of different lengths from this point to subcentres of distribution at which it is desired to maintain any given voltage. By arranging one centre of distribution to each phase the pressure may be regulated from this centre of distribution, directly from the generating station without difficulty, the neutral compensator taking care of the drop due to the current in the neutral wire. The compensator in the phase wire is set to take care of the drop in single-phase branches from the four-wire feeder to the single-phase subcentre of distribution.

H. B. GEAR.

*No. 10.—What is the average drop in voltage across the fuses by which station voltmeters and wattmeters are protected?*

It should be an easy matter to proportion the fuses and their terminals so that their resistance and the consequent drop in voltage would be negligible; especially in the potential circuits of instruments, where the current would not ordinarily

exceed 25 or 30 milliamperes and where the protection desired is against currents enormously greater than normal.

A. M., N. Y. ED. CO.

Fuses are not generally used for this purpose except for high-voltage work where fuses are used to protect against short-circuits in the voltage transformers. These fuses being in the primary circuit, their drop is a negligible percentage of the voltage.  
(UNSIGNED.)

*No. 11.—A four-wire, three-phase, 60-cycle feeder runs from the station to a centre of distribution from which radiate three unequally loaded single-phase feeders connected between phase wires and neutral. What is the best method of connecting voltmeter compensators in the station so as to give an accurate indication of the voltage on each single-phase feeder at the centre of distribution?*

For a four-wire, three-phase (star-connected) system, connect each voltmeter and compensator between one of the outside wires and the neutral, with the series transformer of each compensator on the outside wire; the wiring being the same as for single-phase circuits.  
(UNSIGNED.)

Compensating voltmeters, having their current and potential coils so connected as to receive and indicate the potentials of the phases to be regulated, will, after careful adjustment, furnish the necessary means at the station to enable accurate regulation of voltages at selected centres of distribution.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

## O

### BELTS AND SHAFTING

*No. 1.—Which is the most reliable of the various formulæ for determining the width of a leather belt?*

The average allowable working tension for single leather belts is about 65 pounds per inch in width; for double leather, about 80 pounds. To find width of belt required to transmit

any given horse-power, multiply the working strain per inch in width by speed of belt in feet per minute and divide by 33,000. The quotient will be the horse-power a belt one inch in width will transmit if belt is touching one-half the circumference of pulley. This divided into power will give the width of belt required to transmit any horse-power. The power transmitted will vary from the above as belt is in contact more or less than one-half the circumference of pulley. Belts conforming to the above rule will give good service.

J. A. MALONEY.

The thickness of a belt varies from three-sixteenths to five-sixteenths if single, and from three-eighths to three-fourths if double.

$f$  = the safe strain per square inch of section = 320 pounds.

$d$  = thickness of belt.

Then safe strain per inch of width =  $320 d$ .

$v$  = velocity of belt in feet per minute.

$w$  = width of belt in inches.

$$\text{Safe load in horse-power} = \frac{w \times 320 \times d \times v}{33,000}.$$

(UNSIGNED.)

The safe working tension is assumed to be about 45 pounds per inch of width, equal to a velocity of about 60 feet per minute per horse-power, which is safe in practice for single belts in good condition.

Let  $C$  = circumference in inches of pulley.

Let  $D$  = diameter in inches of pulley.

Let  $R$  = revolutions per minute.

Let  $W$  = width of belt in inches.

Let  $H$  = horse-power that can be transmitted by belt.

Formula :

$$H = \frac{C R W}{144 \times 60}.$$

To simplify the process substitute  $D$  for  $C$ , and dividing the constant ( $144 \times 60$ ) by 3.1416, the ratio of circumference to the diameter, the formula would be :

$$H = \frac{D R W}{2750} \text{ or } W = \frac{H 2750}{D R}.$$

The transmitting efficiency of double belts of average thickness to that of single belts is as 10 : 7.

W. J. C., N. Y. ED. CO.

*No. 2.—What is the relative efficiency of paper, wood and iron pulleys?*

Don't know what the strength of paper is, but the tensile strength of any material divided by the weight per cubic unit will give a correct basis for comparison as to the strength in pulley.

Cast-iron weighs 450 pounds per cubic foot; its strength per square foot is 1,444,000 pounds.

$$\frac{1,444,000}{450} = 3200.$$

Ash weighs 34 pounds per cubic foot; its strength per square foot is 1,152,000 pounds.

$$\frac{1,152,000}{34} = 33,882, \text{ or in other words,}$$

a pulley built of ash is about 10 times as safe as a good cast-iron pulley of same weight, size and speed.

$$\left( \frac{33,882}{3200} = 10.58 \right).$$

This would allow the wood pulley to run at  $\sqrt{10.58} = 3.25$  times the speed of the cast-iron with equal safety.

(UNSIGNED.)

We have found the paper pulley when kept clean to be very satisfactory. Wood pulleys are short-lived under heavy work. Iron pulleys will answer every purpose when properly proportioned, if the belts are kept clean and free from machine oil and dressed with some preparation of tanner's oil three or four times per annum. Have been running belted railway generators for 13 years, using iron pulleys and at intervals carrying as much as 100 per cent overload, without running the belts exceedingly taut. We find that most of the trouble attributed to pulleys and belts is due to the improper care of the belt.

JAS. E. PYLE.

*No. 3.—Does piercing or grooving the surface of an iron pulley add to its efficiency? If so, to what extent?*

Neither piercing nor grooving the surface of an iron pulley adds to the efficiency of the belt.

W. F. KINGAN.

Piercing or grooving of pulley surface is often resorted to where large belts run at high speed, in order to relieve the air pockets that are carried around the pulley under the belt, thereby giving a larger surface contact than would be the case if the air were allowed to remain under the belts.

(UNSIGNED.)

The piercing of iron pulleys with short grooves on each side of the perforations running lengthwise with the belt has been said to show as high as 60 per cent greater power-transmission capacity than they would show before the perforating was done, but we can not give the exact condition of the belt under which these tests were made. We understand that the William Sellers Company, of Philadelphia, have claimed a great advantage for the system.

JAS. E. PYLE.

## P

### OIL AND WASTE

*No. 1.—What precautions are necessary to avoid trouble with cylinder and valve lubrication with superheated steam?*

Be sure to have an oil that will stand up under the temperature, and feed enough. It will take about 50 per cent more oil than with wet steam.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 2.—Is there any simple and effective method of testing lubricating oil without prolonged use under actual operating conditions?*

To make effective lubricating oil tests, make a self-oiling bearing, split horizontally, so that the upper half of the bearing will rest on the shaft. Place lever across cap, pivot it close to the shaft on the bearing, similar to the safety-valve lever. Arrange to run the shaft at about 1000 r.p.m. Load the lever heavily enough to give the bearing about 2000 pounds per square inch of bearing surface. Start the oil in the bearing at a temperature of about 70 degrees and take temperature readings every minute until the temperature will go no higher, which requires

about 30 or 40 minutes. Remove the oil from the bearing and wash with gasolene, permitting the bearing to cool. Start the second oil to be tested and treat in a like manner. Have found this method of testing oil to show a wide variation of lubricating value in different oils, and have had no trouble with poor oil since we have adopted this method.

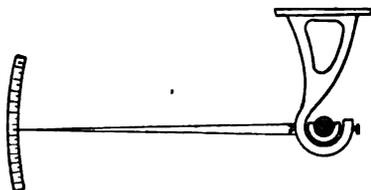
•THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

There are several tests that can be made with comparative ease. For viscosity tests use the Bailey apparatus, consisting of a sloping plate of glass over a box, heat being applied in some convenient manner from the inside. A thermometer placed in the box gives the temperature. Allow the oil to drop on the glass and note the time it takes each sample to travel the length of the glass; also its condition, whether resinous or not, etc. This will give a good idea of the viscosity of the oil.

For the flash test, heat the oil in a cup of convenient size, using a thermometer to give the temperature reached. After oil has reached 350 degrees Fahrenheit, pass a flame across it, and if it has vaporized the gas will light. A good oil should show a flash test of 450 to 500 degrees Fahrenheit. This test will give an excellent idea of the quality of the oil; if it is adulterated it will show a low flash test.

L. J. LISBERGER.

A simple method of testing lubricating oils is to hang an ordinary shaft hanger from a uniformly rotating shaft. Fasten a log pointer to the hanger so that it may swing over a gradu-



ated scale. The various oils to be tested may be put in the hanger and the deflection for each oil noted. The oil giving the least deflection will evidently be the best lubricant. See diagram.

J. F. DOSTAL.

*No. 3.—Does it pay to use waste presses for recovering oil, and reusing waste?*

Our experience leads us to believe that it does. Our oil press has saved an average of eight barrels of oil per year. In addition, we wash the waste, dry it on a screen and use it for a great many purposes, thereby saving our new, clean waste for particular work.

WILLIAM R. GARDENER.

In my opinion, yes.

F. C. S., MALDEN ELECTRIC CO.

Yes, it does pay. In one instance the cost of oil was reduced 45 per cent in one month, and out of every 100 pounds of oily waste 40 pounds of clean waste and 40 pounds of oil were obtained.

LOUIS I. PORTER.

In a plant of any size a simple, home-made waste press, and a simple arrangement for washing the rags or waste, pays well.

AUGUSTA RY. AND ELEC. CO.

It certainly pays to use a waste press and use the oil and waste over again. Of course the oil should be filtered before using.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Our experience has shown that centrifugal waste wringers save considerable oil that would otherwise be lost, and the waste so dried is suitable for rough work.

W. F. W., N. Y. ED. CO.

It does certainly pay, particularly where the towels are used for wiping machinery and waste for general wiping, as not only is there considerable oil saved, but the towels and waste can be used over and over again. A 12-inch press costs about \$25, and I have no doubt that it will save 200 per cent of its cost every year.

E. P. COLEMAN.

*No. 4.—Does graphite give satisfactory service as a cylinder lubricant, especially if the condensed steam is returned to the boilers?*

We have used graphite for a cylinder lubricant with very great success, but the graphite collects in the exhaust pipe, drips, etc., to a practically prohibitive extent. We would not advise its use where the condensed steam is returned to the boilers, unless careful experiments could be followed up to ascertain results.

THE EDISON ELEC. ILL'G CO.  
OF WEST CHESTER, PA.

Yes. I consider the use of graphite in connection with oil in cylinder lubrication as of great benefit in operating conditions and in resultant economy, decreasing the cost of maintenance and materially increasing the life of cylinder.

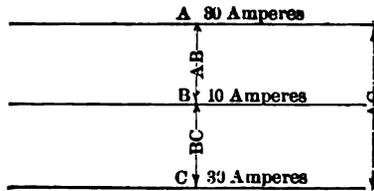
G. WILBUR HUBLEY.

## DISTRIBUTION



### POLE LINES AND CONDUIT SYSTEM

*No. 1.—In an unbalanced three-phase system—for example, such as shown—with current in  $A = 30$  amperes, current in  $B = 10$  amperes, current in  $C = 30$  amperes, what will be the relation of the voltages to each other, and why? That is, will two of the voltages be higher than the others, or two lower than the others, and which will be alike and which the odd one? My experience shows that  $AC$  equals  $AB$ , while  $BC$  is considerably higher.*



In an unbalanced three-phase system with 30 amperes in  $A$ ,

10 amperes in *B* and 30 amperes in *C* we are approaching the condition of a single-phase distribution across *AC*. We only need to go a little further and reduce still more the current in the *B* wire to have all the load on *AC*. Your assumption, therefore, that the voltage across *AC* would equal *AB* is incorrect, as the greatest drop would occur between *A* and *C*, as the greatest load is carried over the *A* and *C* wires.

In an unbalanced three-phase system the relative voltages can easily be determined by adding the currents in *A* and *B*, *B* and *C* and *A* and *C*. The wires whose current sum is the greatest will always have the least voltage, as they will have relatively the greatest drop. Those having the least sum will therefore also have the least drop and the greatest voltage. In the case given the current in *A* plus the current in *B* equals 40. The current in *B* plus the current in *C* equals 40. The current in *A* plus the current in *C* equals 60. The greatest drop will therefore occur over the wires *AC*, while, the other sums being equal, the potentials across *AB* and *BC* will be equal. Actual operation shows that this is the case.

W. T. M., N. Y. ED. CO.

At a substation 12 miles distant from our generating station we have three ammeters, one on each wire, for a three-phase circuit. *A* registers 35 amperes; *B*, 36 amperes, and *C*, 25 amperes, under an all-lighting load, with no power on the circuit. The voltmeter registers, when on *A* and *B*, 112 volts; when on *B* and *C*, 112 volts, and when on *C* and *A*, 120 volts. We found the load on *C* and *A* much smaller than between the two other lines.

C. L. HOON.

In an unbalanced three-phase system, the current in phase *A* being 30 amperes; *B*, 10 amperes, and *C*, 30 amperes, the voltage between *AB* will equal the voltage across *BC*, and *AC* will be the least. Assuming a Y-connection in armature and the same impedance in each leg, then the drop in voltage in each leg will be proportional to the current flowing. In order to calculate approximately the voltage across any phase, voltage across phase at no load divided by  $\sqrt{3}$  will give voltage in each leg. From this is subtracted the drop due to current flowing and

impedance in each phase. One-half the sum in any two legs is taken and multiplied by 1.73, giving voltage across phase. Results show  $AB = BC$ , and  $AC$  is less.

C. W. HUMPHREY.

Voltages  $AB$  and  $BC$  will be alike.  $AC$  will be less than these.

E. P. COLES.

It seems to the writer that you will obviously get the same voltage across  $AB$  as you would across  $BC$ , and that the voltage across  $AC$  would be different and lower than the other voltage. The reason being that in the circuits  $AB$  and  $BC$  identically the same conditions exist. You get the drop of voltage produced by the resultant of 30 amperes in  $A$  and 10 amperes in  $B$ , and 30 amperes in  $C$  and 10 amperes in  $B$ , while in the circuit  $AC$  you have the voltage produced by the resultant of 30 amperes in both  $A$  and  $C$ .

M. C. TURPIN.

*No. 2.—What method of treating wooden poles seems to give the best result in preserving tops and butts from decay?*

We are much interested in the "cement butt," which is placed in the ground and the pole set on top of it, the pole being held by heavy iron straps running from the bottom of the cement butt a few feet up the pole. These butts are on the market, and there seems much to recommend them. Our experiments are not of sufficient duration to warrant conclusions yet.

GEO. B. LAUDER.

The life of a pole is dependent on the part in the ground, and the top will always outlive the part in the ground despite any preservative that can be put on the butt. Poles should be cut in January. The application of coal tar or burning of the butt helps to preserve its life.

W. J. C., N. Y. ED. CO.

We find that three or four coats of C. A. wood preserver on the butts of poles increases their life in this locality over 50 per cent. Let each coat dry before applying the next, and paint at least six and a half feet from the bottom of pole, so that

there will be about 12 inches of painted surface above the ground. A liberal use of white-lead paint, using little turps, is about the best covering from top to a distance of five or six feet from the ground, this five or six feet being painted some dark color, or black. The action of the sun is less on a white surface than on any other color.

CHAS. H. PETERS.

Roof the tops at an angle of about 45 degrees, and give them a good coat of paint, also painting all gains before putting on cross-arms. I have never found anything to preserve the butt that I thought paid for the time used in putting it on.

HERBERT L. BRAGDON.

*No. 3.—What is the relative life of chestnut and white-cedar poles?*

The result of our experience shows that a chestnut pole has 30 per cent longer life in our soil. The life of a white-cedar pole seems to be largely in the outer shell; when the shell rots through the pole will break off. With a chestnut pole the rotting does not seem to begin so quickly, and it will not break so quickly after it does begin to rot.

GEO. B. LAUDER.

It depends entirely upon the soil. Under some conditions chestnut will outlive white cedar. The southern cedar, or what is known as "juniper," will outlive either chestnut or white cedar.

GEO. L. COLGATE.

As 10 : 7 in favor of the chestnut.

W. J. C., N. Y. ED. CO.

It depends on the soil in which the poles are set. As a rule, a chestnut pole is one-third longer-lived than a cedar, and, wood for wood, is much stronger, cedar being quite brittle under a heavy load.

HERBERT L. BRAGDON.

The ordinary life of chestnut poles is 10 or 11 years, while that of cedar poles is about two years longer. The ordinary life of poles is limited by decay, which usually occurs five or six inches below the ground, caused by frequent alternation of surface moisture and air. When poles are set in concrete footing,

if a cement casing one-inch thick be carried up from four to eight inches above grade, so designed at the top as to shed water running down the pole, preventing surface water from reaching butt, protecting exposed portion of pole from the action of the elements by a covering of good paint, etc., under favorable conditions the lifetime of poles might be extended to 15 or 20 years, or even more.

F. S. CHANDLER.

*No. 4.—What is the apparent life of iron poles?*

Fifteen to 20 years, dependent on local conditions.

G. WILBUR HUBLEY.

Iron poles have not been in use long enough to determine the actual life, but it has been estimated by some of the engineers in Europe, where they are much more generally used than in our country, that they will last at least 40 years.

M. C. TURPIN.

Have not lived long enough to say.

HERBERT L. BRAGDON.

*No. 5.—In treating poles to preserve them from decay, what is considered the best and most economical preservative, and how much oil or other preservative should be forced into the wood per cubic foot?*

The point at which poles decay is just at the surface of the ground. If the earth is removed for about one foot in depth and a coat of hot tar applied to the pole for one foot below the surface to a point one foot above the surface, the life of the pole will be increased. This should be applied about once in three or four years. Then if the pole is painted with a good metallic paint once in five years, the life of the pole will be doubled. I have tried several preservatives for the butt of the pole, but experience proves that they do not materially lengthen the life.

GEO. L. COLGATE.

*No. 6.—What system of underground conduit has been found satisfactory under service conditions for transmission of high-voltage alternating-current service?*

Almost any underground conduit will be satisfactory for high-voltage service, but the best, we think, is the conduit made of vitrified clay.

(UNSIGNED.)

The most satisfactory underground conduit is the drawing-in-and-out system, with adequate manholes. The material of the conduit may be either iron pipe (where great strength is required) or vitrified tile.

CALVIN W. RICE.

*No. 7.—What has been the experience with the use of lead-covered underground cables (rubber insulation) on single-phase, alternating-current distribution?*

We have used rubber-covered lead-incased cable on underground work, single-phase service, for several years. If the two conductors are put in the same lead casing the service will be entirely satisfactory, or if on three-wire system the two conductors are put in a lead casing and a bare wire is used for a neutral, the service will be entirely satisfactory, as the neutral wire and the lead casing around the other two cables form practically a concentric cable and consequently the impedance effect is practically done away with. I would not recommend the use of single rubber-covered and lead-incased cables for alternating-current work, as they are not only more expensive than the twin or duplex cable, but not so satisfactory.

(UNSIGNED.)

The only requirement for successful use of lead-covered cable is that the outgoing and incoming wire be preferably under the same lead sheath, or with the two single-conductor cables, adjacent in the same conduit.

CALVIN W. RICE.

Results have been very satisfactory; have had no trouble to amount to anything.

HERBERT L. BRAGDON.

*No. 8.—Is it considered good practice to run telephone lines on the same poles with high-tension circuits, and if so, can the telephone be used in case of leaky insulation or line trouble?*

We have a telephone line on a pole carrying 10,000-volt feeders, and have had no trouble for three years, so far as talking is concerned. Regarding the practice from the point of safety, I don't recommend it fully.

GEO. B. LAUDER.

We do not consider it good practice, even though the wires be transposed. We have a few such cases and the telephone company has considerable trouble from induction. We once had a private telephone line—to an auxiliary water-power plant—run on the same poles with a 2400-volt, two-phase circuit, and, notwithstanding the fact that we used a double-twisted insulated wire for the telephone, it always gave trouble and we finally took it down.

WILLIAM R. GARDENER.

The advisability of running telephone lines on the same poles as high-tension circuits is an open question, but we have 90 miles of transmission line carrying three-phase current at 40,000 volts, and the entire distance is covered by a telegraph line located from five to seven feet below the transmission line on the same poles. About one-half of the line is composed of No. 11 hard-drawn copper and the other half of No. 10 BB galvanized-iron wire

This telephone line is divided into sections between substations, so that any section can be cut out in case of trouble. It has always worked very nicely and is used by the train-dispatcher in dispatching all the trains on 46 miles of electric road. It works perfectly unless there is trouble on the transmission line, in which case there is instantly plenty of trouble on the telephone line. This, however, is of very infrequent occurrence, and the greater part of the time the telephone service is very satisfactory.

We find that a telephone line under these conditions must be treated with great respect in insulating, and regarded as if it were carrying several thousand volts' pressure, as any one coming in contact with it while grounded will be treated to very severe shocks.

JAS. B. FOOTE.

At one time I considered it very poor practice to run a telephone line on the same poles with high-tension circuits, as my experience in that line had been anything but satisfactory; but we are at present operating a telephone line on the same poles with a 30,000-volt, three-phase transmission line, for 50 miles, and we get most satisfactory results. We treat the line as being highly dangerous, and have put in every precaution possible to make it safe. We attribute the satisfactory operation to a very thorough transposition of both telephone and power circuits.

A. O. WHITMORE.

The larger transmission companies seem to avoid constructing telephone lines on the same poles as extremely high-tension transmission circuits where possible to do so. If telephone circuits are placed on transmission line poles, it is necessary to have the telephone line insulated nearly as well as the transmission line, in order to have reliable telephone service, especially at times of leaky insulation on transmission lines and line trouble.

E. P. DILLON.

Yes; telephone lines may be successfully operated on the same poles with well-constructed high-tension circuits. But the same high-tension circuits should be placed above the telephone lines. "In case of leaky insulation or line trouble," it would be necessary to remedy it, but that assumes that the line has not been properly installed, which is contrary to the recommendation.

CALVIN W. RICE.

We do not consider it good practice to run telephone lines on the same poles with high-tension circuits, unless the telephone line can be run on the lower arms, as the light wires used by the telephone companies are apt to give trouble by breaking and falling upon the high-tension wires. The telephones will not give good satisfaction unless the insulation is very high.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

Very good results may be obtained if proper spacing, transposition and insulators are provided. A ground on the high-tension system seriously affects parallel telephone lines.

S. D. S., N. Y. ED. CO.

It is not good practice to have any foreign wires on a high-tension line, as they are a continual source of danger both to linemen and to the general public. If telephone lines are run on the same line they are very apt to be noisy, especially if there is any leak of current from the high-potential lines during wet or foggy weather.

HERBERT L. BRAGDON.

The best telephone service can only be secured when the telephone lines are on separate poles, but there are to-day in operation many telephone circuits which are constructed on the same poles with high-tension circuits and are giving reasonably good satisfaction.

E. H. MATHER.

A well-installed telephone system six or seven feet below the high-tension wires is ordinarily satisfactory, and will of course indicate trouble such as leaking insulation on the high-tension line.

AUGUSTA RY. AND ELEC. CO.

*No. 9.—What is the best method of patrolling and repairing high-tension lines?*

High-tension lines can best be patrolled by men on foot or horseback. The patrolman should travel slowly enough to discover cracked insulators or burned pins so these can be replaced before a breakdown occurs.

E. H. MATHER.

To keep down cost of patrolling and insure its being frequently and properly done, a good passageway should be provided, the full length of the line.

AUGUSTA RY. AND ELEC. CO.

A long-distance overhead high-tension transmission line should be equipped with a complete telephone system. For patrolling, the line should be divided into sections and each section assigned to an inspector. His duty should be to traverse this section once every day and make a report upon the conditions of line. Any trouble or condition that is likely to cause trouble should be reported to the line superintendent at once. The length of sections and interval of inspection trips depend entirely upon local conditions; however, too much stress can not be placed on the matter of systematic inspection. Repairs should not be attempted on extra high-tension lines while they are alive.

If continuity of service is a controlling factor, two separate circuits should be strung, or, better, two separate pole lines some distance apart. In either case, one circuit can be killed while repairs are being made on the other.

IRVING E. BROOKE.

*No. 10.—Are there any state laws requiring that overhead conductors shall have insulating covering?*

One state has just passed a law requiring ample and satisfactory protection, without specifying who shall be judge as to whether the requirements have been fulfilled.

AUGUSTA RY. AND ELEC. CO.

*No. 11.—Is a grounded conductor stretched along a transmission line, over or near the transmission wires, of any utility as a protection against lightning discharges?*

I do not consider a grounded conductor as indicated to be of any practical service, but rather to be a detriment, on a transmission line. It tends to lower the insulation to the ground, and makes any handling of the line or repairs on poles anywhere near this wire exceedingly dangerous, and as a lightning precaution I do not consider it valuable.

A. O. WHITMORE.

It is generally conceded that the grounded conductor is of some utility, but a better method of line protection is to install lightning arresters, which recent experiments show should be placed as often as one in every quarter mile. The location of these arresters should be with reference to the topography of the country.

CALVIN W. RICE.

We have tried barbed wire stretched above the transmission line with frequent grounds, without any success whatever.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

There is much diversity of opinion as to the efficacy of a grounded wire strung as stated. Some eminent engineers believe in it, while others do not.

A. R. MacKINNON.

A bare wire running on top of the poles over a line and frequently connected to earth is, no doubt, some protection, but it is a very good thing for a man to keep clear of it if he is working on live wires.

HERBERT L. BRAGDON.

The benefit of such a wire as a protection against lightning would be less than the danger occasioned by having a grounded wire near a transmission line.

W. T. M., N. Y. ED. CO.

We find a grounded conductor, stretched parallel to and over high-tension wires, to be a protection against lightning discharges.

E. H. MATHER.

Yes; but this method of protection from lightning has its disadvantages, and it is not to be recommended.

G. WILBUR HUBLEY.

*No. 12.—Is there any way of locating, from the generating station, ground crosses and open-air circuits on a high-tension transmission line?*

Our transmission lines, which are arranged in three sections in the form of a closed triangle, are so connected by switches that an open circuit or ground can be located in a few moments on the section of triangle affected and on the circuit in that section, the transmission lines being double circuits. This permits us to cut out the trouble line and continue service on the rest of the system with a minimum break in service.

E. P. DILLON.

Yes; see the article in this connection by George B. Hanchett, in the last February number of *The Central Station*.

A. R. MacKINNON.

If the transmission line is polyphase and the cross is between two of the phase wires, it can be located from the generator end by the Murry loop method. At the receiver end tie together one of the crossed phases and one of the uncrossed phases and use the remaining uncrossed phase at the generating end as a return for the Murry loop. A ground on transmission line may be located in the same manner, using the ground for return. Where an alternating current is available, an open circuit can be located by the relative charging current of the open phase and a continuous-phase wire.

A. D. GILMORE.

*No. 13.—What is the best method of locating open circuits in an overhead series arc system?*

It is convenient to have the ends of loops brought to the same pole wherever conveniently possible, as each loop can then be treated as a separate circuit and be tested on the pole with a magneto, cut out of circuit, repaired and cut into circuit readily.

GEO. B. LAUDER.

First, put a ground connection on both wires of the circuit at plant. Second, take a magneto bell, go to the centre lamp on the circuit and disconnect one side. Connect one wire from the bell to the ground, and try the other one on each of the circuit wires. The side that rings is closed toward the plant in that direction. The side that does not ring is open toward the plant in the other direction. Connect the circuit again at the same lamp, and go two or three lamps toward the plant on the open wire. Test as at the first lamp, and keep working on the open wire until the break is found at a lamp or between two lamps.

P. E. COWLES.

In each arc circuit we have regular points known as test lamps at which points the inspector tests for an open circuit between ground and line, the station end of the circuit being grounded during tests. By this means the open circuit is soon determined to be within a limited territory, after which it is a comparatively easy matter to locate the exact point of trouble.

E. P. DILLON.

Our method is to connect the positive side of our three-wire system through a one-ampere inclosed fuse and a 16-cp lamp to one side of the arc circuit; the negative side of the three-wire system connected similarly to the other side of the arc circuit, the negative of the three-wire system being grounded. Inspector opens the line at a given lamp or point and connects a 16-cp lamp between either end and the ground. The lamp not lighting from one end indicates an open circuit on that part of the line.

TOLEDO RYS. AND LT. CO.

Ground both ends of the lines at station. Then go to a lamp near the centre of system, disconnect the leads and test with a magneto bell to earth. If a ring is obtained it is evident that that side is clear. The other side, giving no ring, is followed to, say, the half of that division. The test is again made. If the line is open ahead it can be followed from lamp to lamp, or if behind it is certain that it is between the lamp now under test and the last one tested.

A. PETERS.

Have had a very successful method of locating breaks in the overhead series arc system where 125 volts or some other low-tension system is available by grounding one side of the low-tension system and connecting the opposite side to one end of arc circuit, so that a linemen can readily feel the current on the side of circuit attached to the low-tension system. He can then trace the line from that end of the circuit, dividing the circuit into sections, knowing that as long as he can feel current the circuit is closed at the end attached to the low-tension, and as soon as he finds a part of the line without current he has passed the break. By this means we have always been able to locate our breaks in a very short time, usually losing little more time than is required to drive a team over the line to the break.

THE EDISON ELEC. ILL'G CO.

OF WEST CHESTER, PA.

A very good test for open circuits is to connect an incandescent lamp in series with the ground to the positive wire of your circuit at the station. Then tap your circuit at any lamp, and if your circuit shows current your trouble is ahead of you; if not, the trouble is on your positive wire between you and

the station; if ahead of you, go further out and try again. I find this simple test a very satisfactory one

HERBERT L. BRAGDON.

One way in which to find an open circuit on a series arc line is to ground both ends of the circuit in the station; then take a magneto bell and go out to about the centre of the circuit and open it up; ground one wire of the magneto and ring out each end of the wire in the circuit with the other end of the magneto. If the bell rings through one wire and not through the other the open circuit will be on the line through which you can not ring in the direction of the station. Then close the circuit at this place and go about half-way to the station and open the line and repeat the same operation. This will tell which quarter of the circuit the trouble is on, and by opening this up two or three times the open circuit will soon be found.

F. W. BULLOCK.

On circuits with direct-current Thomson-Houston lamps, use an ordinary magneto testing generator with polarized bell. Leave circuit open at station and test across same at any convenient point outside. If bell does not ring, try again farther out. If bell rings at this point, break is between the two testing points. If a power-driven magneto generator is used, take the bell only outside and test as above, but interpret results in the opposite sense. If circuit is a belt line, ground one side of generator at station and test between circuit and any good ground connection outside.

On circuits with differential lamps, take testing current from a 220-volt circuit. Connect this to arc circuit through two 16-cp, 110-volt lamps in series. If direct current is used, lineman may test by short-circuiting with a piece of wire, noting whether or not he gets an arc. If alternating current is used, lineman should use an incandescent lamp for testing across circuit, as the arc would be too small to give reliable indications.

M. P. R., N. Y. ED. CO.

There are two methods of testing the overhead series arc system for open circuit:

1. Ground one side of the circuit in the plant and test from

each lamp to ground with magneto; this will locate the "open" between two certain lamps. If connections at these two lamps are all right, test from line at each pole between these lamps. A wire will sometimes break inside the insulation and not fall, on account of the insulation remaining intact.

2. Another method is to leave the line open at the switch-board and test each loop; that is, where both sides of the circuit are on the same pole.

S. B. RICHEY.

Outages due to open circuits and grounds on series overhead arc circuits have practically been eliminated in a station operating about 450 arc lamps of this class by the following methods:

Circuits are tested regularly at 8 a. m., 12 noon, 3 and 5 p. m., and one hour before starting time. Records of the tests are kept in a book having detachable checks. These checks have printed on them in large figures the hour of test and date. After test has been made they are placed on a file conspicuously located at the works office. In case of trouble, a red check is substituted for the white one torn out of the book. It is the duty of the line foreman to call up the station regularly at test hours, and he is informed of the conditions of the test. If, for any reason, the line department should not be available for trouble hunting, the foreman of the arc-lamp department immediately takes charge of the case.

A liberal number of test points are permanently designated in each circuit, carefully selected in such a way as to reduce traveling to a minimum. These test points are equipped with a convenient ground connection.

Guide maps of the circuits are prepared in the following manner:

Make *one* tracing of the district covered by *all* the circuits; use red ink; exaggerate width of streets; place street names inside of blocks. Locate circuits with lamps numbered, testing points designated by letters on a second sheet of tracing cloth laid over the first; use heavy black lines.

Make blue prints through *both* sheets at once. The print will show streets, etc., as faint background upon which the circuit stands out clearly in bold white lines. The second tracing only will have to be revised in case of alterations. The first

remains permanent, and it, or part of it, can be used for all circuits.

In case of open circuit it is a fixed rule to ground the side of the circuit leading to lamp No. 1 at the switchboard. Special plugs are used to prevent meddling until the trouble is cleared.

The usual method of testing with a magneto is too familiar, I suppose, to need description.

Have the magneto mounted on a board which also carries two small reels, the metallic cores of which are permanently connected to the binding posts of the magneto through reliable contacts. Solder a single flexible cord of convenient length to the core of each reel, and provide crank for rapid winding up.

Generally speaking, it is best to go first to the testing point which cuts the circuit in half, but familiarity with the circuits and a little judicious use of the magneto at the station before starting out will readily indicate which end of the circuit is nearest to the trouble.

The various points given will greatly reduce the time required for clearing a circuit, but, after all, the prevention of trouble is of vastly more importance than any method of locating it.

Make it a rule, whenever trouble is found at any one point, to devise a remedy that will permanently prevent a recurrence of the same trouble and immediately apply the remedy to all other points of the circuits similarly liable to cause trouble. Strict application of this rule will soon eliminate the weak points and make rare the necessity of trouble hunting.

PAUL LÜPKE.

By placing machine on circuit and "jumping" the circuit at various sections until open circuit is located.

G. WILBUR HUBLEY.

Where an alternating current is available, the open circuit in the overhead series arc circuit can be located by the charging current, the distance to the open circuit on each branch of the circuit being directly proportional to the charging current of that branch.

A. D. GILMORE.

*No. 14.—What is the best method of locating grounds in an overhead series arc system?*

First, have both ends of the circuit open at the plant. Second, go to the centre lamp on the circuit and test as for an open circuit. The side that rings is the one that has the ground on it. Continue testing as above, except that you keep working on the wire that rings instead of the one that does not.

P. E. COWLES.

A good method is to have a bank of lamps at the station, having the whole in series across mains. If the old-style open arcs are in use, the voltage of each lamp should be approximately the same as that of the arc lamps. Generally, 50-volt lamps are used. Between each pair of lamps a tap is taken off leading to a stud in a board. Over the studs passes a contact having a connection to earth through a detector or galvanometer, the number of incandescent lamps being the same as the number of arcs burning. If the contact is moved over the studs until the galvanometer shows no deflection, the number of lamps from + side of line to ground connection will be the same as the number of arcs between station and ground on the line.

Another method is to leave open both ends of arc circuit at station. Open circuit, say at centre, and using a magneto one side of which is earthed, try to ring through line. If magneto rings, the ground is on the line being tested. Leaving line open at this point, cut the circuit again and test. By this method the ground can easily be found, though not so rapidly as by the lamp method.

A. PETERS.

By opening the circuits at the lamps or cut-out boards and testing between the separate sections and the ground with a magneto bell, the section that rings will indicate that there is a ground on it, and by dividing that part of the section at different places, the ground can be easily and quickly found.

F. W. BULLOCK.

Use testing outfits recommended for locating open circuits, cutting off portions of circuit until ground is removed. On direct-current arc circuits, voltage readings taken from each side of circuit to ground may be used in locating grounds, provided the sum of the two ground readings equals the voltage

across the circuit. If such is not the case the readings do not indicate a ground connection of low enough resistance to do any harm.

M. P. R., N. Y. ED. CO.

I have never found anything that did any more satisfactory work in hunting grounds on an arc circuit than a good magneto that would ring through from 40,000 to 50,000 ohms resistance. Any ground that can not be picked up with that will never do any harm.

HERBERT L. BRAGDON.

The same arrangement of fuses and lamps is used as for testing open circuits, with one of the lamps connected to one side of the circuit near the station. The inspector opens the circuit wire to which the lamp is connected at the station and connects his lamp between either side of the ground. His lamp not burning on either side indicates a ground between that side and the station. Lamp burning on one side indicates ground in opposite direction.

TOLEDO RYS. AND LT. CO.

By the use of a bank of lamps connected by switch to cut the lamps in and out as desired. One terminal of the lamp board is grounded and the other plugged to either side of the circuit to be tested, all lamps being cut into circuit and then cut out by switch. The indication of lamps burning at normal voltage will give approximately the location of the ground on circuit and will also indicate which side of the circuit is grounded. When circuit is not in service the magneto bell can be used to indicate if circuit is open or closed; also to indicate the presence of a ground on circuit.

G. WILBUR HUBLEY.

*No. 15.—What is the best method of protecting high-tension lines from crosses with telephone, telegraph and call wires?*

The best method, when a crossing is unavoidable, is to carry the transmission line over the line in question, placing the transmission line on two poles, of such length and distance apart that a wire on transmission line breaking at one pole will swing clear of the line crossed. If this is impracticable, a very safe method is to string a net under the transmission line on a separate cross-arm, and broader than the distance between centres

of wire in line, always grounding net by a wire of liberal carrying capacity.

E. P. DILLON.

High-tension wires should be placed above the telephone, telegraph and call wires. They are necessarily mechanically stronger, and so danger from their dropping to the other systems is very remote. Where it is impossible to avoid placing the telephone or telegraph wires over the high-tension wires, then mechanical protection should be provided.

CALVIN W. RICE.

Wherever possible, run high-tension wires above other wires, using heavy enough construction to make a breakdown practically impossible. Where this can not be done, run guard wires parallel to high-tension wires. A good way to do this is to run a guard wire on each end of arms carrying high-tension wires, and put arms above high-tension wires with several more guard wires run on same.

M. P. R., N. Y. ED. CO.

The only sure way of protecting high-tension lines from crosses with telephone and telegraph wires is to place them above all foreign lines.

E. H. MATHER.

The installation of a cradle wide enough to catch all the wires to be protected from a high-tension system, or to catch all the high-tension wires if they are above, is a good method. This cradle is made by extending a number of wires from pole to pole in a horizontal plane and placing parallel wooden strips across them every one or two feet.

AUGUSTA RY. AND ELEC. CO.

*No. 16.—Has the alternating current any injurious electrolytic effect upon underground metallic structures, such as water or gas pipes?*

I have never seen any injurious effects from the alternating current.

HERBERT L. BRAGDON.

We believe not, since it has not the property of causing electro-deposition of metals, which depends solely on direct current.

CHAS. H. PETERS.

No.

G. WILBUR HUBLEY.

*No. 17.—What is the best method of protecting underground lead-sheathed cable from electrolysis from the return current from a street-railway system?*

The best method of protecting from electrolysis wires used in underground cable, is to solder short lengths of copper wire to the lead casing of each cable in each manhole, then solder together all these copper wires and ground them in each manhole. If this grounding is carefully done, very slight trouble will be experienced from electrolytic action.

(UNSIGNED.)

First, secure adequate return for the railway system. Second, amply bond the lead-sheath cable to all water pipes, gas mains, etc.

CALVIN W. RICE.

If possible, arrange with the street-railway company to better its line conditions and also the bonding of its tracks. Make tests on cables with a low-reading voltmeter often enough to determine whether there is an appreciable difference of potential to ground. Where this is found, break lead sheaths on cables. Also examine your own cables to make sure that the trouble is due to street-railway current and not to leaks from your own lines.

W. E. CARLTON.

Use ducts of vitrified clay or some other good insulating material. Drain well and dry. If water surrounds the cable, bond the sheath to the nearest railway return at frequent intervals.

L. J. LISBERGER.

Bond all lead sheaths together and run heavy return to street-railway system.

HERBERT L. BRAGDON.

Whenever an electric current leaves a metallic pipe and passes through the earth, the surface of the pipe is corroded or gnawed away by the chemical action set up by the current, finally eating through the pipe and starting a leak.

Part of the current used on the railway circuits may pass from the rails to the pipe and thence along it to the neighborhood of the motors, where it passes back to the track and the moving cars. The mischief is done at this point, and not while the current is passing through the pipe. One ampere flowing steadily from an iron pipe will eat away nearly 20 pounds of metal in a year, or if the metal be lead, 75 pounds per year. This destruction would occur at the place where the current leaves the pipe, and if the conditions are such as to limit the exit surface to a small area, the damage at this point would be serious.

In order to ascertain if the water, gas pipes and underground cables in our streets are in danger of injury from stray electric currents, voltmeter readings should be taken between the rails and the pipes or cables. If the instrument indicates any difference of potential, it should be considered reason for alarm, as some of the worst recorded instances of electrolysis have occurred where the measured potential difference was only one or two volts.

Iron water pipe has been riddled in five to eight months.

Surface protection of pipes in Boston, by painting them with asphalt and the like, has been shown by experience to be practically worthless, as the corrosion seems to work under the paint.

To prevent electrolytic destruction of neighboring pipes by stray currents from the rails, the proper return circuit of the railway should be made so good that the current would not seek an easier path back to the generator. In order to do this, a perfect connection should be made from rail to rail. If the resistance of the bonds and their contacts were negligible, there would be very trifling stray currents. In some of the larger cities it has been found, where it is shown there is a difference of potential between the pipe and track, that a copper wire of sufficient capacity connecting the pipe, the rail, and carried back to the generator, has, to a great extent, eliminated the trouble. This, while good so far as it goes, will not prevent electrolysis at the joints of a pipe where the connection is poor from an electrical standpoint.

Doctor Louis Bell gives the following advice with regard to this matter:

*“First—Use the continuous rail system, or*

*“Second—Bond very thoroughly. Put the positive pole of the generator on the overhead line, join the negative directly to the track without intentional earth connections, and*

*“Third—In any case, investigate the potential between track and buried conductors and run supplementary wires from these conductors to the dynamo, if necessary.”*

WILLIAM R. GARDENER.

To protect cables in manholes from electrolysis, connect lead covering to a point on rails that is always negative to the lead. Explore underground territory with low-reading voltmeter and keep cables clear of iron pipes and racks in manholes where these are found to be negative to the cables.

D. W. ROPER.

*No. 18.—What is the best method of protecting cables in manholes—first, from burnout from adjacent cables under faults; second, from electrolysis; third, from mechanical injury?*

Cables and manholes may be protected, first, from burnouts from adjacent cables, by a grounded metallic covering; second, from electrolysis, as per answer to the preceding question; and third, from mechanical injury, in similar manner to that given first. In addition, it may be well to first wrap the cable in asbestos of about one-eighth-inch thickness and then cover the whole with galvanized-iron wire or tape, protecting the whole with a grounded metallic sheet.

CALVIN W. RICE.

Cables in manholes may be protected from burnouts by surrounding them with vitrified tile, which can be bought split and placed around the cables, after which the joints can be cemented, making a compact conduit entirely insulating one cable from another.

G. B. SPRINGER.

Bond all lead sheaths together and run heavy return to street-railway system; fasten all cables securely to wooden strips around sides of manhole.

HERBERT L. BRAGDON.

Cover the cables in the manholes with split tile, well cemented. You then have the cables about as well protected as they are in the straight conduit.

B. E. STROHM.

Protection from burnouts can be obtained by wrapping cables with a form of asbestos tape reinforced by metal bands. The placing of cables where possible in recesses formed in the brickwork of which the manhole is built, in addition to wrapping the cable, is an excellent preventive from burnouts or mechanical injury. Protection from electrolysis is obtained by laying cables in vitrified ducts, breaking the lead sheath frequently and inserting joints at all such breaks. Any means that will interrupt the continuity of lead sheath will accomplish the desired result, except when cables are under water at all times. Under the latter condition, the installation of a large bare cable, bonded to all cable sheaths at each end of the wet section, will materially aid in protecting cables.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

(1) Wrap cables with asbestos banded on. (2) Locate cables in shelves in manholes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Wrap cables with one-fourth-inch sheet asbestos, known as "fire felt," with the lap toward the brickwork, and bind same with galvanized steel tape of about No. 29 gauge and five-eighths inch wide, binding the tape as closely as possible. This will protect the cable both from hot metal, from adjacent cable faults, and ordinary burnouts, while also acting as protection against mechanical injury.

H. S., N. Y. ED. CO.

*No. 19.—What results have been obtained from using lightning arresters on secondary lighting circuits? Is it considered good practice?*

The use of lightning arresters on secondary circuits would seem to tend to cause a discharge on the primary circuit to jump the transformer and go to ground on the secondary. We

have avoided secondary arresters, preferring to place them on the primary side.

GEO. B. LAUDER.

Lightning arresters are very seldom used on secondary circuits and are rarely of any use. All secondary circuits should be grounded, which furnishes the best lightning protection possible.

M. P. R., N. Y. ED. CO.

If secondary circuits are properly grounded no lightning arresters are necessary.

H. B. GEAR.

*No. 20.—What policy will result in the least interruption of service: numerous cut-outs on primary lines, protecting all taps, or few cut-outs on lines, the station fuse or circuit-breaker being depended upon for protection?*

The best method of running primary circuits is to run out a set of main feeders in as nearly a straight line as possible from the station to the end of the district that they are intended to feed, then put a set of junction boxes for each pair of lateral primaries running from this main circuit. In case of trouble on any lateral, the fuses protecting it will be blown and a small district will be without light, the area in which trouble may be looked for being very much less than if no fuses are used on the primary circuit except those at the central station. The ideal way of operating a primary system would be to have enough main primary circuits so that the laterals from each of these main circuits would take care of only one or two blocks in width on either side of the main circuit.

(UNSIGNED.)

With primary circuits properly fused at station and all transformers fused on primary, we experience very little interruption to service; at all events, trouble is always very materially localized.

E. P. DILLON.

We find it most advantageous to use numerous cut outs in the primary line, running our distribution circuit in sections from a main feeder with cut-outs at each branch. In this man-

ner only the branch affected need be in darkness, while the service of our other patrons is not disturbed.

FAIR HAVEN ELECTRIC CO.

I find the least interruption of service by having cut-outs on primaries. I keep cut-outs at centre of distribution fused to 50 per cent above the load on that line, and at every branch put in expulsion fuses, fused to 50 per cent over the transformer capacity on the branch.

In case of a short-circuit anywhere on the line, I find that the fuse will go at the nearest cut-out on the station side of the short and not affect the rest of the system, and a call of "lights out" means to look over the branch from which the call is received.

In case the linemen wish to work anywhere on the line, they can protect themselves by pulling the nearest plug between where they wish to work and the station.

We have had our three-phase system arranged in this way for two years and have had very little trouble on our lines.

F. B. DOTEN.

We find that individual cut-outs for separate circuits give the best service, for the reason that a fuse blowing on one of these circuits will not interrupt service on the other lines, while the opening of the circuit-breaker at the station affects a considerable number of lines.

A. R. MACKINNON.

The station fuses or circuit-breaker should be depended upon entirely. A heavy ground or a short-circuit can be carried or burned off at less expense than the interruption of the service would cause.

GEO. L. COLGATE.

Keep your arrangement of fuse boxes on primary distributing lines as simple as possible. Do not fuse any taps that are likely to take more than 30 amperes. On heavy taps put in cut-out boxes, but strip them up solid. This will allow for opening line ready for test.

W. E. CARLTON.

Our policy is to eliminate possible chances of trouble. Use primary fuse protection at each transformer, and depend on station fuses for protection against line trouble.

TOLEDO RYS. AND LT. CO.

The fewest number of cut-outs possible will give the least interruption of service.

G. H. CUSHMAN.

Use no cut-outs at all outside of station except those on transformers. Exceptions may sometimes be made of particularly bad branch circuits, such as those that run through thick trees and are especially liable to get into trouble.

M. P. R., N. Y. ED. CO.

For reliability of service, the best policy is to reduce cut-outs on the primary to a minimum.

G. WILBUR HUBLEY.

With small plants we find the least interruption to service is secured by dividing the lines into sections, each of which is protected by a set of primary cut-outs.

E. H. MATHER.

Theoretically, cut-outs at each primary tap should form a safeguard against interruption of the feeder service. But practice discounts the efficacy of this method of protection. The safety of the cut-out itself, the improbability of securing the proper proportion of current-carrying capacity in the strips in every case, due to failure of linemen to replace strips with others of same size, or to the importance of the customer; the coincident blowing of primary strips and station fuses at times of heavy load periods, and lastly, the safety of the modern transformer and high standard of wiring from transformer to customer, are all points which discount the worth of the primary fuse.

"Least interruption to service" may be interpreted to mean either interruptions of comparative frequency but of short duration or infrequent interruptions of comparatively long duration; the first condition being exemplified by blowing of station fuses due to fewer number of primary tap fuses, the station fuse

being in all cases more easily and quickly replaced than the line fuses. This consideration must be weighed by the engineer in charge of the installation with due regard to the class of service and relative importance of the customers.

In general, protect line against less important services and keep the important services alive for as great a proportion of each 24 hours as is possible.

B. JAMIESON.

Use a cut-out on every branch from the primary line, and also on every transformer.

EDGAR B. GREENE.

Too many cut-outs become a nuisance; they represent so many weak points on the line. Have cut-outs where each circuit begins, and keep your pole line in good shape.

CHAS. H. PETERS.

In my opinion, the least number of cut-outs on the line, depending upon station fuses or circuit-breaker for protection.

F. C. S., MALDEN ELECTRIC CO.

The least interruption of service will probably result from tying feeders solid to mains at centre of distribution. Branch mains of smaller wire should be connected to mains through cut-outs. Tie-lines between feeders should have switches in circuit. Switches should also be properly located in each feeding system, so that one feeder may supply two or more systems through the tie-lines in the event of a mishap on one feeder or its mains.

ROBERT LINDSAY.

Numerous cut-outs on all taps.

AUGUSTA RY. AND ELEC. CO.

*No. 21.—What is the best method of locating grounds and short-circuits on live underground cables, both direct and alternating current? Is there danger of damaging cable where about seven-ampere alternating current is used for the purpose of testing?*

Thirty to 40 amperes of alternating current intermittently applied to a cable will cause no harm or trouble; and by using

a coil and telephone receiver along the cable in question, troubles may very easily be located.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 22.—What is the best and most efficient lightning protection for a high-voltage transmission line not exceeding 10 miles in length?*

Standard lightning arresters are offered by the principal manufacturing companies.

CALVIN W. RICE. .

Efficient lightning arresters in station and on pole line. An ample number of arresters should be used; for example, four to a mile has been shown to be good practice. Particular care should be given to their proper installation, especially in regard to ground-wire connection.

G. WILBUR HUBLEY.

Arresters and choke coils at both receiving and generator end should give good protection, the arresters being of some recognized make applicable to the voltage of the line.

E. P. DILLON.

This question calls for a high-tension transmission line not exceeding 10 miles in length. I therefore assume that the voltage on this line is not in excess of 10,000 or 15,000 volts, as this would be the usual voltage selected for a line of this length. It has come to my notice in a transmission line that I installed in 1901 that highly-satisfactory results were obtained in the following manner:

The line voltage is 11,000, the transmission lines, nine miles. The line wires are No. 4 bare-copper triangulated, 48 inches on each side of the triangle. On the very peak of the pole is fastened ordinary barbed wire. On the extreme end of each cross-arm there is located a strand of No. 6 galvanized-iron wire. The barb and galvanized wire is grounded three times per mile, and the line wire is transposed every fifth of a mile. This line crosses one of the spur ranges of the Rocky Mountains and is exposed to very vivid lightning in the spring, but from 1901 until the present time we have not lost a single transformer

on either end of the line and have suffered practically no inconvenience at all on account of lightning.

THOMAS B. WHITTED.

*No. 23.—What are the advantages, if any, in transposing the wires of a four-mile, 10,000-volt circuit carrying alternating current?*

A 10,000-volt circuit implies small currents and small wires. On such a line four miles long it is doubtful if any practical good would result from transposition.

GEO. B. LAUDER.

All depends on the kind of system used. For three-phase work, especially with the equilateral-triangle method of putting up wires and where the telephone is not used on the same poles, I do not consider transposition to be of any value. It is only advantageous where the telephone line is run parallel to the alternating-current line a considerable distance, or where two circuits are run on the same set of poles.

A. O. WHITMORE.

They are very small.

AUGUSTA RY. AND ELEC. CO.

*No. 24.—What method has been employed to overcome the inductive currents on lead-covered cables when used for alternating-current distribution?*

Place the outgoing and incoming circuits under the same lead sheath, but when that is not possible bring the several single-conductor cables together in the same conduit.

CALVIN W. RICE.

Put both sides of the circuit in the same cable. The induction from one wire will then neutralize that from the other.

AUGUSTA RY. AND ELEC. CO.

*No. 25.—On alternating-current secondary circuits, the use of inclosed-arc lamps having an induction coil for regulating*

*voltage across arc has the effect of increasing the drop that the secondary would have on a non-inductive load. Where incandescent and inclosed arcs are run from the same secondary, we have had trouble on account of the drop in voltage produced by the arc, since when the arcs are turned off the voltage will rise to normal. Is there any practical remedy for this difficulty?*

I understand that this drop in voltage is unavoidable, and with the ordinary transformers can not be remedied.

GEO. B. LAUDER.

The trouble may be overcome by putting in a large transformer in place of a number of small ones, when running both the arc and incandescent lights from the same secondary circuit will be satisfactory, as the power factor will be higher; in other words, with a transformer carrying, say, ten six-ampere, alternating-current arc lamps and ten 16-cp incandescents, the power factor would be about 75, while if the transformer carried only one arc lamp and the balance of its capacity in incandescents, the power factor would probably be 95. In the business portion of the city the total arc-lamp load in watts is not so high as the total incandescent-lamp load in watts, and the power factor would be better if the total of the two loads could be carried on a few large transformers.

(UNSIGNED.)

By having plenty of transformer capacity and secondary wires, and arc-light wiring large enough to carry the load with practically no drop, the trouble can be remedied to a very great extent.

HERBERT L. BRAGDON.

There will always be some reduction in the secondary voltage of a transformer when arc lamps constitute part of its load, but this drop can be reduced to a minimum by using a transformer of good regulating qualities and ample capacity.

If each arc lamp requires six amperes and 110 volts, the apparent watts are 660, and this is the minimum transformer capacity that should be provided for each arc lamp.

It is also important that the secondary service wires and the

interior wiring be of ample capacity, as the inductive loss in wiring must be taken care of in addition to the C<sup>2</sup>R losses.

J. H. HALLBERG.

The only practical remedy that has presented itself to us is to install transformers where arc-lamp load exceeds a certain percentage of the total arc and incandescent load, according to the regulation desired.

TOLEDO RYS. AND LT. CO.

Use transformers with best regulation possible on inductive loads. Be generous in the use of copper and keep wires as close together as possible to minimize inductive drop.

M. P. R., N. Y. ED. CO.

Install wire of suitable size to care for the additional drop caused by the inductive load.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The only remedy, so far as we know, is to use more copper in buildings and provide ample transformer capacity.

CHAS. H. PETERS.

*No. 26.—What should determine the size of wire to be used in a secondary system fed by transformers in parallel? Should it be made large enough to take care of all prospective needs, or should it be made of moderate size and additional transformers be connected to it at the proper points when the drop becomes too great?*

It is pretty hard to anticipate future needs. We built a belt line a number of years ago, and have since added not only to the size of wire originally put up, but have added transformers from time to time. The obvious advantage of transformers in parallel on a secondary system is to enable the use of large transformers placed at intervals. On the face of it, a large secondary would be needed, but it would seem that each case would require particular study.

GEO. B. LAUDER.

A cable large enough for a secondary system fed by transformers need not be much more than sufficient for present requirements, as transformers may be added from time to time to take care of the growth of the business.

(UNSIGNED.)

It would depend entirely upon distances. Under usual conditions, the secondaries should be of moderate size and transformers added at points where the drop becomes too great.

GEO. L. COLGATE.

When the secondaries are to cover any great amount of territory, it is better to use moderate-sized wire and add transformers as needed, as the load is so very liable to change that it would be difficult to locate a single transformer at the centre of distribution.

HERBERT L. BRAGDON.

Ordinarily, we would prefer to install standard-size secondaries best calculated to suit average conditions, and take care of increase, both for distance and capacity, by adding transformers.

TOLEDO RYS. AND LT. CO.

Can not be answered in a general way, as local conditions determine best method to follow. It is usually better to cut secondary mains into sections, with one transformer feeding each section. Mains should be of moderate size and cut into smaller sections as load grows.

M. P. R., N. Y. ED. CO.

It is cheaper, and better in the end, to be liberal in the size of your secondary mains. One large transformer to a block is better than its equivalent, as regards capacity, in smaller ones, since losses and chances of burnouts through lightning will be reduced in the larger units.

CHAS. H. PETERS.

Given the cost of energy at the station switchboard and the value of transformers and wire, the most economical size of secondary can be readily computed for any particular load density. For instance, with energy at one cent a kw-hour and with a maximum drop of two per cent, No. 4 wire will be the best

size when the load has an average density of 20 kilowatts per 1000 feet. With a load of 40 kilowatts per 1000 feet, the best size is No. 0 wire. Roughly, the best size will be found to coincide with the carrying capacity of the wire in sizes above No. 2. If the secondary line is being constructed in a neighborhood where there is a likelihood of considerable growth in the future, it is advisable to put up a somewhat larger secondary wire than would be needed immediately and to provide the additional capacity by inserting the additional transformers from time to time.

A large part of the lighting business in the outlying districts of cities is, however, not even approximately evenly distributed, so it is not usually advisable to install secondaries to carry more than the load that is immediately in view, since if an interconnected system is constructed there will be long stretches of idle line that will be of little value.

H. B. GEAR.

Where transformers feed a secondary system in parallel, the amount of copper connecting groups of transformers should be such that at maximum load the drop on the tie-lines is very small; if the drop is large there is no gain in the multiple arrangement, as each group of transformers will feed the load connected in close proximity to it, and will neither receive nor give help to the other transformers or groups of transformers.

ROBERT LINDSAY.

Allowing two per cent drop on the basis of total lights wired will provide for ordinary prospective increase of business.

G. WILBUR HUBLEY.

The character and condition of the load make a fixed rule impossible. Each case should be treated by itself.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 27.—What are the advantages, if any, of the varnished cambric-insulated cables over paper or rubber-insulated cables?*

The advantages of varnished cambric-insulated cables over paper or rubber-insulated cables are the following:

Over both—lower cost.

Over rubber—has a longer life and is not affected by oils or gases.

Over paper (assuming the paper has a lead protection)—is easier to install and does not require a pot-head.

S. O. SWENSON.

*No. 28.—Is it advisable to install unsheathed cable in underground conduit under any conditions?*

It is not advisable under any condition to install unsheathed cables in underground conduits. If rubber-covered cable be used unsheathed, the heating and cooling of the conductors with the different current values that may be passing will, in time, with the assistance of atmospheric conditions, cause the rubber to become partially vulcanized, and when this condition takes place cracks will form in the rubber cable, destroying the insulation and causing short-circuits, necessitating the removal of cable. With lead sheathing these troubles will be obviated, and while the lead-incased cable may be more expensive initially, it will last so much longer that it will be less expensive in the end.

(UNSIGNED.)

If you will give some specific data, I shall be pleased to answer this question in detail.

CALVIN W. RICE.

I think it poor practice to install unsheathed cable in conduits, as it is very liable to mechanical injury in drawing in, and is also liable to deteriorate very fast on account of gases and other causes that might develop in any system of conduits.

HERBERT L. BRAGDON.

No; it would be shortsighted economy to use unshathed cables even for the neutral, with live current-carrying legs sheathed, for the best conduit system ever constructed is liable to dampness, and any current on the neutral due to an unbalance of the system will go to ground at points where it is in contact with the lead sheath of the other cables; should this current be heavy enough, the lead sheath would be destroyed at all points of contact, thus making junk of possibly thousands of feet of

cable where a small amount of additional first cost would have prevented any damage.

B. E. STROHM.

No; the life of cables that are installed in underground conduits without metallic sheathing will be limited, owing to water and the great amount of moisture invariably found in all underground systems. Any cable with an insulation made of fibrous material, such as paper or hemp, will stand moisture but a short time, even when treated with the best of waterproof compounds. Rubber-insulated cables will last for a longer period, but this insulation will soon be affected by underground gases, which will cause it to disintegrate and admit moisture. Lead sheathing increases the cable's cost slightly, but adds greatly to the length of its life, and it also enables the cables to be withdrawn from the ducts at any time, which is often impossible when the braid on a cable without lead sheathing becomes rotted and strips off from the cable in the attempt to pull it out.

H. S., N. Y. ED. CO.

No.

G. WILBUR HUBLEY.

*No. 29.—What is the commercial limit of size of copper conductors when used as feeders for distribution of alternating current of 2000 volts at a distance of one and one-half miles from centre of distribution?*

The commercial limit would seem to be the smallest size safe to use, regarding mechanical strength. We have used much No. 6 and believe No. 8 could be safely used at 2000 volts; sizes under No. 8 have not enough mechanical strength to take the risk of breaking.

GEO. B. LAUDER.

Enough feeders should be run out from station so that there shall not be more than 100 kilowatts at maximum load on any feeder, and with 2000 volts and a centre of distribution one and a half miles from the central station 100,000-circular-mil cable would be amply large for this purpose.

(UNSIGNED.)

The limit is somewhat determined by the frequency used. For 60 cycles we limit to No. 0 B. and S. Local conditions might influence the limit one way or the other.

TOLEDO RYS. AND LT. CO.

If feeders larger than No. 0000 are needed, I think it advisable to draw in more cable.

HERBERT L. BRAGDON

No. 00 copper is about the heaviest that can be strung on such lines to look well and retain a good appearance. If this size is insufficient, run others and connect them in multiple.

CHAS. H. PETERS.

Copper conductors as large as No. 0000 B. and S. gauge may be installed for use as feeders of 2000-volt systems without serious difficulty. Such feeders would be capable of carrying 400 kilowatts with seven per cent loss at the maximum load at a distance of a mile and a half. There are very few cases, however, where it would be advisable to attempt to carry as much as 400 kilowatts on a single feeder, owing to the large number of customers who would be inconvenienced by the operation of a circuit-breaker due to any trouble on the feeder. Two feeders of No. 0 B. and S. gauge wire dividing this load equally would be preferable from an operating standpoint in a large majority of cases.

H. B. GEAR.

*No. 30.—What has been the practice and experience as to size of conductors, and how many conductors can be successfully run in a single duct of underground system for the distribution of 2000-volt, 60-cycle, alternating-current circuits?*

It is not advisable to run more than one set of cables in one duct, for the reason that should two or three sets be run and one set break down, it would damage all three and require them to be removed for repairs. As many cables as desired may be run in one duct, however, provided they can be pulled in, if no consideration is taken for the results liable to follow from one being damaged.

(UNSIGNED.)

The largest cable that can be handled practically is about two and five-eighths inches in diameter, the lead sheath being one-eighth inch in thickness. From this you may determine the number of conductors in installation that can go in such a cable.

CALVIN W. RICE.

The size of conductors must be determined by the capacity of the machine or the amount of load to be carried on each circuit. Six No. 6 or even No. 4 B. and S. wires can be pulled with safety into a three-inch duct. Four No. 0000 cables can be pulled into a three-inch conduit.

B. E. STROHM.

Three duplex cables can be run in a single duct, but I think it advisable to run only one in each duct if possible to get enough ducts to do so, as after two or three cables are run in one duct if one cable becomes defective from any cause it is impossible to draw it out for repairs without drawing out all in the same duct, thereby causing an interruption in other circuits and much unnecessary labor and expense.

HERBERT L. BRAGDON.

*No. 31.--What is the cost per duct-foot of conduit construction, complete with manholes, for high-voltage alternating system?*

The cost varies according to the kind of conduit, number of ducts run, and the character of the excavation. The average cost for installing vitrified clay conduit in macadam is about as follows: For two ducts, 80 cents; four ducts, 98 cents, and six ducts, \$1.20 per trench-foot. A good manhole will cost about \$75.

WILLIAM R. GARDENER.

From 15 to 30 cents, according to conditions.

CALVIN W. RICE.

The cost per duct of all conduit construction varies with the kind of pavement, the number of ducts to be laid, the conduit used, and the manner of laying. When laid with three inches of concrete surrounding the ducts, as is common prac-

tice, and with conduit costing from four to six cents per duct-foot, the total cost will vary from 15 to 30 cents per duct-foot. This price does not include manholes. Higher prices are paid for a comparatively small number of ducts in a high-priced pavement. Manholes will cost from \$75 to \$150 each, depending on size, method of construction and kind of pavement.

W. E. CARLTON.

The cost per duct-foot of conduit construction of course varies considerably according to the number of ducts and the size of the manholes installed, as well as the kind of paving in which the work is done; but for an average of, say, from nine to twelve ducts in cedar-block pavement the cost would be about 30 to 33 cents per duct-foot, including manholes. The cost in granite pavement would be 33 to 35 cents, and in asphalt pavement runs as high as 50 to 60 cents per duct-foot. A larger number of duct lines may be laid much cheaper.

G. B. SPRINGER.

*No. 32.—Has it been found practicable in a high-voltage underground system to place transformers in manholes? Are not drainage connections to sewers absolutely essential?*

It is not only practicable, but it is desirable, to place transformers in manholes where they are intended to feed underground systems. Such transformers are made with watertight cases, the top being put on over a gasket packing, so that connections to sewers from manholes may be avoided. But in a conduit system the cost of putting drains to manholes would be so small in comparison with the entire cost of the conduit work that it would be extremely bad practice not to drain the manholes.

(UNSIGNÉD.)

Yes; drainage connections are advisable, but are not absolutely essential.

CALVIN W. RICE.

Yes. Of course the manholes must be drained.

GEO. L. COLGATE.

We have good results from the Edison three-wire tube. Have mains and services installed since 1895 to 1897.

TOLEDO RYS. AND LT. CO.

Have had very good success with transformers in manholes. Local conditions for manholes determine whether or not it is essential to drain to sewer. On high land, where you have only to contend with surface water, there is no need of sewer connections if the inside cover is well screwed down on a gasket. Under the above conditions I think it advisable not to connect to sewer, as it gives one more chance for sewer gases to work back into manholes and conduits. We have one manhole where we found it policy to connect to sewer, as about four feet of water stood in it all the time.

HERBERT L. BRAGDON.

Transformers are frequently placed in manholes where it is impossible or undesirable to put them on private premises. It is necessary that the manholes be dry, and in every well-constructed conduit line they should be provided with sewer connections.

G. B. SPRINGER.

Transformers in manholes are certainly practical from an economical as well as from a safety standpoint. In installing them in the manholes a larger range is obtained for service taps from a single transformer than is possible where they are placed on the premises of the customers. Liabilities arising from deaths and injuries to persons coming in contact with primary current are brought to a minimum, as all high-voltage current is in the conduit, which is the property of the company or corporation, and only employees of the company need be cautioned; while high voltage on the premises of a private person leaves the company liable for the safety of the public.

Sewer connections should be made from all manholes wherever possible. In placing transformers in manholes, have them high enough for the cover to be above the ducts. You are then doubly sure that water can not reach them, for if the sewer connection becomes blocked the water will flow out of the ducts to the next manhole where the sewer outlet is clear.

B. E. STROHM

A great many are in use and giving very little trouble. As far as drainage connection to the sewer is concerned, I do not consider it absolutely essential. I should first make the manhole waterproof, and if connected to the sewer it should

be done with a check valve to prevent any back sewerage reaching the transformers.

W. J. C., N. Y. ED. CO.

(a) Yes, up to 2300 volts.

(b) If soil is sandy, manholes will drain themselves in a short time; in clay soil, all manholes containing transformers should be drained to sewers.

ROBERT LINDSAY.

Yes. Manholes should be drained.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 33.—What is the best system of distribution from underground mains: Edison tubes, centre poles for each block, or some other system?*

The drawing-in-and-out system, with conduits and manholes.

CALVIN W. RICE.

This depends on arrangement of streets and alleys, also on local requirements. If centre poles for each block can be used it will generally be found very much cheaper than individual underground service.

W. E. CARLTON.

Edison tubing is, without doubt, the best system of low-voltage distribution on the market to-day.

HERBERT L. BRAGDON.

Edison tubes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Edison tube construction has some advantages, particularly in the convenience of making frequent taps to customers' premises. On the question of repairs, however, it is at a disadvantage, as digging is always necessary, which, in the winter, is not always possible. Where the cost of installation is not a factor, a regular conduit construction is the best that is possible to install, as additions or repairs may be made at any time without interruption to the service.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 34.—What is the best way of removing asphalt pavement for underground conduit work and of replacing it after the work is done?*

Dig it up and have the city put it back, as it can do the work cheaper. This plan avoids all chances for an argument as to whether or not it is right when finished.

HERBERT L. BRAGDON.

A tool commonly called a "Hardy," having a sharp edge like a hatchet and a flat head upon which a sledge may be struck, can be used to cut the asphalt into square blocks, which can be replaced after the work is done. This keeps the pavement in fairly good condition until permanent repairs can be made.

G. B. SPRINGER.

Mark the paving off in squares of about two feet each by cutting an incision from one-half to three-quarters inch deep; fill this crack with kerosene oil and set it on fire. When the oil has burned up you will find that the asphalt has lost its brittleness and can be cut through very readily without breaking, and the pieces of two feet square can be removed. When the work is completed the squares can be replaced in their original position.

B. E. STROHM.

*No. 35.—What has been the general experience with aluminum feeders, and at what price per pound does it pay to use aluminum as compared with copper?*

One thing to take into consideration is the possibility that the price of aluminum may be greatly reduced by some new process, and any money invested in aluminum has an uncertain value as an asset; but, while the market value of copper fluctuates over considerable range, it is probable that copper wire will always be a good asset.

GEO. B. LAUDER.

*No. 36.—Does it pay to put up sections of lead-covered insulated wire through trees to obviate the wearing of insulation and consequent grounding?*

The protection is questionable. The lead sheath is separated from the conductor by a comparatively small amount of insula-

tion and lies quite close to the conductor. In rainy weather the sheath will nearly always be grounded on the conductor anyway, and the current will flow from the conductor back along the lead to the place where the lead is in contact with the tree.

GEO. B. LAUDER.

I do not think it pays to run in sections of lead-covered cable through trees. The lead soon chafes off, and this is liable to ground the conductor to the sheath, making it alive to ground the whole distance.

HERBERT L. BRAGDON.

It is not generally considered good practice to use lead-covered wire through trees. The lead is so heavy as to require very strong construction, and introduces an element of weakness through the difficulty of protecting the insulation at ends of lead. Special tree wires are now made with rubber core and extra strong weatherproof braids that will stand considerable abrasion.

M. P. R., N. Y. ED. CO.

Lead covering would soon wear away.

AUGUSTA RY. AND ELEC. CO.

I think not.

F. C. S., MALDEN ELECTRIC CO.

It is not good construction to put up sections of lead-covered cable through trees. It is better to trim the trees; but, where this can not be done, a satisfactory protection has been found in the use of two half-round oak strips grooved and boiled in paraffin, over a rubber-covered wire.

ROBERT LINDSAY.

It does not pay to put up sections of lead-covered wire through trees to prevent grounding; the better remedy is so to construct the lines that they will not come in contact with the trees.

E. H. MATHER.

*No. 37.—How do you overcome the tree-trimming nuisance?*

When obliged to run through trees, set poles as near the trees as possible and use eight-foot or ten-foot cross-arms, allowing yourself room to spread your wires out, thereby clearing your tree.

HERBERT L. BRAGDON.

I interpret the nuisance referred to as being the protests of property-owners. A little education in the way of illustrating the beauty of well-trimmed trees will help in this matter, and I have also found it well to get, if possible, an ordinance passed by the authorities authorizing the trimming of trees under the direction of the street superintendent. The legalizing of the trimming puts a stop, to a large extent, to the property-owners' protests.

GEO. L. COLGATE.

We overcome the tree-trimming nuisance sometimes by the aid of the city officials and by doing the trimming in spring and fall before and after the leaves appear and disappear.

W. J. C., N. Y. ED. CO.

The use of tree insulators of some types will help.

AUGUSTA RY. AND ELEC. CO.

Construct the lines, even at considerable additional expense, so they will not come in contact with trees.

E. H. MATHER.

We trim trees when we can get permission. We put in new wire when the insulation is worn out, using tree insulators or longer cross-arms, taping short sections, and so forth.

FRED B. HUBBELL.

Steer clear of trees as much as possible, even to the extent of building new lines if there is a clear thoroughfare near by. If the trees are small, put in longer poles and raise your wires. When a limit is reached in this direction, tell the property-owners that the current in the wires will surely kill the trees and that rather than see them die you would like their permission to trim the tops a little. They will usually grant it.

CHAS. H. PETERS.

*No. 38.—Is it advisable to place fuse box at the junction of the primary main with service line in manhole? If so, what style of fuse box is most satisfactory, and how should it be mounted and connected?*

It is not advisable to use any high-voltage fuses whatever in manholes of an underground system. Anything up to 500 volts may be fused in an ordinary underground junction box, but 1000 volts and upward should be fused only at the station ends of the primary feeders. (UNSIGNED.)

Do not use fuse box in a manhole for a service tap. Connect up solid and make a waterproof joint with tape and compound. The best fuse box will gather dampness and corrode, which in time is sure to cause trouble, while no particular advantage is gained, as your main and service are protected by a cut-out where the service enters the customer's premises from shorts on a customer's wiring. B. E. STROHM.

*No. 39.—What is the practice of lighting companies with regard to their weatherproof line wires that have become frayed and the insulation rendered useless? Have they erected new insulated wire, or taped up the old insulation, or left the lines alone?*

We have taken some in and allowed more to remain; don't know what we are going to do. GEO. B. LAUDER.

It is our custom to replace the wire where the insulation becomes frayed so badly as to be liable to excite public comment. WILLIAM R. GARDENER.

When the insulation becomes frayed and useless, it is the best policy to run in new wire and sell the old for junk, both for looks and for safety from other wires coming in contact with them. HERBERT L. BRAGDON.

Generally erect new wire.

M. P. R., N. Y. ED. CO.

In the matter of frayed insulation of overhead wires, where lines are isolated and carrying unimportant loads, the lines might be allowed to remain if well insulated from grounds at the points of supports. Where the relative danger is greater on account of close proximity of telephone or other wires, dangerous loads, or even in the absence of these conditions, where public sentiment makes it a matter of policy, wires should be entirely renewed. Except in special cases where frayed wire is due to some special local cause and not to general deterioration, taping the wires exposed to the elements is an expensive and ineffective expedient. Often the weatherproof insulated wire is more dangerous than bare wire would be, in the false security it would give the lineman as to its protective qualities.

F. S. CHANDLER.

It is better policy to add new wire, especially where it is necessary to put up new poles and cross-arms at the same time.

AUGUSTA RY. AND ELEC. CO.

Our practice is to erect new insulated wire.

F. C. S., MALDEN ELECTRIC CO.

It is good practice for lighting companies to replace with new wire weatherproof line wires that have become frayed.

E. H. MATHER.

*No. 40.—Should transformers be fused on both the primary and secondary, and what percentage of overload should be allowed in fusing when transformers are connected in parallel to secondary mains?*

We think it advisable to fuse both sides where transformers are paralleled. The percentage of overload is hard to state. In practice, the fuses must be heavy enough to do the work. We fuse them up heavily, so that only a short-circuit would probably blow them. If you have many transformers in parallel, and fuse them lightly, one may go out and then another, and the rest will naturally follow, as the load remains constant, while each transformer that goes out puts its load on those remaining.

GEO. B. LAUDER.

We fuse transformers only on primary, in many cases allowing 50 to 75 per cent overload capacity in fuses.

E. P. DILLON

Yes, if transformer is running in parallel with others; otherwise, the transformer, if cut out and only primary fuses taken out, will have the same loss, caused by secondary being connected to lines, as would be the case if secondary were open and primary joined to primary lines. A switch could be used instead of a fuse, although if the cartridge type of fuse is used it acts as both a switch and a fuse. I should say, fuse about one-third higher than rated capacity of transformer.

A. PETERS.

The fuses should be capable of about 50 per cent overload for a short period.

J. H. HALLBERG.

We use primary fuses only, at 150 per cent capacity of the transformer.

TOLEDO RYS. AND LT. CO.

It is only necessary that transformers be fused on the primary side, as the current in the secondary coil is always proportional to current in primary. When transformers are connected in parallel to secondary mains the fuses should allow an overload of 50 per cent.

SAMUEL KAHN.

Fuse primary only, except where more than two are connected in parallel. Fuse for 50 to 100 per cent overload.

M. P. R., N. Y. ED. CO.

Ordinary step-down transformers for lighting service should be fused on primary side only.

S. B. RICHEY.

Transformers should be fused on the primary only, and not over 50 per cent overload should be allowed.

FRED B. HUBBELL.

Transformers connected in parallel on both the primary and secondary sides should be fused on both the primary and

secondary. If, for any reason, a fault should develop in one of the transformers, blowing its primary fuse, and there are no secondary fuses, a rush of current from the other transformers through the secondary line is apt to cause trouble by blowing all the primary fuses of the other transformers, cutting out the entire system.

E. A. WAGNER.

We see little advantage in fusing the secondaries of transformers. Allow primary fuses on overload capacity of 50 per cent, otherwise they are liable to blow on the slightest provocation.

CHAS. H. PETERS.

The method of fusing transformers in Denver is very satisfactory. The primary of the transformer is fused to 100 per cent overload, and junction fuses in the secondary three-wire are placed midway electrically between the transformers and fused to full-load secondary current of the transformers. The neutral is not fused.

J. F. DOSTAL.

Transformers should be fused on the secondary as well as the primary side in cases where they are connected in parallel with other transformers, unless the secondary line is provided with sectional fuses that will cut out a section of the line in case the primary fuses on the transformer blow for any reason. Secondary fuses are of no value on transformers that are not interconnected. Fifty per cent overload should be allowed in fusing transformers connected in parallel.

H. B. GEAR.

We run our transformers in parallel with the secondaries fused 50 per cent over normal load.

S. S. INGMAN.

Fuse transformers on primary only, and for overload of 50 per cent.

G. WILBUR HUBLEY.

We obtain very satisfactory results by fusing transformer on the primary side only, and not using any transformers connected in parallel.

EDGAR B. GREENE.

Yes; for about 25 per cent overload.

AUGUSTA RY. AND ELEC. CO.

Yes. Fifty to 100 per cent.

G. L. THOMPSON.

*No. 41.—What results have been obtained with grounded secondaries—first, as to protection from high voltage; second, damage to transformers from lightning?*

Very good protection from high voltage is obtained by grounding secondaries. Very little trouble will be caused by lightning if oil is used in transformers and they are required to stand an insulation test when new of 8000 to 10,000 volts.

M. P. R., N. Y. ED. CO.

So far as we can see, the result of grounding secondaries is to give lightning an advantage in destroying transformers. Manufacturers scheme to increase the insulation resistance between primary and secondary coils, but such a system of grounding would seem to neutralize their efforts to a large extent. Grounding that may offer an excellent path to lightning may be absolutely worthless as a protection to life. In fact, from practical experience in our state, we find the greatest difficulty in obtaining a satisfactory ground.

CHAS. H. PETERS.

Grounding secondaries is a protection against high voltage and does not materially increase lightning risk.

E. P. COLES.

With the best transformers now on the market, we do not find it necessary to ground the secondary wires to prevent damage from the high-tension circuit. In our opinion, the grounding of the secondaries increases the liability of damage from lightning.

E. H. MATHER.

*No. 42.—Can satisfactory lighting service be obtained when incandescent lamps and alternating-current motors are furnished from the same circuit from generators under 500-kw capacity? If so, under what conditions?*

Yes. We are at present operating in one district about 1000 horse-power in single and polyphase motors on generators

of from 300 to 500 kilowatts. A generous allowance of copper in lighting circuits is better than separate power circuits on account of our territory being large, and the excessive cost and overcrowding that would be occasioned by the extending of these circuits on poles already fully occupied is very objectionable.

It is much cheaper to supply the extra automatic generator-regulating apparatus necessary, than to maintain a separate power service. As to methods necessary for operation, see L-29.

W. T. M., N. Y. ED. CO.

With good governors and independent motor circuits, the results with the best kind of alternating-current motors should be satisfactory.

AUGUSTA RY. AND ELEC. CO.

Yes, to a certain extent, if a good automatic regulator is used on the generator.

F. C. S., MALDEN ELECTRIC CO.

Yes; by use of Tirrill regulator.

E. P. COLES.

No.

G. WILBUR HUBLEY.

The best lighting service can not be given when alternating-current motors are operated on the same circuits with incandescent lamps. With a generous supply of copper wire and good regulation at the station, reasonably good service can be given.

E. H. MATHER.

With 1200-volt, 800-kw, single-phase generators and No. 0000 feeders, lighting service is satisfactory when horsepower of motor multiplied by miles from station does not exceed 25. The fluctuations in voltage on lamps at time of starting motor can be considerably reduced by connecting the motor to a three-wire transformer with a double voltage and throwing switch to full voltage after motor ceases to accelerate its speed. This scheme takes only one-fourth as much cur-

rent from line as starting motor at full voltage, and gives sufficient torque in nearly all cases. D. W. ROPER.

*No. 43.—What would cause a greasy appearance in the contacts on 1000-volt junction boxes after having been closed from six months to a year? I have also noticed this at station on General Electric expulsion-type fuse blocks.*

*No. 44.—What is the best method of connecting up 2300-volt service cables to customers' premises with the company's lines at the manholes? (a) where both the main line and the service line are three-wire cables; (b) where both are two-wire cables; (c) where both are single cables?*

The best method of connecting up 2300-volt service cables to the customer's premises is to tap the lateral cables to main cables in the service box, putting a lead sleeve with wiped joints over the connection and filling this sleeve with compound. Whether the cables are one, two, or three-wire, this same method may be used. The conductors to customer's premises should then be taken through an iron pipe directly to customer's switchboard and there ended in a cable head of cast iron with porcelain bushings through which the conductors should project. The same style head might be used with either style cable, and after this head has been filled with compound no trouble should be experienced. (UNSIGNED.)

*No. 45.—Please describe the operation of blasting for pole hole, stating where the materials may be procured, of what they consist, and what precautions must be observed in their use?*

An inexperienced person should never be trusted to use material necessary for blasting pole holes. It is highly dangerous, and the best results can be obtained by those who have had considerable experience in mining operations. Materials used are nitroglycerin of the 40-per-cent variety, with the usual cap and fuse for exploding. Holes are generally drilled on a slant, so as to give a lifting chance to the powder, and not have it simply blow up a pothole at the bottom. This refers only to rock holes. Holes in cement, or other similar material, should be shot with black blasting powder, and the holes may be made

by driving the drill or the bulldozer straight down. It is sometimes advisable with this class of holes to first place a smaller charge to "spring" at the bottom of the hole, and then place a larger charge to lift and shake up the ground generally.

A. O. WHITMORE.

The rock being bored, a hole is drilled with a regular rock drill having a diamond or flat point and being usually struck with a heavy hammer while the drill is turned and worked up and down to keep it free. A hole about an inch and an eighth in diameter should be drilled about three feet deep. After it is well cleaned out, get a stick and a half of giant powder (dynamite), making sure that the substance is fresh. Do not on any account accept stale powder. All powder is dated; never accept any over three months old, and do not take it then if the wrapper has a greasy look. Get two or three yards of fuse and the same number of caps. Lower one stick of powder into the hole and place the cap on the end of about three feet of fuse. Split the fuse before placing the cap on and stick the cap into a hole made with a stick in the half stick of powder. Press the powder gently around the cap and then lower by fuse into the hole until the half stick rests on the whole one. Then place any dry tamping over the stick of powder and work it very gently with a stick until solid, gradually filling up to top of hole and tamping harder as the surface is neared. All being ready for the blast, get some heavy timbers, railroad ties for example, if hole is near residences, and place these across the hole. They act as a blanket and prevent pieces of rock from flying. Apply a match to end of fuse and stand at a safe distance. It is a good thing to have two holes drilled fairly close together. Then if by any chance the shot misses fire, a second shot placed alongside will usually fire the missed shot. Never try to drill out a missed shot unless you are an old hand.

A. PETERS.

Drill holes at the corners of a triangle, one foot apart and nearly as deep as you want the hole to be. Put half a stick of dynamite in each hole for a seamy or rotten ledge and less for fine-grained hard rock. Explode by connecting in series with blasting magneto. Caps and magneto can be obtained at any contractor's supply house.

ANDREW F. HALL.

The materials and tools that we employ for blasting, which is mostly in native rock (granite), are as follows: Ordinary rock drills, .75-inch octagon steel, two feet, four feet and five feet long, a five-pound or seven-pound short-handled drill hammer, a spoon to clean drill dirt out of the holes, giant powder, caps and fuse. Our men usually drill the rocks they encounter in digging, by standing in the holes, bending their legs as much as possible, and with their backs braced against the dirt they are in the best position for this class of work. We usually drill into rocks about eight or ten inches, using water in the hole and a wet rag wrapped around drill to prevent splashing. After the hole is cleaned out, take about a quarter of a stick of giant powder, which should have been previously thawed out by being kept in a warm place. Split it with a knife, cut off about 18 inches of fuse, and after splitting the end half an inch slip a cap over it and press the point of the knife into the top of the cap (open end) to secure it in place. Insert the cap in the stick of giant powder already split and gently press the ends together, leaving the greased paper cover on, just as it comes. Lower charge into hole and with a piece of stick gently push it to the bottom. Now sprinkle a little dirt on top and lightly tamp it, adding more and tamping again until hole is filled up. All is now ready for firing. Throw several pieces of wood over the hole to prevent rocks from flying, light the fuse and have one man stationed at each point where people or vehicles are likely to be encountered, in order to warn them. If for any reason the charge should not fire in a minute or two, don't be in too much of a hurry. If smoke from the fuse ceases to come from hole after a reasonable time, it is likely that it has gone out before reaching the cap. In this case, if the fuse is too short to relight, pick the charge out with a piece of wood, exercising due care in the process. It is better to put in these "pop-shots," rather than larger charges, as the latter wreck the holes entirely. CHAS. H. PETERS.

*No. 46.—What results have been obtained by placing lightning arresters between high-potential lines in addition to those connected between lines and ground? Has resonance been diminished thereby?*

This arrangement has resulted in having the same discharge distance between line and line, and lines and earth, thus allow-

ing lines to discharge to each other more easily than in the arrangement having gaps only to earth. It also has the advantage of keeping the same number of gaps between lines even if one should ground.

In regard to resonance, we can find no records showing where such an arrangement has removed resonance from the line, although theoretically it should result in lessening the surgings due to discharges from lightning. (UNSIGNED.)

Good results; resonance is decreased.

E. P. COLES.

In the case of one three-phase line with a working voltage of 7400, a spark gap showed at certain times 15,000 to 20,000 volts between wires. By making the number of gaps in the lightning arresters the same between wires as between each wire and ground, the maximum voltage obtainable was about 9000; the extra potential being carried off as a brush discharge across the gaps. This change was made by simply connecting together the middle points of the three series of gaps already connected between wires and ground.

M. F. R., N. Y. ED. CO.

*No. 47.—Has any one found a durable paint for stenciling names and numbers on poles?*

Lamp-black and turpentine will last in our climate (eastern Colorado) about a year.

W. H. BANES.

*No. 48.—How much does it cost to install the ordinary "dead-man" anchorage for guying a pole, and what service have they given in practical operation?*

First-class anchorage for guying poles can be installed for about \$4.00 per pole, where there is no blasting.

E. H. MATHER.

The cost will vary considerably in different localities. Service is very satisfactory.

E. P. DILLON.

Six-foot galvanized guy rod and washer (about).....	\$0.50
Price of old pole about four feet long.....	?
Guy wire (about).....	.25
Digging hole and pulling up guy .....	1.00
Total (about).....	\$1.75

An anchor guy well put in will stand until the day of judgment. In over 20 years' experience I have never seen one pulled up.

HERBERT L. BRAGDON.

*No. 49.—What is the relative first cost of installing an underground system in a city of 50,000 population as compared with the cost of installing an overhead system?*

The comparative cost of underground and overhead systems in a city of 50,000 population depends on the density of the load, the arrangement of streets and alleys, the kind of pavement, and the system of lighting employed. It is doubtful if there is any city of this size where it would pay to put lighting underground for the residence portion of the city. It might pay to put the lines underground for the business district if the load is sufficiently concentrated, although even this is doubtful.

W. E. CARLTON.

In the absence of figures or reports upon which to make an analysis, this question can only be discussed in general terms, as it is largely dependent upon local conditions. The relative cost would be governed by area covered by system, divided by load distributed, or load density per unit area, the cost of underground installation being relatively greater as the load density diminishes, approaching the point where the cost of underground investment will more than balance prospective income, or become prohibitive. Where the load is compact within a small area, the relative cost of underground installation will diminish, while on the other hand the increased risk of overload lines so placed, as well as considerations of public policy, requiring more frequent renewals, safeguards, increased accident risks, etc., would make the relative cost of overhead lines greater than under first condition.

F. S. CHANDLER.

*No. 50.—What is the relative cost of maintaining an underground system in a city of 40,000 population as compared with the overhead system?*

In general, the cost of maintenance should be considerably less on underground lines than on overhead lines of the same size. This, however, would depend on whether the high-tension or low-tension system was in use, and also, in case manhole transformers were used, whether good drainage could be obtained for the manholes.

W. E. CARLTON.

See answer to question No. 49.

F. S. CHANDLER.

*No. 51.—Is it considered advisable to ground the neutral wire of a three-wire, direct-current, 125 and 250-volt system, operated from two generators of 125 volts each in series?*

Yes.

G. WILBUR HUBLEY.

Yes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 52.—If the ground is to be used, how should it be made to obtain best results? State advantages and disadvantages.*

Ground connection should be made with No. 4 B. and S. copper cable, inclosed in one-inch galvanized-iron pipe, the pipe to extend 10 feet above surface and six feet below the surface of the ground. The end of the copper wire should be connected with a large plate which is buried at a depth of at least six feet below the surface.

G. WILBUR HUBLEY.

Ground connections should be made at the station of ample capacity to carry the maximum unbalanced current, and all cable sheaths and junction-box neutral bars should be grounded at intervals throughout the system. Ground stakes driven into bottom of every manhole and connections to suitable ground plates are the means usually employed on such a system. The advantages of grounding the neutral largely consist in furnishing paths for unbalanced current to flow in, which have greater conductivity than the neutral cable, and also provide a path for the current to return to the station in the event of the neutral cable being destroyed.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 53.—Has the practice of ventilating subway systems by means of connection to smokstacks proven satisfactory as a means of preventing gas explosions in manholes?*

It has undoubtedly helped to decrease the trouble.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 54.—Is there any satisfactory type of fuse box for use in manholes on high-tension circuits of 2300 volts or over?*

No.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 55.—Will the placing of lightning arresters on series alternating arc circuits prevent or minimize the trouble due to breaking down of lamp insulation? If so, how many should be placed per mile of circuit?*

The proper protection of series alternating arc lamps is a subject that can hardly be treated without taking up the lamp circuit as a whole, the characteristics of the current with which it is supplied, and the nature and character—so far as is known—of the disruptive discharges of atmospheric electricity.

Lightning discharges seem to be divided into three classes: the direct stroke (including the forked discharge); the second discharge, which follows the first (due to the disruptive change in the electrostatic condition of the atmosphere, which in the readjustment of its static balance induces high potential in adjacent lines); and the third and most dangerous class to the series arc line with its high insulation, which results, so far as I am able to learn, from the following conditions:

When a difference of potential exists between a cloud and the earth, the earth and cloud may be considered as the two coatings of a condenser, each accumulating opposite charges. On account of its proximity to the earth and its parallelism with it, the line accumulates a like charge. Now, when the cloud is discharged, either to the earth or to another cloud, the earth is discharged also. The line, on account of its high insulation, is not discharged as quickly, leaving it at an immense difference of potential from the earth. If the direct discharge

comes in contact with the lines (as, in my opinion, it occasionally does in exposed locations), but little need be said on the question of lightning arresters, unless there happens to be one in that particular location, in which event a new one would probably be required. Against the other two forms of discharge, in which by "absorption" or induction potentials are built up within the line itself, it seems to me a fortunate accident that the arc-lamp circuit, if wholly aerial and equipped with differentially wound series lamps, hung on improved hanger-boards of relatively higher insulation than the line itself, has a nearly perfect equipment for the dissipation of the electrostatic potentials above referred to.

Unquestionably, the majority, if not all, of lightning discharges in their many forms manifest themselves in an oscillating current of very high period. As currents of this character rapidly exhaust themselves in heat in passing through choke coils, what better path could be offered for their dissipation than that presented by the series winding of the lamps, which act as successive buffers to their passage? But as a decided reflection has been observed in the immediate vicinity of these choke coils, particular attention must be given to the insulation between the lamp and its suspension; otherwise there will be a breakdown of insulation between the lamp mechanism and its case.

The choke coil of the lamp is not a very efficient one, and relies more on numbers than on individuality for its ability to check the rush of disruptive discharges. Unfortunately, this is not the case with respect to the lead or iron-sheathed cables through which it is necessary to carry underground branches of arc-light circuits. Here the choke coil is found in an accentuated form; and lightning arresters of the most approved type, and installed in the most careful manner, are necessary; their ground connections being preferably attached to the metal sheath of the cable itself. These arresters, as well as those at the station, should be bridged across the line to the common ground, so arranged that the spark gaps between the wires will be double that between either wire and the ground. Lightning arresters for these locations should be designed with sufficient spark gap to withstand at least 50 per cent more voltage than the maximum potential of the circuit at full load, as in the use of constant-current transformers a potential of from 20 to 50 per cent

in excess of normal working voltage is observed in the arc circuit when opened. Indeed, many of the breakdowns in lamp insulation have been attributed to lightning that are readily traceable to this increase of potential on open circuits and to the rush of current incident to the accidental opening of series alternating arc circuits and then the closing of same with the coils of the transformer in their most efficient position and the de-energized lamp offering practically a short-circuited path.

It has recently been the writer's privilege to design an open-circuit protector in the form of an underload release oil switch that he believes renders negligible the difficulties incident to these conditions.

In conclusion, will say that there have been no cases brought to the writer's attention in which it was necessary to install lightning arresters on series alternating arc-lamp lines except for station and underground cable protection.

G. E. PALMER.

I do not advise placing lightning arresters on series alternating arc circuits, excepting at a central station or at substations.

F. C. S., MALDEN ELECTRIC CO.

Lightning arresters on alternating series lamps will minimize the breaking down of lamp insulation. Number installed per mile should be not less than one, and that depends somewhat on the amount of adjacent telegraph and telephone wires, trees, etc. On exposed elevations or high ground, the number should be increased.

W. F. KINGAN.

With lightning arresters at station end of series arc circuits, we have practically no trouble from lightning on the arc systems. The slight additional protection afforded by line arresters would not justify expense of first cost and maintenance of line arresters.

E. P. DILLON.

*No. 56.—Are overhead lines used in conjunction with a limited amount of underground cable more difficult to maintain than a complete system of overhead lines?*

Overhead lines used in conjunction with a limited amount of underground lines are more difficult to maintain than a strictly

overhead system, owing to the difficulty of making joints between underground cables and overhead lines that will permanently withstand the various kinds of weather to which they are subjected. The problem of properly guying and supporting poles that are used to support underground cables is also one that is very trying in many cases. The presence of the grounded sheathing of lead cables also makes it much more dangerous for linemen than the ordinary overhead construction.

H. B. GEAR.

We do not think overhead lines used in conjunction with a limited amount of underground cable are more difficult to maintain than a complete system of overhead lines. With this construction, however, there would probably be an increased liability to damage from lightning, unless the underground work be first-class.

E. H. MATHER.

We find such circuits easier to maintain. There is less trouble with the cable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Our experience has been that it is no more difficult to maintain the overhead lines under these conditions. Our difficulty has been to maintain the limited amount of underground cable from burnouts by lightning.

WILLIAM R. GARDENER.

No. Probably less so.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 57.—What is the length of life of the average rubber-covered wire and cable?*

Life of insulation ought to be 10 years under average conditions.

G. WILBUR HUBLEY.

Cable in use 10 years on our system is still in good condition, showing only a slight deterioration under test conditions.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 58.—What is the most effective method of grounding for pole lightning arresters for alternating-current circuits under different conditions, such as on paved streets and in dry, hilly country?*

In this system, covering a territory where the soil is exceptionally dry, we derive good results from our line arresters by grounding them in this manner: A one-inch galvanized pipe is driven about 10 feet into the earth and to this pipe the ground wire is well soldered. About four feet from the surface of the ground, fine-crushed coke is filled and tamped around the pipe to a depth of two or three feet and at a radius of about 18 inches from the pipe.

E. P. DILLON.

Pipes driven until water is reached have been used successfully in such districts as described.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 59.—What is the best and most convenient device, in the hands of workmen, for detecting whether high-tension cables are alive or not?*

Use special transformer for testing cable.

G. WILBUR HUBLEY.

A coil and telephone receiver will give the desired indication if any current is flowing in the cable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 60.—In an Edison three-wire system supplied from one or more distributing stations or substations, what is a reasonable maximum drop and average energy loss in direct-current feeders? In mains, services and house lighting? In unaccounted-for losses?*

Allow 10 per cent drop in feeders; two per cent in mains; unaccounted-for losses should be within 10 per cent.

G. WILBUR HUBLEY.

Maximum drop in feeders, 10 per cent. Average energy loss, two per cent. Mains and services, five per cent.

W. F. KINGAN.

For one-hour maximum period: Feeders, 12 per cent; mains, services, house lighting, three per cent. No strictly unaccounted-for loss is reasonable.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 61.—What is the insulation resistance during wet weather of the regular two and three-petticoat insulators that have been in service from three to five years under ordinary street conditions?*

This is a difficult question to answer. A properly constructed insulator should not deteriorate in the length of time mentioned. A dry, dusty insulator is not as effective as a clean, wet one. There are, however, so many points involved in the question that a really satisfactory answer can not be given.

(UNSIGNED.)

*No. 62.—What is a good method for dead-ending heavy primary pole-line feeders; something that will answer the purpose of the regular strain insulators?*

*No. 63.—What is a good method for splicing cable of 300,000 circular mils or larger?*

I do not consider it good practice to splice cables of large capacity. The use of a sleeve makes a much better job both mechanically and electrically.

E. W. LLOYD.

Use a special conical brass coupling, with union joint, similar to hose coupling. The ends of cable are placed in coupling and then wedged out to the conical surfaces, sweated with solder and carefully filed to true surfaces on end. The ends are butted together and secured by screwing to the nut. A soft-copper disc should be inserted between ends before joint is tightened and set.

G. WILBUR HUBLEY.

*No. 64.—Assuming a direct-current two-wire distribution that is to be changed to alternating-current three-phase, which is the better secondary distribution—three-wire delta or four-wire Y?*

The four-wire, Y-connected, three-phase secondary would be preferable to the three-wire delta connected, owing to the possibility of operating the secondary with 110-volt lamps and still securing the advantage of 200-volt distribution in the amount of copper required. Better than this, however, is the ordinary single-phase, three-wire system. In this system there are only two sides to balance, and the problem of connecting and balancing large installations is simpler than it is with the three-phase system. The three-phase feeder can easily be balanced on the primary taps, thus securing all the advantages of the three-phase transmission on the feeder.

H. B. GEAR.

With a two-wire secondary distribution where two circuits are used, the four-wire Y connection would be the most satisfactory, as all four wires would be in use. Where two wires only are used these could remain as two-wire distribution, connected as one leg of the four-wire Y system.

E. H. MATHER.

Four-wire Y.

W. F. KINGAN.

A four-wire system would be preferable if motor service is to be supplied in any quantity. Such a distribution would be more economical in copper and would furnish transmission at higher voltages for the longer distances.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 65.—In a banked-transformer system, is there a practical method of cutting out the transformers from plant at light loads, thereby saving core loss?*

No.

G. WILBUR HUBLEY.

No.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 66.—How often have you found fires in buildings to have been started by electric-light wires, and how did you find it to happen?*

In every instance from the blowing of fuses.

GEO. L. COLGATE.

We have had only one fire in 12 years that we are sure started from electric wires. This was fortunately discovered and put out without doing much damage.

A heavy wind and rain blew off the cover of a transformer that had not been thoroughly bolted, and filled it with water. This was followed by a severe lightning stroke which followed the secondary wires and grounded on a water pipe, the distance from wires to pipe being four inches. The transformer was not injured.

FRED B. HUBBELL.

Three cases that I am sure of. A four-inch cast-iron soil pipe ran from the ground up through the building and passed through a double roof. The old roof was covered with metal and had a flange clamped to this iron pipe to prevent rain from coming down between pipe and roof. This old roof was covered with six inches of sawdust and another roof was constructed over it having the same attachments from metal roofing to soil pipe. A wire in this building became grounded on this soil pipe and in trying to pass to the ground caused a shower of sparks between the joints of the soil pipe, showing that where the soil pipe was joined and calked the conductivity was poor, and that it could jump to ground only here and there, on account of the poor joints. The collar that attached this old metal roof to pipe showed signs of sparking also, as the collar had some packing between it and the soil pipe. It was evident to my mind that as the current had difficulty in getting to ground on account of the poor insulation of pipe joints, it went from the pipe to this collar and iron roofing to the wet bricks and other pipe to ground, and at the point where the collar was clamped to pipe sparks were emitted, setting fire to the dry sawdust on the top of the old roof. This covering with sawdust is a practice quite common in this city, to prevent the heat of the building from striking the roof and melting the ice and snow on the roof.

W. F. KINGAN.

*No. 67.—Is it advisable to use insulated wire for long transmission line with 15,000 or 20,000 volts tension? If so, why?*

It is not advisable to use insulated wire for high-tension lines, as the insulation is absolutely of no value and is objectionable because it offers greater surface to the wind and for the accumulation of sleet in winter. E. H. MATHER.

No.

G. WILBUR HUBLEY.

Insulation on wire used on a transmission line of 15,000 to 20,000 volts is of no value for insulating purposes, but in some climates is some protection against corrosion of the wires.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 68.—Has any one found an entirely satisfactory fuse cut-out for 220-volts? What have been your troubles with same?*

If you will use ordinary inclosed fuses, which are now being manufactured, you will probably have very little trouble with them on 220-volt circuits. The use of open-link fuses is still continued for this service, but the underwriters require that they be covered over with a steel box, or asbestos-lined wood box. Of course, the inclosed fuse is limited at this time to about 500 amperes capacity; above this capacity we have found it expedient to use copper link fuses, which cause very little trouble. When a copper link fuse blows, it spits out a small section of the copper at a point where there is the smallest cross section. E. W. LLOYD.

*No. 69.—We have a 220-volt direct-current system. Sometimes telephone lines come in contact with our lines. The ringing coils in the telephones have just the exact amount of resistance to permit enough current to pass through to heat the coils, but not enough to blow a .75-ampere fuse. We have had several fires started in this way and have found no effective remedy for it. What can be done?*

A small magnetic short-circuiting device, the action of which will short-circuit the telephone coils, can be placed in the telephone circuit. This will cause enough current to pass to blow the fuse. The device need not be very expensive, and should be effective in every case.

GEQ. L. COLGATE.

The starting of fires by crossing of telephone and low-tension electric-light circuits is a serious matter and should be remedied by the reconstruction of whichever circuits are defective.

E. H. MATHER.

## R

### ARC LAMPS

*No. 1.—How should the winding of the magnets of a constant-potential arc lamp be altered so that the arc will give a violet light for photographic purposes?*

Increase the length of the arc by rewinding lamp magnets with a smaller wire, bringing out loops at intervals. The length of the arc of the ordinary multiple lamp can be increased without rewinding by decreasing the reactance or resistance and arranging mechanism for a longer pick-up.

S. G. R., N. Y. ED. CO.

I should say, change the lamp to a 220-volt, single carbon lamp. The lamp in question, if built for 110 volts, will give a violet light if a small carbon is used and coils arranged to draw a long arc.

A. PETERS.

Any standard direct-current 220-volt or alternating-current 104-volt multiple inclosed-arc lamp will serve the purpose. In order to produce violet rays, as long an arc as possible should be maintained.

J. H. HALLBERG.

As the violet color is due to the lengthening of the arc, make adjustment to secure this, and increase the current.

CHAS. H. PETERS.

Winding should be altered so that a long arc can be maintained. How winding should be changed depends entirely on make of lamp.

P. J. SMITH.

Increase the ampere turns by tapped connections, increasing the arc voltage.

BENJAMIN FRANKLIN.

To get a greater amount of violet light from an arc lamp, the arc needs to be lengthened. This may be done by increasing the number of turns in the series solenoid and decreasing the number on the shunt solenoid in the mechanism of the lamp. This increases the voltage on the arc, and consequently the ballast resistance in the lamp needs to be decreased. This decrease of the ballast can not be carried beyond a certain extent, as the arc becomes unstable and the lamp refuses to work.

CLAYTON H. SHARP.

Alternating-current multiple lamps have been successfully used for photographic purposes by connecting the magnets in multiple, and dividing the reactive coil into two parts, connecting these also in multiple. Care should be taken that these two parts are connected in the proper direction. Suspend the lamp without either case or outer globe. Under these conditions the lamp will take about 10 amperes and approximately 700 watts.

For direct-current multiple lamps, the magnets can be connected in multiple, and special external resistance should be used with sufficient current capacity. In both cases the arc voltage should be adjusted as high as possible, as the longer the arc and the higher the arc voltage, the more violet the light will be, consequently the more active chemically.

The above assumes lamps constructed with double solenoids and U-shaped core.

It is important that no outer globe be used, as this would cause the excessive heat generated to melt down the inclosing globe. In any case, the breakage will be high, but not excessive.

R. FLEMING.

High voltage produces violet light. It is not advisable to change standard lamps to any extent. Standard lamps can be

used and voltage adjusted as high as possible for steady burning. If one lamp is not sufficient, two or more lamps can be better used.

G. L. THOMPSON.

Weaken potential coils.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 2.—How does the operation of a series arc lamp indicate whether or not the shunt coil is open-circuited.*

In an inclosed lamp, by a flaming arc usually long enough to warp the inner globe and by the feeding of the carbon—a complete rupture of the arc being necessary to accomplish such a result. In an open lamp, by the “mushrooming” of the carbons.

S. G. R., N. Y. ED. CO.

The lamp will refuse to feed if the shunt is open, and when the carbons are drawn apart it will give an arc several inches in length before the armature will be drawn down sufficiently to allow the upper carbon to drop.

T. D. EVANS.

By shunt coils refusing to attract the shunt armature and feed the carbon as it burns away.

J. H. HALLBERG.

Lamp will not feed.

P. J. SMITH.

Lamp will not feed, armature remaining close to series magnet.

BENJAMIN FRANKLIN.

If the shunt coil of a series arc lamp opens, the series magnet will pick up the carbons as far as it is possible for them to go, and will hold the mechanism in this position until the arc becomes sufficiently long to jump across to some part of the structure, melting down the inner globe and surrounding parts. This will continue until the insulation is burned away and metallic connection is made across the arc by fusing the parts together. It practically means the destruction of the lamp.

R. FLEMING.

Lamp fails to feed and may burn out if circuit is not interrupted, allowing carbons to come together.

G. L. THOMPSON.

Lamp will not feed.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 3.—What is the average life of carbons in a 7.5-ampere, 60-cycle, series alternating arc lamp street-lighting system, under actual working conditions?*

Our experience with 400 lamps over an average period of two and a half years shows about seventy hours.

TOLEDO RYS. AND LT. CO.

About 65 hours actual burning with 9.5-inch by half-inch upper and 5.75-inch by half-inch lower carbons.

M. P. R., N. Y. ED. CO.

We have a large number of 7.5-ampere, 60-cycle, series alternating arc lamps, which have been in use for several years. We find that the life of 9.5-inch by half-inch carbons will average about 55 hours when the lamps are run under usual conditions.

JAS. B. FOOTE.

The carbons in our 7.5-ampere, 60-cycle, series arcs last from 95 to 100 hours, using 5.5-inch lower and 9.5-inch upper carbons.

F. B. DOTEN.

This depends upon make of lamp, quality of carbon, and the trimmer. Under proper conditions a half-inch by 9.5-inch or 10-inch carbon should give not less than 75 hours' life in a 7.5-ampere series alternating inclosed-arc lamp.

J. H. HALLBERG.

About 60 hours.

P. J. SMITH.

The average life of carbons in a 6.6-ampere series inclosed-arc lamp, which should not differ very materially from a 7.5-ampere lamp, is 100 hours.

THE EASTON POWER CO.

With 12-inch carbons, No. 7 globe (G. E.) and careful operation, a minimum life of 100 hours is easily obtainable.

R. FLEMING.

Seventy-five hours where 9-inch upper carbons are used.

BENJAMIN FRANKLIN.

This varies considerably at different plants, depending on length and size of carbons, condition of inner globes and arc-lamp adjustments.

G. L. THOMPSON.

*No. 4.—What is the average life of inner globes in such a system?*

About 1500 hours for clear and 1000 hours for alabaster glass.

J. H. HALLBERG.

Our inner-globe lamp renewal is five per lamp per year.

TOLEDO RYS. AND LT. CO.

On a circuit of 101 lamps burning all night and every night, we use 70 inner globes per year. One inner globe, therefore, lasts nearly a year and a half on an average. We consider this a good record. Outers last two years each, on an average, on the same circuit. The lamps burn on an average of 10.5 hours per night the year round.

THE EASTON POWER CO.

Twelve hundred hours to 1800 hours.

BENJAMIN FRANKLIN.

Numerous reports indicate an average life of three months, or four per year. For 6.6-ampere lamps, a life of four months, or three globes per year, is obtainable. Much depends on care in handling.

R. FLEMING.

*No. 5.—How can the Ball Company's arc lamps be operated so as not to break the inner globes continuously?*

Cut the lamps voltage down to about 75, and in trimming be careful to keep the length of lower carbons uniform and not too long. There is certain to be excessive inner-globe breakage in any lamps unless the gas cap is equipped with a petticoat to prevent a flaming arc from striking the glass.

EDITOR.

*No. 6.—How can an ordinary open-arc lamp be changed over to the inclosed-arc system?*

There is no practical commercial way in which this can be done satisfactorily.

BENJAMIN FRANKLIN.

The cost of making change so that lamp would be satisfactory would almost pay for a new lamp. Attempts in this line always fail to bring satisfactory results.

P. J. SMITH.

The ordinary open-arc lamp can be changed to the inclosed system if the series windings are already of the proper capacity, by increasing the pick-up action of the lamp and by inserting a small resistance in series with the shunt so that the present shunt coils will work under practically the same potential as they did on the open-arc circuit. By using an open-bottom inner globe with a globe holder to fit the carbon holder of the lamp, the inner globe can easily be provided for. Care must be taken, however, to have the rods shortened to prevent the upper carbon holder striking the globe cap before the lamp cuts out. Should the lamp be required to work in outside service it will be necessary to provide a weatherproof shade immediately above the outer globe to protect the inner globe from rain and snow. We have equipped a number of Thomson-Houston 6.8-ampere lamps in this manner for street service and are using them on 6.6-ampere circuit with 75 volts at the arc with very satisfactory results. The single lamps are much better adapted to the change than the double ones.

JAS. E. PYLE.

Can best be accomplished by purchasing new lamps.

G. L. THOMPSON.

An open-arc lamp can be changed over to an inclosed-arc by rewinding the series magnets for smaller current and the shunt magnets for higher voltage, and arranging the mechanism so as to lift the carbons higher than is possible with the standard equipment. This can be done in some lamps, but not in others. Shunt lamps should not be changed over in this way, as sufficiently close regulation is impossible. Lower frame should be fitted with globe-holder attachment. The economy of this practice is doubtful, and perfect operation can not be assured.

R. FLEMING.

As a general rule, it does not pay to change an open-arc lamp into one of the inclosed-arc type.

J. H. HALLBERG.

Alter mechanism so as to provide for the longer pick up of the arc, increase the number of turns on magnet and add resistance or reactance.

S. G. R., N. Y. ED. CO.

*No. 7.—Which is most suitable for raising and lowering street arc lamps; hemp, braided cotton, or stranded-wire rope?*

We prefer stranded-wire rope with a hemp core in the centre. This gives strength with flexibility. This is known as "arc-light suspension cable," and can be readily obtained.

GEO. B. LAUDER

We find the best rope to be four-strand, tallow-laid manilla, either half-inch or five-eighths.

P. E. COWLES.

We have found braided cotton the most suitable rope for raising and lowering street arcs. Sampson spot cord is what we are now using. Self-supporting hangers should be used in all cases.

L. E. WATSON.

We have had best results from a flexible stranded-wire rope.

E. P. DILLON.

Our experience has been that a stranded-wire rope with a hemp centre is the best for this purpose, as in spite of its higher first cost the great increase of life makes it much cheaper in the long run than either hemp or cotton. It is also nearly as flexible, quite flexible enough to give good satisfaction.

FAIR HAVEN ELECTRIC CO.

Stranded-wire of soft metal closely woven, with counter-weight to keep rope taut at all times.

S. G. R., N. Y. ED. CO.

A stranded-wire rope will give longer service in most localities. A little care in the use of a good circuit-breaker at the lamp, and placing the cable drums about eight feet from the ground will prevent any accidents to the general public from stray currents.

C. C. GARTLAND.

I prefer Sampson arc-lamp cord. The lamp should be held in position by self-locking pulley and hook.

ANDREW F. HALL.

We have always found stranded-steel rope the best, but when using it be careful to keep your arc system clear of grounds.

CHAS. H. PETERS.

Stranded-wire rope, by all means.

F. C. S., MALDEN ELECTRIC CO.

Stranded-wire cable.

P. J. SMITH.

Manilla rope is preferable; it will not freeze stiff as braided-cotton rope will in winter.

ROBERT LINDSAY.

Wire.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Stranded-wire rope is far more reliable.

AUGUSTA RY. AND ELEC. CO.

Filled braided cotton.

BENJAMIN FRANKLIN.

Stranded-wire rope is most suitable if care be taken to thoroughly insulate the lamp from the suspending end of the cable, and also to carefully protect the cable from accidental contact with high-tension wires on the pole. As an extra precaution, the pulley over which the cable runs should be grounded at the base of the pole. This entirely prevents accident to persons touching the cable.

R. FLEMING.

Stranded-wire rope is better suited for raising and lowering arc lamps because it is stronger and makes a better appearance in the streets than either hemp or cotton rope.

E. H. MATHER.

*No. 8.—What is the life of opalescent as compared with clear inner globes for inclosed-arc lamps?*

Clear globes seem to have the longer life.

W. H. BANES.

We have noticed no difference when using the same make and shape of globe.

AUGUSTA RY. AND ELEC. CO.

Average 15 per cent less.

BENJAMIN FRANKLIN.

Approximately 90 per cent.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The life of the ordinary opalescent globe is short as compared with that of clear globes, but globes are now on the market of special glass that have as long life as the best clear globes. So-called "flashed or plated" glass, from which ordinary opalescent globes are made, is not suitable for the purpose, on account of internal strains in the glass when subjected to changes in temperature.

R. FLEMING.

*No. 9.—When it is proposed to change from 9.6-ampere open street arcs to the alternating-current inclosed system, is it commercially advisable to offer the 6.6-ampere or the 7.5-ampere lamps?*

In considering the question of changing from 10-ampere arc lamp to the alternating inclosed-arc lamp, we have always been thoroughly convinced that it is good business policy to offer nothing less than 7.5-ampere size; and when changing from 6.8-ampere open-arc to the alternating inclosed, to offer the 6.6-ampere size. We have done this in several instances and found the result perfectly satisfactory in every case.

JAS. B. FOOTE.

I would suggest 7.5-ampere, inclosed alternating-current lamp if the old-style open arc has been used. The 7.5 amperes can then be cut down by degrees, but at first the glare of the open arc will be missed by the public, and if a 6.6-ampere arc is substituted for it at once, the public will pass quite a few remarks not at all complimentary to the light or the company.

A. PETERS.

If the change means lamp for lamp, and new lamps are to be hung on old supports, the 7.5-ampere lamp should be used. If, however, the new lamps can be lowered within 20 or 25 feet of the street, a 6.8-ampere to seven-ampere lamp would do.

J. H. HALLBERG.

Commercially, only the 6.6-ampere lamp could be offered, regardless of its lack of efficiency as compared with 9.6-ampere arc lamp.

G. WILBUR HUBLEY.

Lamps of 7.5 amperes. BENJAMIN FRANKLIN.

Lamps of 7.5-amperes are more suitable as substitutes for 9.6-ampere open-arc lamps. If, however, the circuits can be rearranged to permit of installing a greater number of lamps, the 6.6-ampere lamps will give somewhat better distribution of light, assuming the same total watts consumed.

R. FLEMING.

Where change is made lamp for lamp, it is generally advisable to use 7.5 amperes. If, however, lamps are properly located, a larger number of 6.6-ampere lamps would give a better distribution.

G. L. THOMPSON.

Our experience is that illuminating power of 6.6-ampere inclosed arcs is not equal to a 9.6-ampere open arc. Would suggest a 7.5-ampere lamp if equal illumination is desired.

TOLEDO RYS. AND LT. CO.

Lamps of 6.6 amperes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

In view of the tendency to rate arc lamps according to their arc wattage, the 7.5-ampere alternating-current inclosed lamp is the only safe equivalent of the 9.6-ampere open lamp.

S. R. G., N. Y. ED. CO.

*No. 10.—What are the relative maintenance costs of series inclosed-arc street lamps equipped with closed-base inclosing globes and similar lamps equipped with open-base inclosing globes having removable lower holders?*

Fifty per cent more.

BENJAMIN FRANKLIN.

The difference in maintenance cost between lamps equipped with open-base and closed-base inclosing globes is not great. Everything will depend upon methods of handling. If lamps are equipped with removable lower holders the cost of maintenance should be decidedly in favor of the open-base type of inclosing globe. Breakage with this type of globe is reduced to a minimum. The cost of globes is also somewhat less.

R. FLEMING.

The maintenance cost of closed-base inner globes on inclosed-arc lamps is about 25 per cent greater than for the open base globe.

J. H. HALLBERG.

It is difficult to give the relative costs. The life of carbons is greater, the lamps are easier to trim, and globe breakage is less, when equipped with open-base inclosing globes.

G. L. THOMPSON.

Lamps with closed-base inner globes show from five to ten per cent shorter carbon life and about 30 per cent longer inner-

globe life; but as the cost of the inner globes is greater, there is comparatively little difference in cost of operation.

EDITOR.

We find that the maintenance cost of inner globes for arc lamps equipped with the closed-base globes is about 23 per cent greater than for lamps equipped with the open-base globes. We have no accurate record of the total maintenance cost of the two different forms of lamps.

E. H. MATHEP.

*No. 11.—Is there such a thing as a successful and efficient 220-volt, direct-current, multiple inclosed-arc lamp that is sufficiently free from violet rays for store service?*

No 220-volt, multiple inclosed-arc lamp is free from violet rays. The lighting efficiency of the 220-volt multiple lamp is approximately one-half of a 110-volt lamp.

G. L. THOMPSON.

The ordinary 220-volt, direct-current multiple lamp is unsatisfactory, on account of the violet light. Twin lamps with two arcs in series are, however, in successful operation. The most efficient method for 220-volt lighting is to connect two lamps in series.

R. FLEMING.

No.

BENJAMIN FRANKLIN.

Yes; Tarring and Company make such a lamp.

CHAS. H. PETERS.

Standard 110-volt lamps connected two in series on 220-volts are giving good results, and some of them, I believe, give better service than 110-volt lamps.

E. A. ASPNES.

Yes, the General Electric Company's twin-carbon, 220-volt lamp is a success. For store lighting I would advise the 110-volt, five-ampere lamp. The twin-carbon lamp has a tendency to be slightly unsteady, but at that it is a good lamp and is excel-

lent for outdoor work. The splitting of the 220 volts between arcs does away with the violet rays. A. PETERS.

No. It is practically impossible to build a multiple, 220-volt, direct-current lamp that will give a white light. The best in this line is the double-carbon, three-ampere lamp, operating two 80-volt arcs in series in the same inner globe.

J. H. HALLBERG.

For commercial service off 220-volt mains use a twin inclosed lamp having two carbons in one inclosing globe, both burning at 80 volts across the arc at 2.75 amperes.

S. G. R., N. Y. ED. CO.

*No. 12.—What is the difference in efficiency and cost of operation per 100 inclosed-arc lamps operated from constant-current transformers, and 100 open arcs operated from modern constant-current dynamos, lamps being of same wattage in both instances and running 4000 hours per year?*

12 per cent; \$1000.

BENJAMIN FRANKLIN.

One hundred lamps is too small a number to bring out the most important item of difference in the cost operation—that is trimming. In a large system there is a difference of about 40 per cent in the labor item in favor of the direct-current lamp, which also has the advantage in the matter of carbons and inner globes. Theoretically, the alternating system has the higher efficiency and requires less station labor and station repairs. Practically, I have yet to see this demonstrated by coal-and-repair records and station payrolls. So far as repairs are concerned, two of our stations operating direct-current inclosed-arc lamps and aggregating over 7,000,000 arc-lamp-hours during the past two years, show a total cost of repairs to arc dynamos of about \$26 for the entire period. EDITOR.

*No. 13.—Why are not cut-outs more generally used when installing series arc lamps; a cut-out whereby the lamp will be*

*entirely disconnected from the circuit when handled by the trimmer or inspector?*

Absolute cut-outs should be used on all arc lamps.

ANDREW F. HALL.

Am not aware of any installation of series arc lamps without absolute cut-outs. Should think this advisable in all cases.

F. C. S., MALDEN ELECTRIC CO.

Cut-outs should be installed at every series arc lamp, so that it would be impossible for the trimmer to be hurt while trimming a lamp, or an inspector in examining a lighted lamp.

W. F. KINGAN.

Not reliable nor satisfactory, and adds complication to the system.

G. WILBUR HUBLEY.

On account of high-tension circuits. Present practice does not favor handling of lamps on large circuits. Modern plant outages are less than one-fourth of one per cent. With usual rate of dockage this will not pay inspection expenses.

BENJAMIN FRANKLIN.

All series arc lamps on our system are provided with absolute cut-outs. No other method is safe.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Hanger-board cut-out switches should always be used.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

## S

### INCANDESCENT LAMPS

*No. 1.—What do you consider the best system of incandescent series lighting for small towns and suburban districts?*

The alternating-current series system supplied through a regulator or a constant-current transformer. This will prove reliable, flexible, and economical to maintain.

WILLIAM R. GARDENER.

We have in use here in our streets both the Westinghouse shunt coil and the Auto-Electric Shunt Company's shunt. The latter seems to us the best system, on account of its entire adaptability to various circuits and conditions, and we are able to use it on our 52, 104 or 220-volt circuits absolutely without changing it, whereas the Westinghouse shunt coil must of necessity be wound for the circuit on which it is to be used.

FAIR HAVEN ELECTRIC CO.

Use 3.5 to 5.5 ampere lamps on circuits run from constant-current transformers. Lamps of 1.75 amperes have been advocated of late, but these present the alternatives of very high-circuit voltage, or a small number of lamps per circuit, with consequent high construction cost.

M. P. R., N. Y. ED. CO.

Series incandescent lamps operated by constant-current transformers form, in our opinion, the best system of street lighting for small towns, because both the first cost and maintenance expense are less than in any other system.

E. H. MATHER.

Constant-current transformer supplying current at 1.75 amperes and using standard 50-volt lamp.

F. C. S., MALDEN ELECTRIC CO.

If the primary voltage is 2200, connect 21 lamps of 104 volts each in series, with shunt box at each lamp. This method has proved very satisfactory, and practically covers about 80 per cent of the street series incandescent lighting of small towns and suburban districts.

C. C. GARTLAND.

Multiple series.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 2.—Can Nernst lamps be operated successfully on a 25-cycle circuit?*

Yes.

CALVIN W. RICE.

Yes; the one difference being in the life of the glower, which is shorter on 25-cycle than on 60-cycle.

GEO. L. COLGATE.

Yes; Nernst lamps are successfully operated on 25-cycle circuits. The fluttering ordinarily caused by the light-giving element following too closely to the current wave is practically done away with in the Nernst lamp, even on frequencies as low as 20 cycles.

This is simply because the filaments or glowers are comparatively thick and retain nearly their maximum temperature during the reversals of the current. It has been determined by Huels that the per cent change of light from the ordinary 16-cp 110-volt incandescent lamps from maximum momentary candle-power is about twice that of the Nernst 88-watt 110-volt lamp. The life of a Nernst glower on 25 cycles is about half as long as on 60 cycles; nevertheless, this life is more than compensated for by the fact that the lamp can operate successfully on circuits that would otherwise be unsuited for illuminating purposes, at the same time giving a steady, pleasing, economical light.

M. W. HANKS.

*No. 3.—Does the power absorbed by an incandescent lamp at constant voltage increase or diminish with use, and to what extent?*

Power consumed by lamp decreases with use at constant voltage, and as the resistance increases the current decreases. The energy consumed will decrease from 5 to 20 per cent, depending on the life and quality of the lamp.

EDGAR SWITZER.

As the carbon of filament has a tendency to become deposited on the inside of globe, it stands to reason that as the area of the filament becomes less in time and its resistance higher, less power is consumed.

CHAS. H. PETERS.

The power absorbed by an incandescent lamp does not change appreciably with age, but the candle-power drops off materially.

C. W. HUMPHREY.

The power absorbed by incandescent lamps of the usual types first increases and then decreases with use. A curve showing the wattage consumption at intervals during the life of a lamp has the same characteristic rise and fall as has a candle-power curve for the same lamp, but differs in degree. When the normal lamp has lost 20 per cent of its initial candle-power, its watt consumption is about five per cent less than its initial watt consumption.

PRESTON S. MILLER.

Watts diminish as the lamp becomes old, provided the impressed voltage is the same.

W. F. KINGAN.

The power absorbed by incandescent lamps at constant voltage diminishes with use, averaging about five per cent decrease during

the same period that the candle-power declines 20 per cent; that is, during the useful-life period, which is about 500 hours for the 16-cp, 3.1-watt, 100 to 130-volt lamps.

FRANCIS W. WILLCOX.

Decrease.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 4.—To what extent does voltage affect life of an incandescent lamp?*

The following are the average results of several tests made to find out the effect of increase of voltage on incandescent lamps; the value of close regulation is surely apparent:

A lamp at normal voltage has 100 per cent life.

The same lamp one per cent above normal loses 18 per cent life

"	"	"	two	"	"	"	"	30	"	"
"	"	"	three	"	"	"	"	44	"	"
"	"	"	four	"	"	"	"	55	"	"
"	"	"	five	"	"	"	"	62	"	"
"	"	"	six	"	"	"	"	70	"	"

WILLIAM R. GARDENER.

Variation in voltage affects the life of the incandescent lamp in accordance with the following table:

VARIATION OF LIFE WITH VARIATION IN VOLTAGE FOR LAMPS OF ALL VOLTAGES AND EFFICIENCIES

Per Cent of Normal Voltage	Per Cent of Normal Life
90	810
91	655
92	525
93	420
94	340
95	273
96	220
97	181
98	149
99	120
100	100
101	81
102	66
103	54
104	44
105	37
106	31
107	26
108	21
109	18
110	15

FRANCIS W. WILLCOX.

The candle-power of an incandescent lamp increases five per cent for every volt above normal electromotive force, while the life decreases by about 10 per cent. The candle-power decreases five per cent for every volt below normal electromotive force, while the life increases by about 25 per cent. These percentages are only approximate and vary with different manufacturers.

H. W. METTLER.

With three per cent voltage increase life will be decreased about 50 per cent.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The following extract from a table published by the Lamp Testing Bureau, New York, under date of March 6, 1900, gives information that will answer the question. The information is based on the 3.1-watt lamp.

VARIATION FROM NORMAL-VOLTAGE		NORMAL LIFE	
Per Cent		Per Cent	
Low	{ 5	Increase	{ 200
	{ 4		{ 145
	{ 3		{ 95
	{ 2		{ 50
	{ 1		{ 22
	Normal		Normal
High	{ 1	Decrease	{ 19
	{ 2		{ 34
	{ 3		{ 45
	{ 4		{ 55
	{ 5		{ 64

PENINSULAR ELEC. LIGHT CO.

The effect of increased or decreased voltage upon the life of incandescent lamps is shown in a general way in the following table, in which the approximate life values of a normal 16-cp, 110-volt, 3.5-watt lamp, when burned at various voltages, are shown. These values are based upon the assumptions that a lamp of this type burns 900 hours to 80 per cent of initial candle-power at normal voltage, and that the lamps are operated at approximately constant potential.

Volts	Life to 80 Per Cent Initial Candle-power	Volts	Life to 80 Per Cent Initial Candle-power
120	200 hours	109	1061 hours
119	230 "	108	1231 "
118	269 "	107	1440 "
117	304 "	106	1709 "
116	362 "	105	2003 "
115	420 "	104	2410 "
114	486 "	103	2880 "
113	575 "	102	3373 "
112	666 "	101	3914 "
111	773 "	100	4556 "
110	900 " (assumed)		

PRESTON S. MILLER.

*No. 5.—Wanted—A weather-proof dipping solution for coloring incandescent lamps red, blue or green. A great many lamps are used at Christmas for outside decorations, and I have never yet seen any that looked even reasonably well after a snow or rain storm.*

Have never been able to obtain coloring solution for incandescent lamps that would stand exposure to the weather.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

The General Electric Company will gladly furnish free coloring material to any user of their lamps. We believe we are using the best material that is obtainable, but it is not possible to guarantee it to stand indefinite exposure to snow and rain.

FRANCIS W. WILLCOX.

*No. 6.—What are the lowest frequencies that can be satisfactorily used on commercial lamps of the various voltages at the present time?*

Forty cycles, except where Nernst lamps are used. These can be operated on 25 cycles very satisfactorily and successfully.

GEO. L. COLGATE.

Probably the lowest frequency at which 100-volt incandescent lamps can be used is 25 cycles per second. With this frequency the flickering is noticeable, but for many purposes not unendurable. With higher-voltage lamps and lamps of lower candle-power—that is, having finer filaments—the flickering is more noticeable

than with the higher-candle-power, lower-voltage lamps, in which the thermal sluggishness is considerably greater.

CLAYTON H. SHARP.

The lowest frequency on commercial incandescent lamps at the present time is about 25 cycles.

FRANCIS W. WILLCOX.

*No. 7.—What method of maintaining Nernst lamps has been found satisfactory to both lighting company and customer?*

Where the lighting company has enough lights on its circuits to warrant it, the most satisfactory method is to have the maintenance in the hands of the lighting company. Small users have found it more satisfactory to contract with the Nernst Lamp Company for maintenance.

GEO. L. COLGATE.

The free renewal of glowers and other parts. Also all necessary repairs. Careful oversight on the part of the company insures a high standard of light, and free oversight—that is to say, the inclusion of the cost in the price of the current—means greater satisfaction with the service. Small bills for repairs and parts will cause annoyance; where included in the monthly bill for the entire service, will pass unnoticed. A poor light at whatever cost is a bad advertisement.

J. P. R., N. Y. ED. CO.

*No. 8.—What advantage, if any, has the Nernst lamp over other illuminants?*

Quality of light, economy, and high power factor.

GEO. L. COLGATE.

It is the best competitor of gas on alternating-current systems. It will interest your customers, as a rule, in preference to other illuminants. It enables the central station to give a light easily maintained at practically full candle-power, provided the cost of renewals is placed at a price that competes in cost of maintenance with other lamps.

R. W. ROLLINS.

The maximum light from a Nernst lamp is directly downward from the glowers, a condition ordinarily very desirable. There is

no flickering, and the absence of shadows is a characteristic of the type. The distribution of light is satisfactory. After burning for about 500 hours, the globe becomes quite a little blackened, but this is confined almost entirely to the upper part, and the effective downward candle-power is affected only to a small extent; about one per cent.

PENINSULAR ELEC. LT. CO.

*No. 9.—What has been the experience in the matter of Nernst lamp renewals?*

Where regulation is fair the renewals will cost less, candle-power for candle-power, than with incandescent lamps.

GEO. L. COLGATE.

Expensive.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 10.—Should or should not lamp renewals be furnished and delivered free to customer?*

My experience has been that the matter of renewals should be in the hands of the lighting company, as it enables it to improve the quality of the service. The delivery to the customers is a matter of convenience. If a lamp inspector makes regular rounds he will occasionally replace discolored lamps where the user would not.

GEO. L. COLGATE.

In answering this question it is assumed that Nernst lamps are referred to. All renewals should be furnished and installed in the lamps by the company. The less the customer has to do with the lamp the better.

PENINSULAR ELEC. LT. CO.

Lamp renewals should certainly be furnished free to all central-station meter customers, and delivery of the lamps should be made by the station, the customer thus obtaining good lamps to replace old, dim and burned-out lamps. A good plan is to leave spare lamps in pasteboard boxes with each consumer. The consumer then uses lamps from the spares to replace old, dim and burned-out lamps, and the central-station wagon makes monthly visits, exchanging the box of new spare lamps for the old box.

FRANCIS W. WILLCOX.

We believe that in order to maintain a first-class lighting system it is necessary for the electric-light company to furnish free lamp renewals, although it does not seem necessary to deliver the lamps to the customers. Where customers purchase their own renewals it is not possible to induce them to change the lamps as often as is necessary to maintain an efficient system of illumination.

E. H. MATHER.

Lamps should be furnished free and renewed as often as necessary.

ANDREW F. HALL.

Yes.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

Incandescent lamps should be renewed and delivered free to customers.

W. F. KINGAN.

If the question of popularizing your service and getting patrons to advertise you as being liberal and accommodating is to be considered as of any value, incandescent lamps and renewals should be furnished and delivered to customers free of cost.

PENINSULAR ELEC. LT. CO.

*No. 11.—What is the difference in efficiency between the ordinary reflecting shades, such as are used upon incandescent street hoods, when presenting a clean, white surface and when old and rusty?*

I have made tests with the regular oval filament and the ordinary reflector shade, such as is used on incandescent street hoods, to find the difference in efficiency between clear, white surface and an old, rusty surface. I find that the clear, white surface gives me 11.4 mean spherical candle-power, and assuming that the rusty surface would give no reflection, and the shade would cut off the candle-power from 290 degrees to 70 degrees, the mean spherical candle-power would be 9.37, or 82.2 per cent, showing a loss of 17.8 per cent due to rusting.

FRANCIS W. WILLCOX.

In answer to this question, would say, judging from the appearance of the ordinary reflecting shade, which is painted white on the underside, that after it becomes covered with dirt and is rusty, at least 50 per cent of its efficiency is lost. Conditions would largely determine this loss. If you will use a steel reflecting shade with porcelain enameled covering you will have no trouble from rust, and the white surface can be cleaned in a few minutes, keeping the reflecting power of the shade at its highest efficiency for a number of years.

E. W. LLOYD.

Ordinary street incandescent lamp reflecting shades are practically useless as reflectors after becoming old and rusty, though they still accomplish their purpose as protection to the lamps.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 12.—Are renewed lamps as economical and satisfactory to consumers as new first-class lamps?*

It does as well as any incandescent lamp.

GEO. L. COLGATE.

Certainly not.

W. H. BANES.

To customers of intelligence I should say renewed lamps were not as satisfactory, as they cannot be as economical as first-class lamps. The average customer can be imposed upon with impunity, if desired.

A. O. WHITMORE.

There is too much difference in candle-power of renewed lamps to make their use desirable under any circumstances. When a consumer notices a dim lamp he condemns the system and not merely the lamp itself.

EDITOR.

Our experience with renewed lamps has not been very promising, the life and efficiency being an unknown quantity.

S. S. INGMAN.

I think not.

F. C. S., MALDEN ELECTRIC CO.

Customers do not appreciate renewed lamps if they can recognize them as such. We should not like to say that there are no good and uniform renewed lamps, but our experience with them is that they are a mixed lot, and unsatisfactory.

THE SHERBROOKE PR., LT. AND HT. CO.

Our experience with renewed lamps has shown that they are dear at any price.

GEO. S. CARSON.

See answer to S 13.

FRANCIS W. WILLCOX.

The question is rather unfair in that it demands a comparison between *any* renewed lamps and *only first-class* new lamps. The question of lamp values is not so much "Are the lamps new or repaired?" as "Who made the lamps?" Speaking generally, a lamp manufacturer who can make a first-class new lamp can make an equally good renewed lamp, and the converse is also true. Generalization on the question of lamp values is, however, very unsatisfactory. A determination of the value of each make and shipment affords the only sure method of arriving at true conclusions.

PRESTON S. MILLER.

Many renewed lamps now on the market are not economical and do not give as satisfactory service as new first-class lamps.

E. H. MATHER.

*No. 13.—Is it economical for a station that gives free renewals, to supply renewed lamps?*

It is not economical for a station to furnish renewed lamps, or any other lamp that is not the best lamp obtainable for the service desired. The question of *free* renewals has no bearing on the matter, the point being that the quality of lamp determines the quality of light service. The best possible lamp should therefore be obtained to secure the best character of service. Free renewals is the accepted policy for insuring the use of the type of lamp that the intelligent station manager selects, instead of leaving it to the option of the uninformed customer. This being the case, it would be a double error for the central-station manager to select a re-

paired lamp, or any type of lamp inferior to the best obtainable, simply because of the low first cost.

FRANCIS W. WILLCOX.

We are not inclined to regard renewed or "refilled" lamps with the same degree of assurance that we regard first-class lamps. They are undoubtedly cheaper in first cost, but I will not call them more economical, considering that word in its broadest sense. It must be remembered that when it comes to lamps the best is the cheapest in the end. In these days of competition, the prices of lamps of first merit are so nearly the same that when a lamp base is worth from five to eight cents it would seem to us that something must suffer. A first-class service cannot be given with cheap lamps, and on such service hinges the success of every plant.

CHAS. H. PETERS.

In my judgment, no.

F. C. S., MALDEN ELECTRIC CO.

It is not economical for a station that gives free renewals to supply renewed lamps unless they are equal in efficiency to new lamps. The best lamps are needed for good service, and will be appreciated.

E. H. MATHER

It depends upon who renews the lamps. We have proven conclusively that a manufacturer who can make thoroughly high-grade lamps can renew the same lamps after use, and that the actual value of the lamps so renewed is fully equal to the value of new lamps of the same make; also that a manufacturer who cannot make originally a good lamp cannot produce good lamps by renewing after use the best lamps made by any maker. The value depends upon *who* makes the lamps, not upon the fact of the lamps being new or repaired. In other words, Jones' renewed lamps are equal in value to Jones' new lamps, but Smith's renewed lamps may be of much higher value than any of Jones' lamps.

WILSON S. HOWELL.

It is not economical to give poor lamps, whether new or renewed.

AUGUSTA RY. AND ELEC. CO.

No; if you are to give free renewals the new lamp is always the cheapest.

W. H. BANES.

It is evident that the person giving free renewals must charge rates that will allow him to make up for lamps burned out. Where one desires to get the best results obtainable for the least money, I should not consider it economical to use refilled lamps. These lamps are generally inferior in wattage and give poorer light, owing to the blackening of the glass from previous usage. Of course, as a general rule, customers do not know when they get the best results or the most light for their money, and it is cheaper to furnish poor lamps than good ones if you can make the customer pay for the wattage no matter what light he gets.

A. O. WHITMORE.

No; the best lamps are the cheapest in the long run.

GEO. L. COLGATE.

*No. 14.—Is it good policy to color lamps free of charge for temporary holiday decoration?*

We believe it is good policy to furnish free colored lamps for temporary holiday decoration. It pays the same as any other advertising.

THE UNION ELEC. LT. AND PR. CO.

We have always found it good policy to loan colored lamps to our customers free of charge, and for this purpose we use lamps that have been taken out by the inspectors on account of unsatisfactory candle-power. These lamps when colored are as satisfactory as any others for decorative purposes, and a considerable stock is kept on hand.

JAS. B. FOOTE.

Make a small charge covering material and labor.

W. H. BANES.

We believe it pays in good will to color lamps free of charge. The costs are small, and a bright boy will color hundreds in a day. In colored lamps illumination is not the object so much as at-

tractive display. We use for this purpose returned lamps that have fallen so low in candle-power as to be unfit for regular service.

WILLIAM R. GARDENER.

I have always found that on such occasions customers willingly paid for such extra service.

GEO. L. COLGATE.

Yes; I consider it good policy to color lamps for customers for temporary holiday decorations, as it creates a good feeling between the customer and company, which is too often overlooked.

W. J. C., N. Y. ED. CO.

No.

J. H. HALLBERG.

No; leave this to the local supply houses.

C. C. GARTLAND.

Yes; it is not a bad plan to dip the slightly blackened lamps brought in for free renewal and keep them on hand for such purposes. Have them carefully cleaned. Frost the brightest, and dip those that are darkest in the darker colors.

THE SHERBROOKE PR., LT. AND HT. CO.

We have not found it so. It becomes an abused privilege, unfortunately. Make a small charge, as people in general don't appreciate something for nothing, although they seem to be always working toward that end.

CHAS. H. PETERS.

We think this a good plan to advertise the incandescent light, as the expense would be comparatively little.

S. S. INGMAN.

The cost of coloring lamps for temporary or holiday decorations is so slight that it may be considered good policy to do this as an accommodation to the customer, thereby increasing his good will and more firmly establishing in his mind the desirability of electric service as compared to other means of illumination.

(UNSIGNED.)

It is only fair to both company and consumer that a charge should be made covering the bare cost of coloring lamps for holiday decorations. This is a special service rendered a few customers, and should be paid for by those who desire such service.

E. H. MATHER.

Where it does not cause too much annoyance or any tendency to call for an extra number of lamps, it is a good way to use dim lamps.

AUGUSTA RY. AND ELEC. CO.

*No. 15.—Can small stations afford the expense of periodical inspection and renewal of incandescent lamps, as a general proposition?*

The expense for a small station would probably wipe out the benefits derived, although it is desirable to have the lamps renewed when they ought to be.

GEO. B. LAUDER.

We do not think that small stations can afford the expense of periodical inspection of incandescent lamps, but must trust to customers to report lamps that do not seem to give ample efficiency.

THE UNION ELEC. LT. AND PR. CO.

Not in a town of less than 5000 population.

W. H. BANES.

Yes.

GEO. L. COLGATE.

Renewals for comparatively small plants can be made by customers calling at the plant or office, and charging lamps against customer will soon show whether lamps are being used properly or not.

AUGUSTA RY. AND ELEC. CO.

No; but the company can give its patrons to understand that when their lamps become blackened they can bring them in and receive new lamps in exchange.

CHAS. H. PETERS.

It is desirable for small, as well as large stations to have periodical inspections and renewals of incandescent lamps, and this can frequently be done by working in an employee who is not engaged the whole of each day on his regular work.

E. H. MATHER.

They can, and the expense will prove a good investment in the closer relations that will result between the company and the consumer. The latter will feel that you consider him of some importance at other times besides billing day. We should remember that it is light the customer is willing to pay for; he neither knows nor cares anything about current or kilowatts; he wants illumination. He cannot get satisfactory service from discolored lamps, but so long as he has to pay for the lamps, he will burn them until they are black in the face, and then complain that his service is poor and his bills high.

WILLIAM R. GARDENER.

The expense of periodic inspection and renewal of incandescent lamps for small stations should not be proportionately any greater than for large stations. In fact, large central stations, particularly in large cities, maintain that they cannot follow the methods of individual inspection of incandescent lamps that is possible in small towns, owing to the volume of their business. On this account the larger stations have adopted the method of leaving a pasteboard box of spare lamps with their consumers and calling to replace this box once a month. This always gives the customer spare lamps for replacing dim or burned-out lamps, and avoids the trouble of sending to the station or office for new lamps. This plan should also work well for small stations.

FRANCIS W. WILLCOX.

There should be no extra expense attached to inspection, as every employee should be expected to notice and report burned-out or badly blackened lamps. If free renewals are given, the cost must be added to the price at which current is sold.

EDITOR.

## T

### TRANSFORMERS

*No. 1.—When self-cooling, oil-insulated station transformers heat up too much, what is the best auxiliary means of cooling?*

We have six 250-kw, step-down transformers, which were built with corrugated cases for self-cooling. These transformers were located in a room that has very poor ventilation, and, as it

was practically impossible to better the ventilation of the air about them, copper cooling pipes were purchased and immersed in the oil surrounding the transformer core and coils. These coils were connected up and water from an artesian well forced through them, and since this was done the temperature has been very satisfactory.

JAS. B. FOOTE.

I have used very satisfactorily a water jacket constructed of ordinary galvanized iron, made somewhat larger than the transformer tank itself, in which the transformer to be cooled was placed and water caused to enter at the bottom and discharge at the top. This scheme operated very successfully during the time I was in charge of this apparatus, although I have heard that there was some trouble afterward from water leaking into the transformer tank from the outside water jacket. This, of course, would have to be carefully looked into. I think this means of cooling can be used very satisfactorily, and very little space is required.

A. O. WHITMORE.

Where a supply of water is available, the most satisfactory method of cooling is to place a few turns of brass or lead pipe inside the transformer case and circulate water through it. When water is not available, a blower may be arranged to furnish a supply of cold air to the transformer cases. In such case the transformer may be placed above a duct or chamber in which the air is maintained at a pressure slightly above atmosphere.

J. S. PECK.

Circulate the oil through a pipe coil immersed in cold running water. It is also possible to lower the temperature of the oil by circulating cool air around the transformer case. In some transformers, where room permits, it is possible to cool the oil by inserting a spiral copper tube in the oil, and circulating cold water through it.

J. H. HALLBERG.

I should build a water tank around the transformers and connect the cold feed-water supply for the boilers to this tank, which would give the circulation of cold water. The water should then be passed through the feed-water heater before entering the boiler.

W. J. C., N. Y. ED. CO.

When oil-insulated station transformers heat too much, the probable cause is overload, and the load should be reduced, or additional transformer supplied. If transformers are not overloaded tests would be advisable. An auxiliary means of cooling an oil-insulated transformer of small size would be rather expensive.

G. L. THOMPSON.

Causing oil to circulate by pumping through water-cooled coils will accomplish the purpose, but such a plan is advisable only as an emergency resort.

G. WILBUR HUBLEY.

Ordinary desk fans placed close to the transformers so as to blow air upon them have done good service.

R. H. THURSTON.

A small coil with water drawn through it will do much to reduce the temperature.

AUGUSTA RY. AND ELEC. CO.

Direct a draft of air against the case of the transformer, using electric fans of suitable size. It might be advisable to place an outside jacket around the transformer, forming an air duct and providing suitable inlet and outlet for air.

E. A. WAGNER.

If a source of water supply is available, a flow of water through a jacket in the casing would perhaps suffice, or the oil itself might be drawn off, cooled and returned again by a pump.

C. F. HAYWOOD.

*No. 2.—Is there any practical device for locating a burned-out fuse on potential transformer used to energize the potential coil of a primary wattmeter on consumer's premises?*

A practical device of value in locating burned-out fuses on potential transformers is the electro-scope made up in portable form. The electro-scope is moved along live conductor and fuse at a uniform distance from it. At point of rupture of fuse, the electro-scope furnishes positive indication. The device is satisfactory for voltages exceeding 800 volts.

E. O. SCHWEITZER.

Why not supply the potential coil of wattmeter with current from the secondary of the transformer feeding the consumer's installation? There would, of course, be a slight loss due to the regulation of transformer, but this would probably be less than the core loss you are charging up against him.

EDITOR.

*No. 3.—What is the best way to protect the circuits of a multiple-circuit, series arc transformer from damage by open circuit?*

Use lightning arresters with small enough number of gaps to be jumped by the high voltage present under open-circuit conditions, thus acting as a safety valve to relieve the circuit and transformer from excessive strain. The resulting current will ruin the lightning arrester if allowed to continue more than a few minutes, but this is generally the lesser evil of the two.

M. P. R., N. Y. ED. CO.

Insert a small electro-magnet in series with each arc circuit arranged to cause a switch to shunt the circuit if it should open. If it be not desirable to install such automatic switch, let the armature of the small electro-magnet drop and close a local bell circuit, thus signalling to the operator that the circuit is open. The operator can then short-circuit the line or pull the secondary plugs, either of which will protect the line.

J. H. HALLBERG.

It is suggested that lightning arresters with high-resistance carbons be connected directly across the terminals of the transformers, so that in case any excessive rise in the terminals is caused by the opening of the series circuit, the same will be limited by the discharge across the lightning arresters.

E. A. WAGNER.

Use an automatic cut-out that opens the primary circuit of the tub upon the occurrence of an open circuit in the secondary.

THE EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 4.—When should a transformer out on the line, exposed to the weather the year around, be scrapped? Some old types have become obsolete. They must begin to deteriorate as soon as installed, and must have a certain length of life beyond which it may*

*be dangerous to go, owing to the ever-present liability of a breakdown. Is it not probable that, as time goes on, we shall hear more and more accidents from breakdowns unless a systematic weeding out of "old" transformers be made? What system would be followed in the weeding-out process?*

A system of regular inspection and tests should be made at intervals of about one year, and weaknesses developed by such tests should be remedied. From past experience I should say that the life of a transformer under normal conditions of service would average from six to eight years, but with the modern improved design of transformers with low temperature limits and consequent low core losses, the life of a transformer, if properly maintained by inspections and tests at periodical intervals, should be from 15 to 20 years, at least.

G. WILBUR HUBLEY.

Two very simple tests will determine when a transformer should be scrapped:

*First—Core-loss Test:*

When the transformer is brought in from the line, the secondary should be excited at the normal secondary pressure, a wattmeter being installed and core loss noted. It can then be determined whether or not the saving in core loss effected by installing a new transformer would warrant the scrapping of the old.

*Second—Breakdown Test:*

A breakdown insulation test between primary and secondary should be made at a potential of three times the primary voltage of the transformer. If the transformer stands this test satisfactorily, it need not be scrapped on the score of deterioration of insulation.

G. N. EASTMAN.

In the absence of any better plan that we know of, we are gradually scrapping our old transformers, regardless of the fact that they have shown no apparent weakness, because we don't want to run an unknown and perhaps indeterminable risk.

GEO. B. LAUDER.

It does not appear to the writer either necessary or advisable to scrap a transformer for no other reason than that it is old. We

test our transformers from time to time for insulation, core loss and regulation, and scrap only those falling below our requirements. The insulation test is made as follows:

A small step-up transformer is taken to the place where the transformer to be tested is located. Its primary is connected to the high-voltage mains and one of its secondaries is connected to the primary and the other to the secondary of the transformer to be tested, the latter having been previously disconnected from both secondary and primary circuits. The secondary voltage of the step-up transformer is twice the primary voltage of the system. The pressure is applied for one minute. The insulation is thereby subjected to twice the working voltage, which is sufficient to develop any serious weakness in the insulation.

WILLIAM R. GARDENER.

The improvement in the manufacture of transformers in the past five or six years warrants the up-to-date manager of a central station in weeding out the majority of transformers that have been in use more than six years. The serviceable life of the modern transformer can be determined only by experience. The aging of the iron and the deterioration of the insulation are the principal points to be considered. A good system to follow is to plan to use transformers in larger units, using three-wire secondaries where the distances warrant it.

GEO. L. COLGATE.

It is undoubtedly a fact that some of the first transformers manufactured are in service to-day. These were made when manufacturers had but little knowledge regarding insulation and proper methods, and improvements have been so great that it is doubtful if any transformer not manufactured within the past five or six years is actually economical. To obviate accidents, it is a good plan to ground the secondaries, and this plan would weed out transformers not provided with proper insulation between primary and secondary.

G. L. THOMPSON.

*No. 5.—What is the effect of running a transformer designed for 125 cycles on a 60-cycle circuit?*

A 125-cycle transformer does not require so much iron in its magnetic circuit as does one for 60 cycles. Operating a 60-cycle

current through a 125-cycle transformer would heat it, if it did nothing more.

GEO. B. LAUDER.

The effect of running a transformer designed for 125 cycles on a 60-cycle circuit is to increase heat and core loss.

WILLIAM R. GARDENER.

The 125-cycle transformer should not be run to capacity on a 60-cycle circuit. The heating in the iron would be excessive, and would result finally in the burning out of the transformer.

E. P. DILLON.

The induction of magnetic lines in the core will be in inverse proportion to the frequency, with consequent extra loss and heating on the lower frequency.

M. P. R., N. Y. ED. CO.

In changing from a 125-cycle to a 60-cycle circuit, the iron loss of a transformer is increased approximately 30 per cent. Practically all modern transformers will operate on both 60-cycle and 125-cycle circuits. Many of the older types of transformers were designed for operating on 125-cycle circuits only. If changed to a 60-cycle circuit, the increased loss may be sufficient to destroy the transformer.

J. S. PECK.

Increased core loss.

G. WILBUR HUBLEY.

It reduces its capacity.

AUGUSTA RY. AND ELEC. CO.

The core loss is increased, as it is greatly dependent on the frequency.

C. F. HAYWOOD.

The regulation would be poorer, copper loss slightly decreased, and iron loss slightly increased, so the effect should not be very bad.

CHAS. H. PETERS.

Heating would be increased at least 10 per cent. A 125-cycle transformer operating under severe conditions would undoubtedly break down quickly if operated at 60 cycles.

G. L. THOMPSON.

The capacity of a transformer is determined by heating, and as the current will not be affected by the frequency the only loss to be considered is the core loss, and mainly the hysteresis loss. Roughly, the core loss of a transformer may be said to vary inversely as the square root of the frequency, so that by decreasing the frequency we increase the core loss and decrease the output for a given loss. In changing from 125 to 60 cycles the core loss is increased about 25 to 30 per cent, the efficiency decreased about one per cent (assuming small transformers), but the regulation is slightly better.

A formula, which would consume too much space to work out here, gives the ratios of capacities to frequencies as follows:

Let  $C$  equal capacity on original frequency  $f$ .  
Let  $C'$  equal capacity on new frequency  $f'$ .

$$\frac{C'}{C} = \left(\frac{f'}{f}\right)^{\frac{1}{2}}$$

From which we see that  $\frac{C'}{C} = \left(\frac{60}{125}\right)^{\frac{1}{2}} = .76$ ,  $C' = C \times .76$ .

The capacity would therefore be reduced 24 per cent by changing from 125 to 60 cycles.

However, it is of course possible to use transformers thus, and many are being so used; but they require especial care and attention in order that they may not burn out. M. C. T.

The core loss of transformers is dependent on the frequency, being lower on lower frequencies for the same transformer. C. F. HAYWOOD.

*No. 6.—Is the Cooper Hewitt selective converter to be a commercial article?*

The Cooper Hewitt converter will certainly be a commercial article. PERCY H. THOMAS.

*No. 7.—Is it in actual use?*

I will state that at the present time it is not in commercial use. PERCY H. THOMAS.

*No. 8.—What are its limits as to voltage, phase and frequency on the primary side, and as to voltage on the secondary side? At what voltage, phase and frequency of alternating primary current are best results obtained?*

There are no definite limits as to voltage, phases and frequencies. All ordinary commercial direct-current voltages are within the range of the converter; each particular converter will have a fairly definite ratio, which will vary with different types of circuit. Any desired direct-current voltage is easily obtainable by means of adjustment by transformers of alternating-current voltage.

The converter is easily arranged for any number of phases. It may be readily used on a single-phase circuit.

The frequency, within commercial limits, is immaterial, provided the converter be adapted to the frequency upon which it is to operate.

PERCY H. THOMAS.

*No. 9.—What, in good practice, should be the loss from the switchboard to consumer's meter, with standard modern transformers and meters, lighting load only?*

Not over three per cent.

W. H. BANES.

This is a difficult question to answer without knowing distances. Under usual conditions, probably from 10 to 12 per cent.

GEO. L. COLGATE.

The above answers are evidently based on the line drop, while the question seems to include all losses, which would amount to from 30 to 40 per cent under the conditions given.

EDITOR.

Twenty to 30 per cent.

W. T. M., N. Y. ED. CO.

The loss between switchboard and consumer's meter depends upon the system used, character of installation, load factor and local condition. As the question does not make reference to any of the above points, the itemized figures as given below might vary

somewhat for different plants, but the total loss should be within the figures for the totals, to be called "good practice":

KW-HOUR LOSS	
Transformer core losses, about.....	15 per cent
Copper losses, about.....	7 "
Meter shunt losses, about.....	3 "
Leakage and unaccounted-for, no more than	5 "
<b>Total.....</b>	<b>30 per cent</b>

KILOWATT LOSS AT TIME OF MAXIMUM LOAD	
Feeder loss, about.....	8 per cent
Line loss, about.....	2 "
Transformer losses.....	2 "
Secondary loss, about.....	2 "
Meter shunt loss, about.....	1 "
<b>Total.....</b>	<b>15 per cent</b>

A further reduction in losses would generally mean an additional investment in copper, the interest on which would often be greater than the savings in energy. S. PRUSINOWSKI.

The percentages of loss during the period of maximum load in an alternating distributing system should be about as follows:

Primary feeder.....	6 to 10 per cent
Primary main, not to exceed..	2 "
Transformer .....	2 "
Secondary main.....	2 "
<b>Total .....</b>	<b>12 to 16 per cent</b>

The kw-hour loss due to line and transformer drop and transformer core loss in some modern system does not exceed 30 per cent of the total generated output. Of this amount, the transformer core loss is about half. H. B. GEAR.

Within an average of 20 to 25 per cent would be good modern practice. G. WILBUR HUBLEY.

*No. 10.—What is the largest size of transformer that you would consider advisable to erect on a pole?*

A 10-kw. It would be better to use smaller ones and distribute them over a greater area. W. H. BANES.

The largest size that we find advisable to put on a single pole is a 15-kw, this size weighing over 1000 pounds.

G. H. CUSHMAN.

On ordinary line carrying poles in city streets, which can not usually be guyed properly, 15 kilowatts is about the limit. On extra heavy short poles, well guyed and carrying no line wires to produce side strain, 30 kilowatts to 50 kilowatts.

M. P. R., N. Y. ED. CO.

Transformers aggregating 150 kilowatts capacity can be safely erected on poles, by constructing a platform between two poles set close together. It is not advisable to install single transformers of more than 30 kilowatts capacity on a single pole. In three-phase installations where transformers may be placed on opposite sides of the pole, the capacity may be as much as 50 kilowatts with safety.

H. B. GEAR.

Twenty-five to 30 kilowatts.

AUGUSTA RY. AND ELEC. CO.

Fifteen kilowatts, unless special construction is used.

G. WILBUR HUBLEY.

A 30-kw transformer is as large as advisable to erect on poles.

G. L. THOMPSON.

Twenty-five, or possibly 30-kw. However, a transformer larger than 7.5-kw should never be mounted at top of the pole, but should be mounted on a substantial platform built on the pole about half-way between the ground and top of pole.

J. H. HALLBERG.

A 100-kw.

F. C. S., MALDEN ELECTRIC CO.

We consider a 15-kw transformer the largest size that should be erected on a pole.

E. H. MATHER.

We should not consider it advisable to erect a transformer larger than the standard 10-kw transformer on a pole, and even that size should not be put on poles with less than 10-inch tops and not over 25 feet from the ground. E. S. ALDRICH.

A 15-kw.

FRED B. HUBBELL.

I should say about 20-kw.

CHAS. H. PETERS.

*No. 11.—We are located 28 miles from the Gulf of Mexico and are 28 feet above sea level. There is a great deal of rain throughout the year and humidity of the atmosphere is very great; summers extremely hot and winters changeable. Is it better, or not, under such conditions, to use oil in line transformers of from 100-light to 500-light capacity?*

Yes; use oil transformers, by all means, and discount the standard rated capacity about 20 per cent.

GEO. L. COLGATE.

The use of oil under the conditions mentioned should certainly be better than if no oil is used with the transformers, particularly if the transformer is designed for the same. If any trouble is experienced due to moisture entering the transformer case, the water should be drained from the bottom of the oil once or twice a year.

E. A. WAGNER.

Oil should be used and the cases tightly sealed by means of felt gaskets.

J. S. PECK.

*No. 12.—What trouble, if any, is experienced from the dissolving by the transformer oil of the insulating compounds used for waterproofing oil transformers?*

When coils and insulating material are treated with varnish that is properly oxidized, the varnish is practically insoluble in transformer oil. Where coils are treated with waterproofing materials having an asphaltum base, a considerable amount of inconvenience may be expected, as such compounds are more or less

readily dissolved by the oil, giving it a black appearance and often forming a heavy, sticky "dope," which is apt to clog the ventilating ducts.

J. S. PECK.

*No. 13.—Is it better to overload a transformer at peak than to stand heavy core loss all day? Will the aging of the iron under overload conditions overbalance the advantages gained from saving in core loss?*

Standard transformers should not be subjected to an everyday peak of more than 25 per cent overload. Test will show that the most efficient load is at 75 per cent of the rated capacity. On the five-kw transformer, for instance, the full-load efficiency will be about 96.5, while the efficiency at 75 per cent of full load will be 96.7, and the efficiency at 25 per cent overload will be something less than at full load. With average conditions this would give an all-day efficiency of 92 to 93 per cent.

GEO. L. COLGATE.

Overloading a transformer at peak will, in general, result in a saving in core loss, but it should be remembered that the regulation of the transformer increases almost directly with the load, so that if the transformer is considerably overloaded its regulation may be very poor, resulting in inferior illumination and a reduced meter reading. This loss of revenue due to the reduced meter reading may more than offset the saving by the reduced core loss.

The aging of the iron depends upon its quality and upon the temperature at which it is operated. In general, there is a critical temperature below which the iron does not age. If the overloading causes the temperature to exceed this critical value, aging will occur. Thus the temperature characteristics of a transformer should be taken into account when making a selection for temporary overload working.

J. S. PECK.

It is better practice to overload a transformer at peak load than to permit excessive core loss throughout the greater portion of the day. The saving by the use of smaller transformers will more than offset the injury caused them by short periods of overload.

E. H. MATHER.

It is better to overload a transformer at peak than to stand a heavy core loss all day. W. F. KINGAN.

First—Yes. Second—No.

F. C. S., MALDEN ELECTRIC CO.

It has been found on the lines of the Denver Gas and Electric Company that transformers up to 20-kw, when balanced, can be run at 25 per cent overload for two hours without any serious effect. J. F. DOSTAL.

Overload transformers at peak load. Twenty-five per cent overload would do no injury under such conditions.

G. WILBUR HUBLEY.

If well-designed modern transformers are used, the greater economy would be obtained by overloading transformers at peak of load. E. P. DILLON.

## U.

### METERS

*No. 1.—Why is it that the speed of a Thomson recording wattmeter is proportional to the load?*

Due to shunt and field currents. ROBERT J. CLARK.

Because of lack of iron in the fields and armature.

A. PETERS.

The torque on the armature is proportional to the ampere turns on the current coil of the meter. T. D. EVANS.

The Thomson recording meter is an electric motor of a special type on a small scale. The armature is in series with a high resistance and directly across the line, and revolves in a field produced by two coils in series, through which the current passes to the load.

As in the ordinary motor, the torque exerted by the armature

varies directly with the product of the field strength and the current, or torque, is proportional to volts  $\times$  amperes = watts. But, since the armature would speed up indefinitely if it did not work, a load is provided by means of a metal disc at the bottom of the meter, revolving between two permanent magnets. As soon as the disc begins to revolve an electromotive force is set up and currents circulate in the disc, producing a retarding force or load exactly as in a generator. The induced currents increase as the speed increases, consequently the retarding force as well, until a point is reached where the speed becomes constant. Then, torque = retarding force. But torque is proportional to watts, and the retarding force is proportional to speed, hence watts are proportional to speed.

F. M. FARMER.

As the armature of the small electric motor in the Thomson recording wattmeter is connected across the circuit in which the power to be measured is expended, and the field coils in series with it, the currents flowing in them are proportional to the electromotive force  $V$  and amperes  $I$  in line, respectively. The intensities of the magnetic fluxes through armature and field coils are proportional to the currents producing same, and as the force action  $F$  between any two magnetic fluxes is proportional to the product of their respective intensities, we see that  $F$  is also proportional to  $VI$ , which is the load. The driving torque  $T$  on the armature, being proportional to  $F$ , is thus seen to vary directly as the load. To turn the copper disc mounted on the armature spindle between the permanent steel magnets requires a driving torque, as is well known, proportional to the speed. We thus have:

Driving torque proportional to load,

Driving torque proportional to speed,

Hence, speed proportional to load.

S. PRUSINOWSKI.

The torque of the Thomson recording wattmeter is directly proportionate to the current in the fields and the current in the armature. The former is connected in series with the main load, and the latter across the line, so its current is determined by the pressure.

The speed is directly proportionate to the torque, neglecting friction; but, as this is compensated for, the theory still holds good.

The retarding mechanism consists of a thin disc passing between the poles of powerful magnets. The generation of eddy currents in the disc, or retardation, is directly proportionate to speed. The meter, therefore, is directly proportionate and correct throughout.

C. C. SUPPLEE.

*No. 2.—What is the theory of the operation of the Fort Wayne induction meter?*

The theory of the operation of the Fort Wayne type-K integrating wattmeter is that of a rotating field caused by the displacement between the series and shunt fields acting upon a closed secondary—that is, the cup-shaped aluminum armature in which currents are induced, setting up fields which react upon the rotating field according to the well-known principle of the induction motor, which is the fundamental principle upon which all induction meters are based.

The question would seem to resolve itself into: How is the rotating field in the above-mentioned meter obtained so that it shall correctly record the wattage of the circuit independently of the power factor? Since the registration of the meter depends directly upon the revolutions of the rotating element, and since the drag of the meter is directly proportional to the speed of the same, it necessarily follows that the torque of the meter must vary directly as the wattage of the circuit.

It will be readily seen that for any given values of  $E$  and  $I$  in the equation  $W = EI \cos. \phi$ , where  $W$  = energy of circuit expressed in watts and  $E$  = electromotive force of circuit expressed in volts,  $\cos. \phi$  =  $\cos.$  of the angle of lag between the impressed electromotive force and the current of the circuit (value of  $\cos. \phi$  = power factor of the circuit), it becomes necessary that the torque of the meter shall vary as the  $\cos.$  of the angle of lag or  $\phi$ .

Thus it follows that, when  $\phi = 0$  or  $\phi = 90$  degrees, the torque of the meter must be its maximum for the given field "intensive." Likewise, when  $\cos. \phi = 0$  or  $\phi = 90$  degrees,  $W = 0$ , so also the torque must be zero, although the intensity of the two fields of the meter will remain the same.

From which it will be readily seen that the two fields that shall set up the rotating field of the meter must change in phase

relation through 90 degrees between maximum torque and zero torque for any given field intensity. And, since two fields having no phase difference will not set up a rotating field thus, the zero torque will be obtained when the two fields are in phase and the maximum torque will be obtained when the two fields are at 90 degrees from each other, under which conditions the torque, eliminating friction, will vary as the  $\cos. \phi$ .

Since the current in the series coils will be lagged back of the impressed electromotive force with the addition of inductive load, it becomes necessary that it be the shunt field that is originally lagged back through 90 degrees, so that were the power factor  $= 0$  the two fields would then be in phase and the torque zero to correspond to the zero watts energy.

The Fort Wayne type-K integrating wattmeter is double-lagged—that is, provided so that the shunt field may be lagged through 90 degrees for either the 133-cycle or 60-cycle circuit. This allows the same meter to be used for either frequency. A meter correctly lagged for 133 cycles may have a lag of only about 75 to 80 degrees on a 60-cycle circuit, which would result in the torque varying directly as the  $\cos. \phi$ , and therefore would not accurately record the watts energy independently of the power factor.

In the Fort Wayne type-K meter, the shunt circuit is divided into two parts, a reactive coil and an armature shunt coil connected in series across the line. Within the opening in the armature shunt coil is the light-load adjusting arm, upon which is wound a few turns of wire shunted across a few turns on the reactive coil. By adjusting the current in this coil by means of a resistance in series and placed on the outside of the reactive coil at the left, the proper lag may be obtained for circuits of 133 cycles or thereabouts.

Below this coil and also within the armature shunt coil, but insulated from it, is placed a secondary winding of a comparatively few turns wound upon the armature shunt-coil core, the ends of which are brought down to a resistance placed at the right on the outside of the reactive coil, but in no way connected with it. This resistance is placed there only as a matter of convenience. By the added effect of this closed secondary, the meter is lagged for circuits of 60 cycles and thereabouts. This secondary may be opened or closed through its adjusting resistance, thus giving a meter

lagged for the high or low frequency by means of the unsoldering or soldering together of the ends of the reactive coil at the right.

Just how the desired lag is obtained for the two frequencies may be shown by the accompanying diagrams. In Figure 1 is shown the phase relation of the fields of the various coils for the obtaining of the higher-frequency lag. If we let  $O - X$  represent the position of the impressed electromotive force, and  $O - Y$  a positive 90 degrees from  $O - X$ , we can represent by the vector  $O - A$  the lag or phase position of the field established by virtue of the inductance of the shunt circuit, which will be largely due to the reactive coil. The field established by the armature shunt coil is passed through the closed circuited armature, causing currents to be induced in the armature which will have a phase position of magnitude equal to  $O - C$ , thus establishing an equivalent or resultant field having direction and magnitude  $O - B$  beyond 90 degrees. The coil on the light-load adjustment arm within the armature shunt coil is connected in a manner to establish a compound field  $O - D$ , the magnitude of which is controlled by the adjustable resistance previously mentioned. Thus, by varying this resistance, one is able to adjust the length of the vector  $O - D$  ( $B - E = O - D$ ) so that the resultant field between  $O - B$  and  $O - D$  will be  $O - E$ , giving the desired 90 degrees lag.

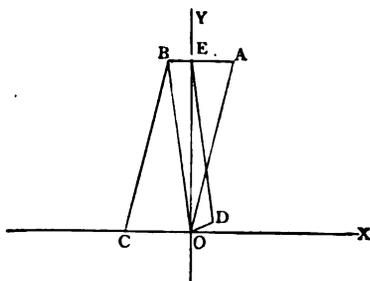


FIG. 1

Figure 2 shows approximately the various phase relations of the fields of the different coils when operating on the lower-frequency circuits. The field established by the shunt will be  $O - A$ , the angle of lag being somewhat reduced, due to less inductance in the shunt circuit at the lower frequency. Also the component  $O - C$  will be less than  $O - C$  of Figure 1, due to the reduction

in the rate of alternations,  $O - C$  and  $O - A$  establishing a phase relation  $O - B$  less than 90 degrees. The component  $O - D$  would also be slightly reduced, due to the reduction in the rate of alternation of the circuit, and a combination of the components  $O - B$  and  $O - C$  would establish a phase position  $O - E$  less than 90 degrees. In order to obtain the required lag of 90 degrees, the secondary coil wound upon the armature shunt-coil core is closed across its resistance, which would set up a field approximately in

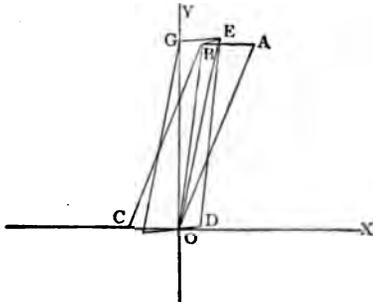


FIG. 2

the direction  $O - F$ , and by varying the adjusting resistance in this secondary, the magnitude of the component  $O - F$  is varied to the extent necessary to bring the resultant between  $O - E$  and  $O - F$  or  $O - G$  at the required 90-degree lag.

A. H. BRYANT.

*No. 3.—What is a simple, yet reasonably accurate, method of testing alternating-current single-phase induction meters in position on the customer's premises?*

Connect a portable indicating wattmeter in series with the customer's meter and turn on a number of lights. By means of a stop-watch the watts passing through the customer's meter can be calculated and compared with those of the test meter.

LOUIS I. PORTER.

With wattmeter and stop-watch a test of approximate accuracy—probably within five per cent—can be made in testing meters on premises.

G. WILBUR HUBLEY.

By the use of a standard portable indicating wattmeter and an adjustable load. The speed of the meter disc as observed with

the aid of a stop-watch is to be compared with the reading of the indicating wattmeter. The adjustable load may be contained in a carrying case and should consist of resistances or lamps arranged to give one-twentieth, one-tenth, one-half and full load of the smallest-capacity meter that is to be tested. A small adjustable resistance will permit of allowing for variations in voltage during the test. For large-capacity meters a series transformer may be arranged in the same case and with windings to step up the current for the various sizes of meters. The standard meter used should be of such capacity and length of scale as to give accurate readings on the various loads checked.

(UNSIGNED.)

A system that pre-eminently meets the requirements is to use a specially wound induction recording watt-hour meter as a test instrument. The special windings are designed to give an increased current and potential *range* that would ordinarily require the use of several separate instruments. The disc-revolutions of the test-meter and of that being tested are compared in such a way that the per cent fast or slow of the latter is at once apparent. The slide-rule is only required when testing permanently sealed meters, and that cranky piece of mechanism, the stop-watch, is not used at all. These features evidently tend toward simplicity. The other requirement—namely, accuracy—is provided for by the aforementioned plurality of current windings, these being of different capacities, but of equal torque at full load. The testing load is always applied to the most suitable windings, thus running the test-meter within desirable limits of torque and speed and avoiding the inaccuracies incident to light loads and to overloads. Obviously, this rotating test meter can readily be used on fluctuating motor loads, such that the needle-swing of an indicating wattmeter would prohibit the use of the latter. The commutator type of test-meter for direct-current work has proven satisfactory, although handicapped by the necessity of commutator and brushes, and by the fact that its potential circuit must be carefully heated before each test. The more recently developed induction test-meter, therefore, being free from the inherent disadvantages of the commutator type, will, no doubt, prove even more serviceable.

W. J. MOWBRAY.

Connect an indicating wattmeter as a standard in circuit with the recording meter, and throw on approximately a full load. Time the disc for a certain number of revolutions with a stop-watch, time of test lasting from 30 to 60 seconds, observing indicating instrument during test. Knowing the time it takes the disc to make a given number of revolutions, the energy the meter is recording can easily be figured by using the formula found in the instruction books issued by various manufacturers on their product. A comparison can then be made between the meter and indicated watts. It should then be tested on light load, or about five per cent of its rated capacity, a smaller capacity standard being used for this test.

Another method is to count the number of lamps and approximate the watts per lamp, instead of using the indicating instrument as a standard. This is very rough, and only a serious error can be detected.

C. C. SUPPLEE.

The only accurate method is by the use of an indicating wattmeter; first, by careful use; second, by having two or more, or a standard resistance, to check against.

AUGUSTA RY. AND ELEC. CO.

There are two methods for testing induction meters on a customer's premises. One of these is the wattmeter method, which necessitates two wattmeters, one for light and one for heavy load, and a resistance box of some description for testing load. The reason two wattmeters are necessary is because it is impossible to read accurately the lower part of the scale on the large wattmeter. It is possible to turn on the customer's lights for load and thus do away with the resistance box, but this is a nuisance to the customer and has but one advantage, which is to see if all the lights are on the meter. In order to carry the instruments two men are required for the above test.

A preferable method on small meters, which requires but one man, is to use a calibrated lamp for light load, and for half or full load a fixed resistance made up of zero temperature co-efficient material, non-inductive.

Determine the watts from the voltage readings in each case,

$$W = c V = \frac{V^2}{R}.$$

(UNSIGNED.)

We connect a portable indicating wattmeter in series with the house meter. The portable meter registers directly in watts, and gives the actual load on the meter at the time the reading is taken. Then we use the following standard formula :

$$\frac{3,600 \times \text{constant (if meter has one)}}{\text{watts as indicated on portable meter}} = \text{seconds per revolution of disc.}$$

By using a stop-watch to obtain the actual time in seconds actually taken by the disc per revolution, the test should be accurate for all purposes.

WILLIAM R. GARDENER.

Use a portable indicating wattmeter and stop-watch.

ROBERT J. CLARK.

The simplest method we know of is to use a bank of lamps and portable wattmeter with stop-watch. We mean to so test all our meters at least once a year.

E. E. LARRABEE.

A load-box, to obtain an apparent load through the use of a series transformer, and a portable wattmeter of long range and of good legibility at the low parts of the scale.

(UNSIGNED.)

Have the testing-man connect in series with the recording wattmeter an indicating wattmeter that has been calibrated and is accurate. By noting with a stop-watch the number of revolutions the dial of the recording wattmeter makes in a given time and the readings of the indicating wattmeter, he can make an accurate test. Knowing the constant of the recording meter and the number of revolutions of the dial in a given time, the watts used can be figured from the following :

$$\frac{3,600 \times \text{constant} \times \text{number of revolutions}}{\text{seconds required to make the number of revolutions}}$$

This indicating wattmeter can be used as a check. The time required is about 15 minutes.

L. J. LISBERGER.

*No. 4.—What is the best method of maintaining the accuracy of standards for meter testing without an expensive laboratory outfit?*

An excellent method for maintaining the accuracy of standards for meter testing is as follows: The laboratory should be equipped with a first-class voltmeter and ammeter of suitable range. These instruments should be periodically checked against a simple form of potentiometer and standard cell. This potentiometer need indicate only a few selected voltages, covering the range within which the station operates. An instrument specially designed for this purpose, which is reliable, accurate, simple to manipulate and inexpensive, has been designed by the Electrical Testing Laboratories, New York, and is on the market under the name of Lamp Testing Bureau pattern potentiometer. This instrument is in use by a number of the largest stations in the country and has been found to be very satisfactory. It is furnished complete with galvanometer and standard cell, all inclosed in a single box about the size of a Weston wattmeter box. Having an instrument of this kind the meter department can keep its voltmeter accurately checked to within 0.1 per cent, and can use this voltmeter to compare other instruments by.

To check the ammeter, a bank of lamps standardized for amperes is required. These lamps need to be carefully seasoned and to have their current consumption accurately determined at one of the voltages indicated by the potentiometer. By varying the number of lamps in parallel at this voltage, any desired current value can be obtained and the readings of the ammeter can be checked. Standardized lamps for this purpose have been furnished by the Electrical Testing Laboratories for constructing lamp banks going as high as 130 amperes. If these lamps are properly selected low-efficiency lamps, they will be very durable for this purpose and will change their current consumption at a given voltage very slowly indeed. Having after this method checked the ammeter and voltmeter, indicating wattmeters can be checked on direct current against them, and the reliability of the standards on which the station is working is very perfectly secured. The expense of an outfit of this kind is quite low, and its simplicity is such that it can be used by a person who has no special training in laboratory methods.

CLAYTON H. SHARP.

As a standard of voltage, a simplified form of potentiometer such as the L. T. B., six point, \$75 instrument, gives excellent results, especially if its standard cell be occasionally compared with two reference cells. Unfortunately, a prejudice exists against the potentiometer for use in the average central station, caused, no doubt, by unfamiliarity with the simplified and portable type and by the idea that a potentiometer must of necessity be a laboratory instrument—expensive, delicate, and extremely complicated. However, the aforementioned form should do much to remove this prejudice, as it is designed for central-station use and can be operated by any person competent to handle an indicating voltmeter.

For ampere standards use ordinary incandescent lamps of 16 or 32 candle-power—50 and 100-cp lamps are less uniform in quality—and burn them at approximately 65 per cent of their rated voltage. It is of course desirable to use the lowest possible voltage in order to get the longest possible lamp-life, but the 65 per cent point is about the lowest at which the lamps will maintain their zero temperature co-efficient. In other words, at a much lower voltage the resistance and hence the amperage will vary somewhat with the temperature of the surrounding air. At the above point, however, the lamps are almost everlasting, and if their use be confined to one or two hours per week for checking purposes the change in amperes would be less than one-tenth of one per cent per year. Obviously, lamps that are mechanically perfect should be selected, and they should then be burned for perhaps 50 hours on rated voltage to season them and to facilitate detection of defects. The exact reduced voltage decided on is then applied by potentiometer or by a voltmeter checked therefrom, and the amperage of each lamp or group of lamps—as indicated by an ammeter known to be correct—is noted for future reference.

W. J. MOWBRAY.

Send standard meters back to laboratory of manufacturer for recalibration at least once each year.

G. WILBUR HUBLEY.

If no reliable standards are kept with which to check instruments, it is advisable to return them occasionally to manufacturer to be tested. Careful handling is very essential in maintaining ac-

curacy. If the pointer is approximately on zero with the current off and moves freely with current on, a good instrument can generally be relied upon for accuracy.

C. C. SUPPLEE.

By sending your standards to a reliable testing laboratory periodically, say once a month. This method insures accuracy at a small expense. But if such a laboratory is not within a reasonable distance, then buy a portable potentiometer and check your own instruments.

F. M. FARMER.

Use instruments of precision that are truly "standards," and do not rely upon "portable" instruments that easily vary their calibration. Certain companies are producing such instruments, semi-portable in form, which will without doubt do the work. They should be sent to a government or other standardizing bureau at regular periods for recalibration.

(UNSIGNED.)

In purchasing standardizing instruments it is well to bear in mind the fact that in order to get results that are worth anything it is necessary to have the best instruments.

The least expensive standardizing outfit that we know of is as follows:

One potentiometer with resistance, standard cell, galvanometer, and microscope for increasing sensibility of galvanometer; one standard .001-ohm resistance coil of 100-ampere capacity; one standard .1-ohm resistance coil of 10-ampere capacity; one Wheatstone bridge with galvanometer.

A detailed list of apparatus needed, with approximate price, is given below:

One potentiometer of simple design.....	\$150
Two standard resistances with coils .....	115
One volt-box for use with potentiometer for voltage measurements, range 15, 150, 1500.....	35
One standard Weston cell.....	15
One microscope.....	15
One Wheatstone bridge with galvanometer.....	125
Total ... ..	\$455

By using the standard cell and the Wheatstone bridge the voltmeter standard can be checked by the "standard cell method," and the voltbox omitted, but it is not advisable.

For the proper use of the above instruments it is necessary to

have a steady current supply for voltmeter and also for ammeter calibrations.

One hundred storage cells of 8 ampere-hours capacity each can easily be arranged so as to be used either in series or in multiple, and with suitable resistances may be used respectively for voltmeter or ammeter calibrations. (UNSIGNED.)

Test standards frequently with a known resistance.

ROBERT J. CLARK.

*No. 5.—What is the allowable percentage of error in recording wattmeters?*

An *apparent* inaccuracy of one per cent is allowable by the meter manufacturer for the reason that a more exact adjustment would be unwarrantably tedious. Similarly, an *apparent* inaccuracy of one, or, as the extreme limit, of two, per cent is allowable in subsequent adjustments by the electric-light company. However, an apparent inaccuracy of two per cent might, due to errors of instruments, observation and such, be equivalent to an *actual* inaccuracy of four per cent. If, therefore, an inaccuracy of approximately four per cent were legalized, meters in service might reasonably be expected to conform thereto.

W. J. MOWBRAY.

Two per cent plus or minus from five per cent load up to load and a half is a liberal allowance, although some manufacturers' guarantee is still better. (UNSIGNED.)

The allowable percentage error of recording wattmeters varies in different places according to state laws, local conditions and facilities. Some companies work as close as within one per cent on full load, and two per cent minus on five per cent of load; others within two per cent on load, and ten per cent minus on five per cent of load. A good average would be within two per cent on load and five per cent minus on one-twentieth load.

C. C. SUPPLEE.

Two per cent fast or slow.

FRED B. HUBBELL.

Two per cent one way or the other.

CHAS. H. PETERS.

The allowable percentage of error in recording wattmeters on laboratory test is generally taken as two per cent. On test in place, four per cent. These limits are very much lower than are generally taken in foreign practice, but are not too narrow for first-class American instruments.

CLAYTON H. SHARP.

One per cent fast and two per cent slow is the error we permit in meters.

G. WILBUR HUBLEY.

Three per cent on a straight-line law meter.

AUGUSTA RY. AND ELEC. CO.

The percentage of error in recording wattmeters allowable in good practice is: Two per cent for commercial purposes; one per cent for shop calibration.

According to the laws of Massachusetts, if a recording wattmeter is within five per cent of being accurate, it is correct within the statutes.

(UNSIGNED.)

Two per cent either way on all loads.

ROBERT J. CLARK.

*No. 6.—What are the advantages and disadvantages of permanently sealed meters as against those from which the cover may be readily removed?*

The main advantages are:

1. Permanently sealing meters gives an assurance that the original calibration and adjustments have not been altered through carelessness or lack of knowledge on the part of those handling the meters.

2. No dust or iron filings can get into the meter to increase the friction or drag.

3. Customers are less likely to question the accuracy of meters calibrated and sealed by the manufacturers than those that may have been readjusted or altered by the local lighting company,

especially when the latter is known to be incompletely equipped with proper standards, as in the case of many of the smaller plants.

The main disadvantages are:

1. If the meters must be returned to the manufacturers for recalibration, etc., it necessitates the carrying of a larger stock of meters to replace those that must be returned; whereas, with meters not permanently sealed, much time and expense can be saved by the lighting plants making their own readjustments and minor repairs.

2. When the meter is permanently sealed less attention is apt to be paid to its accuracy than in the case of meters where the inaccuracies can be readily corrected when installed. Larger inaccuracies will be allowed because of the trouble and expense necessary to the recalibration of the permanently sealed meters.

3. In checking a number of secondary meters together, it becomes necessary to test each separately, as the shunt losses will be measured by the preceding meters; whereas, with meters the covers of which may be removed, the shunts may be connected back of all the series coils, so as not to cause this current to pass through and be measured by them, thus allowing any number of meters to be connected in series and simultaneous readings taken.

4. Another disadvantage with the permanently sealed meter is that with the jewel-bearing meters there is no means by which the rotating element can be kept from hammering upon its jewel during transportation and handling.

5. The friction increases with wear and the meter becomes slow on light loads. With meters not permanently sealed this may be readily corrected and new jewel and bearing points replaced when needed, with but very little trouble and expense.

A. H. BRYANT.

Our customers seem to have less objection to the meter that is sealed up against any alteration. We have just passed through a siege in changing from flat rates to the meter service, and the fact that we used such meters was offered as evidence of their correctness and helped us in some instances.

S. S. INGMAN.

Considering a large central station, well equipped for meter repairing and testing, there is practically no difference. I would,

however, recommend the sealed meter to smaller stations that cannot afford an expensive meter department.

J. H. HALLBERG.

**Disadvantages :**

It prevents ready inspection and adjustment of meters at point of installation. In nine cases out of ten, the trouble in a meter is trivial and could easily be repaired on premises at small expense. If seal is broken, guarantee is void; if not, the company is put to an unnecessary expenditure of time and labor in exchanging meters, besides being obliged to keep a larger stock on hand than is actually required.

It is very often the case that a sealed meter has no friction compensator, so accuracy cannot be obtained even if seal is broken.

C. C. SUPPLEE.

A permanently sealed meter has no advantage after the maker's guarantee expires. A meter readily accessible is advantageous where care is used in installing.

AUGUSTA RY. AND ELEC. CO.

Advantages of permanently sealed meters over those from which the cover may be readily removed are :

They are dustproof.

They are less easily tampered with, and require no adjustment by the installer.

**Disadvantages :**

They cannot be corrected on the system, although experience shows they require it. They have to be shipped back to the factory for all repairs, however slight.

(UNSIGNED.)

Dependent on the size of station, as to its facilities for testing, repairing and recalibrating its own meters. We do not take advantage of the guarantee placed on meters by manufacturers, provided original seals are not broken, as we test, repair and recalibrate meters as necessary and maintain a system of periodical tests on all meters, such tests being made in station.

G. WILBUR HUBLEY.

**Advantages :**

1. The factory calibration is preserved intact. Without a seal the owner of the meter has no assurance that the adjustments have not been changed.

2. The manufacturers guarantee the accuracy of the calibration of a sealed wattmeter. The factory calibration is made by trained experts under the most favorable conditions, and it is not to be expected that a uniformly equal degree of accuracy can be attained when adjustments are made after the meters are installed.

3. The presence of the seal begets confidence on the part of the consumer, who will naturally be inclined to believe that the manufacturers of a meter can best adjust it.

4. It is less expensive and more convenient to install than an unsealed meter. Any lineman can install a sealed meter, since no adjustments of mechanism are required, but it requires a meter expert to make the final adjustments of an unsealed meter before service is begun.

5. The fact that a meter is permanently sealed is an indication of strength and stability. In some meters the shocks of transportation would injure the jewel if the movable element were left in running position. Such meters are shipped with the jewel shaft displaced and the covers left unsealed, that the purchaser may make the necessary adjustments after installation. Sealed meters must withstand all shocks and jars and reach the point of service in perfect order, without adjustment.

**Disadvantages :**

1. The trouble of removing seals when it is desired to change the adjustments after long use. (UNSIGNED.)

There is no advantage at all in permanently sealed meters, but there are great disadvantages in time and trouble when meters have to be opened to be repaired and cleaned.

ROBERT J. CLARK.

*No. 7.—Is it advisable to replace meters and meter rate by automatic controllers and flat rate?*

No.

GEO. L. COLGATE.

No.

G. WILBUR HUBLEY.

No.

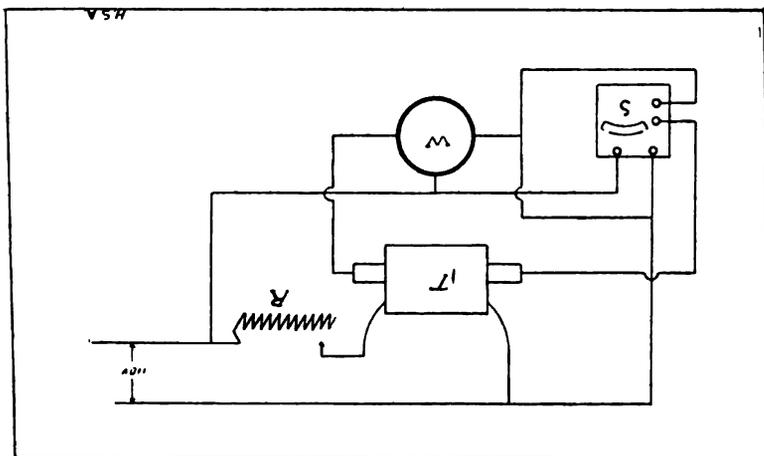
ROBERT J. CLARK.

No.

(UNSIGNED.)

*No. 8.—We use about 1000 meters, alternating current and direct current, of various types, and we should like to get a good arrangement for a complete test-board giving a range of loads from half an ampere to 50 amperes, alternating or direct current; also a means of keeping the load as steady as possible, so as to insure an accurate test.*

A simple and very convenient board for testing integrating induction wattmeters has been arranged by the Denver Gas and



Electric Company. It consists simply of current transformer and a resistance. The current transformer has a ratio of 10 to 1 and is connected up so that the current is stepped up at the above ratio instead of down, as is the usual way of connecting up such transformers. The primary end of this transformer is connected in series with a variable resistance across a 110-volt circuit. The rest of the connections are shown in the diagram. *T* is the transformer, and *W* the integrating wattmeter. One side of the 110-volt circuit is connected to the leads to the wattmeter, so as to get the desired voltage across the potential coil of the wattmeter. The load may be increased through a great range by varying the resistance *R*. It

has been found that a very convenient way of working this resistance is to have a number of different resistance lamps connected in series with a sliding resistance. These lamps may be cut out, one at a time, until about the desired load is obtained, when the sliding resistance may be brought down to as fine a point as is wished.

This testing board has been in use for about six months and has been found to be a very reliable and convenient method of obtaining the loads for the different meters. The standard meter is cut in in the regular way at S.

T. S. RICHARDSON.

*No. 9.—What is the best method of protecting direct-current meters from lightning when connected to a three-wire direct-current overhead network with grounded neutral?*

The best method of protecting direct-current meters from lightning when connected to a three-wire overhead network with grounded neutral, is to put a sufficient number of line lightning arresters on the overhead network. It is particularly necessary that these arresters should be put at the end of each branch running any distance out from the main network. If lightning shows a special partiality for a meter in any particular location, that meter should be protected by choke coils on the service wire and a lightning arrester should be connected to each of the outer wires of the three-wire system on the pole from which the service branches. Choke coils for this purpose can be made of weatherproof wire of the same size as the service wires. We have used in such instances coils of 12-inch internal diameter, wound with No. 10 B. and S. weatherproof wire, five wires in each layer and five layers—making a total of 25 turns. We have used also coils of No. 8 and No. 4 wire, four turns to a layer and four layers deep—making a total of 16 turns. We finish these coils with three layers of paragon tape and mount them on top of the large glass insulators that are made with a saddle to carry a cable on top of the insulator.

PENINSULAR ELEC. LT. CO.

We do not consider it worth while to go to any expense in this matter. (UNSIGNED.)

*No. 10.—What percentage of customers' meters will maintain without attention for one year an accuracy on one-half load within two per cent fast or slow, and what within five per cent error?*

This entirely depends upon what type of meter is used. Seventy-five per cent of induction meters within two per cent; 100 per cent within five per cent. With commutator type of meter none will come within these limits.

F. C. S., MALDEN ELECTRIC CO.

With modern induction meter it would be expected that at least 85 per cent of the meters will maintain accuracy within two per cent, and 10 per cent of the meters within five per cent of absolute accuracy, and remainder at variable percentages of accuracy, owing to accidents or normal conditions of service.

G. WILBUR HUBLEY.

Ninety-five per cent of customers' meters within two per cent either way.

Ninety-eight per cent of customers' meters within five per cent either way.

ROBERT J. CLARK.

The percentage of customers' meters that will maintain an accuracy within two per cent on one-half load for one year without attention is as follows:

Fifty per cent of the direct-current commutator type.

Seventy-five per cent of the alternating-current induction type.

Those which will maintain an accuracy within five per cent are:

Seventy-five per cent of the direct-current commutator type.

Ninety per cent of the alternating-current induction type.

(UNSIGNED.)

*No. 11.—How often should high-grade induction and Thomson recording wattmeters be tested?*

Induction meters should be tested once in from 12 to 18

months. Thomson meters not less than three times a year. (This refers to the older type of Thomson meter.)

F. C. S., MALDEN ELECTRIC CO.

Tests of high-grade induction meters once a year should be amply sufficient, but the Thomson recording wattmeters should be tested about every three months to insure accuracy of regulation.

G. WILBUR HUBLEY.

Twice a year.

ROBERT J. CLARK.

All meters should be tested, at least, once a year. Those that are under heavy and continuous load require four or more inspections a year.

E. H. MATHER.

The question of how often meters should be tested is one to be determined individually by each company, as the performance of meters varies greatly with conditions. If a system of periodic testing is already established, it can be determined whether the adopted period is too long or too short, by a comparison of the cost of testing with the accomplished increase in revenue. This latter can, contrary to the general impression, be closely estimated, but a description of the method of doing so would be too lengthy for insertion here.

W. J. MOWBRAY.

Induction meters should be tested once a year. Recording meters of the commutator type should be tested at intervals of from six months to one year, depending on the local conditions. A good rule to follow in the case of the latter instruments is to test each meter once for every million revolutions of the shaft on the jewel.

(UNSIGNED.)

*No. 12.—In testing alternating-current meters upon consumers' premises, would the accuracy of tests be affected by furnishing the field current by means of a lowering transformer, allowing potential coil to remain upon original circuit?*

A series transformer has been used very successfully for furnishing the field current for wattmeter testing, and seems to be as accurate as when a lamp load is used.

J. F. DOSTAL.

The use of a lowering current transformer in testing alternating-current meters is allowable if it is properly designed and is used on such a load that the power factor will be nearly 100 per cent. Of course, the test instrument should be an accurately calibrated indicating wattmeter or standardized recording wattmeter.

CLAYTON H. SHARP.

No. ROBERT J. CLARK.

No. (UNSIGNED.)

In testing alternating-current meters, the accuracy of the tests will not be affected by the use of a low-voltage transformer to supply the current values, provided that (a) the primary of this transformer be connected in parallel with the primary of the transformer that supplies the pressure for the shunt of the meter, and (b) the current be controlled by a non-inductive resistance; otherwise the phase displacement would not be correct and it would vary with every change of load.

If, however, the primary of the low-voltage transformer should be connected in parallel with the shunt of the meter, then the current in the series coils would be displaced in phase by 180 degrees from the normal non-inductive load condition.

A. H. BRYANT.

The accuracy of tests would *not* be affected by using a lowering transformer, provided the power factor thus obtained be similar to that on which the meter operates. Meters frequently vary in accuracy at different power factors, and hence should be tested on the normal or at, say, unity and one-half. Lowering transformers generally give a power factor of approximately .95, thus substituting nicely for incandescent lamps, but not for motor or other inductive loads. It is possible, however, to obtain low power factors by means of an adjustable reactance inserted in the secondary circuit, the phase displacement being greatly facilitated by the fact that the secondary voltage is very low. The adjustable reactance should be designed so as to avoid magnetic oversaturation of the iron and the consequent distortion of the wave-form. With adjustable power factor in addition to the ordinary equipment for adjustable amperage, the lowering transformer will be found especially serviceable.

W. J. MOWBRAY.

## V

## MANAGEMENT

*No. 1.—What is the best method of encouraging the use of current in residences?*

To encourage the use of current in residences, central-station managers should observe the following points: First, to give good service. Second, to pay particular attention to complaints, no matter how trivial, and answer same promptly. Third, to adjust all claims as quickly as possible, thereby establishing a record for fair dealing.

GEO. B. TRIPP.

The best method is to employ first-class solicitors.

W. T. M., N. Y. ED. CO.

Gain confidence by giving the best attention and most efficient service the business merits. Keep customers in touch with the advantages and conveniences, and arrange rate to enable them to use plenty of current, which will increase the net earnings of the company.

TOLEDO RYS. AND LT. CO.

A good method is to equip small stores or vacant residences in the residence district with those features in the way of fixtures and devices that make electricity in the house particularly attractive; also to take steps to get a very few lamps in good residences, even if the wiring has to be done on a concessional basis, as familiarity with the use of electricity will within a reasonable time result in its general use.

JOHN F. GILCHRIST.

Special plans to get customers to try electric lights, or well pleased customers advertising voluntarily to their friends.

AUGUSTA RY. AND ELEC. CO.

Reduce your rate. This may be done to good advantage, as the peak load for residence lighting does not appear until after the business, or commercial, peak has dropped off.

J. H. HALLBERG.

We use turn-down lamps and a sliding meter rate that gives special advantages to long-hour consumers.

FRED B. HUBBELL.

One of the best methods of encouraging the use of current in residences is to sell electric fixtures at cost or upon the smallest possible margin of profit. We sell at cost, and in this way are able to benefit our customers and ourselves. No words can advertise like the real thing, and nothing shows lighting off to better advantage than nice fixtures and shades. The benefit to the customers comes by making it possible for them to have little or much light, as necessity demands, from a source that is pleasing rather than painful to the eyes. The benefit to ourselves comes from the use of three or four lights where one or two could be made to answer. If a customer can have the illumination he wants at the right time, he is usually willing to pay for it, therefore the benefit is mutual. We also make free lamp renewals, besides replacing fuses and making minor repairs without charge. Courtesy on the part of employees goes a long way toward making pleasant relations between the company and its patrons. A smile will draw a dollar where a grunt will cause a chill.

CHAS. H. PETERS.

*No. 2.—Has not the two-rate meter a special value as applied to motor work, in view of the fact that for many purposes the customer can control the hours of use in a way that is impossible in lighting?*

A successful two-rate meter that will register separately all current over maximum allowable demand, and that will also discriminate between current consumed during time of peak and light station load, would be of the greatest value to central stations, as it would induce operators of large motors to cut off their power before the time of peak load when current is registered on a separate dial and charged for at a high rate.

J. H. HALLBERG.

The only advantage to be gained by the use of the two-rate meter on power customers would be to keep the power off the system at the time of the peak. Its use for this class of service does not seem advisable, in our opinion, from the fact that few customers could or would be benefited by its use, and because the two-rate meter requires considerable extra attention and many adjustments of bills are necessitated by the mechanism failing to act and by the clock stopping.

PENINSULAR ELEC. LT. CO.

The two-rate system of charging for electric current for lights and motors has a special value to a company if it can arrange to have the motors shut down during the peak of the load.

E. H. MATHER.

The two-rate, or three or four-rate method of charging on motor business has a special value, not because a customer can control the hours of use, but for the purpose of encouraging steady loads.

The Minneapolis rate of 7.5 cents per kw-hour on the first and second hours' use per horse-power of motor (26-day month), five cents per kw-hour for the third and fourth hours' use, and two cents per kw-hour for the rest of the day, is an attractive way of securing a large per cent of business per horse-power installed.

I am using the same plan on a steam plant, charging 10 cents for the first two hours and five cents for the remainder, with a minimum of \$2.00 per horse-power per month. The customer may be able to control the hours of use, but when he has 24 hours' service I cannot control him.

GEORGE MAYER.

*No. 3.—On what should the amount of the minimum charge be based—the number of lights installed, the maximum load, or should there be simply a fixed minimum per customer?*

The ideal scheme would be to make a minimum charge on the basis of the maximum load. How to arrive at that basis is troublesome.

GEO. B. LAUDER.

Small and moderate-sized stations cannot afford to install maximum-demand meters for each and every consumer, therefore the minimum guarantee charge should be based on the number of lights installed.

GEO. B. TRIPP.

We prefer taking a percentage of lamps installed, say 50 per cent, and charging a maximum price on the amount for 50 hours' burning per month, all over this amount being charged for at the low rate. This arrangement helps out the long-hour burners. The residences generally pay the maximum for all they use. We charge twelve and a half cents per kw-hour for 50 hours' maximum demand per month, and seven cents per kw-hour for all over this

amount. We do not have many "kicks," and at these prices we can compete with oil gas of 30-candle-power. We give our customers 24-hour service; otherwise we could not hope to compete with gas.

A. PETERS.

We base our minimum charge in stores on the total number of lamps, and in residences on about 40 per cent of the number installed. We make no monthly bill less than a dollar, and where the rating is more than eight lamps the minimum bill is twelve and a half cents per lamp per month.

E. E. LARRABEE.

We base our minimum charge on commercial lighting on the actual installation, as we consider that the entire installation is occasionally used. For residences we make a fixed minimum per customer.

F. L. WILLIAMSON CO.

Our practice is to make a minimum charge based nominally on the number of lamps installed, but in fact based somewhat on the amount invested; for example, for meter-service wires and the customer's proportion of transformer costs. This plan has been quite successful and has met with but little opposition from our patrons.

FAIR HAVEN ELECTRIC CO.

Minimum charge should be based on maximum demand.

GEO. L. COLGATE.

Theoretically, the minimum should be based upon the cost of maintaining the service for the consumer, which is influenced by a combination of the consumer's conditions and maximum load. But theoretically conditions do not always exist, and a compromise is necessary. The maximum load is perhaps the most important single item which influences that cost, especially with the larger consumers.

TOLEDO RYS. AND LT. CO.

We believe the right way is to make a certain charge per 16-cp light installed, say 10 cents per month, and add a certain meter rate to it, but still keep up a certain minimum per consumer that will pay for keeping up the books, reading meters and transformer core losses. Unless this is done, some consumers having a large number of lights installed may not pay enough to pay the interest

on the investment necessary to handle their load; as, for instance, a large church or hall having 100 or more lights installed and only using them occasionally. We have recently put this kind of rate into effect here and it gives satisfaction to both consumer and company.

E. S. ALDRICH.

On the maximum load. The Doherty system embodies the principle of a fixed charge based upon the maximum load or demand.

THE SHERBROOKE PR., LT. AND HT. CO.

The minimum charge should be based on the maximum load.

FRED B. HUBBELL.

We believe it is better to have a fixed minimum charge per customer, and make this just as small as possible without incurring loss. Discrimination is fatal; it breeds a different malady in almost every customer, regardless of the number of lights each has connected.

CHAS. H. PETERS.

The amount of the minimum charge should be based upon the maximum load, as it is this that determines the size of the plant, and therefore the capital investment; it is, however, not always convenient to make charges on this basis, on account of the difficulty in ascertaining just what the maximum load is for each customer.

E. H. MATHER.

For large installations, such as stores and large buildings, the minimum charge should be based on the number of lamps installed. On general residential business there should be a fixed minimum per customer.

F. C. S., MALDEN ELECTRIC CO.

Minimum charge should be based on maximum demand.

G. WILBUR HUBLEY.

The minimum charge should be based upon the maximum amount of current that the customer requires you to provide for his use—therefore, maximum demand.

PENINSULAR ELEC. LT. CO.

The minimum charge should be based upon the maximum demand.

J. H. HALLBERG.

A fixed minimum is far more convenient, and few large customers would reach the minimum bill.

AUGUSTA RY. AND ELEC. CO.

*No. 4.—Is it good policy to charge for meter rent in addition to the charge for current used?*

I think a small minimum charge ought to be made, say 25 cents per month, against any consumer not using an equivalent amount of current. If a consumer does not use that amount per month it is very evident that he is using the service only as an accommodation to himself, and therefore ought to pay for the cost of reading his meter.

A. PETERS.

Under our system of charging we do not think it advisable to charge meter rent.

E. E. LARRABEE.

The minimum charge on maximum demand will take care of this.

GEO. L. COLGATE.

No.

J. H. HALLBERG.

While a rental charge for meters is no doubt justified, it would be better policy to do away with it. The public cannot be convinced of its justice. This charge and the minimum bill would seem to be in a similar class; both justifiable from the supply company's point of view and both obnoxious to the public, and they should be provided for in some other way, like the drummer's suit of clothes in his expense bill: "there, but you can't see it."

THE SHERBROOKE PR., LT. AND HT. CO.

Most general practice would indicate that it is not, but that it is a better policy to include with the minimum charge—or charge for meter rent, whichever it may be called—the right to use a certain number of lamp-hours.

JOHN F. GILCHRIST.

No.

G. WILBUR HUBLEY.

No.

MALDEN ELECTRIC CO.

Rather than charge a meter rent in addition to the charge for current used, each customer should be required to consume enough current so that the profit on this amount will at least cover the interest on the meter and transformer investment.

E. H. MATHER.

We charge a monthly meter rental, but it causes a good deal of trouble.

FRED B. HUBBELL.

Hardly. Abolish meter rent, substitute the minimum charge, and grievances will simmer down to pleasant relations.

CHAS. H. PETERS.

No.

AUGUSTA RY. AND ELEC. CO.

*No. 5.—The writer understands that the Doherty system of meter charges is based upon a low rate for current consumed, over and above a fixed monthly charge per lamp connected per customer. If so, is there any practical way of knowing how many lamps, and their sizes, consumers may have from time to time unless the lamps are counted each time the meters are read? If not, how is the number of lamps upon which the fixed charge is based to be known?*

There are very few instances where customers will increase the demand without the knowledge of the lighting company. This can usually be checked by keeping close track of the wiring contractors who work on the lighting company's circuits.

GEO. L. COLGATE.

In the Doherty system of charging, as we understand it, the fixed charge is not based upon the total number of lamps connected, but upon the maximum demand. The latter is a matter of contract, and is limited to the maximum contracted for by an automatic controlling device, several of which are already on the market.

THE SHERBROOKE PR., LT. AND HT. CO.

An automatic controller is used in connection with the Doherty system, which limits the consumption to a specified maximum demand of current.  
G. WILBUR HUBLEY.

*No. 6.—In cases where the service is uniformly used a stated number of hours daily, is it not of greater advantage to make a flat rate without a meter?*

In my experience I find it under no circumstances to be better to use a flat rate than a meter, particularly if your power is generated from steam. People use at least three times the light on a flat rate that they do on a meter, and it not only makes the producer furnish more power for less money, but it burns out more lamps and gives the consumer less satisfactory results.

A. O. WHITMORE.

In cases where the lamps are cut out at the station or by employees of the company it would be all right to make a flat rate, as an accurate estimate of the consumption can be made, but don't let the customer tell you that he closes at just such a time or that he uses just so many lights a certain number of hours.

E. E. LARRABEE.

If absolutely necessary to make flat rate, always use the meter to check up company's usage.  
GEO. L. COLGATE.

If the uniformity of service does actually exist, the flat rate would be preferable, but general experience shows that such cases are very rare, on account of variation in per cent of cloudiness, condition of business, etc. Even in a moderately large business, the cost of inspection, etc., for insurance of continued uniformity is very large.  
TOLEDO RYS. AND LT. CO.

Yes; provided the same load comes at practically the same time each day. If not, a two-rate meter would be advisable, as current should be sold at a higher rate during time of peak or lap loads. In any case, whether rate is flat or by meter, you should install a meter, as no station should have any services connected without meters; otherwise it is impossible to know how much current is lost or stolen.  
J. H. HALLBERG.

We think it is much more satisfactory where a consumer uses his lights a fixed number of hours daily to make a flat rate without a meter, especially if you can get a reasonable price. In case a meter is installed, the consumer will kick on his high winter bills and be tempted to turn off his lights to keep the bill down to its former level if he has been used to the flat rate. In this way the lighting company will often find its profit less than on the flat rate, especially on early-closing lights. For example, we find that we can get 75 cents per month for lights used until six p. m., while if they were on a meter many of the consumers would not pay over 40 cents at 20 cents per kilowatt. Of course, some kind of check must be kept on this kind of lighting, to protect the company.

E. S. ALDRICH.

We think it well in all cases to have a meter, whether rate is a flat rate or not. A meter will sometimes help to make a flat-rate customer economical, and will pay for itself in this way.

F. C. S., MALDEN ELECTRIC CO.

Most station managers balk at the idea of flat rates, as being a relic of a bad business method that prevailed in the early days of the lighting business; but the writer believes that in congested districts, where the cost of inspecting installations every month is very small, controlled flat-rate business is very good. By controlled business, he means a certain definite number of lamps switched on and switched off either by the company's patrolmen or by reliable devices absolutely under the control of the company, the consumer being charged for the total number of lamps installed burning throughout the entire time that the current is turned on. The advantage is that the price is agreed on, so that there can be no dispute over that, and the customer is not open to every competing illuminant which comes along. This practice generally results in the use of the company's investment much longer hours than would otherwise be the case, particularly in the matter of window lighting, display lighting, signs, and so forth.

JOHN F. GILCHRIST.

It would undoubtedly be far more satisfactory to the customer to make flat rate without meter where the service is used a uniform

number of hours per day, and might be advisable provided the company had control of the use of the service so as to limit the number of hours according to contract. F. E. EAKER.

We cannot conceive of any conditions of service that would warrant the establishment of a flat rate, except for street lighting on station-controlled circuits, as in any other case the company has no control over changes in the customer's conditions involving longer or shorter hours of use, or the possible increase of connected load by additional wiring, or the increase of candle-power of lamps connected.

PENINSULAR ELECTRIC LT. CO.

In most cases it is better to sell current by meter, even at a very low rate, than to give a flat rate. If the current is furnished on a flat-rate system it is a very easy matter for customers, either intentionally or accidentally, to increase the number of lamps, or size of the same, without the central-station manager knowing of the change. E. H. MATHER.

Much depends on the number of hours under consideration. If few, we would certainly recommend a meter basis; if many, the flat rate would perhaps be more advantageous. But it must be remembered that a combination of flat rates and meter rates is very difficult to deal with, if a 24-hour service is given, unless enormous expense is incurred in copper.

CHAS. H. PETERS.

We found but very few customers that regarded seriously their contract as to hours of service. We think flat rates are practical where the service is for the capacity of the installation only, and for the time the business is open, such as motor service.

S. S. INGMAN.

No; but special rates could be made to advantage if conditions of long-burning service justified it or the hours of maximum demand did not coincide with period of peak load.

G. WILBUR HUBLEY.

No, unless the number of amperes and the hours of burning can be closely watched each day at the power-house.

AUGUSTA RY. AND ELEC. CO.

Yes, it is better to have a flat rate where the number of hours is fixed, and the company has control over lighting.

G. H. CUSHMAN.

*No. 7.—Is it advisable when in close competition with gas at from \$1.00 to \$1.60 per thousand cubic feet, to make a reduction of, say, 10 or 20 per cent on meter bills during the season of long nights and heavy loads?*

We should say that the method of reducing the meter bills 10 or 20 per cent arbitrarily during the heavy lighting season would be rather a crude method of arriving at a very desirable result. In our business we have found it better to arrange a schedule of rates based on the maximum demand, which would automatically give a better rate for the greater consumption.

JAS. B. FOOTE.

In all the regular contracts the discount or net rate should vary according to the average consumption per unit of installation or maximum demand, so that during "the season of long nights and heavy loads" the customer would automatically receive a lower net rate for the current consumed. This would render special rebate unnecessary, and all customers would thereby be treated fairly and equally according to the conditions of their service.

W. W. FREEMAN.

The graduated scale of rates, based upon the maximum demand, will take care of this question.

GEO. L. COLGATE.

If the rates are high enough to warrant it, and it is done judiciously, it might be advisable, but when once begun it is hard to stop or to know where to draw the line. It is best to arrange rates to do this automatically, as in a number of different methods of charging.

TOLEDO RYS. AND LT. CO.

It does not seem advisable to make a lower net rate to customers during the winter than for the summer months. The same result can better be obtained by adopting a sliding scale of discounts so that the net rate per kilowatt consumed will decrease as the amount of current consumed increases.

E. H. MATHER.

This may be a feasible scheme in some localities.

AUGUSTA RY. AND ELEC. CO.

*No. 8.—At what price must electricity be sold, using 16-cp, 3.6-watt lamps, 120-watt Meridian lamps, and 44-watt Nernst lamp, to compete with gas at \$1.50 per thousand cubic feet, using mantle with burner?*

If competition upon the basis of cost is intended, the price of electric current would have to be 10 cents per kw-hour, or less, which is a lower rate than most companies make, even in competition with gas at \$1.00 per cubic foot as against \$1.50 as referred to; but, fortunately, electric companies can compete very successfully with gas at prices materially higher per unit of light, on account of the many superior advantages of electric service. In view of this, customers are willing to pay as high as 50 or even 100 per cent more for electric service than for gas. All electric companies are competing with gas more or less successfully, regardless of price charged for current.

W. W. FREEMAN.

Twelve cents per kw-hour, graduated down, the reduction depending upon the increased number of lamp-hours used in each 24 hours, based upon maximum demand. For instance, the customer who has a maximum demand of 10 lamps would pay at the rate of 12 cents if his monthly bill is for no more than 15 kw-hours. If, however, with this demand he used 45 kw-hours his rate should be reduced to 10 cents; if he used 85 kw-hours his rate would be nine cents; if he used 125 kw-hours his rate would be eight cents, and so on down to a minimum of six cents, where from 250 to 300 kw-hours are used on a maximum demand of 10 lamps. Then a somewhat lower rate could be made on a maximum usage, but in every instance the rate of 12 cents

should apply where the maximum demand is used only an average of one hour per day.

GEO. L. COLGATE.

What the public is willing to pay for artificial light is dependent in a broad sense on the service obtained. If the service offered by gas lighting were equal to the convenient service offered by the electric companies, an equal basis of charge might be possible; but the latter service is far superior in point of appearance, health and convenience, so it can not be compared on a basis of equal areas lighted. That the use of electricity for illuminating is coming more and more into favor and advancing more rapidly than gas, is sufficient reason for the continuance of the present charging rates for gas and electric illuminants.

M. W. HANKS.

In this case it is evident that the person asking the question assumes competitive conditions. My experience has been that in case of competition it is a great deal better to get business houses to resort to arc lighting in every possible case, pitting electric-arc lighting against gas lighting. If we take the ordinary gas-arc with gas at \$1.50, it gives us 500 candle-power on a consumption of 15 feet of gas per hour. Therefore, we can obtain, for \$1.50, 500 candle-power 66.5 hours or 500 candle-power one hour for 2.25 cents. Taking, on the other hand, an inclosed-arc lamp consuming, say, 400 watts on a meter charge of 10 cents per thousand watts, we are able to burn the electric-arc lamp one hour for 2.25 cents and it gives us practically 1200 candle-power, or double the candle-power of the gas-arc at only one-fourth of a cent more expense. The convenience of electric lighting in residences as against gas is such a strong point that in case of competition it has been my experience that very few electric consumers would change over to gas from electricity if the electric light for illuminating purposes is not sold at more than 15 cents per thousand watts.

THOS. B. WHITTED.

Gas burners, with mantle, will consume four feet of gas per hour, costing .006 at \$1.50 per thousand cubic feet, and producing the equivalent of two 16-cp incandescent lamps. One

hundred and twenty watts at .006 would mean five cents per kw-hour. It would probably be best to convince the customer of the desirability of electric over gas lighting.

GEORGE MAYER.

*No. 9.—What items of station expense should be taken into account in computing the cost of furnishing current to long-hour consumers whose load does not coincide with the station peak?*

*No. 10.—Is it advisable to work to a strictly meter basis in a small town with limited water-power available for nine months of the year? Normal capacity of water-power about twice present requirements.*

We believe that under the circumstances it is advisable to work to a strictly meter basis, for with the introduction of flat rates the output would greatly increase and you would soon be short of water-power.

THE UNION ELEC. LT. AND PR. CO.

I should say, by all means use a meter system. See answer question No. 6.

A. O. WHITMORE.

We believe the meter basis is the only equitable one for the customer as well as for the company. Water-power is worth money, and the time is sure to come when you will need it all.

E. E. LARRABEE.

Yes; the future demands it.

GEO. L. COLGATE.

We can appreciate the situation of the person who asks this question, as we are working under very similar conditions. We have water-power of abundant capacity the greater portion of the time, and, while we are adhering strictly to a meter basis, we sometimes feel that things would go along more smoothly and we might show greater net earnings at the end of the year were we to give in and give flat rates to our patrons. We are not willing to do this, as we look for a constant increase in our business and look forward to a time in the future when the

entire capacity of our water-power will be called upon and we shall be glad we have not a larger number of customers wasting current of which we might be disposing to good advantage. We made some flat rates to start with and found it the hardest matter in the world to break them off. We are of the opinion that if there are prospects for a growth the best policy would be to adhere strictly to the meter basis, making a rate that would be equitable and insisting upon it that the customers pay for what they use. We believe that under the conditions named a two-rate system of charging would prove very advantageous to both the station and the customer.

F. L. WILLIAMSON CO.

We should say that this all depends on the growth of the town and the amount of business that can be secured, as well as on the price of fuel during the time that water can not be had. We believe that residences using over five lights should be put on meter, and business houses on flat rates.

E. S. ALDRICH.

Meter everything.

ANDREW F. HALL.

Having had experience working under the conditions mentioned, I would say, by all means stick to meter basis.

GEO. S. CARSON.

Yes.

F. C. S., MALDEN ELECTRIC CO.

It is advisable to furnish current on strictly meter basis in small towns with water-power, but not so necessary when power is generated from steam. Some small companies have secured desired results by charging according to the flat-rate system, but for their own information wattmeters have been installed. The presence of a meter, even though it is not used for charging purposes, frequently has a good influence on customers and will at the same time furnish the company a proper record of power sold.

E. H. MATHER.

Yes, it is advisable to work toward a meter basis, making the flat rates such that they may be adapted to meters later on.

AUGUSTA RY. AND ELEC. CO.

A lighting company in a small town must get all the business there is in order to exist, and, unless the flat rates are unduly low, it will generally be found that a change to meter rates will result in a decrease of revenue with no corresponding decrease in operating expenses. This should be obvious from the fact that coal is practically the only variable item of expense affected, and the lessening of the load for the entire run with the exception of the peak-load period, resulting from the adoption of meters, will frequently result in actually increasing the amount of coal used in spite of the lessened output, on account of the poorer efficiency of the entire plant at light loads.

EDITOR.

*No. 11.—Is it good policy for a small lighting plant to require a deposit from its customers for their meters?*

We do not think it is. We like to be as liberal as we can, and we find it is seldom that we have occasion to wish for a deposit.

GEO. B. LAUDER.

We do not think that it is advisable for a small lighting plant to require a deposit from its customers for meters, as it tends to hold people off and, whether justly or unjustly, to cause a feeling of resentment toward the company.

THE UNION ELEC. LT. AND PR. CO.

I consider it good policy to require a deposit, as it is a very good guarantee that your bill will be paid; or, at least, you always have the amount of money deposited as an offset to an unpaid bill.

A. O. WHITMORE.

Yes, if you start in to do so at first; but if your plant has been running for some time, don't attempt to do it.

W. H. BANES.

No. In small towns an acquaintance with financial ability is easy to acquire.

GEO. L. COLGATE.

We find it good policy to require a deposit to guarantee the payment of bills in many cases, but good judgment is required in

making distinctions, as we treat the consumer as liberally as possible.

TOLEDO RYS. AND LT. CO.

It certainly is good policy to require a deposit from customers who are neither property owners nor of recognized standing. We have found from experience that about 75 per cent of the people other than those named above, who used light on a meter basis, forgot that they owed us anything when ready to seek green woods and pastures new. How pronounced is the difference now that we require a meter deposit from the unincumbered! They never forget to call and say good-bye.

CHARLES H. PETERS.

We think requiring a deposit has a tendency to keep a good many desirable customers from using the lights. We have no trouble, however, with a minimum charge.

S. S. INGMAN.

It does not seem necessary for small lighting companies to require a deposit from customers for their meters except in cases of questionable credit.

E. H. MATHER.

It is good policy to ask for deposits on meters from customers unknown to the company or whose credit may not be fully established to the company's satisfaction.

F. E. EAKER.

Where customers are known, it is not good policy.

AUGUSTA RY. AND ELEC. CO.

*No. 12.—What charges, outside of operating expenses, should be taken into consideration when figuring the cost of power at generating-station 'bus-bars?*

Taxes, insurance, interest on bond issue.

W. H. BANES.

Plant depreciation, insurance, taxes and interest.

CHAS. H. PETERS.

When figuring the total cost of power delivered on the 'bus-bars, the following charges should be included: station operating expenses, such portion of the office and general expense

as is chargeable to the station, taxes and fire insurance on generating plant, accident insurance on station labor, and depreciation on station.

E. H. MATHER.

Interest and depreciation on cost of plant.  
AUGUSTA RY. AND ELEC. CO.

*No. 13.—How can the selling price of current be so computed as to give due weight to the prospective load factor of new business?*

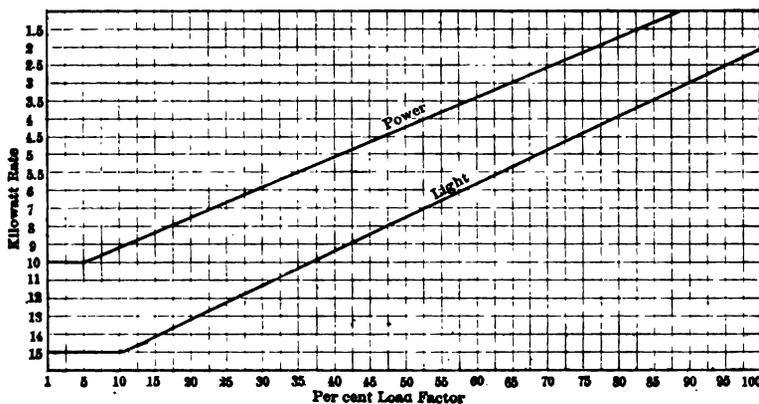
Through the plan of charging now generally adopted, at least by the larger companies, whereby the net cost of current per unit of installation or maximum demand is reduced in proportion as the average consumption of current per unit is increased. By such means, the customer is charged according to the value to the company of the load factor, and every prospective customer is assured in advance of fair treatment.

W. W. FREEMAN.

We have a station load factor of 40.

Total cost of operation per kw-hour.....	.02
Depreciation and interest.....	.01
Net profit must be 50 per cent.....	.015
Electric losses, 25 per cent.....	.0112
Total selling price.....	.0562

The time load factor governs the rate in accordance with the curve given below, this factor being determined by the temporary installation of a recording indicating wattmeter.



H. M. BEUGLER.

*No. 14.—Is the extra holiday lighting for decorative purposes, etc., desirable business?*

We believe that extra holiday lighting for decorative purposes pays, because the strong point of electric lighting is its adaptability for just such work.

THE UNION ELEC. LT. AND PR. CO

Hardly desirable; but you have to use a certain amount of judgment and tact in dealing with these things, so you had better accept the inevitable.

W. H. BANES.

I do not think that extra holiday lighting for decorative purposes, as a general thing, is desirable business to go after, but a certain amount of this business must be taken on to accommodate yearly customers.

GEO. B. TRIPP.

Such business is desirable, because it emphasizes the many utilities of electric service and tends to increase its general use. If decorative lighting begins for holiday use it is likely to be extended to other seasons of the year for special occasions, and any features that tend to render electricity of special value to the customer operate to the benefit of the illuminating company.

W. W. FREEMAN.

We believe that anything that attracts attention to the usefulness and convenience of the electric light is good advertising, and the holiday lighting will bring in a little money, too.

E. E. LARRABEE.

Only desirable from the point of getting new business through acquainting the public with the desirability of electric lighting.

GEO. L. COLGATE.

Not unless you have plenty of surplus station capacity. Such lighting comes at the peak, at the very season when you can least afford it, and it would be a great mistake to load up your station with lighting that lasts for only a few weeks of the year.

EDITOR.

Holiday lighting is not desirable, because it is just at the time of the year when the demand is the greatest, and the average station has plenty of load without taking on a temporary and unprofitable line of business.

G. H. CUSHMAN.

Where the plant is capable of handling the extra business, this is the best possible advertising.

S. S. INGMAN.

Only in case you wish to advertise your business.

J. H. HALLBERG.

Perhaps not altogether desirable, as our principal holidays come at the season of heaviest load in this hemisphere; but the public demands it, and of course it means revenue. With Christmas along about the 25th of June, we would get out special canvassers for this kind of business.

THE SHERBROOKE PR., LT. AND HT. CO.

The extra holiday lighting for decorative purposes is desirable business if a company has sufficient capacity in its plant and distribution system for such business.

E. H. MATHER.

It is very desirable from an advertising standpoint, although at first it may not be so from the standpoint of direct returns. Anything of this kind that tends to popularize electricity as a means of decoration and display must ultimately result in profit to the lighting companies.

JOHN F. GILCHRIST.

The extra holiday lighting for decorative purposes may be considered desirable business, not so much for the limited income, but rather for the reason that it shows the customer one of the many advantages of using electricity as an illuminant. The additional income derived from this class of business is usually not sufficient to justify any expense upon the part of the company to obtain the same.

F. E. EAKER.

The extra holiday lighting, while not desirable business on account of the December peak, is yet desirable from the standpoint of serving your customer with what he wants in light. This class of lighting also encourages additional use of electric light.

EDGAR B. GREENE.

In the opinion of the writer, this question should be considered in a large way, leaving out entirely the matter of actual profit on the sale of the current, and instead, considering its effect on the business in general. Electric light costs more to make, and consequently the selling price is higher, than other illuminants, but it is used because it is better, safer, cleaner and more convenient than any other light. Holiday decorations form one means of impressing the consumer with this point. It is the only light that can be used for general decorative purposes anywhere and everywhere with safety and convenience. "A pleased customer is the best advertisement." We find that hardly anything pleases our customers more than suggestions and help in the matter of holiday decorations. We have held several customers by making a special effort in this line. We try to impress them with the fact that by using electricity their stores can be made more attractive and draw the attention and excite the interest of the passer-by even against his will. We wish some one with more knowledge than the writer would write an article on the hypnotic attraction of a large show-window beautifully decorated, with electric lights, flashing out here and there like harbor lights pointing the way to peace and safety, or twinkling like the stars above, causing all beholders to exclaim, "Isn't it lovely?"

A store front can be decorated with electricity in such a way that people are obliged to look at it whether they want to or not. Now, this advertises not only the store, but the advantages of using electric light; that is one reason why we think it pays.

WILLIAM R. GARDENER.

Where the rates are made in consideration of the temporary character of the business, and incandescent lamps are returned, it adds to the income, but also adds to the peak of the load.

AUGUSTA RY. AND ELEC. CO.

Yes, by all means. It is an excellent advertising medium and also makes friends. In many instances decorative lighting in one form or another will be retained permanently. Everything should be done to encourage this feature of the electric-light industry, such as the loan of lamps, colored or uncolored, the suggestion of ideas, and even the submission of designs.

W. R. B., N. Y. ED. CO.

*No. 15.—Where prospective new business requires an increase in capacity of station or line, what percentage on the additional investment should the estimated net earnings show?*

This depends very largely on the character and permanency of the new business, the character of the investment necessary, whether all or any part of the investment will be applicable in supplying other prospective business, the amount of salvage in case the business is lost, and often on several other considerations. The net earnings should be sufficient to cover a liberal allowance for depreciation and a fair return on the money invested. Obviously, the depreciation (whether actual wearing out or becoming obsolete) depends on whether the investment is in overhead or underground copper, pole line or underground conduit, kind and character of station apparatus or building, and so on. In general, the estimated yearly net earnings should show from 10 to 25 per cent, depending upon character of and conditions under which additional investment is made.

P. JUNKERSFELD.

Twenty per cent.

FRED B. HUBBELL.

The estimated net earnings from prospective new business should be at least 10 per cent to cover the interest and depreciation of the additional capital investment.

E. H. MATHER.

*No. 16.—What is the best method of handling slow-paying customers in case of active competition?*

Arrange with your competitor that you will not install service for his delinquents, and have him refuse service to yours.

This is a mutual advantage, and you can agree on it even if you are at war on everything else.

GEORGE MAYER.

I should say the best way to handle slow-paying customers, even in case of active competition, would be to stamp across their bills: "Bills are due when presented, and on all bills more than 30 days overdue we shall charge 10 per cent per month until paid," which would be a straight business proposition and one that a competitor could not greatly profit by, as if you lost a few such customers by so doing you could better afford to lose them than to supply them and not get your pay, and your competitor would not be gaining much by getting them.

C. J. ABBEY.

Let your competitor have them. You do not compete successfully if you do any business at a loss.

GEO. L. COLGATE.

Make the base rate fairly high and allow a proportionately large discount for prompt payment.

EDITOR.

I can not see why the correct method of handling slow-paying customers in case of active competition should be any different from cases where no competition exists. If the customer is merely slow but perfectly good, it would seem to be advisable in many cases to let the matter stand; but in the case of a customer who does not mean to pay, there can be no particular harm in driving him over to your competitor, as his name on the books is no ornament, his business is of no value, and the current supplied should be diverted into better channels. If he should go over to the competitor, I can not see where the said competitor would be at all benefited.

E. P. COLEMAN.

Give a liberal discount for cash and extend every possible courtesy. Make them feel your good will and your interest in them, but under no circumstances allow the impression to exist that you are their slave. Be liberal and reasonable, but firm, and if such treatment fails, let them go over to the enemy. It

is probable that 70 per cent of them will find before long that they made a mistake in leaving you and will be willing to return to the fold. Treat such cases just as if they had never left you, extending the old courtesies, etc., and let the enemy have the rest.

CHAS. H. PETERS.

As liberal a policy as possible in all matters pertaining to the customer, and a good, conscientious and tactful collector.

F. C. S., MALDEN ELECTRIC CO.

*No. 17.—Is it advisable to show meter readings on the bills as well as the amount of current registered?*

Yes; it gives the customer confidence.

W. H. BANES.

By all means give the customer every item of information concerning the company's charges for current and encourage the customer to read his own meter and check his monthly bills, so as to satisfy himself of their accuracy rather than to have any doubt concerning them. Any idea on the part of the customer that there is any secrecy or mystery concerning the company's meters tends to prejudice the customer against the company.

W. W. FREEMAN.

We believe it advisable to show the customer everything, and teach him to read the meter, too, if he wishes.

E. E. LARRABEE.

Yes, always.

GEO. L. COLGATE.

Yes; because the customer is entitled to all information regarding his meter reading, and when these figures are withheld he is apt to doubt the honesty of the company.

A. R. MACKINNON.

In the majority of cases the customers pay no attention to the meter readings; in some cases, however, the statement of the meter readings seems to be a source of satisfaction to the customer.

ALBERT S. PRICE.

It is advisable to enter on all bills the meter readings as well as the amount of current consumed, if for no other purpose than to show the customer that no information is to be kept from him.

E. H. MATHER.

Yes. F. C. S., MALDEN ELECTRIC CO.

This method inspires confidence. J. H. HALLBERG.

We find that it gives better satisfaction to show the meter readings on the monthly bills, as in case of a mistake in reading the meter the consumer can look at the meter and the error can easily be corrected, so that the customer will not think the company is purposely overcharging him. Quite a number of our consumers even request the meter readings when the meters are read, and we never have any trouble from giving them the readings so long as we have a good, careful man to read the meters.

E. S. ALDRICH.

It is probably better, but we doubt if even 10 per cent of our customers ever look at them, preferring to kick on general principles and not go into particulars if they think the bill too high. When you can get a customer educated to the point of reading his own meter and checking the bill thereby, he is sure to drop from your list of unreasonable kickers. To catch you in an occasional error is then a pleasure to him and he bears no ill-will. But, alas! such customers are scarce.

THE SHERBROOKE PR., LT. AND HT. CO.

It certainly is. Unless this is done, the "doubting Thomases" will think you want to keep them in the dark and overcharge them for light. If meters have constants, include them on bills; in fact, give all needed information, so that they can figure the results for themselves. We would suggest, however, that if a minimum charge is made and the bill is below this amount, it is better to omit all readings. The reason for this is obvious.

CHAS. H. PETERS.

Yes. G. WILBUR HUBLEY.

Yes. The bills should contain as much information as the customer desires, so that he feels satisfied as to the accuracy of the charge. A great many customers read their own meters and carefully check the results. Giving this information engenders good feeling and confidence in the company's methods.

N. Y. ED. CO.

*No. 18.—Should meter bills show discounts when made out?*

We do not show the percentage discount on our bills, and have frequently found it advantageous not to do so.

GEO. B. LAUDER.

Not until paid.

W. H. BANES.

The bills should give the customer full information concerning every feature of the charge made therein.

W. W. FREEMAN.

We stamp our bills subject to a certain discount if paid at the office of the company on or before the tenth of the month. The discount is figured and deducted on the stub.

E. E. LARRABEE.

Yes.

J. H. HALLBERG.

Yes; it will often prevent trouble with a customer over an apparently exorbitant bill.

C. C. GARTLAND

We think the amount of the "discount if paid before a given date" should be shown on the bill, but, of course, not deducted.

THE SHERBROOKE PR., LT. AND HT. CO.

No; otherwise, you will be receiving checks at all times in the month for amounts less discounts. Every time you send an explanation it costs three cents, at least, and this kind of thing becomes tiresome. State on bills the percentage of discount allowed and the date limit, preferably in colored type. Stick to that rule.

CHAS. H. PETERS.

Yes. F. C. S., MALDEN ELECTRIC CO.

No. G. WILBUR HUBLEY.

Discount for consumption should show, but not discount for cash, as this might cause confusion.

AUGUSTA RY. AND ELEC. CO.

*No. 19.—What is a fair price for 1200-cp, direct-current street arc lamps, burning 4000 hours per year, when fed from an underground circuit, as compared with lights fed from overhead lines?*

Consider the additional investment per lamp for the underground installation and take 10 per cent of this amount, which should represent about the additional revenue per year for each underground lamp.

J. H. HALLBERG.

*No. 20.—Where the number of, and price paid for, street arc lamps is too small to warrant a special inspector, what is the most satisfactory method, to both company and municipality, of checking outages?*

We do not feel that price obtained for street arc lights should ever be so low that it would not cover the cost of special inspection, for in our opinion no other method is satisfactory, either to the company or the municipality, unless it is specified in the contract that the municipality is to do its inspecting and report outages.

THE UNION ELEC. LT. AND PR. CO.

If constant-potential, 220-volt lamps are used, an ammeter will show if there are any outages. On open series arcs or on inclosed series arcs the voltmeter readings will indicate the outages. Have readings made one hour apart on ammeter or voltmeter in connection with the regular half-hour wattmeter readings and entered on the slip. This is always a check against any claim for outages.

A. PETERS.

Outages on such small installations can be practically eliminated by properly gauging your carbons and carefully trimming the lamps. I believe that some kind of recording station wattmeter would be the most satisfactory solution.

J. H. HALLBERG.

We furnish our lamp trimmer with blocked, perforated report blanks, having the number and location of each lamp printed thereon, and a space left opposite for his report. He is required to state the condition every lamp is found in from day to day, and these reports are kept on file in our office. Should a dispute arise we always have the reports to fall back on, but have never yet had occasion to use one. If the report shows an "out" the reason is ascertained, and if not satisfactory that lamp goes into the hospital.

CHAS. H. PETERS.

We find reports from policemen, on proper form, to be satisfactory.

AUGUSTA RY. AND ELEC. CO.

The police should report the hour when the lamp goes out of service and the time when it relights, but in order to avoid imposition a regular patrol should be made at least once each night. About midnight is the best time, and a regular record should be kept of these patrols and the condition of the lights.

S. S. INGMAN.

It is a difficult matter to check outages of a system where no inspector is employed. If small towns require a record of outages, it is only fair that they should pay the cost of the same. This should be but a few cents per day.

E. H. MATHER.

*No. 21.—Taking as a base a station with an output of 15,000 kilowatts per day, what general methods are used to determine the electrical losses?*

Determine the number of kw-hours output from the bus-bars per month and check this figure against the total number of kw-hours delivered for the same month, as indicated on all

consumers' meters or otherwise recorded as kw-hours of current sold. It is well to separate the city lighting from the commercial system.

J. H. HALLBERG.

The difference between the output as recorded by the station switchboard wattmeters and the registered current on the house meters, will give the unaccounted-for current or the electrical losses of the distribution system.

G. WILBUR HUBLEY.

The general methods used to determine losses in such plants are a system of recording wattmeters on all generators, or, where this is impracticable, on all feeders. Alternating meters are also placed on totalizing alternating-current arc panels as well as on the station lighting panel and transmission panels, etc. In this way it is an easy matter to figure the efficiency from the switchboard to the consumer's meter, and while this may not be correct for any one month, due to the number of days required for reading the various meters, the average for a number of months will give satisfactory results.

W. T. M., N. Y. ED. CO.

*No. 22.—What is the best and most logical system for comparative records of the consumption of oil, waste, etc.: per kw-hour, per engine-hour, or per thousand revolutions of engine?*

The most logical system and the one that is generally used for comparative records of the consumption of oil, waste, packing, etc., is that which is based on a cost per kw-hour, as the total cost per kw-hour at the switchboard is that which a central-station manager must know before he is in a position to figure prices.

GEO. B. TRIPP.

Both kw-hour and engine-hour records should be kept, as nearly the same amount of oil and waste is required when the engine is running without load as when it is fully loaded, and neither constitutes a perfectly fair criterion without the other.

EDITOR.

Assuming that all the engines in a station are of the same size, the most logical unit for use in comparative records for the consumption of oil, waste, etc., is the engine-hour; as the load carried by the engine bears a very slight relation to the amount of these supplies used.

W. F. W., N. Y. ED. CO.

As the base unit in the electric plant is the kw-hour, it would seem advisable to make all comparative records of oil, waste, etc., on this unit.

E. H. MATHER.

*No. 23.—What is the most practical scheme for keeping a record of stock supplies in a central power station?*

We believe that the best method of keeping stock supplies is to charge everything that goes into the store-room to supplies and to credit every item that is taken out of the store-room to supplies, and charge it to whatever account it is used for, such as street lights, house wiring, repairs, construction, etc. A book can be kept in the store-room for this purpose, and while it is sometimes a little difficult at first to train employees into keeping the memoranda accurate, this can be done when the system is thoroughly explained to them and the object shown.

THE UNION ELEC. LT. AND PR. CO.

The most practical scheme for keeping account of stock supplies in a central power station is by means of the stock-card system. The stock cards should be kept up to date by the stockkeeper and inventories taken every month. There should be two cards for each kind of material, one indicating the receipts, date, and from whom received, and the other the material taken out, together with a record of the orders, by whom issued, and for what particular job. The stock cards should, of course, be supplemented by foreman credit and debit tickets, which, after having been checked and approved by the proper authorities, are sent to the accounting department for proper distribution charges. The above scheme is only a general outline for keeping stock records, it being unnecessary to go into the details of the usual receipt forms, etc., as these depend more or less upon the size of the plant.

C. A. KELLAR.

We have tried several plans to keep track of supplies furnished for use in the station, but no one worked entirely satisfactorily. We now make an inventory on the first of each month, which does fairly well, tending to inform the station man on what he has and what he will need. A comparison with the previous month's report shows what has been used, which can be checked by the daily report.

S. S. INGMAN.

*No. 24.—Is there any law against the use of postal cards for billing purposes? Have postal-card bills been found satisfactory in service?*

In this city, both electric companies, the gas company, the water department of the city, and one telephone company, use postal cards for billing purposes. There seems to be no objection on the part of the customers.

ALBERT S. PRICE.

There is a law against using postal cards for duns, but I know of no law prohibiting their use for bills. One of our companies has used the postal-card bill for several years with great success. The name of consumer and the amount of bill are in duplicate on the back of the card, and when paid at the office the card is put into a stamping machine that receipts one end, which is returned to the customer, and cuts off the other end, which drops into a box provided for the purpose. With this plan a man can take in the money as rapidly as he can count it, and receipts for it at the same time. At the end of the day the cashier checks the amount of money in the cash drawer against the amount represented by the bill stubs in the box.

EDITOR.

We do not know of any law against the use of postal cards for billing purposes, but such a system does not seem desirable, as customers rather object to having such publicity given to their private accounts.

E. H. MATHER.

There would seem to be no law in the matter excepting expediency. We know of one company in this province that does it. We prefer the envelope with slot showing the con-

sumer's name and address, as this admits of sending several bills to one address for one stamp, which is often necessary.

THE SHERBROOKE PR., LT. AND HT. CO.

*No. 25.—Is it advisable to charge for small jobs of repairing for your lighting customers, such as inserting fuses, repairing sockets, loosened wires, etc.?*

We do not think it advisable to charge for all repairs done, or repairing occasioned by ordinary wear and tear where no material is used; otherwise, we charge for time and material.

A. O. WHITMORE.

We know of no reason why charges should not be made for repairing small jobs in customers' houses, the same as for any other work, unless it is directly the fault of the company that repairs are needed.

THE UNION ELEC. LT. AND PR. CO.

We do not charge for replacing fuses, etc., as it gives us a chance to ascertain what was doing when the fuse went out and often leads to a lecture on some of the things users of the light should not do.

E. E. LARRABEE.

We make a nominal charge for all such work, as it takes our men from other work, and as we have always done so there is no complaint.

FAIR HAVEN ELECTRIC CO.

No; it is better to do these jobs free of charge.

T. D. EVANS.

It may be considered advisable to do small jobs of repairing, such as inserting fuses, repairing sockets, etc., without charge, in view of the fact that the consuming public feel that the payment of regular monthly bills is all that they should be called upon to stand. Any additional charges for small repairs usually cause a great amount of dissatisfaction, which may eventually lead to the loss of the business.

F. E. EAKER.

No.

G. WILBUR HUBLEY.

All wiring should be kept in first-class condition, and to encourage our customers to report any small defect, we do such small repair work as renewing fuses, repairing sockets, etc., free of charge.

E. H. MATHER.

Furnishing fuses and such little labor as may be necessary should be done free.

AUGUSTA RY. AND ELEC. CO.

Our experience is that it is better to have nothing to do with wiring, repairs to installations, and the like. The rates for service have to be made to cover the cost of such service if no direct charge is made, and a charge of this kind is often hard to collect. If you do not collect from one and do from another there is likely to be trouble. Besides, some customers are continually wanting some attention to their installation when it does not cost them anything, while when they have to pay directly for the work they get along very well with less attention.

S. S. INGMAN.

No.

F. C. S., MALDEN ELECTRIC CO.

We do not believe it to be good business to charge for inserting fuses, repairing sockets, etc., unless new material has to be used. We do not believe in repairing sockets, as when a socket is so far used up as to need repairing it is better, as a rule, to put in a new socket and save trouble in the future, as most people do not know what the trouble is and will kick harder if the light goes out the second time than they would to pay 25 cents for a new socket. In this way the profit on the socket will pay for the time used in changing it, and no current will be lost by lights going out. The above is based on the supposition that the lighting company does all the wiring, but we would not repair work of careless contractors without charge. We believe in doing wiring at low rates so as to keep out outside contractors, as more business and better satisfaction will be obtained by this method, in small towns especially.

E. S. ALDRICH.

If you can limit the minor repairs for customers to the items named, it would be good policy to make no charge except for material used, but it is sometimes difficult to draw the line.

THE SHERBROOKE PR., LT. AND HT. CO.

We do not, unless the materials are furnished and more than half an hour's work is required.

ANDREW F. HALL.

We do not find it advisable.

FRED B. HUBBELL.

No; it is not good policy to charge for this class of work, at least so far as our experience goes. We make all such repairs free. There is always some bright and honest boy who wishes to learn something about electricity and is willing to work for a small wage until he becomes more valuable. Give such boys a chance. With a little instruction they soon learn how to make small repairs in a very satisfactory way at a very small cost to the company, and often they grow to be indispensable.

CHAS. H. PETERS.

We should say that the small amount of time and trouble required for this work is well spent, as it helps greatly to ingratiate the company with the customer. We have always found that the customer expects this service from the company *gratis*; at least this is true with small companies.

A. R. MACKINNON.

It is best where possible to have all such work done by a contracting company, that may not be owned and controlled by the lighting company. This avoids all question as to the liability of the company to make these repairs without charge.

GEO. L. COLGATE.

*No. 26.—Do you consider mill lighting good business at regular rates; that is, mills that are operated only 55 hours per week?*

No. Mill lighting comes in at the peak of the load and at no other time. Any lighting that enters into the peak and is

used for a short time only, and for not more than half the year at that, can not ordinarily be very desirable at any price.

GEO. B. LAUDER.

Mill lighting at regular prices is the poorest kind of business, and we do not think any plant can afford to take it. We have some mills running all night, which we consider good business.

E. E. LARRABEE.

Yes, if rates are based on the maximum-demand system.

GEO. L. COLGATE.

We do not. Mills running 55 hours per week will use light on an average 140 hours per year before six p. m. A 400-light transformer has a core loss of about 200 watts; this for a year will amount to 8760 hours  $\times$  200 watts = 1752 kilowatts.

One hundred and forty hours  $\times$  400 lights  $\times$  50 watts = 2800 kilowatts. The meter will register 2800 kilowatts, and the leakage in the transformer will be 1752 kilowatts, or 62 per cent of that registered on the meter. Suppose the rate per kilowatt to be 10 cents, then the amount actually received per kilowatt will be 38 per cent, or 3.8 cents.

The writer would recommend that the meter be placed on the primary side of the transformer. While this may not at first appear quite fair to the customer, a little reflection, taking into consideration the matter of interest depreciation, etc., on 400-light capacity of line transformer and other apparatus, will prove that he will have no just cause to feel aggrieved.

WILLIAM R. GARDENER.

Hardly the best business, but what are you going to do about it?

THE SHERBROOKE PR., LT. AND HT. CO.

We consider it a little better than none.

FRED B. HUBBELL.

*No. 27.—Is it good policy for a company to take the agency for motors, electrical supplies, etc., in its territory?*

Only provisionally, until the field can encourage and support sufficient contractors to guarantee, through competition,

reasonable prices. The company should, of course reserve the right to undertake any features of this character at any time that its business requires their being pushed energetically, and where such a plan can be effected more advantageously by the company itself than through contractors.

W. W. FREEMAN.

We do not think it the best policy for a central station to take the exclusive agency for a special make of motors. It is, of course, expected that the central plant will recommend to its customers what is considered the most economical and best make of motors; but as it is the general custom for the customer to buy his own motor there is always a certain sense of responsibility attached to the central plant that "stands pat" on one make of motor. We consider it of the utmost importance that central stations, at least in smaller towns, should carry a full line of supplies, and it has been our policy to furnish these to our customer at as near cost as it is possible to figure them. We have found in a number of instances where we have made parties figures on fixtures and supplies that they had afterward secured figures elsewhere and came back to us and got the goods and told us they were pleased to say that our figures were lower than they had been quoted elsewhere. This is a small matter to central stations, but it makes the trade feel good to think that the electric company is really selling stuff at a small margin above cost.

LITTLE FALLS WATER PR. CO.  
OF MINNESOTA.

Indirectly, yes.

GEO. L. COLGATE.

An electric-light company advances its interests considerably by handling motors and supplies. Having an interest in the motors sold, the company sees that they are kept in good condition. If the motor is shut down, the company is losing revenue. If an outsider sells the motor to the customer, he is in no haste to repair it, while the company is, and in making a quick repair increases the revenue. The company will also endeavor to sell an economical motor and one adapted to the

work in hand and not have to lose customers because their bills are too high, due to inefficient motors and poor installation.

E. W. LLOYD.

Our experience is that it is good policy for a company to take the agency for motors.

EDGAR B. GREENE.

I believe that it is good policy, especially in the large cities where there is more or less competition from other central-station electric-lighting companies, from gas companies or from isolated plants. While I believe that this branch of business can be made to show a profit in and of itself, this is not the most important reason for taking up this line of work.

The principal advantage that it gives a central-station company is in the fact that it enables it to obtain a closer relation with the concerns with which it is doing or is likely to do business. I have seen cases repeatedly where an electrical contractor or motor agent would secure the contract for wiring motors from one of our customers, and through the acquaintanceship formed in the execution of this contract, and the additional work required from time to time, he would form a connection that would enable him later to sell a complete isolated plant and all its equipment. In the meantime the central-station company has had comparatively few points of contact with the customer, the principal thing being the monthly presentation of bills for current.

On the other hand, I have frequently seen cases where a customer has sent in to the central-station company for bids on motors or wiring to be used in connection with an isolated plant, or in competition with a gas engine, and the fact that the central-station company has secured the contract for wiring and motors has enabled it to turn the customer's attention to central-station service and secure the entire contract for the supplying of current from central-station supply.

From the very nature of the case, the interests of the central station are to a large extent opposed to those of the concerns that handle machinery and supplies; and while there have been cases where an outside electrical contractor has influenced a customer to come on central-station service, such cases are few and far between.

This additional business will, of course, require more care and attention to detail on the part of the central-station management, but by the employment of suitable help this business can be made profitable, and, at the same time, adds considerably to the "sphere of influence" of the central station.

S. MORGAN BUSHNELL.

The writer believes it is, although the matter should be handled in an extremely broad and far-sighted way; that is to say, sharp and offensive competition with other dealers should not be indulged in. On the contrary, they should be made to feel that the main reason for the company being in the field is to feel the pulse of that end of the business and protect its own interests from the abuse that too little attention will result in, and to protect its customers in the matter of getting fair prices for wiring and apparatus, although not endeavoring to get ruinous prices for them.

JOHN F. GILCHRIST.

Where no one else is pushing good motors or when prices for motors or supplies are too high, the lighting company should take the business up for its own protection and advancement.

AUGUSTA RY. AND ELEC. CO.

No.

G. WILBUR HUBLFV

The buying and selling of goods is not in the regular course of business of electric-light companies, and it is therefore frequently advisable to leave this with good local houses so long as the territory is properly served.

E. H. MATHER.

*No. 28.—Is it to the interest of a company to do wiring for its customers free of cost?*

We do arc-light wiring free of cost, and have found it to be of great advantage in picking up business. To do general wiring free of cost is questionable, and should be carefully considered. The conditions governing one plant might make it possible, while other conditions might not.

GEO. B. LAUDER.

Unless you can charge enough for service to make up for the cost of doing wiring, I should say it was poor policy to wire free of charge. It is true that lights once in will usually be retained, but we do not think that customers need be given any such inducement to get them to start.

A. O. WHITMORE.

A company will soon get a lot of money invested if it does wiring free. We think it better to make the consumer invest some of the money, as he is then more likely to use the light.

E. E. LARRABEE.

No.

GEO. L. COLGATE.

Decidedly not. The investment is large to begin with, and each new tenant of a building would require many changes at the expense of the company that at his own expense do not seem so absolutely necessary.

FAIR HAVEN ELECTRIC CO.

We do not think it to be to the best interests of a central station to do wiring free of cost. For the last two years this company has been doing wiring at actual cost, and at certain stated seasons has for a month or six weeks advertised special low rates, which were about 10 to 20 per cent below the actual cost. This has resulted in a large increase in our private lighting load, and in the above-mentioned time we have added almost 50 per cent to our connected load. We should be afraid in wiring at cost that a number of people would wire because it was not costing them anything and would not use the current until they got ready. This would necessarily tie up a great deal of money.

LITTLE FALLS WATER PR. CO.

OF MINNESOTA.

We do not think it is for the interest of the company to do wiring for its customers free of charge. It is, however, frequently desirable to do this work at cost.

E. H. MATHER.

No.

G. WILBUR HUBLEY.

It pays a lighting company to do some wiring free, others at cost, depending on the contracts it can secure. We have done both.

S. S. INGMAN.

Free wiring is largely a matter of condition. If the revenue warrants it, yes. If not, no. Sometimes a valuable customer can be secured by spending a very few dollars on wiring.

E. W. LLOYD.

No. After wire and other supplies have been in service some time they can not be used elsewhere on new work. I do not see why we should wire buildings free of charge any more than why we should pipe them free for gas.

ANDREW F. HALL.

It is doubtful. Why should a company incur such expense? We do approve, however, of wiring on the smallest possible margin of profit. Instead of giving property owners a free installation, direct a portion of such expense toward a better and cheaper service.

CHAS. H. PETERS.

It is for certain classes of lighting, under reasonable restrictions. General free wiring would, however, ruin any company.

JOHN F. GILCHRIST.

It would probably be to the interest of a company to do wiring free of charge where the guaranteed income per lamp is sufficient to warrant the same.

F. E. EAKER.

*No. 29.—Is it advantageous for large lighting companies to carry their own liability and fire insurance?*

This must depend largely upon the premiums required in individual cases by the insurance companies. Generally speaking, liability insurance can be effected more satisfactorily and at a lower cost to the company through insuring; but it is sometimes difficult to obtain such insurance at reasonable rates, covering overhead construction, high-tension risks. The average company should be able to obtain such insurance for high-tension risks at a premium of about five per cent of the annual

payroll and for low-tension underground at about one and a half per cent, such premiums covering accidents to employees and public liability as well. When such rates can be obtained it is generally advantageous to the company to insure. In the case of fire insurance, the local conditions should largely control. Where buildings are fireproof and plants operated continuously, the company can generally carry its own insurance advantageously, especially where high rates for insurance are charged; and this is especially true when several companies can combine their risks under a mutual arrangement. Where plants are so constructed or surrounded as to involve a material fire hazard it is wise to carry at least partial insurance in responsible companies.

W. W. FREEMAN.

As regards fire insurance, we should think large companies would do better to carry their own risk. We quote the usual dynamo clause, cut from an elapsed policy, a careful perusal of which will show that the insurance company is fairly well protected:

"This insurance excludes any loss or damage to dynamos, exciters, lamps, switches or motors, such as may be caused by electric currents, whether artificial or natural, and will be liable only for such loss or damage to them which may occur in consequence of fire in the building herewith described and originating outside of the machines themselves."

Employers' liability policies are often more nominal than actual in the protection offered, but the above dynamo clause beats anything ever seen in the latter class of policies.

THE SHERBROOKE PR., LT. AND HT. CO.

Large lighting companies that are financially strong can frequently carry their own liability insurance at a profit, while small companies can hardly afford to take the risk. The fire-insurance rates on modern power stations are so low that we should not think it advisable for companies in general to carry this class of insurance.

E. H. MATHER.

In view of the excessive verdicts that seem to be the fashion in accident cases where corporations are concerned, it is doubtful whether any company can afford to carry its own liability insur-

ance. One adverse decision may wipe out the premiums for years in the case of a small plant.

On the other hand, fire-insurance rates on properly-designed modern central stations are out of all proportion to the risks involved, and a great many lighting companies would save money by carrying their own insurance, provided their bond issues do not expressly stipulate that a satisfactory amount of insurance must be carried in a reliable company. EDITOR.

*No. 30.—Is it good business policy to make installations of motors for power in mills, factories, etc., simply on permission of owner, depending on satisfactory results to obtain contract after six months' satisfactory operation?*

If the basis of charge is the meter, it is very hard to tell a man what his probable bill will be and the man is loath to take the chances himself. If a company has a fairly good idea of the horse-power required and the income desired, and wants the business, I think it might pay to make the installation on trial. We have done so in several instances and are still holding the business thereby gained. GEO. B. LAUDER.

There is never any good business reason for attempting to get business in this way. My experience has been that if customers are using power and the lighting company's rates are satisfactory, they can be convinced of satisfactory results without any offer being made that is not on good business lines. GEO. L. COLGATE.

To install motors simply on permission of the owner may be a little precarious; but along this line, to make a contract for a term of years at a price that would prevail under such conditions, and then give the customer the right to cancel the contract after a trial period of six months or a year—combining with that privilege the agreement to take his motors off his hands at practically the cost of installation—is legitimate pioneering and good business policy, provided the central-station man has made a careful study of the situation and is convinced in his own mind that the arrangement is going to be advantageous to the customer. JOHN F. GILCHRIST.

It is good business for a company to install a motor in a mill or factory to demonstrate the operation of the motor and the actual cost of power, if there is reasonable opportunity of securing a new customer.

E. H. MATHER.

Only when quite positive of the results.

AUGUSTA RY. AND ELEC. CO.

There may be conditions where such a policy would be justifiable, but in place of it we offer the following suggestion: If a mill or factory is operated by steam, ask permission to take a set of steam-engine indicator diagrams, under varying conditions of operation. From these, compute the average horsepower developed, and in this way you can give your prospective customer a good idea of what it will cost him per day to operate by electricity. Furnish him estimate covering expense of change. If it is to his advantage, he will not be slow in availing himself of your power, and in the majority of cases will furnish motors, etc., himself.

CHAS. H. PETERS.

If a small installation of two or three motors which could be rented to the customer—yes. It would not pay to make the investments on the proper motor installation with wiring, changes in shafting, and belts, for a period of six months. The proper analysis of the hours of running of the machines in any factory, and the proper motor installation, would determine whether or not electric current could compete with power plants in factories. If such analysis showed that the electric power was as cheap or cheaper than the cost of running the isolated plant, liberal concessions might be made on the cost of the installation of motors if the contract was of sufficient length.

E. W. LLOYD.

*No. 31.—What results have been obtained in supplying Nernst lamps on flat rate?*

If a given amount of light must be furnished on flat rate, the lighting company can furnish it most economically by the use of Nernst lamps.

GEO. L. COLGATE.

*No. 32.—Where a company has been operating on the flat-rate basis, and the Nernst lamp has come into use, would you require them to go on a meter or would you treat a 44-watt lamp as the equivalent of a 16-cp incandescent? Meter rate, 10 cents per kilowatt; flat rate, 25 cents for residences and 60 cents for stores, etc.*

Put in the meter. Never lose an opportunity to change from flat rates to meter basis. GEO. L. COLGATE.

In candle-power, the 44-watt Nernst lamp is not the equivalent of a 16-cp incandescent lamp, but the wattage of the two is about the same. The 44-watt Nernst lamps that we have tested have shown an initial candle-power of about 14, which has fallen to from 8 to 10 in 200 hours. With the larger Nernst lamps, three and six glowers, the meter would be the only fair method of charging, as when a glower burns out the input as well as the candle-power decreases.

PENINSULAR ELEC. LT. CO.

*No. 33.—Is it advisable to charge an employee with damages caused by gross or ordinary carelessness? If so, to what amount in dollars?*

In a large corporation it is not always possible to treat with an employee on the same footing as in a small company; the relations are not so close. As a rule, it hardly pays in the long run to be too exacting with an employee. If the carelessness is habitual the man should be discharged; if it is a case of the "first time" I should be loath to make a change.

GEO. B. LAUDER.

Even the best employee is liable to make a mistake, but one that is worth retaining will not make the same mistake twice. Would suggest forgiveness for the first offense and dismissal for the second.

WILLIAM R. GARDENER.

Discharging is preferable.

W. T. M., N. Y. ED. CO.

It is not advisable, as a rule, to charge employees with damages caused by gross or ordinary carelessness. Satisfactory service can not be given by careless employees, and such should be dismissed.

E. H. MATHER.

It should be to some extent, depending upon conditions and upon the employee's record.

AUGUSTA RY. AND ELEC. CO.

*No. 34.—How do you meet gas-engine competition?*

It is practically impossible to meet gas-engine competition on the basis of cost, but gas engines are so frequently unreliable and always more or less objectionable because of odor that the absolute reliability, safety and cleanliness of electric power render it easy in many cases to displace gas engines. The best way to meet gas-engine competition is to acquaint the prospective customer with the superiority of the electric motor in all respects, making it indispensable regardless of the fact that in cost of operation it may prove more expensive than gas. A list of gas engines displaced by electric motors in the territory in question will always prove convincing and exceedingly valuable.

W. W. FREEMAN.

As I take it, this means gas engines running machinery and where gas is sold at about 90 cents per 1000. By the proper installation of motors, cutting out all the waste shafting generally used with gas-engine drive.

E. W. LLOYD.

The cost of power, cost of maintenance, repairs and operation, as well as fire risks, should be able to win for motors.

AUGUSTA RY. AND ELEC. CO.

By proving that central station prices are competitive. The preliminary investigation should show the amount of current generated by the plant, the cost of gas, labor and supplies. Compared with the result should be shown the cost of corresponding central-station service. In the comparison the advantages of security, the unlimited capacity of the service, freedom from noise, dirt, danger and care should be manifest. In addition to personal calls, letters

containing the facts, repeated in various ways, should be sent from time to time. If the position of the company is well taken, there should be no question concerning the ultimate result.

C. K. N., N. Y. ED. CO.

*No. 35.—How do you meet the isolated plant competition?*

Isolated-plant competition can be met successfully only through most intelligent and thorough effort. The cost of plant operation should be figured accurately, including interest and depreciation, and compared with the cost of central-station service. Special forms for such purpose are indispensable. A merchant will frequently be willing, upon proper presentation of the case, to show his figures and enable the central-station man to discuss them with him and point out the inaccuracies where the comparison appears to be in favor of the plant. There is no question that the isolated plant is passing, and that in the case of new buildings, regardless of the size, the central-station company can by intelligent work clearly prove its case to the satisfaction of the prospective customers. A list of isolated plants abandoned in favor of central-station service in the territory in question is found to be a most convincing argument. The central-station company should constantly keep before the public through its advertising methods the fact, if such be the case, as it should be, that in practically all new buildings being erected and equipped the idea of an isolated plant is abandoned and central-station service invariably adopted.

W. W. FREEMAN.

By refusing auxiliary service to such plant and its consumers; or, if this is impossible, by making the fixed monthly charges for auxiliary services prohibitive.

J. H. HALLBERG.

Take all business you can secure at a profit; otherwise let some other fellow have it. When you can get the private-plant man to keep track of the expense of running his plant you are likely to get him as a customer at a fair rate.

S. S. INGMAN.

The writer believes that the way to meet isolated-plant competition is by securing on each case that comes up a full and free discussion of the merits of the isolated plant as compared with those of central-station service.

The first thing to be done is to form 'as nearly as possible an accurate estimate of the probable consumption of current by the building under consideration. This should be fully discussed with the customer and should be based, not only on the ideas of the customer as to his probable requirements, but also on the actual results in buildings using current under similar conditions. The customer will usually estimate his consumption very much higher than the results will prove, and this estimate would naturally be in favor of the isolated plant, as the fixed charges on a plant are the same in either case. After having arrived at a common basis with the customer, so far as the estimate on current to be consumed is concerned, there should be a carefully tabulated statement of the various costs entering into the operation of an isolated plant. These costs should be estimated, not on a theoretical basis, using the guaranteed consumption under test conditions, but should be figured on the basis of the actual results as shown in similar installations. These results should be secured by the central-station company from as many sources as possible, and should be at hand in a convenient form so as to be accessible to the customer if necessary. The customer usually finds that after figuring the matter over in this manner, taking into account all the different costs of operating a plant, he has omitted a large portion of these costs from his consideration, and in nearly every case he will find it to his advantage to accept the central-station proposition.

The writer believes that the reason so many plants are installed is due nearly always either to a misunderstanding on the part of the central-station company of the requirements of the customer, or to a misunderstanding on the part of the customer of his own requirements in the cost of operating his own plant, or to a misunderstanding on the part of both customer and central-station company. Even in those cases where a customer is secured to the central station, it is sometimes found by the central-station management that the business has been taken at a very unnecessarily low figure, owing to a misapprehension of the amount of current required for the building.

The writer believes that a careful consideration of the foregoing points would prevent central-station companies from making the extremely low figures that are sometimes made, and would materially lessen the number of unprofitable customers. In the

nature of things the central-station company should be able to supply current to nearly all classes of customers at a price profitable both to the central station and to the customer.

S. MORGAN BUSHNELL.

The lower rates should overcome cost of current and operation with interest on the investment, in isolated plants. Furnishing steam heating sometimes assists to this end.

AUGUSTA RY. AND ELEC. CO.

By making rates that will compete with the cost of operating the private plant. Conditions vary so that it has been impracticable to do this with a single schedule, and therefore wholesale schedules have been adopted. Divided into three forms, they are sufficient to meet all varieties of plant competition. With this point covered, careful estimates are prepared showing the cost of operating a private plant under the conditions which will prevail in the building with the comparative cost of the full Edison service. The company should be familiar with the building plans from the earliest practicable moment, should ascertain the amount of current that will be required for light and power, and with carefully prepared advance estimates should seek a hearing, always with the principals, at which the architect and the engineer are present. Each building will be found to have its own characteristics, but the electrical requirements of each may be accurately predetermined. In addition to frequent calls on the part of an agent of good appearance, a series of letters should be sent as frequently as possible without exciting undue comment or opposition. It is also desirable to acquaint the principals in such transactions with any important contracts that have been signed; sometimes by a personal call; sometimes by letter; and, possibly, once or twice in the course of the negotiations by telegraph. Much depends upon the agent.

W. H. W., N. Y. ED. CO.

*No. 36.—Which plan produces the best results and the most business; solicitors on salary or on commission basis?*

It is the writer's opinion that with the proper men more satisfactory results can be obtained with solicitors on salary, and that new business can be produced on that basis more cheaply to the central station than on commission. This company's cost on

*new business* turned in for the year 1903, on salary basis, was 5.647 cents per 16-cp equivalent. FRANK W. SMITH.

We have found the compromise plan to give good results; that is, small salary and a commission.

WILLIAM R. GARDENER.

Arguments can be advanced in favor of either plan, but our experience has proven to our satisfaction that the best results are obtained from a combination of salary and commission. The salary gives the company the right to control the work of the solicitor and to have him devote such time and effort as is necessary to hold business in his territory, which is even more important to the company than obtaining new business, and the additional commission affords the necessary impetus to put forth every possible effort in obtaining new business. The successful electric-lighting solicitor must be willing to work during all hours and under all conditions, and it is not within human probability that any man will continuously put forth unusual effort unless the compensation is commensurate to the effort. The commission basis, when adopted solely, however, restricts the company in the control of the solicitor to an undesirable extent, and we therefore believe that the salary should be based on the fair value of the solicitor's services up to a certain accomplishment in new business in each month and commission allowed on the excess of such figure. This plan has been in operation with us for two years, and the results are exceedingly gratifying.

W. W. FREEMAN.

We should unquestionably state that the only method that has proven successful here of paying solicitors has been on a commission basis. We made the rate 25 cents per 16-cp lamp. At certain seasons of the year a good solicitor has been able to make more money on this method than he could on a salary basis. We have not been in the habit of keeping a solicitor out all the time, but at certain seasons we send a man out and keep him out, and crowd the thing for a few months.

LITTLE FALLS WATER PR. CO. OF MINNESOTA.

Small salary, and commission on all business above a certain amount.

GEO. L. COLGATE.

From close observation, extending over many years, we are inclined to believe that the solicitor that produces the best results is a first-class service, at a reasonable rate, backed up by noticeable courtesy on the part of all employees. Reform or weed out the uncouth, so that customers can make the requirements known to a smiling face.

CHAS. H. PETERS.

*No. 37.—Please give examples showing cost per 16-cp equivalent for new business (1) on salary basis, and (2) on commission basis.*

*No. 38.—In view of the fact that electric-lighting companies are evincing a lively interest in the subject of advertising, would it be to the interest of the association to establish and maintain an advertising bureau to act as a clearing-house for ideas in this line and to assist members in framing and distributing their advertising matter?*

The suggestion for an advertising bureau to act as a clearing-house for ideas in this line is worthy of consideration. One man cannot know it all—our Question Box illustrates this statement—but inasmuch as all the questions in the box will be answered, it proves that all men together know all, and working together and for each other the perplexities of judicious business-bringing advertising would be reduced to a minimum.

WILLIAM R. GARDENER.

In view of the fact that the companies that do the most active advertising endeavor to keep in touch with each other's methods and are constantly exchanging ideas, and in view of the further fact that the number of companies doing advertising is rapidly increasing each year, and consequently the difficulty of this exchange, each with each, is becoming much greater, the establishing of a headquarters for advertising ideas would undoubtedly be of great service to the members of the association.

LA RUE VREDENBURGH.

We have advocated the clearing-house idea for advertising as well as for high-class employees for some time, and hope to see it adopted at the next meeting.

S. S. INGMAN.

Most assuredly, yes.

F. C. S., MALDEN ELECTRIC CO.

We believe it would be a good idea for the association to maintain an advertising bureau, as considerable business can always be secured by judicious advertising in towns of 3000 population and over, and as a rule electric-light managers in most plants have neither time nor ability to do this work as it should be done.

E. S. ALDRICH.

It would be a very good idea, and should receive the co-operation of all the actively advertising lighting companies.

AUGUSTA RY. AND ELEC. CO.

The plan suggested, for making the association a clearing-house for ideas and methods of advertising, promises to prove of advantage and would no doubt develop into a most interesting and profitable branch of the association's work.

The first point that occurs to one is the fact that there is absolutely no question of competition as each lighting company comprising the association operates in a distinct and separate field. The aim of each company—namely, to interest the public, is identical with that of every other one. A comparison of ways and means always results in improvement along every line, including the ways of publicity. The individual in charge of the advertising of one company would gain an untold benefit by learning the experience of those operating along the same line, and in turn would be anxious to submit his ideas, plans and results gained to the members of the association, desiring their criticism, knowing that it would be sincere and intelligent. In the same manner that two heads are better than one, the character and scope of the publicity of each company would increase and broaden in much quicker time than if each person in charge of the advertising kept his maturing plans from the light of day.

C. B., N. Y. ED. CO.

*No. 39.—Is it better to punish an employee for breach of rules by suspension or fine, or to warn first, and then discharge, upon being satisfied as to his indifference or incompetency?*

Warn first, and then discharge. This gives the man a show, and habitual disobedience, especially in a central station, ought not

to be tolerated. Suspension or fine always makes a man sore and you can't tell when he may get back at you. With very large corporations a system of fines and suspension would probably work to better advantage than with a comparatively small one.

GEO. B. LAUDER.

I would suggest "To warn first, and then discharge." An indifferent or incompetent employee should be conspicuous by his absence in the electric-lighting business.

WILLIAM R. GARDENER.

Railroad companies have found that warning, suspension and discharge system is the best.

GEO. L. COLGATE.

It is better to warn first and discharge on second offense.

W. T. M., N. Y. ED. CO.

Warn, and show them where they are wrong, and if that has no effect discharge them for the good of the corporation.

ANDREW F. HALL.

It is better to punish an employee for breach of rules by suspension rather than by fine and upon being satisfied of his indifference or incompetency, by discharge.

E. H. MATHER.

It is better to warn and keep a record of an employee's actions, rather than suspend or fine.

AUGUSTA RY. AND ELEC. CO.

Warn first, and discharge on second offense, if fault is due to indifference or incompetence.

G. WILBUR HUBLEY.

*No. 40.—In an electric plant, operating continuously, what is a fair cost per boiler-horse-power per year to cover the stand-by losses in maintaining plant under full steam pressure—assuming careful design and good pipe-covering?*

*No. 41.—What is the best method of competing with the so-called Humphrey gas-arc lamp?*

We have regained several customers who were led astray by the seductions of the Humphrey gas-arc lamp by installing on trial

the General Electric Company's concentric diffuser arc lamps, and also Meridian incandescent lamps.

WILLIAM R. GARDENER.

Electric companies cannot compete with the Humphrey gas-arc lamp on a basis of equality in cost and where economy must be the controlling feature, as is the case with many small merchants, it is exceedingly difficult to compete with this lamp. The reliability and superiority of the electric service must be constantly presented to the prospective customer. By use of the three-ampere arc lamp and the three-glower Nernst lamp for alternating circuits, an electric service can often be furnished at a cost satisfactory to the customer because of its many advantages and notwithstanding its increased expense compared with gas.

W. W. FREEMAN.

Nernst 44-watt lamps, or arc lamps.

GEO. L. COLGATE.

Good, live, hustling agents, that know their business and how to meet the argument of comparative cost.

F. E. EAKER.

The Nernst lamp, latest type Meridian, or low energy arc, or five-light Holophane cluster all furnish a light superior in color to the Humphrey gas-arc. The incandescent arc, 6 to 7.5 amperes, is much superior and a practical competitor where it permits a reduction in the number of lamps.

AUGUSTA RY. AND ELEC. CO.

Competition in cost, appearance, freedom from annoyance, and quality of light. The revenue to be derived from arc lighting unquestionably justifies the loan of the lamps and their maintenance in the highest state of perfection. Lamps should be hung free of cost, and, where necessary to compete with the service in question, the wiring might advantageously be installed at the expense of the supplying company. It is unnecessary to add that the lamps furnished should be of the latest description containing all modern improvements, and that the globes as well as the carbons should be maintained in the highest degree of excellence.

E. A. M., N. Y. ED. CO.

*No 42.—Is the Meridian incandescent lamp a successful competitor of the Humphrey gas-arc lamp?*

Some central stations have used the Meridian lamp successfully in competition with Humphrey gas-arcs by the use of three or four-light cluster fixtures supporting Meridian lamps.

FRANCIS W. WILLCOX.

The Meridian lamp, owing to its soft light and decorative features, is a good competitor of gas. An attractive three-light fixture can be supplied for about \$2.50, which I find meets with success.

R. W. ROLLINS.

The Meridian lamp cannot compete with the Humphrey gas-arc in candle-power and operating cost. The latter gives about 250 candle-power and uses from 16 to 20 cubic feet of gas per hour. Four 105-watt Meridian lamps would distribute about as much useful light as a gas-arc. In artistic appearance, quality of light, and the direction in which the useful light is thrown, the Meridian lamp is distinctly superior. The electric light does not vitiate the air of the room as the gas-arc does and this is often an important consideration.

PENINSULAR ELEC. LT. CO.

*43.—Are the advantages of the card system of bookkeeping sufficient to warrant changing from the book accounts to the card system?*

We have been operating for a period of about one year, under a consumers' card system which is vastly superior to the old method of keeping consumers' accounts in a series of ledgers. We are making a saving of 27 per cent in actual cost of cards over the books formerly used. In the opinion of the writer the most important point gained by the use of said cards is that if you have any dispute with a consumer and he wants to look over his account as kept by your company, you can ask your accountant to bring in the consumer's ledger card and the consumer can then see the original records of his account as kept on one card for a period of four years. This was an impossibility under the old method of accounts, because you could not afford to show the book

ledger to a consumer, as he would then have a chance to see the accounts of other consumers who might have special rates.

GEO. B. TRIPP.

Yes.

GEO. L. COLGATE.

Use both cards and books. Under some conditions the cards are better than books, and there are others where the books can not be replaced to advantage.

S. S. INGMAN.

Some years ago this company installed a card-ledger system, and after using it four or five years closed it and transferred the balances into a loose-leaf ledger. After using that for a couple of years we were perfectly satisfied with the old bound book and transferred our accounts to that.

Our customers' accounts are all kept in a register, only the operating, maintaining, general expense, personal accounts and accounts payable being kept in the general ledger. We use cards for our customers' records and transformer records, and find them a good deal better than any method of keeping these records in books, but we would not advise the use of card ledgers or loose-leaf ledgers for general labor purposes.

LITTLE FALLS WATER PR. CO. OF MINNESOTA.

*No. 44.—Does the Nernst lamp obtain for your company business that could not otherwise be obtained?*

On our alternating-current system we have secured business by the use of the Nernst lamp much more easily than we could have obtained it by the use of any other known illuminant. On the direct-current system the inclosed-arc lamp, in many places, is preferred.

R. W. ROLLINS.

The Nernst lamp undoubtedly gives the supplying company an additional means of competing with other forms of illumination. It covers a field lying between the incandescent and the arc lamp which has not been heretofore fully covered. In our sub-urban-alternating current territory the three and six-light glower lamps have secured the return of a number of customers who

found the usual arc light too expensive. It has also been effective in retaining customers who found incandescent lighting too expensive.

J. P. R., Jr., N. Y. ED. CO.

*No. 45.—What is the liability of the supply company for damages caused by electric current beyond point of delivery on customers' premises?*

While there might be a great variance of opinion even among our best lawyers upon this matter, judging from the decisions of the courts upon several cases of injury by electricity, it would seem that the supply company is held liable unless relieved by a specific contract. If the question is intended to apply to all classes of customers under ordinary contracts and methods of delivery, my opinion is that the point of delivery would be at the lamp or appliance used. Although a customer may own all the wires and appliances in his building, they become a part of the supply company's system when connected for service, and therefore the supply company is as liable as though it owned the wires and appliances, for the reason that it is not the wires and appliances that do the damage, though they may cause it indirectly, but the energy delivered to them.

C. J. ABBEY.

Many companies have been mulcted in heavy damages by the courts for accidents that happened on customers' premises, beyond the point of delivery.

EDITOR.

*No. 46.—To what extent should a supply company carry on inspection of customers' wiring installation?*

A lighting company should never connect to customer's wiring installation until it has been inspected and accepted by underwriters.

GEO. L. COLGATE.

It would be desirable if the customer's wiring were subject to inspection and approval or rejection by the supply company.

G. WILBUR HUBLEY.

Inspection of customers' wiring should be carried on to such an extent as to prevent theft of current, grounds, short-circuits,

and to insure placing of motor loops and outlets in convenient places.

C. W. HUMPHREY.

A central-station company should carry on inspection of its customers' wiring installations to a sufficient extent to assure itself that the consumer has provided himself with an installation that complies with the spirit of the underwriters' rules. It is better to have all wiring done safely, even though the expense may be greater, than to connect wiring that may cause trouble a little later, making the consumer dissatisfied with his electric service, and increasing the already too prevalent impression that all fires of unknown origin are electrical fires.

H. B. GEAR.

A supply company should thoroughly inspect customers' wiring installations and approve the same before connecting for service, to avoid possible damages arising from improper and imperfect wiring, as the supply company is supposed to know the nature of the energy supplied, and the possibilities of danger from it from all sources, while the customer is not. The burden is therefore on the company, and if a proper inspection is made and all possible dangers properly guarded against, I think the chances for damages would be small.

C. J. ABBEY.

*No. 47.—What rates are electric-light companies in small towns getting for pumping city water with electric motors?*

*No. 48.—What success has been attained in devising a systematic method of recording and satisfactorily analyzing all cases of troubles in the operation of central-station systems?*

*No. 49.—What is the relative reliability of direct current and of alternating current and the satisfaction to customers in general city service?*

*No. 50.—What is the best light to furnish in competition with the Welsbach burner for street lighting? In a town of about 11,000 inhabitants, very much scattered, we have about 25 miles of street occupied by our wires. The annual appropriation for street lighting is about \$6500. The Welsbach people, through the local gas company, "captured" this year's town meeting and voted*

*one-half the appropriation for gas lights at \$25 per light, all night, 25 nights per month. What can we put up against it, cost and character of light considered?*

The Nernst lamp.

GEO. L. COLGATE.

A 32-cp lamp burning 4000 hours per year will net .052 per kw-hour at \$25 per annum. This lamp, with a reflector, will meet and vanquish competition, leaving a nice profit at the price named.

GEORGE MAYER.

Twenty-five-cp series incandescent lighting.

F. C. S., MALDEN ELECTRIC CO.

*No. 51.—What is considered a good average income per kilowatt connected and per kilowatt demand load?*

*No. 52.—What is considered a good load factor?*

Forty per cent.

EDITOR.

## W

### MISCELLANEOUS

*No. 1.—How can iron rods be used to best advantage to supplement the tensile strength of the concrete in building a concrete engine or dynamo foundation?*

Under ordinary conditions there should be no advantage in using iron rods. Special conditions would have to be treated by themselves.

EDISON ELEC. ILL'G CO. OF BOSTON.

*No. 2.—Is there any formula for determining the size or number of rods to be used for this purpose?*

*No. 3.—Please give rules for designing water rheostats for testing dynamos, and such details of construction as may be necessary.*

The February, 1901, and October, 1903, issues of the *American Electrician* give full details for constructing water rheostats.

B. A. SCHAK.

*No. 4.—What are the proper proportions of the solution in an ordinary sal-ammoniac battery cell?*

Five and a half ounces sal-ammoniac per cell.

B. A. SCHAK.

In a quart cell use one-quarter pound sal-ammoniac to sufficient warm water to fill up the cell.

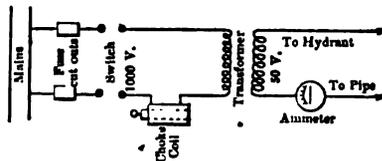
A. PETERS.

Six ounces per cell.

G. WILBUR HUBLEY.

*No. 5.—Do any of the members use electricity for thawing out frozen water pipes? I mean those pipes connecting the mains in the street to private houses or other buildings, and also the interior piping. If so, please give details as to amount of current and voltage required for various sizes and lengths of pipe, method of connection and regulation, troubles experienced, etc.*

Owing to the unusually severe winter, many water pipes were frozen in the city streets, several of which the plumbers, after repeated trials, were unable to thaw out. The city authorities requested us to assist them. We supplied the current, and the work was placed in charge of one of the city engineers, who, being furnished with directions, experienced no difficulty in cleaning the pipes. The apparatus was mounted in a wagon, and consisted of the following: One 600-light transformer with 50-volt secondary connection; two single-pole primary transformer cutouts; one ammeter; one double-pole, single-throw switch; one choke coil and sufficient No. 6 wire to make connections from transformer to the pipe.



The secondary wire was usually connected to a hydrant, the other to the pipe, just beyond the frozen section. Below will be found data of some of the operations, as shown on the city engineer's record book:

Size of Pipe	Length	Time Taken to Thaw Out	Maximum Amperes
0.75-inch	75 feet	5 minutes	100
0.75 "	150 "	15 "	100
0.75 "	200 "	6 "	110
1 "	600 "	60 "	60
2 "	60 "	4 "	160
4 "	50 "	15 "	300
4 "	180 "	10 "	400
4 "	300 "	60 "	140
6 "	50 "	30 "	160

WILLIAM R. GARDENER.

We have used the electric thaw this winter with good success, thawing numerous house pipes and even as large a main as six-inch. The apparatus used is very simple and such as would be easily obtainable in any central station. We use two five-kw transformers connected in parallel. We should have preferred a single transformer, but could not spare one of sufficient capacity. One of the secondary leads (at 100 volts) was connected directly to the sill cock of the house to be thawed and the other brought through some simple form of resistance (we used a box of salt water with copper plates on the ends of the wires), and an ammeter to the sill cock of another house. The current was then turned on, regulating the amount well within the limit of the capacity of the transformers, generally using from 90 to 100 amperes. In ordinary cases the water came in from 15 to 35 minutes in both houses. In no case were we longer than an hour and 10 minutes.

FAIR HAVEN ELECTRIC CO.

This company owns the city water plant and also the electric-lighting system, and we have been using electricity for thawing out mains and service pipes for the last four years. We assemble 45-kw capacity of transformers with volt and ampere meters on a low-hung wagon, using a water rheostat in connection. In thawing water mains we locate our wagon between two hydrants and connect to the head of each, using 50-volt secondary so as to get the greater number of amperes. With the capacity that we are able to turn out we can thaw a 320-foot block of six-inch pipe in four hours. For services, we get as near to the service as possible and connect to the nearest fire-plug or service-box and to any pipe or faucet inside the building. This kind of work will take, on an average, five minutes to each service.

The past winter has been one of the longest and most severe

that has been experienced in this part of Minnesota for a great number of years. Our water mains are all down seven and a half feet, but we have had to keep the current on them continuously for the last six weeks of the season so that we could depend on the mains and hydrants being ready for service at any time. We have also had business enough to keep another wagon continuously at work on water services. If we had not this method of thawing out 75 per cent of our services would have been out of service this winter.

We have been charging \$2.50 for the services that took us only five to ten minutes to thaw out, and the price increased with the additional time required by the work.

LITTLE FALLS WATER PR. CO. OF MINNESOTA.

We have used electricity for the last two years to thaw out frozen water pipes. We have thawed out about 125 this year, with no failure.

We use transformers of 15-kw capacity, connected so as to get 50 or 100 volts as needed, and place them on a sled or wagon so that they can be hauled from place to place. The secondary connections are made from one side of the switchboard to a water rheostat and from there to the house side of the pipe, and from the other side of this switchboard to the hydrant nearest to the house, so that the current will have to pass through the pipes that are frozen, using as low a voltage as will be sufficient to crowd the ampere capacity of the transformer through the pipes.

On interior piping, make the connection on each side of the freeze-up and be careful not to put on too much heat if lead pipes are in circuit, as that might loosen the joints where they are fastened to the iron, or might melt the lead pipes. I find that 150 amperes will thaw out 100 feet of three-quarter-inch pipe under ground inside of an hour, and 200 to 250 amperes will be required on one-and-one-half-inch pipe for one and one-half to two hours.

One must use judgment in thawing with electricity, as the cases differ; but the main thing is to have the wire large enough to carry the current and good connections to cut down loss, and use as low a voltage as possible to crowd the current through.

LT., HT., TRANSIT AND PUB. SERVICE CO.

We have thawed out a large number of water pipes this winter, in sizes ranging from one-half-inch to two-inch. We do

not run a day circuit, and regulated the current by means of the exciter rheostat, the voltage varying with the length of pipe in circuit.

We had four transformers in multiple—a total of 15 kilowatts—connected for 50 volts. These we connected and placed in a wagon which we towed from place to place very conveniently. We used only the instruments at the power station. By means of the telephone we had the current regulated and turned on or off, as required. Connections were made at the stop-cocks of adjoining houses or at a hydrant. Our secondaries consisted of two No. 4 wires on each side, which, in case of two-inch pipe, got so hot that the insulation boiled out. The current used, the voltage and length of pipe were approximately as shown in the following table:

Pipe	Current	Voltage	Time	Length of Pipe
0.5 -inch	150 amperes	20	45 minutes	100 feet
0.75 "	100 "	30	120 "	200 "
0.75 "	300 "	30	10 "	80 "
1 "	200 "	40	20 "	150 "
2 "	500 "	50	120 "	50 "
2 "	300 "	25	30 "	125 "

The varying voltage for similar lengths of pipe is due to the resistance of the bell and spigot joints in the cast-iron mains.

FRED B. HUBBELL.

Pipes have been thawed by electricity for upwards of 25 householders in Chicago during the past winter. For the ordinary house it is sufficient to mount two 15-kw or 20-kw transformers on a wagon, connecting the primaries in series across 2000-volt mains and the 115-volt secondaries in multiple. Connection is then made on the secondary side from a fire-hydrant in the street to a faucet in the building. It does not usually require more than 10 minutes to start the water and rarely more than half an hour. The energy used averages from 10 to 20 kilowatts. No attempt was made to regulate the current, and no difficulty was experienced in accomplishing the work. The pipes thawed were mostly under 1.5 inches in diameter and averaged from 50 to 125 feet in length from the street main to the building.

The Chicago Telephone Company has experienced very serious trouble during the past winter due to the freezing of water in the conduits, which compressed their cables so greatly as to destroy the value of the paper insulation. They have accordingly

equipped a thawing wagon with three large transformers, current being taken from the overhead primary lines as needed. Connection was made for the purpose of thawing from one end of the lead sheath and iron pipes to the other. Most of the freezing occurred in the iron pipe laterals. Owing to the fact that there was no running water to aid the thawing process when once started, as there is in the case of water pipes, it was necessary for them to use the current from two to three hours and in very large amounts. In one particularly difficult case a current of 2500 amperes at 30 volts was applied to a three-inch iron pipe containing cable for upwards of two hours, occasional rests being taken to allow the leads of the transformers to cool off.

The amount of energy required for most of these cases averaged about 40 kilowatts.

H. B. GEAR.

We did a good deal of this work in February. Most of the services were so situated that we could work on two house connections at a time. The services thawed were principally those with lead service pipes. Some of the iron service pipes thawed were found to be split by the severe frost, and it was decided to leave this class of service alone. We used our ordinary secondary voltage (104) and had our transformer fused to carry 240 amperes at this voltage.

THE SHERBROOKE PR., LT. AND HT. CO.

Yes. A one-inch pipe 220 feet long was thawed with 60 amperes at 105 volts in alternating current in one hour and 15 minutes. Another pipe, one inch in diameter and 1200 feet long, was thawed with 100 volts, time and current not read. In both cases the 110-volt secondary of transformer was connected to pipe with water rheostat in series, primary of transformer being connected direct on 2200 volts.

E. P. COLES.

We have used with very good results during the past winter a 10-kw transformer of 1050 volts primary and 50 volts secondary for thawing out frozen water pipes, using a choke coil in the primary to reduce voltage to about 40 volts for starting and cutting out until there would be 50 volts within a very few moments; thereby using the maximum output of the transformer.

There was a difference in time of from five minutes to two

hours on the same size of pipe and approximately the same lengths. On a four-inch pipe with the same transformer we have thawed out 450 feet in 58 minutes, and on other sections of four-inch pipe about 300 feet long it has required three hours to thaw out. No doubt the variation of time could be accounted for by the number of feet actually frozen up in the pipe. The method of connection used was to connect in the premises on the spigot with one cable of the secondary, connecting to the nearest available fire-plug with the other secondary. EDGAR B. GREENE.

The electrical thawing of water pipes has been successfully conducted with direct current by two methods.

One method employs 120 volts direct current from underground mains, controlled by water rheostats, connection being made at manhole, lamp-post or service, if convenient.

The other method employs a storage battery with suitable connections for obtaining different voltages.

Of 148 cases, covering lead and iron service pipes, of from .5-inch to 1.5-inch diameter, the following figures were obtained:

Amperes	average	327	Maximum	550	Minimum	160
Volt drop	"	12.3	"	40	"	5
Time (minutes)	"	8	"	45	"	2

The lengths of pipe in these cases varied from 25 to 125 feet.

Larger pipes have also been thawed, in one instance a six-inch water main, the current in this case averaging 907 amperes applied for one hour.

The principal difficulties encountered have been where pipes are blocked with solid matter, not permitting the water to flow when the ice is loosened, and with broken pipes or rusty joints in iron pipe, preventing the circuit from being completed through the pipe. A. M., N. Y. ED. CO.

One hundred and fifty feet of 1.5-inch wrought-iron pipe required 45 volts and 275 amperes for one hour. (Voltage includes drop in 300 feet of No. 1 wire used for secondary connections.)

Fifty feet of .5-inch wrought-iron pipe required 20 volts and 250 amperes for five minutes.

Fifty feet of .5-inch lead pipe required 15 volts and 250 amperes for five minutes.

Voltage required is quite variable, depending to a large extent on condition of pipe joints.

A 50-volt, 15-kw transformer was used with water rheostat in secondary circuit. An adjustable reactive coil in primary circuit would have been preferable to rheostat. One connection was usually made to nearest fire-hydrant and the other to pipe just inside building. Care must be taken to prevent melting lead pipe; 250 amperes is a safe current under nearly all conditions.

M. P. R., N. Y. ED. CO.

Electricity as a means of thawing frozen water pipes came into use in New York city during the last, an exceedingly severe, winter. The frost went deeper into the ground than previously in 36 years, and in one instance a main passing under the East River was frozen. Two methods were employed:

(a) Current from the nearest building service, supplied through water rheostats.

(b) Current from a storage battery mounted on an automobile truck.

The current required for thawing a pipe approximately one inch in diameter amounted to 350 amperes at 120 volts. Where the service was simply frozen, success invariably followed; a broken pipe or foreign substance would prevent successful results. One four-inch pipe on a pier was melted in 38 minutes with 720 amperes at 120 volts; a six-inch main frozen through an entire block was thawed out in one hour with 1000 amperes at 120 volts.

E. A. N., N. Y. ED. CO.

*No. 6.—Can an ordinary electric call bell be operated successfully in series with five incandescent lamps on a 500-volt direct-current circuit?*

Yes. Connect the circuit in shunt around one of the five lamps in series on 500-volt circuit, or connect german silver or other resistance coils of wire in series with five lamps on 500 volts, and then connect bell across the proper amount of resistance required to operate it. A bell circuit thus connected is always reliable and trustworthy, and no care or expense for operation or maintenance is required.

G. WILBUR HUBLEY.

*No. 7.—I have three six-inch electric bells connected in series with a push-button, but they do not operate satisfactorily. What is the best method of connection?*

Vibratory bells will not work well in series. Change the connections on all but one of the bells so that they will be single-stroke bells. Connect all the bells in series as before. The one vibrating bell will vibrate itself and cause all the others to vibrate with it.

P. E. COWLES.

I think that if you will connect the coils on two of these bells straight through, leaving the current to pass through only one interrupter, you will get the results desired on this arrangement if you have the battery power properly arranged—that is, sufficient to operate the three bells.

A. O. WHITMORE.

Take off the vibrators of two bells, allowing the vibrator of the remaining bell to work the three.

A. PETERS.

The bells would probably work all right in multiple or by making two of them single-stroke, letting the third one make and break for all.

E. E. LARRABEE.

Cut out the vibrating contact-breaker in two of the bells, simply connecting their magnet coils in series with each other, and also in series with the magnet coil of the one bell on which the vibrating contact-breaker is left in circuit; then the vibrator on one bell will make and break the circuit for all of them. In other words, use two single-tap bells and one vibrating bell.

JOHN F. GILCHRIST.

Adjust two of the bells so that the contact will not be broken when the armature is attracted by the magnet, and allow the other one to make and break the circuit.

S. B. RICHEY.

Make two of them single-stroke and they will work properly in series.

ANDREW F. HALL.

Put the bells in multiple and put on three or four cells of battery if the bells are large, connecting them in multiple also, and you should have no trouble.

S. S. INGMAN.

Connect two of the bells for single-stroke bells, using the third for a vibrator, and connecting the three in series.

LT., HT., TRANSIT AND PUB. SERVICE CO.

*No. 8.—Please give the percentage of light reflected by surfaces of each of the various colors.*

The percentage of light reflected by various surfaces has been given by Sumpner in the following table, which can be found in the appendix to Patterson's translation of Palaz's "Photometry":

#### REFLECTING POWERS

	Per Cent		Per Cent
White blotting-paper.....	82	Deep-chocolate paper.....	4
White cartridge-paper.....	80	Planed deal (clean).....	40 to 50
Tracing-cloth.....	35	Planed deal (dirty).....	20
Tracing-paper.....	22	Yellow cardboard.....	30
Ordinary foolscap.....	70	Parchment (one thickness)....	22
Newspapers.....	50 to 70	Parchment (two thicknesses)...	35
Tissue-paper (one thickness)....	40	Yellow-painted wall (clean)....	40
Tissue-paper (two thickness)....	55	Yellow-painted wall (dirty)....	20
Yellow wall-paper.....	40	Black cloth.....	1.2
Blue paper.....	25	Black velvet.....	0.4
Dark-brown paper.....	13		

CLAYTON H. SHARP.

The table given below shows the results of a special test made for the purpose of enabling the writer to answer this question, and was made with a photometer, using a lamp that gave exactly 16 candle-power with black paper. The different colors were obtained by using cartridge-paper, placed in a reflector frame designed for the purpose, which was kept in the same position during all the experiments:

#### REFLECTING POWER OF COLORS

Color	Candle-power	Per Cent of Reflecting Power Over Black
Black	16	0
Blue	16.65	4
Green	16.75	4.7
Red	17	6.25
Terra-cotta	18	12.5
Yellow	19.5	20.62
Cream	19.37	21
White blotting-paper	20	25
Glass mirror	25	56.2

WILLIAM R. GARDENER.

The following table gives the candle-power of a Meridian lamp using colored Bristol-board as a reflecting surface:

CANDLE-POWER OF LAMP	CANDLE-POWER OF LAMP WHEN USING COLORS AS A REFLECTING SURFACE				
	Red	Yellow	Green	Blue	Purple
53	4.4	6.73	3.72	3.08	2.9

(UNSIGNED.)

*No. 9.—Can not some manufacturer invent a socket that will not allow a customer on flat rate to change a certain candle-power lamp for one of greater candle power? For instance, so that when he contracts for 10-cp lamps he can not use a 16-cp or a 25-cp lamp?*

Would not the customer be as liable to change his socket as his lamp? Moral: Go on to the meter basis wherever possible.

GEO. B. LAUDER.

*No. 10.—What would be the loss on 1250 horse-power at full load as follows: Generated at 2000 volts, three phase, 60 cycles; stepped up to 20,000 volts and transmitted 18 to 20 miles on three No. 4 bare copper wires; stepped down at sub-station and delivered at distributing switchboard at 2,000 volts? Current to be used for power (induction motors) as well as for light.*

As I figure it,

20 kilowatts stepping up	}	= 97 kilowatts total, or 130 horse-power.
58 " on the line		
19 " stepping down		

This, assuming that the 1250 horse-power is the amount delivered (not generated), and that the transformers are at their most efficient point for the load given. GEO. B. LAUDER.

Allowing 97 per cent efficiency for transformers, 1250 horse-power at consumer's end would require 957,215 watts on line side of step-down transformer.

$$\text{Area, c.m.} = \frac{\text{distance} \times \text{watts}}{\text{per cent loss} \times (\text{voltage})^2} \times 1500.$$

$$41,738 = \frac{105,600 \times 957,215}{\text{per cent loss} \times (20,000)^2} \times 1500 = 9.8 \text{ per cent loss in line.}$$

This would require 1,061,215 watts as the line side of the step-up transformer and 1,094,035 watts at the machine.

Watts generated.....	1,094,035
Watts delivered.....	932,500
Watts loss.....	161,535

or 14.7 per cent.

$$\text{Volts loss in line} = \frac{9.8 \times 20,000}{100} \times 1 = 1960 \text{ volts.}$$

Voltage at generator, 2196 volts.

(Formulae are from General Electric Company's bulletin 9041.)

P. E. COWLES.

The energy loss would be 13.5 per cent. The voltage drop, including inductive and other losses, would equal 14 per cent of the generated potential.

W. T. M., N. Y. ED. CO.

Assuming that the power factor for the mixed load is 85 per cent, the calculated loss in transmitting the energy as stated in the above problem is 14 per cent of the generated output of 1250 horse-power, or a loss of 175 horse-power.

C. A. KELLAR.

*No. 11.—What would you consider a fair estimate of cost for operating (24-hour service) under the above conditions as compared with the cost of operating a combined generating and distributing station, also provided with ample water-power and situated as nearly as possible in the centre of its field of distribution, which field is the same as would be served by the 20-mile transmission and substation above?*

*No. 12.—What, in your experience and from best information, is the probable excess of actual cost of electrical and hydraulic developments over original estimates when five per cent has been allowed for contingencies, and five per cent for engineering and superintendence by the engineers making the estimates?*

*No. 13.—What is meant by the expression "circular mils"?*

A circular mil is the cross-section area of a circle having a diameter of one-thousandth of an inch. A wire of 10 circular mils capacity, for instance, would not have a diameter of 10 one-thousandths of an inch, but would have 10 times the sectional area of one circular mil.

GEO. B. LAUDER.

A circular mil is a unit of area employed in designating the cross-sectional area of wires and other circular conductors. It is equal to .78540 of a square mil. If the diameter of a wire is given in mils, the square of its diameter gives the cross-sectional area in circular mils.

WILLIAM R. GARDENER.

One-thousandth of an inch equals one mil. The circular mils of a wire may be found by squaring the diameter in mils.

B. A. SCHAK.

A circular mil is a unit of area and is the area of a circle one-thousandth of an inch in diameter. As areas of circles are proportional to the squares of their diameters, the number of circular mils in any circle, or wire, is the square of the diameter expressed in thousandths of an inch as a whole number.

W. T. M., N. Y. ED. CO.

*No. 14.—Is there any authoritative treatise, or any compilation of reliable testimony, in regard to death or injury to persons or animals from electric shock?*

The Department of Gas and Electric Light Commissioners of the Commonwealth of Massachusetts publish each year a full report of all accidents in their state from gas or electricity.

CALVIN W. RICE.

*No. 15.—What is the best way to educate the public to a realization of the fallacy of municipal ownership?*

In every city are intelligent citizens, men of property and influence, often members of the city council, who through dread of change or conservatism, natural or acquired by experience, do not believe in the latter-day doctrine of municipal ownership of public utilities. Many of these men would be glad to talk against the

idea if they had facts and figures to illustrate and support their opinions. Not having these, they are placed at a disadvantage when the subject is under discussion. I firmly believe it to be for the advantage of public-service corporations to see that such men are interviewed and that proper literature on the subject is furnished them. I do not wish to be understood as advocating anything in the nature of a campaign for the purpose of stirring up agitation on the subject. It is better to "let sleeping dogs lie," but I do believe in supplying our friends with arms and ammunition against the day that is certain to dawn in every city, when the municipal-ownership dog awakes and shows his fangs. This usually occurs about the time the city contract is to expire.

WILLIAM R. GARDENER.

Persistency in bringing to the notice of the public, through the daily papers, the failures on this line, the reasons for the same, and any discussion brought about in this connection, is bound to help our cause. The Good Roads people are furnishing an example of what can be done by persistently bringing their point before the intelligent people of the country. S. S. INGMAN.

Analyze carefully the detailed reports of any municipal plant and compare the distribution of costs with similar reports of supply company. The fallacy of municipal ownership is usually self-evident on such investigation. G. WILBUR HUBLEY.

The best way to show the public the fallacy of municipal ownership is, first, to give the best service possible and charge only enough to net a reasonable return, and second, to show failures on the part of the municipalities that have installed their own plants. E. H. MATHER.

*No. 16.—What is the usual percentage of current for light and for power on alternating-current central-station plants in representative cases?*

Average case will probably show approximately 75 to 85 per cent for lighting load and from 15 to 25 per cent for power current. G. WILBUR HUBLEY.

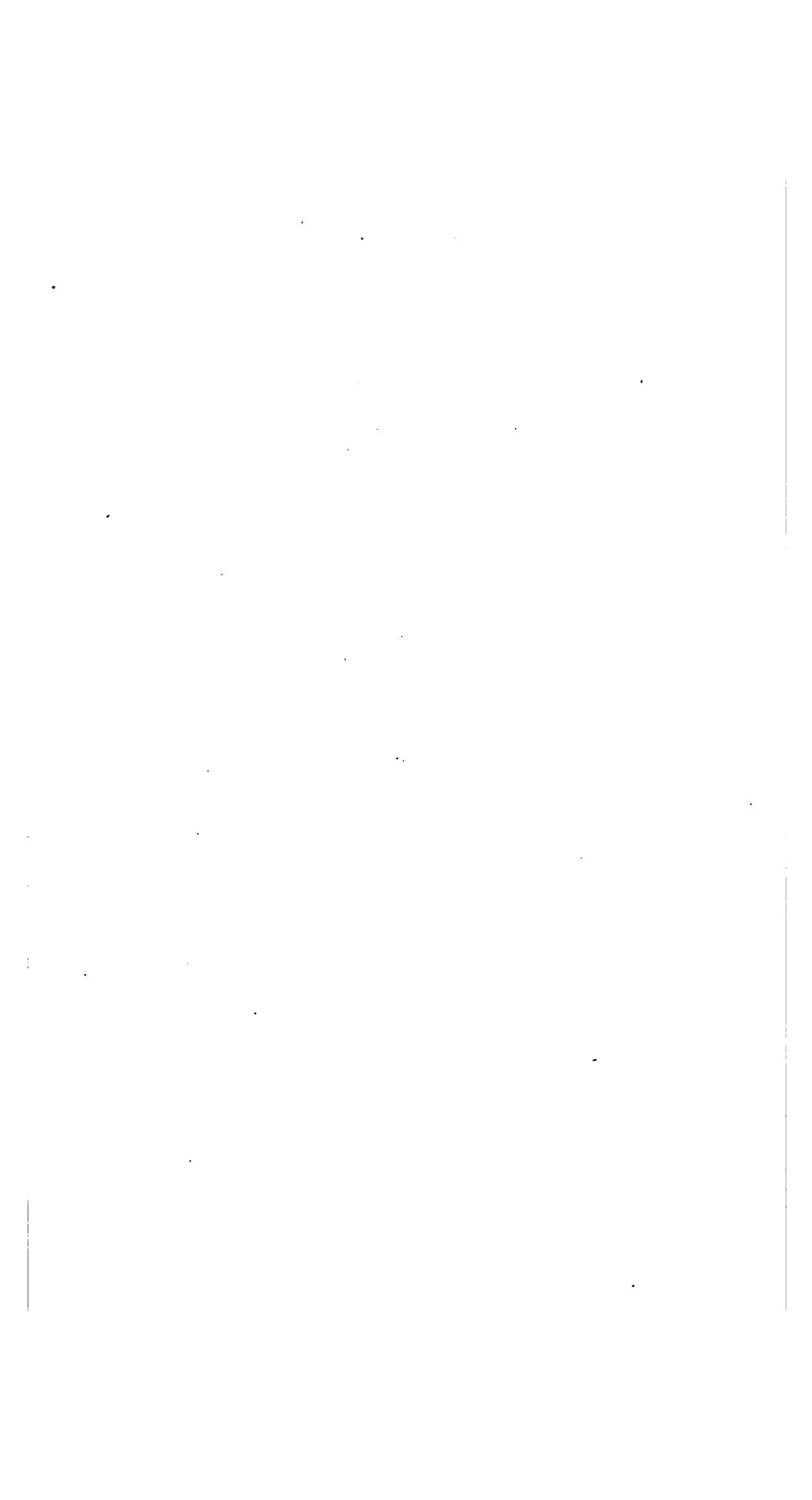
*No. 17.—What is the power factor at different hours on the alternating-current output of central stations supplying lights and motors?*

*No. 18.—What is the comparative value of electric currents and 700 heat-unit gas as used for cooking purposes?*

*No. 19.—What is the efficiency of conversion of heat in the ordinary cooking utensils as operated by gas stoves and high-grade electric utensils?*

The Electrical Testing Laboratories have just installed a very complete electrical kitchen, and they expect in the course of the next few months to get some valuable data, taken under working conditions, as to the value of electricity for cooking purposes.

F. M. FARMER.



## INDEX—I

Each contributor has been given a number, which immediately precedes his name. The numbers following the name of a contributor indicate the numbers of the questions that have been answered by him.

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- 4 Aspnes, E. A., Mgr. Montevideo Elec. Lt. & Pr. Co., Montevideo, Minn.  
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- 5 Augusta Ry. and Elec. Co., Augusta, Ga.  
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- 7 Beaman, David W., Supt. New Bed. Gas & Ed. Lt. Co., New Bedford, Mass.  
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- 8 Beugler, H. M., Elmira Water, Lt. & R. R. Co., Elmira, N. Y.  
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- 28 Cushman, G. H., San Antonio Gas & Elec. Co., San Antonio, Tex.  
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- 33 Dostal, J. F., Denver Gas & Elec. Co., Denver, Colo.  
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- 34 Doten, F. B., Electric Lt., Ht., Tr. & Pub. Service Co., St. Cloud, Minn.  
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- 42 Evans, T. D., San Antonio Gas & Elec. Co., San Antonio, Tex.  
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- 47 Franklin, Benjamin.  
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- 48 Freeman, W. W., Sec. Edison Electric Ill'g Co. of Brooklyn, N. Y.  
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- 56 Goodrich Co., The B. F.  
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- 57 Greene, Edgar B., Edison Elec. Ill'g Co. of Altoona, Pa.  
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- 58 Hall, Andrew F., Supt. Southbridge Gas & El. Co., Southbridge, Mass.  
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- 59 Hallberg, J. Henry, Cincinnati, O.  
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- 60 Hanks, M. W., Nernst Lamp Co., Pittsburg, Pa.  
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- 61 Hartman, H. T., Editor, Land Title Building, Philadelphia, Pa.  
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- 63 Hodgkinson, Francis, Engr. Westinghouse Mach. Co., East Pittsburg, Pa.  
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- 64 Hollingsworth, C. H., Engr. Elec. Lt. & Pr. Co., Cheboygan, Mich.  
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- 65 Hoon, C. L., The United Lt. & Pr. Co., Georgetown, Colo.  
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- 66 Howell, Wilson S., Electrical Testing Laboratories, New York city.  
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- 67 Hubbell, Fred. B., Supt. Westport Water & Elec. Lt. Co., Westport, Conn.  
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- 92 Lüpke, Paul, Engr. Pub. Ser. Corp. of New Jersey, Trenton, N. J.  
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- 107 Miller, Preston S., Electrical Testing Laboratories, New York city.  
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- 108 Milne, James, Toronto, Ont.  
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- 135 Palmer, G. E., Pettingell-Andrews, Boston, Mass.  
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- 136 Peck, J. S., Westinghouse Elec. Mfg. Co., Pittsburg, Pa.  
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- 137 Peninsular Electric Lt. Co., Detroit, Mich.  
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- 139 Peters, Chas. H., Supt. The Durango Lt. & Pr. Co., Durango, Colo.  
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- 143 Pyle, Jas. E., Gen. Mgr. The Edison Elec. Ill'g Co. of West Chester, Pa.  
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- 145 Rice, Calvin W., 44 Broad street, New York city.  
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- 152 Schuchardt, R. F., Chicago Edison Co., Chicago, Ill.  
L 1, 22, 26.
- 153 Schweitzer, E. O., Chicago Edison Co., Chicago, Ill.  
T 2.
- 154 Sharp, Clayton H., Electrical Testing Laboratories, New York city.  
N 2, 3. R 1. S 6. U 4, 5, 12. W 8.
- 155 Sherbrooke Pr., Lt. & Ht. Co., The, Sherbrooke, Canada.  
S 12, 14. V 3, 4, 5, 14, 17, 18, 24, 25, 26, 29. W 5.
- 156 Sims, W. F., Chicago Edison Co., Chicago, Ill.  
D 1. E 28, 36, 37. F 11. J 1. L 24, 27.
- 157 Skillman, Percy H., Hunterdon Electric Light Co., Lambertville, N. J.  
D 6.
- 158 Smith, F. Ellwood, Genl. Mgr. Somerville Elec. Lt. Co., Somerville, Mass.  
D 9. E 50. H 12. I 7. K 1.

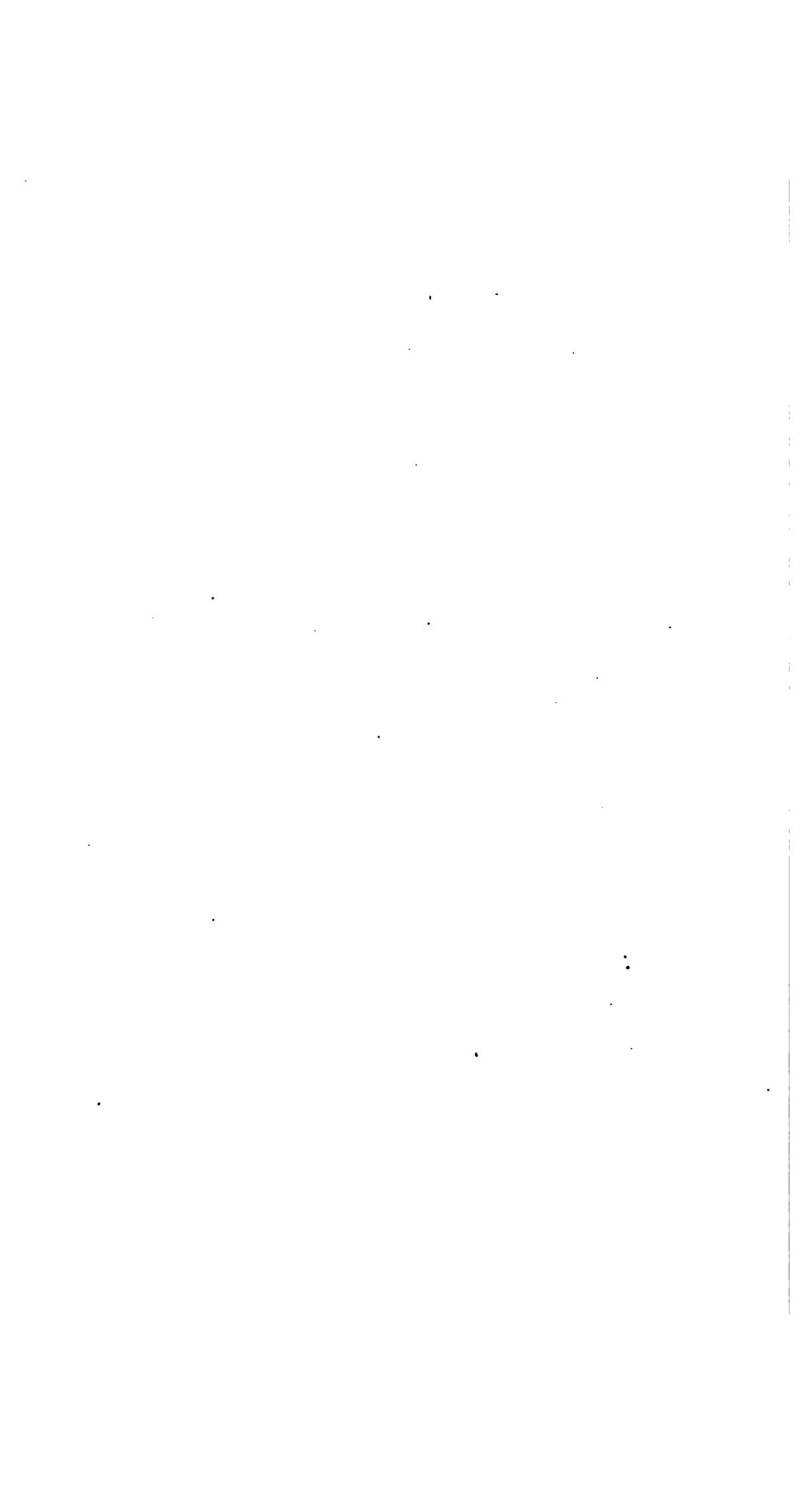
- 159 Smith, Frank W., Sec. United Elec. Lt. & Pr. Co., New York city.  
V 36.
- 160 Smith, P. J., Chicago Edison Co., Chicago, Ill.  
R 1, 2, 3, 6, 7.
- 161 Smith, S. S., The Ball & Wood Co., New York city.  
G 5, 6, 9, 12, 14, 20, 21, 27.
- 162 Snow Steam Pump Works, 114 Liberty street, New York city.  
J 4.
- 163 Sprague, H. A., Sec. Shiawassee Lt. & Pr. Co., Corunna, Mich.  
N 6.
- 164 Springer, G. B., Chicago Edison Co., Chicago, Ill.  
Q 18, 31, 32, 34.
- 165 Steubenville Traction & Lt. Co., Steubenville, O.  
C 1, 2, 5. E 4, 5, 6, 8, 10, 12, 13, 15, 16, 17, 19, 20, 22, 23, 25, 28,  
29, 31, 32, 33.
- 166 Strohm, B. E., Chicago Edison Co., Chicago, Ill.  
Q, 18, 28, 30, 32, 34, 38.
- 167 Supplec, C. C., General Electric Co., Philadelphia, Pa.  
U 1, 3, 4, 5, 6
- 168 Swenson, S. O., Chicago Edison Co., Chicago, Ill.  
I 3, 5. L 26. Q 27.
- 169 Switzer, Edgar, Chicago Edison Co., Chicago, Ill.  
M 2. S 3.
- 170 Thomas, Percy H., Ch. Elec'n Cooper Hewitt Elec. Co., N. Y. city.  
T 6, 7, 8.
- 171 Thompson, G. L., General Elec. Co., Philadelphia, Pa.  
N 8. Q 40. R 1, 2, 3, 6, 9, 10, 11. T 1, 4, 5, 10.
- 172 Thurston, R. H., Chicago Edison Co., Chicago Ill.  
H 10. J 3, 6. T 1.
- 173 Tingley, E. M., Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.  
L 1, 2, 3, 4, 15, 16, 17, 19, 26.
- 174 Toledo Rys. & Lt. Co., Toledo, O.  
C 5. E 6, 14, 20, 21, 29, 30, 41, 52. L 30, 33, 34, 44. Q 13, 14,  
20, 25, 26, 29, 32, 40. R 3, 4, 9. V 1, 3, 6, 7, 11.
- 175 Tripp, Geo. B., Genl. Mgr. Colo. Springs Elec Co., Colorado Springs, Colo.  
C 3. D 9. V 1, 3, 14, 22, 43.
- 176 Turpin, M. C.  
Q 1, 3.
- 177 Union Electric Lt. & Pr. Co., The, Unionville, Conn.  
B 1, 2, 4, 5. S 14, 15. V 10, 11, 14, 20, 23, 25.
- 178 Unsigned.  
E 29, 33. J 2, 7. K 1, 2, 3, 4, 5. L 3, 4, 31, 32, 33, 34, 35, 36, 38,  
39, 40. N 2, 3, 8, 9, 10, 11. O 1, 2, 3. Q 6, 7, 17, 20, 25, 26,  
28, 29, 30, 32, 38, 44, 46, 61. S 14. U 3, 4, 5, 6, 7, 9, 10, 11, 12.  
W 8.

- 179 Vail, J. H., Pennsylvania Iron Works, Philadelphia, Pa.  
E 13, 16, 20, 49. K 4.
- 180 Vredenburgh, La Rue, 3 Head Place, Boston, Mass.  
V 38.
- 181 Wagner, E. A., Fort Wayne Elec. Works, Fort Wayne, Ind.  
Q 40. T 1, 3, 11.
- 182 Watson, L. E., Supt. The Northwestern El., Ht. & Pr. Co., Kearney, Neb.  
B 1, 2, 4. L 7, 10, 11, 17. R 7.
- 183 Whitford, Reid, U. S. Asst. Engr. U. S. Eng. Office, Georgetown, S. C.  
C 2, 5.
- 184 Whitmore, A. O., Supt. Amer. Falls Pr., Lt. & Wtr. Co., Pocatello, Ida.  
Q 8, 11, 23, 45. S 12, 13. T 1. V 6, 10, 11, 25, 28. W 7.
- 185 Whitted, Thos. B., Con. Engineer, Denver, Colo.  
B 7. Q 22. V 8.
- 186 Willcox, F. W., General Elec. Co., Harrison, N. J.  
S 3, 4, 5, 6, 10, 11, 12, 13, 15. V 42.
- 187 Williamson Co., F. L., Clay Center, Kan.  
V 3, 10.
- 188 Wilson, John A., Public Service Corp. of New Jersey, Trenton, N. J.  
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## INDEX III

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- 4 Is there any simple method of testing a three-phase generator for regulation, using ordinary station instruments?—p. 169.

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- 7 What is likely to cause a direct-current, constant-potential generator to lose its magnetism?—p. 174.
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- 13 To what extent is the speed of a compound-wound motor affected under a widely varying load, say from one-eighth load to 20 per cent overload, while the voltage of supply remains practically constant? What change of speed would there be with a variation of from two to five per cent in the voltage?—p. 182.
- 14 In a small plant which can not afford a laboratory equipment, what is the best method of locating short-circuits or grounds in armature or fields of a direct-current generator or motor?—p. 183.
- 15 Why should a 125-cycle, single-phase dynamo on a one-mile transmission line give a better light than a 133-cycle machine operating over the same line and transformers with precisely the same voltage and conditions?—p. 185.
- 16 How is the capacity of a three-phase alternator computed from its current and voltage?—p. 186.
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- 18 Why does the commutator of a Wood dynamo tend to burn at the bars opposite the armature spider arms?—p. 190.
- 19 Are 60-cycle, double-current generators commercially satisfactory for lighting service where load is reasonably uniform?—p. 190.
- 20 Assuming compound-condensing Corliss, or equally economical engine and dynamo units of 200 to 300 kilowatts, will the annual operating economy with direct-connected dynamos be sufficient to offset the additional fixed charges over direct-belted units? Hours of service 7000 annually and average load factor 40 per cent.—p. 191.
- 21 What is the loss in efficiency in using carbon brushes instead of copper gauze on 125-volt, direct-current generators? Is there any modified type of carbon brush or mode of treating carbon brushes that will obviate this loss?—p. 192.

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- 22 What precautions are necessary in coupling and operating two direct-belted alternators, of same design and make, in multiple?—p. 192.
- 23 To what extent will a three-wire dynamo, equipped with one commutator and balancing coil, stand unbalancing of load on the two sides of the system?—p. 194.
- 24 Have alternating-current motors been used satisfactorily for crane and hoist work when supplied from lighting circuits?—p. 195.
- 25 How can compound-wound, direct-current generators of different types and sizes running in parallel be made to divide the load automatically?—p. 196.
- 26 Is it advisable to connect in multiple both the alternating-current and the direct-current sides of rotaries in substations?—p. 198.
- 27 Have three-phase, 60-cycle, alternating-current motors been successfully applied to passenger-elevator work?—p. 200.
- 28 What is the approximate resistance of the armature and of the field of a 75-hp street-railway motor? What is the resistance of the rheostat used in starting same?—p. 200.
- 29 What is the best method of operating passenger elevators from a three-phase, alternating-current system?—p. 200.
- 30 In economic operation of a unit in the central station where for a considerable number of hours the generating apparatus is operated with but one-sixth to one-fourth of full load, would it not result in a large saving of fuel and wear and tear to install a unit of one-fourth capacity, with the same steam supply, to carry the small load? Is it not considered good practice, therefore, in the small station to have two units in this proportion; and what is found to be the comparative cost of operation?—pp. 201-202.
- 31 When motors are operating continuously for refrigerator or pumping stations, what is the most practical safety device to use in connection with three-phase motors to protect them from burnouts from single-phase current in case a fuse blows?—p. 203.
- 32 What is the relative cost of maintenance of induction motors and of direct-current motors in general city service?—p. 204.
- 33 In starting the direct-current side of a double delta or a diametrically connected rotary converter that has the transformer and regulator permanently connected, the transformer and regulator windings act as a short-circuit on the direct-current brushes. What is the best method of reducing the current at the instant of starting? What results are obtained in practice by the method described?—p. 205.
- 34 What are the objections to grounding the neutral of a high-tension, three-phase, star-connected generator?—p. 205.
- 35 Two star-connected, three-phase generators of same capacity running in parallel with grounded neutral show a neutral current proportional to the difference in load on the two machines. This current does not appear in the ammeters on the phase wires of the

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- machines. What is the nature of this neutral current, and what is its course through the winding of the two machines?—p. 206.
- 36 How do currents in the grounded neutrals of star-wound generators affect operating conditions? How can they be eliminated?—p. 206.
- 37 Can two generators driven by rope drives from the same shaft be synchronized independently?—p. 206.
- 38 What has been your experience with alternating-current induction motors in connection with derrick hoists; are they efficient, and can loads requiring careful lifting, such as flasks in a moulding shop, be lifted without damage?—pp. 206-207.
- 39 Have you any installations of air compressors direct-belted to alternating-current three-phase motors with automatic starter and stopper? If so, has the customer had any trouble with such installations? Are they efficient and reliable?—p. 207.
- 40 How does the efficiency of induction motor speed control compare with the efficiency of direct-current motor control?—p. 208.
- 41 Is it a fact that the air-gap at the top between armature and frame of large engine-type generators is considerably greater when machine is not running? If so, what is the explanation?—p. 208.
- 42 What is the usual energy consumption of refrigerating machines per ton of refrigerating capacity? Also kw-hour consumption per ton per season in northern states?—p. 209.
- 43 What is the energy consumption per car-mile of high-speed hydraulic electric-driven elevators?—p. 209.
- 44 Can an ordinary modern-type, 500-volt, compound-wound, direct-current generator be easily changed to feed into a three-wire system? Can the armature be tapped out to a slip ring, and in this case will the generator work satisfactorily under out-of-balance conditions, and how much out of balance must the system be to cause serious sparking?—pp. 209-210.
- 45 In operating two machines in series on the Edison three-wire system, how nearly balanced should the negative and positive be? If unbalanced on either side, would it have a tendency to affect the operation of or injure the machines?—p. 210.
- 46 The writer was called to repair a motor that operated a coffee mill. The machine would run and pull the load, but the brushes were throwing fire terrifically, and on one or two occasions the current leaped from brush to brush. Upon examining the armature, it was found to be in perfect condition and the fields were found to be open. The motor was shunt-wound and free from grounds and connected up properly, and would continue to run when the upper half of the frame and one field coil were removed, but would pull no load as it did when these parts were in place. Why did it run with the fields cut out?—pp. 210-211.

## M

## STORAGE BATTERIES

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- 1 How can one tell when a storage battery is fully charged?—p. 211.
- 2 How often must the acid in storage batteries be removed and renewed?—p. 213.
- 3 What precautions are necessary in cutting out batteries and dynamos in case of line troubles or excessive overloads; also in cutting out batteries and dynamos after disconnection?—pp. 214-215
- 4 What records are essential in order to obtain a low-maintenance cost of batteries?—p. 216.
- 5 Does the storage battery require any extra or special labor?—p. 217.
- 6 Is the total line loss lessened or increased by installing a storage battery with booster at the centre of distribution instead of at the generating station?—p. 218.
- 7 Is the investment in storage batteries to be used exclusively for excitation warranted in large and moderate-sized plants?—p. 219.

## N

## SWITCHBOARD INSTRUMENTS AND STATION WIRING

- 1 What methods of voltage regulation have proven successful where single-phase lighting circuits are distributed across the phases of three-phase machines, when these machines also serve highly inductive load in motors and arc lamps?—p. 220.
- 2 How often should such switchboard instruments as ammeters and voltmeters be tested to insure reasonable accuracy?—p. 221.
- 3 Are hot-wire instruments reliable in practical every-day service, and do they give equally accurate results with both direct and alternating currents?—p. 222.
- 4 The old Thomson-Houston alternating-current ground detector consisted of a choke coil, with an incandescent lamp shunted across a few of the turns that were of heavier wire than the rest, thus making the combined carrying capacity at this point much greater than that of the rest of the circuit with which it was in series. Why was this necessary?—p. 224.
- 5 Please describe a simple form of ground detector for use on Edison three-wire system.—p. 224.
- 6 With a single-phase six-mile, 5500-volt transmission, how would you turn on and off from the power-house street lights that are located at feeder end?—p. 225.
- 7 Is there any form of automatic voltage regulator adapted to control an Edison three-wire system, which will not only regulate properly with one pair of machines, but will regulate and insure proper division of the load when several generators are operated in multiple?—p. 226.

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- 8 What type of time-limit device for circuit-breakers has given the most reliable service ; mechanical, electro-mechanical, or electrical?—p. 227.
- 9 Are compensators for voltmeters on alternating-current circuits satisfactorily taking the place of pressure wires?—p. 227.
- 10 What is the average drop in voltage across the fuses by which station voltmeters and wattmeters are protected?—p. 228.
- 11 A four-wire, three-phase, 60-cycle feeder runs from the station to a centre of distribution from which radiate three unequally loaded single-phase feeders connected between phase wires and neutral. What is the best method of connecting voltmeter compensators in the station so as to give an accurate indication of the voltage on each single-phase feeder at the centre of distribution?—p. 229.

## O

## BELTS AND SHAFTING

- 1 Which is the most reliable of the various formulæ for determining the width of a leather belt?—p. 229.
- 2 What is the relative efficiency of paper, wood and iron pulleys?—p. 231.
- 3 Does piercing or grooving the surface of an iron pulley add to its efficiency? If so, to what extent?—p. 231.

## P

## OIL AND WASTE

- 1 What precautions are necessary to avoid trouble with cylinder and valve lubrication with superheated steam?—p. 232.
- 2 Is there any simple and effective method of testing lubricating oil without prolonged use under actual operating conditions?—p. 232.
- 3 Does it pay to use waste presses for recovering oil and reusing waste?—p. 234.
- 4 Does graphite give satisfactory service as a cylinder lubricant, especially if the condensed steam is returned to the boilers?—p. 235.

## Q

## POLE LINES AND CONDUIT SYSTEM

- 1 In an unbalanced three-phase system—for example, such as shown—with current in  $A = 30$  amperes, current in  $B = 10$  amperes, current in  $C = 30$  amperes, what will be the relation of the voltages to each other, and why? That is, will two of the voltages be higher than the others, or two lower than the others, and which will be alike and which the odd one? My experience shows that  $AC$  equals  $AB$ , while  $BC$  is considerably higher.—p. 235.
- 2 What method of treating wooden poles seems to give the best result in preserving tops and butts from decay?—p. 237.

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- 3 What is the relative life of chestnut and white-cedar poles?—p. 238.
- 4 What is the apparent life of iron poles?—p. 239.
- 5 In treating poles to preserve them from decay, what is considered the best and most economical preservative, and how much oil or other preservative should be forced into the wood per cubic foot?—p. 239.
- 6 What system of underground conduit has been found satisfactory under service conditions for transmission of high-voltage alternating-current service?—p. 239.
- 7 What has been the experience with the use of lead-covered underground cables (rubber insulation) on single-phase, alternating-current distribution?—p. 240.
- 8 Is it considered good practice to run telephone lines on the same poles with high-tension circuits, and if so, can the telephone be used in case of leaky insulation or line trouble?—p. 240.
- 9 What is the best method of patrolling and repairing high-tension lines?—p. 243.
- 10 Are there any state laws requiring that overhead conductors shall have insulating covering?—p. 244.
- 11 Is a grounded conductor stretched along a transmission line, over or near the transmission wires, of any utility as a protection against lightning discharges?—p. 244.
- 12 Is there any way of locating, from the generating station, ground crosses and open-air circuits on a high-tension transmission line?—p. 245.
- 13 What is the best method of locating open circuits in an overhead series arc system?—p. 246.
- 14 What is the best method of locating grounds in an overhead arc system?—p. 250.
- 15 What is the best method of protecting high-tension lines from crosses with telephone, telegraph and call wires?—p. 252.
- 16 Has the alternating current any injurious electrolytic effect upon underground metallic structures, such as water or gas pipes?—p. 253.
- 17 What is the best method of protecting underground lead-sheathed cable from electrolysis from the return current from a street-railway system?—p. 254.
- 18 What is the best method of protecting cables in manholes—first, from burnout from adjacent cables under faults; second, from electrolysis; third, from mechanical injury?—p. 256.
- 19 What results have been obtained from using lightning arresters on secondary lighting circuits? Is it considered good practice?—p. 257.
- 20 What policy will result in the least interruption of service: numerous cut outs on primary lines, protecting all taps, or few cut-outs on

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- lines, the station fuse or circuit-breaker being depended upon for protection?—p. 258.
- 21 What is the best method of locating grounds and short-circuits on live underground cables, both direct and alternating-current? Is there danger of damaging cable where about seven-ampere alternating-current is used for the purpose of testing?—p. 261.
  - 22 What is the best and most efficient lightning protection for a high-voltage transmission line not exceeding 10 miles in length?—p. 262.
  - 23 What are the advantages, if any, in transposing the wires of a four-mile, 10,000-volt circuit carrying alternating current?—p. 263.
  - 24 What method has been employed to overcome the inductive currents on lead-covered cables when used for alternating-current distribution?—p. 263.
  - 25 On alternating-current secondary circuits, the use of inclosed-arc lamps having an induction coil for regulating voltage across arc has the effect of increasing the drop that the secondary would have on a non-inductive load. Where incandescent and inclosed arcs are run from the same secondary, we have had trouble on account of the drop in voltage produced by the arc, since when the arcs are turned off, the voltage will rise to normal. Is there any practical remedy for this difficulty?—pp. 263-264.
  - 26 What should determine the size of wire to be used in a secondary system fed by transformers in parallel? Should it be made large enough to take care of all prospective needs, or should it be made of moderate size and additional transformers be connected to it at the proper points when the drop becomes too great?—p. 265.
  - 27 What are the advantages, if any, of the varnished cambric-insulated cables over paper or rubber-insulated cables?—p. 267.
  - 28 Is it advisable to install unsheathed cable in underground conduit under any conditions?—p. 268.
  - 29 What is the commercial limit of size of copper conductors when used as feeders for distribution of alternating current of 2000 volts at a distance of one and one-half miles from centre of distribution?—p. 269.
  - 30 What has been the practice and experience as to size of conductors, and how many conductors can be successfully run in a single duct of underground system for the distribution of 2000-volt, 60-cycle, alternating-current circuits?—p. 270.
  - 31 What is the cost per duct-foot of conduit construction, complete with manholes, for high-voltage alternating system?—p. 271.
  - 32 Has it been found practicable in a high-voltage underground system to place transformers in manholes? Are not drainage connections to sewers absolutely essential?—p. 272.
  - 33 What is the best system of distribution from underground mains: Edison tubes, centre poles for each block, or some other system?—p. 274.

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- 34 What is the best way of removing asphalt pavement for underground conduit work and of replacing it after the work is done?—p. 275.
- 35 What has been the general experience with aluminum feeders, and at what price per pound does it pay to use aluminum as compared with copper?—p. 275.
- 36 Does it pay to put up sections of lead-covered insulated wire through trees to obviate the wearing of insulation and consequent grounding?—p. 275.
- 37 How do you overcome the tree-trimming nuisance?—p. 276.
- 38 Is it advisable to place fuse box at the junction of the primary main with service line in manhole? If so, what style of fuse box is most satisfactory, and how should it be mounted and connected?—p. 278.
- 39 What is the practice of lighting companies with regard to their weatherproof line wires that have become frayed and the insulation rendered useless? Have they erected new insulated wire, or taped up the old insulation, or left the lines alone?—p. 278.
- 40 Should transformers be fused on both the primary and secondary, and what percentage of overload should be allowed in fusing when transformers are connected in parallel to secondary mains?—p. 279.
- 41 What results have been obtained with grounded secondaries—first, as to protection from high voltage; second, damage to transformers from lightning?—p. 282.
- 42 Can satisfactory lighting service be obtained when incandescent lamps and alternating-current motors are furnished from the same circuit from generators under 500-kw capacity? If so, under what conditions?—p. 282.
- 43 What would cause a greasy appearance in the contacts on 1000-volt junction boxes after having been closed from six months to a year? I have also noticed this at station on General Electric expulsion-type fuse blocks.—p. 284.
- 44 What is the best method of connecting up 2300-volt service cables to customers' premises with the company's lines at the manholes? (a) where both the main line and the service line are three-wire cables; (b) where both are two-wire cables; (c) where both are single cables?—p. 284.
- 45 Please describe the operation of blasting for pole hole, stating where the materials may be procured, of what they consist, and what precautions must be observed in their use.—p. 284.
- 46 What results have been obtained by placing lightning arresters between high-potential lines in addition to those connected between lines and ground? Has resonance been diminished thereby?—p. 286.
- 47 Has any one found a durable paint for stenciling names and numbers on poles?—p. 287.

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- 48 How much does it cost to install the ordinary "dead-man" anchorage for guying a pole, and what service have they given in practical operation?—p. 287.
- 49 What is the relative first cost of installing an underground system in a city of 50,000 population as compared with the cost of installing an overhead system?—p. 288.
- 50 What is the relative cost of maintaining an underground system in a city of 40,000 population as compared with the overhead system?—p. 288.
- 51 Is it considered advisable to ground the neutral wire of a three-wire, direct-current, 125 and 250-volt system, operated from two generators of 125 volts each in series?—p. 289.
- 52 If the ground is to be used, how should it be made to obtain best results? State advantages and disadvantages.—p. 289.
- 53 Has the practice of ventilating subway systems by means of connection to smokestacks proven satisfactory as a means of preventing gas explosions in manholes?—p. 290.
- 54 Is there any satisfactory type of fuse box for use in manholes on high-tension circuits of 2300 volts or over?—p. 290.
- 55 Will the placing of lightning arresters on series alternating arc circuits prevent or minimize the trouble due to breaking down of lamp insulation? If so, how many should be placed per mile of circuit?—p. 290.
- 56 Are overhead lines used in conjunction with a limited amount of underground cable more difficult to maintain than a complete system of overhead lines?—p. 292.
- 57 What is the length of life of the average rubber-covered wire and cable?—p. 293.
- 58 What is the most effective method of grounding for pole lightning arresters for alternating-current circuits under different conditions, such as on paved streets and in a dry, hilly country?—p. 294.
- 59 What is the best and most convenient device, in the hands of workmen, for detecting whether high-tension cables are alive or not?—p. 294.
- 60 In an Edison three-wire system supplied from one or more distributing stations or substations, what is a reasonable maximum drop and average energy loss in direct-current feeders? In mains, services and house lighting? In unaccounted-for losses?—p. 294.
- 61 What is the insulation resistance during wet weather of the regular two and three-petticoat insulators that have been in service from three to five years under ordinary street conditions?—p. 295.
- 62 What is a good method for dead-ending heavy primary pole-line feeders; something that will answer the purpose of the regular strain insulators?—p. 295.
- 63 What is a good method for splicing cable of 300,000 circular mils or larger?—p. 295.

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- 64 Assuming a direct-current two-wire distribution that is to be changed to alternating-current three-phase, which is the better secondary distribution—three-wire delta or four-wire Y?—p. 296.
- 65 In a banked-transformer system, is there a practical method of cutting out the transformers from plant at light loads, thereby saving core loss?—p. 296.
- 66 How often have you found fires in buildings to have been started by electric-light wires, and how did you find it to happen?—p. 297.
- 67 Is it advisable to use insulated wire for long transmission line with 15,000 or 20,000 volts tension? If so, why?—p. 298.
- 68 Has any one found an entirely satisfactory fuse cut-out for 220-volts? What have been your troubles with same?—p. 298.
- 69 We have a 220-volt direct-current system. Sometimes telephone lines come in contact with our lines. The ringing coils in the telephones have just the exact amount of resistance to permit enough current to pass through to heat the coils, but not enough to blow an ampere fuse. We have had several fires started in this way, and have found no effective remedy for it. What can be done?—p. 298.

## R

## ARC LAMPS

- 1 How should the winding of the magnets of a constant-potential arc lamp be altered so that the arc will give a violet light for photographic purposes?—p. 299.
- 2 How does the operation of a series arc lamp indicate whether or not the shunt coil is open-circuited?—p. 301.
- 3 What is the average life of carbons in a 7.5-ampere, 60-cycle, series alternating arc lamp street-lighting system, under actual working conditions?—p. 302.
- 4 What is the average life of inner globes in such a system?—p. 303.
- 5 How can the Ball Company's arc lamps be operated so as not to break the inner globes continuously?—p. 304.
- 6 How can an ordinary open-arc lamp be changed over to the inclosed-arc system?—p. 304.
- 7 Which is most suitable for raising and lowering street arc lamps; hemp, braided cotton, or stranded-wire rope?—p. 305.
- 8 What is the life of opalescent as compared with clear inner globes for inclosed-arc lamps?—p. 307.
- 9 When it is proposed to change from 9.6-ampere open street arcs to the alternating-current inclosed system, is it commercially advisable to offer the 6.6-ampere or the 7.5-ampere lamps?—p. 308.
- 10 What are the relative maintenance costs of series inclosed-arc street lamps equipped with closed-base inclosing globes and similar lamps equipped with open-base inclosing globes having removable lower holders?—p. 309.

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- 11 Is there such a thing as a successful and efficient 220-volt, direct-current multiple inclosed-arc lamp that is sufficiently free from violet rays for store service?—p. 310.
- 12 What is the difference in efficiency and cost of operation per 100 inclosed-arc lamps operated from constant-current transformers, and 100 open arcs operated from modern constant-current dynamos, lamps being of same wattage in both instances and running 4000 hours per year?—p. 311.
- 13 Why are not cut-outs more generally used when installing series arc lamps; a cut-out whereby the lamp will be entirely disconnected from the circuit when handled by the trimmer or inspector?—pp. 311-312.

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## INCANDESCENT LAMPS

- 1 What do you consider the best system of incandescent series lighting for small towns and suburban districts?—p. 312.
- 2 Can Nernst lamps be operated successfully on a 25-cycle circuit?—p. 313.
- 3 Does the power absorbed by an incandescent lamp at constant voltage increase or diminish with use, and to what extent?—p. 314.
- 4 To what extent does voltage affect life of an incandescent lamp?—p. 315.
- 5 Wanted—A weather-proof dipping solution for coloring incandescent lamps red, blue, or green. A great many lamps are used at Christmas for outside decorations, and I have never yet seen any that looked even reasonably well after a snow or rain storm.—p. 317.
- 6 What are the lowest frequencies that can be satisfactorily used on commercial lamps of the various voltages at the present time?—p. 317.
- 7 What method of maintaining Nernst lamps has been found satisfactory to both lighting company and customer?—p. 318.
- 8 What advantage, if any, has the Nernst lamp over other illuminants?—p. 318.
- 9 What has been the experience in the matter of Nernst lamp renewals?—p. 319.
- 10 Should or should not lamp renewals be furnished and delivered free to customer?—p. 319.
- 11 What is the difference in efficiency between the ordinary reflecting shades, such as are used upon incandescent street hoods, when presenting a clean, white surface and when old and rusty?—p. 320.
- 12 Are renewed lamps as economical and satisfactory to consumers as new first-class lamps?—p. 321.
- 13 Is it economical for a station that gives free renewals, to supply renewed lamps?—p. 322.

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- 14 Is it good policy to color lamps free of charge for temporary holiday decoration?—p. 324.
- 15 Can small stations afford the expense of periodical inspection and renewal of incandescent lamps, as a general proposition?—p. 326.

## T

## TRANSFORMERS

- 1 When self-cooling, oil-insulated station transformers heat up too much, what is the best auxiliary means of cooling?—p. 327.
- 2 Is there any practical device for locating a burned-out fuse on potential transformer used to energize the potential coil of a primary wattmeter on consumer's premises?—p. 329.
- 3 What is the best way to protect the circuits of a multiple-circuit, "series arc transformer from damage by open circuit?—p. 330.
- 4 When should a transformer out on the line, exposed to the weather the year round, be scrapped? Some old types have become obsolete. They must begin to deteriorate as soon as installed, and must have a certain length of life beyond which it may be dangerous to go, owing to the ever-present liability of a breakdown. Is it not probable that, as time goes on, we shall hear more and more accidents from breakdowns unless a systematic weeding out of "old" transformers be made? What system would be followed in the weeding-out process?—pp. 330-331.
- 5 What is the effect of running a transformer designed for 125 cycles on a 60-cycle circuit?—p. 332.
- 6 Is the Cooper Hewitt selective converter to be a commercial article?—p. 334.
- 7 Is it in actual use?—p. 334.
- 8 What are its limits as to voltage, phase and frequency on the primary side, and as to voltage on the secondary side? At what voltage, phase and frequency of alternating primary current are best results obtained?—p. 335.
- 9 What, in good practice, should be the loss from the switchboard to consumer's meter, with standard modern transformers and meters, lighting load only?—p. 335.
- 10 What is the largest size of transformer that you would consider advisable to erect on a pole?—p. 336.
- 11 We are located 28 miles from the Gulf of Mexico and are 28 feet above sea level. There is a great deal of rain throughout the year, and humidity of the atmosphere is very great; summers extremely hot and winters changeable. Is it better, or not, under such conditions, to use oil in line transformers of from 100-light to 500-light capacity?—p. 338.
- 12 What trouble, if any, is experienced from the dissolving by the transformer oil of the insulating compounds used for waterproofing oil transformers?—p. 338.

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- 13 Is it better to overload a transformer at peak than to stand heavy core loss all day? Will the aging of the iron under overload conditions overbalance the advantages gained from saving in core loss?—p. 339.

## U

## METERS

- 1 Why is it that the speed of a Thomson recording wattmeter is proportional to the load?—p. 340.
- 2 What is the theory of the operation of the Fort Wayne induction meter?—p. 342.
- 3 What is a simple, yet reasonably accurate, method of testing alternating-current, single-phase induction meters in position on the customer's premises?—p. 345.
- 4 What is the best method of maintaining the accuracy of standards for meter testing without an expensive laboratory outfit?—p. 349.
- 5 What is the allowable percentage of error in recording wattmeters?—p. 352.
- 6 What are the advantages and disadvantages of permanently sealed meters as against those from which the cover may be readily removed?—p. 353.
- 7 Is it advisable to replace meters and meter rate by automatic controllers and flat rate?—p. 356.
- 8 We use about 1000 meters, alternating current and direct current, of various types, and we should like to get a good arrangement for a complete test-board giving a range of loads from half an ampere to 50 amperes, alternating or direct current; also a means of keeping the load as steady as possible, so as to insure an accurate test.—p. 357.
- 9 What is the best method of protecting direct-current meters from lightning when connected to a three-wire direct-current overhead network with grounded neutral?—p. 358.
- 10 What percentage of customers' meters will maintain without attention for one year an accuracy on one-half load within two per cent fast or slow, and what within five per cent error?—p. 359.
- 11 How often should high-grade induction and Thomson recording wattmeters be tested?—p. 359.
- 12 In testing alternating-current meters upon consumers' premises, would the accuracy of tests be affected by furnishing the field current by means of a lowering transformer, allowing potential coil to remain upon original circuit?—p. 360.

## V

## MANAGEMENT

- 1 What is the best method of encouraging the use of current in residences?—p. 362.
- 2 Has not the two-rate meter a special value as applied to motor work,

## QUESTION

- in view of the fact that for many purposes the customer can control the hours of use in a way that is impossible in lighting?—p. 363.
- 3 On what should the amount of the minimum charge be based—the number of lights installed, the maximum load, or should there be simply a fixed minimum per customer?—p. 364.
  - 4 Is it good policy to charge for meter rent in addition to the charge for current used?—p. 367.
  - 5 The writer understands that the Doherty system of meter charges is based upon a low rate for current consumed, over and above a fixed monthly charge per lamp connected per customer. If so, is there any practical way of knowing how many lamps, and their sizes, consumers may have from time to time unless the lamps are counted each time the meters are read? If not, how is the number of lamps upon which the fixed charge is based to be known?—p. 368.
  - 6 In cases where the service is uniformly used a stated number of hours daily, is it not of greater advantage to make a flat rate without a meter?—p. 369.
  - 7 Is it advisable when in close competition with gas at from \$1.00 to \$1.60 per thousand cubic feet, to make a reduction of, say, 10 or 20 per cent on meter bills during the season of long nights and heavy loads?—p. 372.
  - 8 At what price must electricity be sold, using 16 cp, 3.6-watt lamps, 120-watt Meridian lamps, and 44-watt Nernst lamp, to compete with gas at \$1.50 per thousand cubic feet, using mantle with burner?—p. 373.
  - 9 What items of station expense should be taken into account in computing the cost of furnishing current to long-hour consumers whose load does not coincide with the station peak?—p. 375.
  - 10 Is it advisable to work to a strictly meter basis in a small town with limited water-power available for nine months of the year? Normal capacity of water power about twice present requirements.—p. 375.
  - 11 Is it good policy for a small lighting plant to require a deposit from its customers for their meters?—p. 377.
  - 12 What charges, outside of operating expenses, should be taken into consideration when figuring the cost of power at generating-station 'bus-bars?—p. 378.
  - 13 How can the selling price of current be so computed as to give due weight to the prospective load factor of new business?—p. 379.
  - 14 Is the extra holiday lighting for decorative purposes, etc., desirable business?—p. 380.
  - 15 Where prospective new business requires an increase in capacity of station or line, what percentage on the additional investment should the estimated net earnings show?—p. 383.
  - 16 What is the best method of handling slow-paying customers in case of active competition?—p. 383.

## QUESTION

- 17 Is it advisable to show meter readings on the bills as well as the amount of current registered?—p. 385.
- 18 Should meter bills show discounts when made out?—p. 387.
- 19 What is a fair price for 1200-cp, direct-current street arc lamps, burning 4000 hours per year, when fed from an underground circuit, as compared with lights fed from overhead lines?—p. 388.
- 20 Where the number of, and price paid for, street arc lamps is too small to warrant a special inspector, what is the most satisfactory method, to both company and municipality, of checking outages?—p. 388.
- 21 Taking as a base a station with an output of 15,000 kilowatts per day, what general methods are used to determine the electrical losses?—p. 389.
- 22 What is the best and most logical system for comparative records of the consumption of oil, waste, etc.: per kw-hour, per engine-hour, or per thousand revolutions of engine?—p. 390.
- 23 What is the most practical scheme for keeping a record of stock supplies in a central power station?—p. 391.
- 24 Is there any law against the use of postal cards for billing purposes? Have postal-card bills been found satisfactory in service?—p. 392.
- 25 Is it advisable to charge for small jobs of repairing for your lighting customers, such as inserting fuses, repairing sockets, loosening wires, etc.?—p. 393.
- 26 Do you consider mill lighting good business at regular rates; that is, mills that are operated only 55 hours per week?—p. 395.
- 27 Is it good policy for a company to take the agency for motors, electrical supplies, etc., in its territory?—p. 396.
- 28 Is it to the interest of a company to do wiring for its customers free of cost?—p. 399.
- 29 Is it advantageous for large lighting companies to carry their own liability and fire insurance?—p. 401.
- 30 Is it good business policy to make installations of motors for power in mills, factories, etc., simply on permission of owner, depending on satisfactory results to obtain contract after six months' satisfactory operation?—p. 403.
- 31 What results have been obtained in supplying Nernst lamps on flat rate?—p. 404.
- 32 Where a company has been operating on a flat-rate basis, and the Nernst lamp has come into use, would you require them to go on a meter or would you treat a 44-watt lamp as the equivalent of a 16-cp. incandescent? Meter rate, 10 cents per kilowatt; flat rate, 25 cents for residences and 60 cents for stores, etc.—p. 405.
- 33 Is it advisable to charge an employee with damages caused by gross or ordinary carelessness? If so, to what amount in dollars?—p. 405.
- 34 How do you meet gas-engine competition?—p. 406.
- 35 How do you meet the isolated plant competition?—p. 407.

## QUESTION

- 36 Which plan produces the best results and the most business ; solicitors on salary or on commission basis?—p. 409.
- 37 Please give examples showing cost per 16-cp equivalent for new business (1) on salary basis, and (2) on commission basis.—p. 411.
- 38 In view of the fact that electric-lighting companies are evincing a lively interest in the subject of advertising, would it be to the interest of the association to establish and maintain an advertising bureau to act as a clearing-house for ideas in this line and to assist members in framing and distributing their advertising matter?—p. 411.
- 39 Is it better to punish an employee for breach of rules by suspension or fine, or to warn first and then discharge, upon being satisfied as to his indifference or incompetency?—p. 412.
- 40 In an electric plant, operating continuously, what is a fair cost per boiler-horse-power per year to cover the stand-by losses in maintaining plant under full steam pressure—assuming careful design and good pipe-covering?—p. 413.
- 41 What is the best method of competing with the so-called Humphrey gas-arc lamp?—p. 413.
- 42 Is the Meridian incandescent lamp a successful competitor of the Humphrey gas-arc lamp?—p. 415.
- 43 Are the advantages of the card system of bookkeeping sufficient to warrant changing from the book accounts to the card system?—p. 415.
- 44 Does the Nernst lamp obtain for your company business that could not otherwise be obtained?—p. 416.
- 45 What is the liability of the supply company for damages caused by electric current beyond point of delivery on customer's premises?—p. 417.
- 46 To what extent should a supply company carry on inspection of customers' wiring installation?—p. 417.
- 47 What rates are electric-light companies in small towns getting for pumping city water with electric motors?—p. 418.
- 48 What success has been attained in devising a systematic method of recording and satisfactorily analyzing all cases of troubles in the operation of central-station systems?—p. 418.
- 49 What is the relative reliability of direct current and of alternating current and the satisfaction to customers in general city service?—p. 418.
- 50 What is the best light to furnish in competition with the Welsbach burner for street lighting? In a town of about 11,000 inhabitants, very much scattered, we have about 25 miles of street occupied by our wires. The annual appropriation for street lighting is about \$6500. The Welsbach people, through the local gas company, "captured" this year's town meeting and voted one-half the appropriation for gas lights at \$25 per light, all night, 25 nights per month. What can we put up against it, cost and character of light considered?—pp. 418-419.

## QUESTION

- 51 What is considered a good average income per kilowatt connected and per kilowatt demand load?—p. 419.
- 52 What is considered a good load factor?—p. 419.

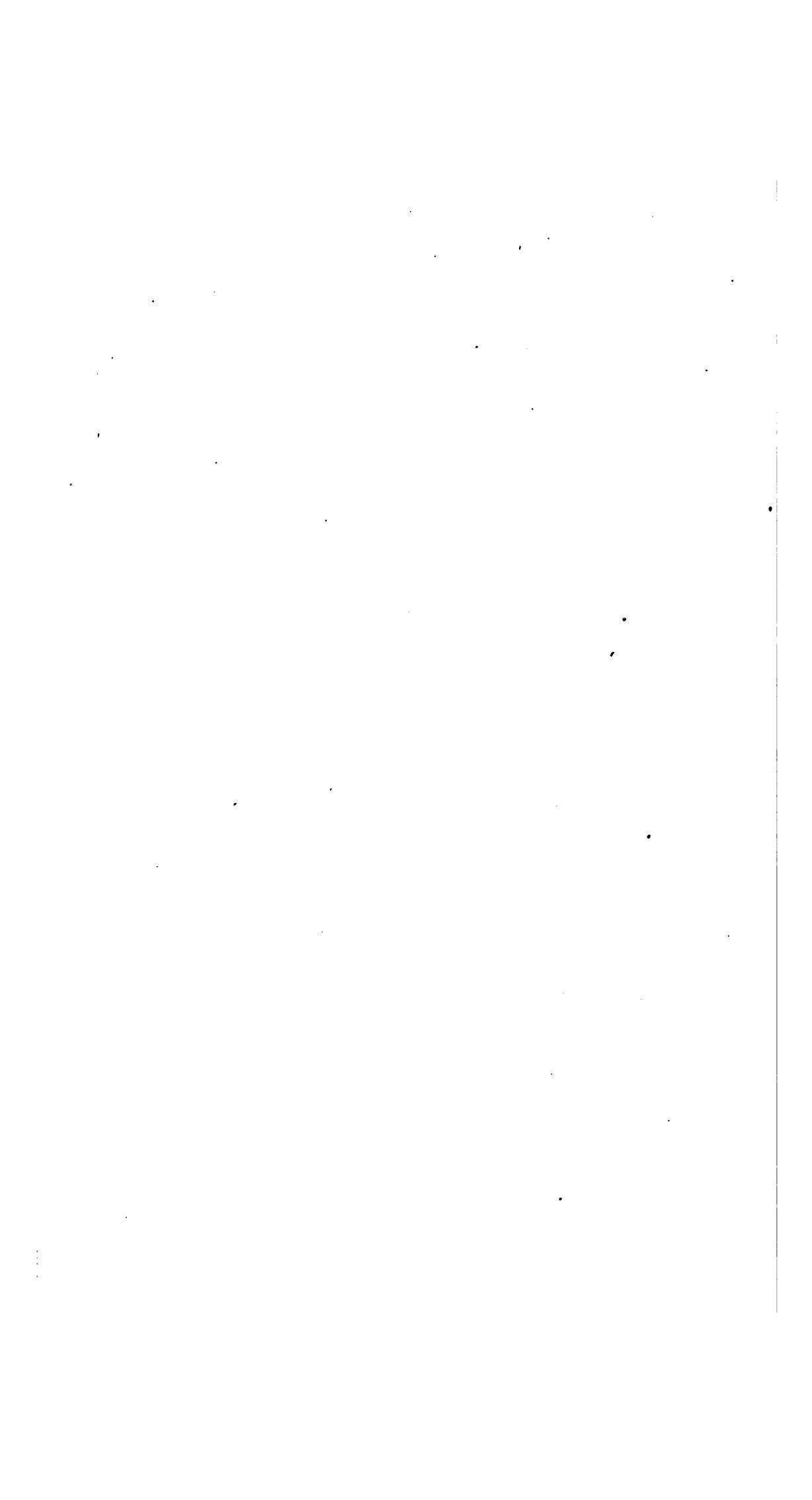
## W

## MISCELLANEOUS

- 1 How can iron rods be used to best advantage to supplement the tensile strength of the concrete in building a concrete engine or dynamo foundation?—p. 419.
- 2 Is there any formula for determining the size or number of rods to be used for this purpose?—p. 419.
- 3 Please give rules for designing water rheostats for testing dynamos, and such details of construction as may be necessary.—p. 419.
- 4 What are the proper proportions of the solution in an ordinary sal-ammoniac battery cell?—p. 420.
- 5 Do any of the members use electricity for thawing out frozen water pipes? I mean those pipes connecting the mains in the street to private houses or other buildings, and also the interior piping. If so, please give details as to amount of current and voltage required for various sizes and lengths of pipe, method of connection and regulation, troubles experienced, etc.—p. 420.
- 6 Can an ordinary electric call bell be operated successfully in series with five incandescent lamps on a 500-volt direct-current circuit?—p. 426.
- 7 I have three six-inch electric bells connected in series with a push-button, but they do not operate satisfactorily. What is the best method of connection?—p. 427.
- 8 Please give the percentage of light reflected by surfaces of each of the various colors.—p. 428.
- 9 Can not some manufacturer invent a socket that will not allow a customer on flat rate to change a certain candle-power lamp for one of greater candle power? For instance, so that when he contracts for 10-cp lamps he can not use a 16-cp or a 25-cp lamp?—p. 429.
- 10 What would be the loss on 1250 horse-power at full load as follows: Generated at 2000 volts, three phase, 60 cycles; stepped up to 20,000 volts and transmitted 18 to 20 miles on three No. 4 bare copper wires; stepped down at substation and delivered at distributing switchboard at 2000 volts? Current to be used for power (induction motors) as well as for light.—p. 429.
- 11 What would you consider a fair estimate of cost for operating (24-hour service) under the above conditions as compared with the cost of operating a combined generating and distributing station, also provided with ample water-power and situated as nearly as possible in the centre of its field of distribution, which field is the same as would be served by the 20-mile transmission and substation above?—p. 430.

## QUESTION

- 12 What, in your experience and from best information, is the probable excess of actual cost of electrical and hydraulic developments over original estimates when five per cent has been allowed for contingencies, and five per cent for engineering and superintendence by the engineers making the estimates?—p. 430.
- 13 What is meant by the expression "circular mils"?—p. 430.
- 14 Is there any authoritative treatise, or any compilation of reliable testimony, in regard to death or injury to persons or animals from electric shock?—p. 431.
- 15 What is the best way to educate the public to a realization of the fallacy of municipal ownership?—p. 431.
- 16 What is the usual percentage of current for light and for power on alternating-current central-station plants in representative cases?—p. 432.
- 17 What is the power factor at different hours on the alternating-current output of central stations supplying lights and motors?—p. 433.
- 18 What is the comparative value of electric currents and 700 heat-unit gas as used for cooking purposes?—p. 433.
- 19 What is the efficiency of conversion of heat in the ordinary cooking utensils as operated by gas stoves and high-grade electric utensils?—p. 433.



# Wrinkles

CHARLES H. WILLIAMS, *Editor*



# WRINKLES

## 1

### **Circle Diagrams for Keeping Track of the Economical Working of Men and Apparatus**

Valuable information for a station manager to have clearly in mind is the arrangement of the different shifts of men in relation to the time of operating different machines and different kinds of apparatus, and it is only after a careful analysis that it will be possible for a manager to know accurately whether or not he is getting the maximum efficiency out of his employees by having their hours of working so arranged that each man is worked to his best ability at all times.

In order that such information may be clearly presented, circle diagrams may be constructed, which will be found to give a comprehensive, graphical statement of the actual conditions that exist. In preparing such diagrams, faint concentric circles are drawn, the number of such circles depending upon the number of men or the number of machines, engines, boilers or generators under consideration, each man or each machine to be considered being given one circle. From the common centre, radial lines are drawn, 24 in number, representing 24 hours of the day. When several different classes of employees are to be considered, or when different kinds of apparatus or the time of operating different kinds of apparatus are to be shown on one diagram, different kinds of lines are made use of to distinguish one from the other.

Referring to accompanying chart *A*, the solid lines represent firemen, and the broken lines represent the time of working of the different engineers. For instance, starting at one o'clock in the morning, it will be seen that one fireman is on duty from one a. m. until eleven a. m. At eight a. m. another fireman starts to work, and is on duty until six p. m. Another fireman starts working at three o'clock in the afternoon, and ends his shift at one o'clock in the morning, while one coal passer, whose labor is charged to the boiler-room as a generating cost, starts to work at seven o'clock in the morning and works until six at night. In the same manner, we have one engineer coming on duty at two o'clock p. m. and working until midnight. Another works

from four o'clock p. m. until four a. m., while a third works from four o'clock a. m. until four p. m.

Referring next to chart *B*, the time of operation of different engines in use is shown. In the station under consideration, the engines (four in number) are numbered consecutively from the centre of the circle out. No. 1 engine starts at 5.30 a. m. and

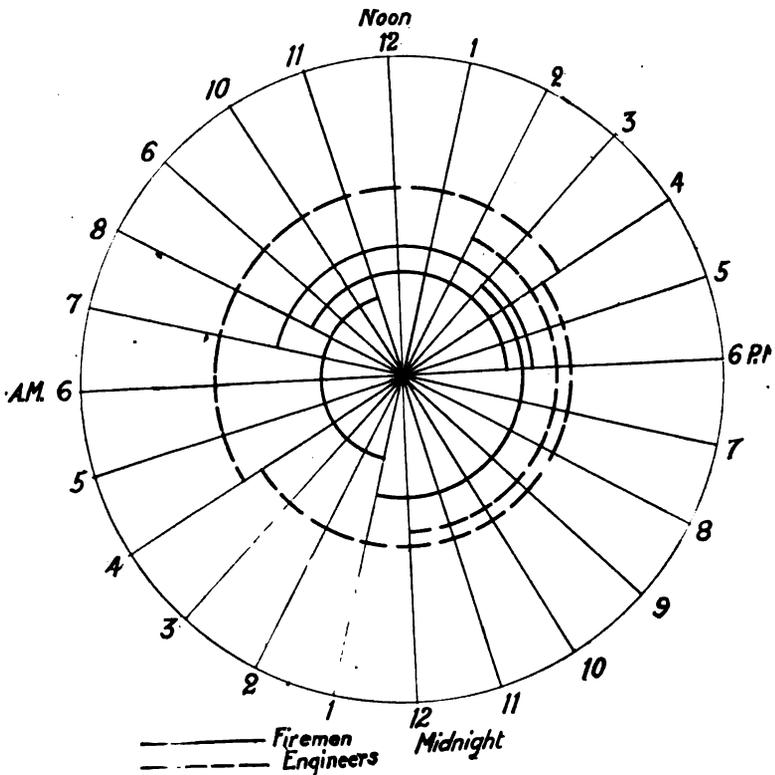


CHART A—FIREMEN AND ENGINEERS

runs continuously until one o'clock the following morning; No. 2 runs from 12.45 a. m. until 7.30 a. m.; No. 3 from five p. m. to twelve midnight; No. 4 from 6.45 a. m. until four p. m.

Referring to chart *C*, we find the time of operating the individual generators; the solid lines representing alternating-current machines, the dotted lines the 500-volt direct-current

machines and the dash-and-dot lines representing direct-current arc machines.

Referring to chart *D*, the time of operation of the three boilers is shown.

With the four charts before him, the station manager can see at a glance for any hour in the day the number of men who

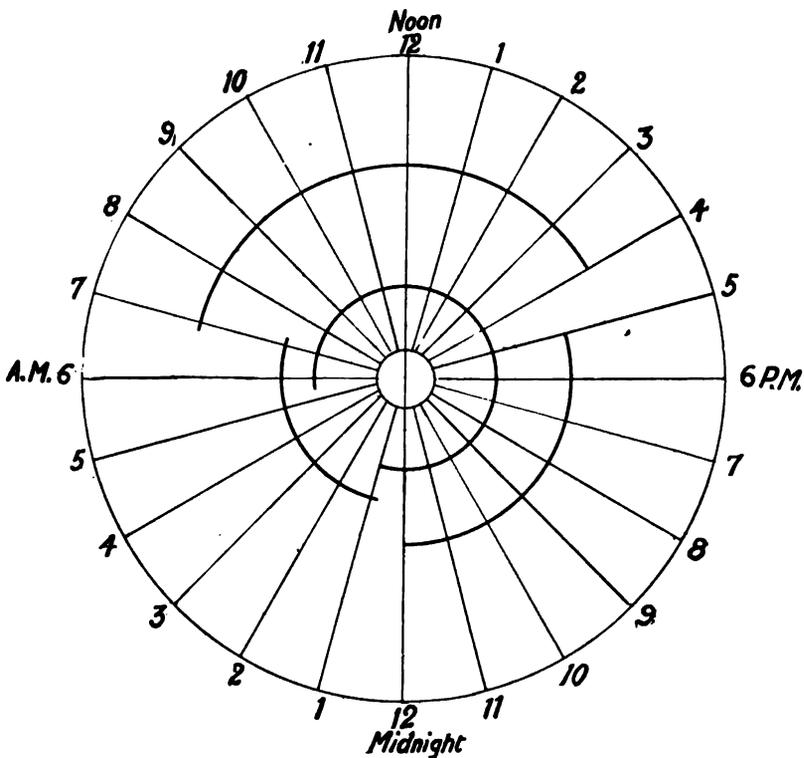


CHART B—ENGINES

are on duty at the plant, also the number of boilers, engines or generators that are operating, and unless a careful analysis has been made of the work that is required of the different men, it will very frequently be shown that much greater responsibility and much more work is thrown upon one shift than upon another.

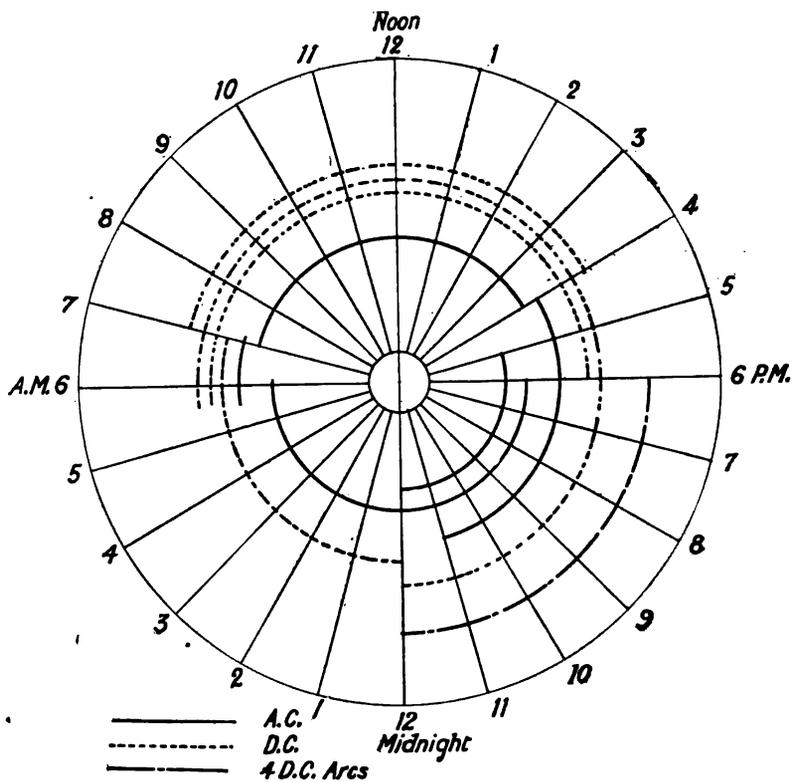


CHART C

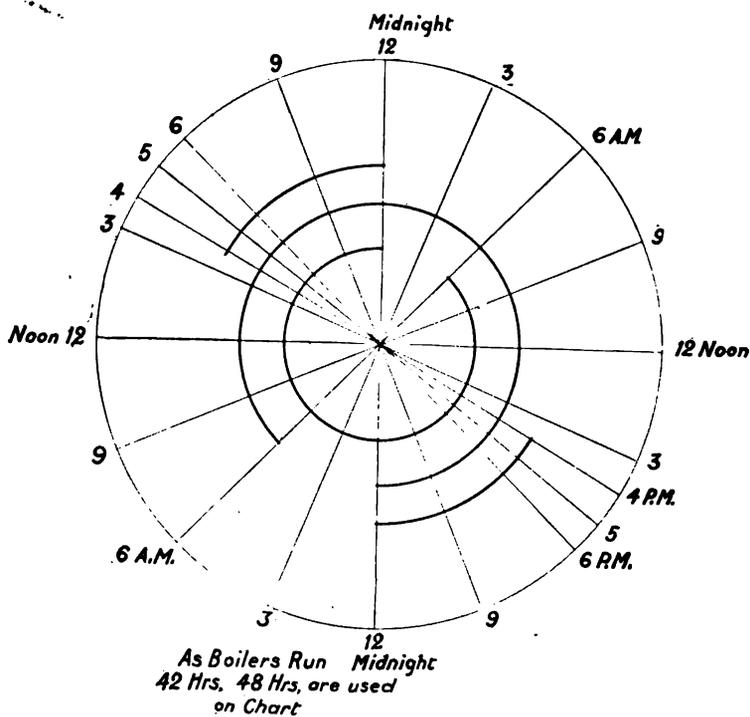


CHART D—BOILERS

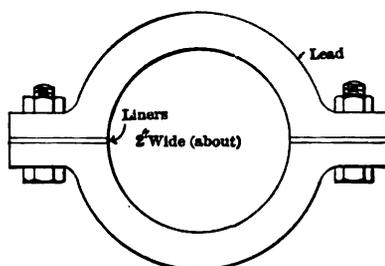
Of course, it is necessary in making the comparisons between the shifts to consider the output of the station at the hour under consideration, as well as the other work, such as cleaning and repairing, that is required of station men operating a small plant. This scheme also lends itself as a ready argument against increased help, which is sometimes unreasonably asked for, as it will show quite forcibly the duties required of the individual workmen.

R. GRIEVES, Columbus, Ohio

## 2

### Truing Engine Pins

In operating an engine the crank pins, cross-head pins and the pins in the valve gear have a tendency to wear flat, even with the best of care, and the difficulty of having a quietly running engine with cool pins can frequently be traced to this cause. Some engineers file their pins and smooth them up, but this requires a very skilled man and is a long and tedious operation. Re-turning the pins in place is difficult and has the disadvantage of materially reducing the size of the pin, as the tool must go under the hard skin to make a perfect cut.



LAP FOR TRUING ENGINE PINS

We have adopted the practice of lapping pins that have become flattened. The process is simple, quick, and leaves a smooth and perfect pin.

The lap is of lead or of cast-iron faced with lead and is made in halves with liners, similar to an eccentric strap. The faces of the two halves should be fitted together nicely and the lap be bored to the size of the pin to be lapped, with the liners slotted so as to facilitate their removal without taking out the bolts. For a pin six inches long the lap should be two inches

wide, and should be allowed to move from end to end of the pin. It is made narrow to avoid requiring too much power to work it. In operating the lap the lead is well supplied with emery and oil, clamped on the pin and rotated back and forth, at the same time being moved across the pin at each rotation, as holding continuously in one place has a tendency to make the pin wiry. We have lapped a seven-inch pin, eleven inches long, that was one-thirty-second of an inch out of round, fitted the brasses, and been running again in eight hours. This on a very hard nickel-steel pin. We believe this is as quick as the work could be done with a machine, and there was much less reduction in size than would have been possible had the pin been turned, filed or chipped. During the process, of course, the oil holes are carefully stopped and the emery carefully wiped off. We have found absolutely no bad effects in running after the use of emery powder.

A. GARTLEY, Honolulu, Hawaii

### 3

#### A Scheme to Prevent the Oil from Being Thrown from a Dynamo Bearing

We have had some trouble with one of our machines throw-

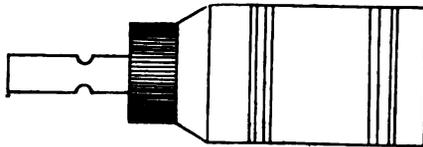


FIG. 1

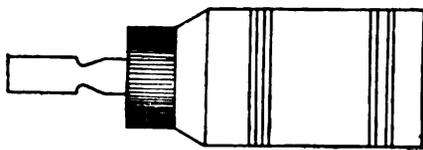


FIG. 2

ing oil up on the commutator. We maintained the oil level in the bearings as low as we dared, but some of the oil would come

out. As you are aware, there is a groove cut into the shaft, which is supposed to keep the oil from running out along the shaft. These grooves are cut into the shaft in the manner shown in Figure 1. I beveled off the side next to the commutator as per Figure 2, and have had no more trouble with oil.

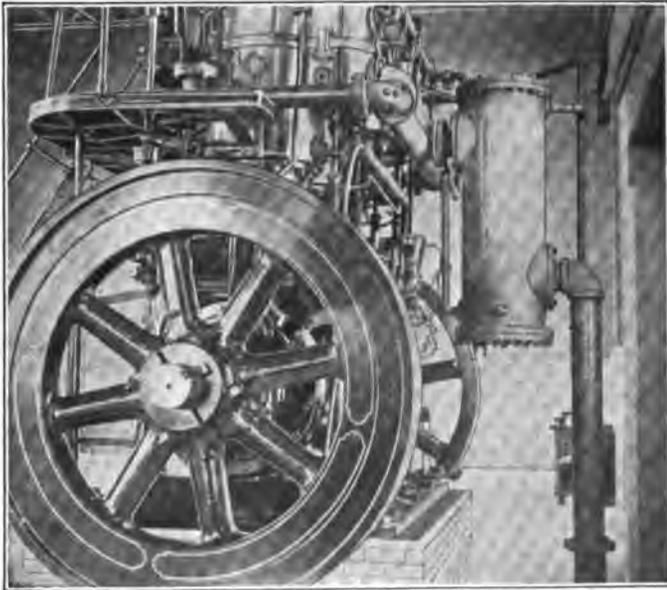
The reason of this is that the oil tends to climb the high side; it will therefore stay in the bearing where it will do some good.

C. G. KNODE, Long Branch, New Jersey

#### 4

##### A Feed-water Heater on a Gas-engine Exhaust

About 40 per cent of all the heat of the gas that goes into a gas engine is lost in the sensible heat of the exhaust gases. If any use can be found for hot water around the plant, this heat can be recovered to a very large extent.



A FEED-WATER HEATER ON A GAS-ENGINE EXHAUST

The cooling water passes around the cylinders in the water jacket, and then generally goes to waste. At the gas-engine plant at Madison, Wisconsin, this water is led through a Wain-

wright feed-water heater after it leaves the jackets, and there takes up additional heat from the exhaust gases that pass on the inside of brass tubes, while the jacket water passes on the outside. By this scheme, the feed water, which enters the jackets at 40 degrees Fahrenheit and leaves them at 100 degrees Fahrenheit, enters the feed-water heater at 100 degrees Fahrenheit, and leaves it at 210 degrees Fahrenheit. The pump that supplies the cooling water to the engine jackets forces this water on through the feed-water heater over to the boilers at the gas works, where it reduces the steam fuel expense 12 per cent on a plant with a make of about 100,000,000 cubic feet of mixed gas per year.

F. M. RICHARDS, Madison, Wisconsin

## 5

### Signal Device for Circuit-breakers of Switchboards

It has been found desirable that circuit-breakers on switchboards and elsewhere have some means of indicating promptly the instant that breaker "opens," in order that the attendant in charge may be notified and give same prompt attention. This is usually done by connection with a bell circuit.

A very reliable and trustworthy method has been found to be to make use of the current of the same circuit in which the circuit-breaker is installed for a signal-lamp and bell circuit. The necessary number of lamps are connected in series across the bus-bar circuit from which the current passing through the circuit-breaker is supplied. The current to operate a bell circuit is supplied from a shunt around one of the lamps in the signal circuit, or in shunt around a resistance placed in series with lamps of the signal circuit. The bell circuit is then wired in such manner that the opening of the circuit will close the signal circuit, and the bell will continue to ring until the circuit-breaker is closed again. The use of dynamo current in this manner can always be relied upon, and it eliminates unreliability and the troubles usually experienced where batteries are employed.

G. WILBUR HUBLEY, Louisville, Kentucky

## 6

### Running Alternators in Parallel

We are operating two 300-kw, two-phase, 2000-volt alternators, direct-connected to vertical cross-compound marine

engines, running 189 revolutions per minute. The alternators are on the ends of an extended shaft, and each engine is fitted with a 13,000-pound flywheel between the alternator and the engine. The cranks are not at right angles nor opposite, but the high-pressure crank leads the low-pressure crank 150 degrees. This crank angle was adopted to give uniformity of rotation during each revolution. We found that notwithstanding this precaution, the heavy flywheel and high speed, there would, under certain conditions, be some variations in speed during each revolution. The machines would run in parallel sometimes

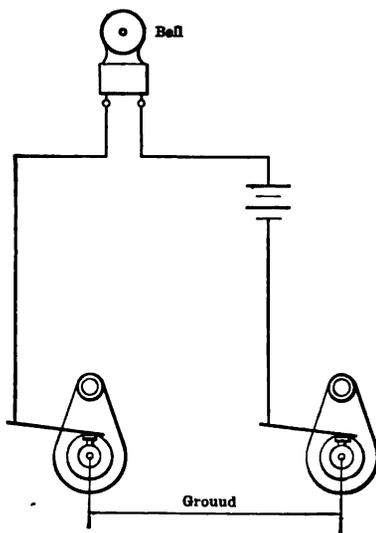


DIAGRAM SHOWING CONNECTIONS

without any surging; at other times the surging would be quite pronounced. The engines are exact duplicates, and we found that when the alternators were thrown in parallel with the cranks of the two engines at the same point of the stroke we would have no difficulty. Since demonstrating this fact we have constantly run our engines under these conditions. To accomplish this we placed on each engine shaft a small wooden disc. A small contact, grounded through the shaft, was placed on this disc in a certain position relative to the crank pin. A small brush, insulated from the ground, was placed in contact

with this disc and two brushes placed in series with a battery and bell. As the contacts on the two engines passed into these brushes the circuit was established and the bell was rung. If the alternators are in synchronism at the same time the switch is closed the engines will then run together for a week at a time, each taking its proportion of the load without surging or disturbance on the electrical end.

A. GARTLEY, Honolulu, Hawaii

## 7

#### **Running Dynamos as Motors in Case of Breakdown of Engine**

If an engine that drives both alternating and direct-current machines breaks down, and it becomes necessary to use the direct-current dynamos during the day, and the single-phase alternator at night, it can be accomplished by disconnecting the connecting rod and valve rod of the engine and running the alternator as a motor, thus driving the direct-current machine during the day, and at night reversing the condition by running the direct-current generator as a motor, thus driving the alternator. A water resistance is used in starting the direct-current machine to be run as a motor, the water resistance being cut out as soon as the machine is up to speed.

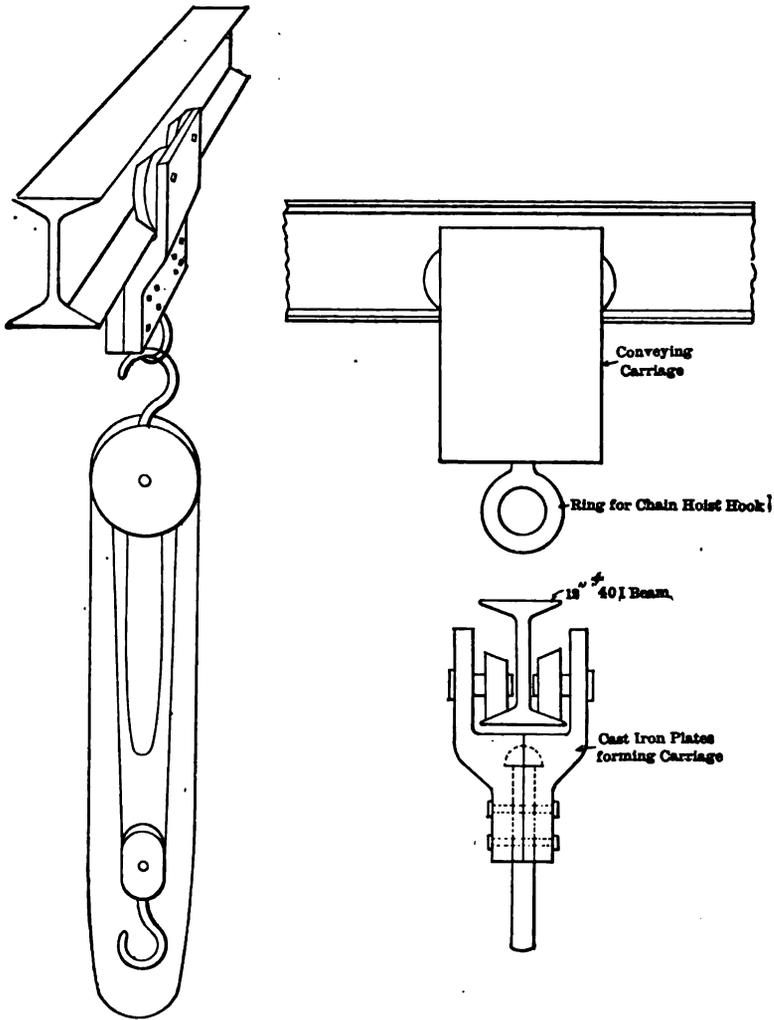
Before the alternator can be thrown on the circuit to be run as a motor it must be brought to synchronism with the other alternating-current generators. This is done by running the direct-current machine as a motor and adjusting its field resistance until synchronism is reached; then the alternator is thrown in and will run as a motor, while the direct-current machine is switched out and run as a generator. A synchronizer can be improvised for the purpose by the use of two line transformers, by connecting the primary of the one to the 'bus-bar and the primary of the other to the terminals of the alternator that is to be run as a motor. The secondaries are connected in series through two lamps.

WM. GALLAHER, St. Louis, Missouri

## 8

#### **A Home-made Travelling Crane**

A great many of the smaller and older stations are not fortunate enough to have a traveling crane in the plant and



DETAILS OF TRAVELING CRANE

have to resort to all kinds of make-shifts in order to do heavy lifting, which is bound to occur along with repair work. A cheap and quite satisfactory arrangement can be made use of as follows :

Out of eight-inch by ten-inch pine timbers make two (*A*) frames which fit snugly into an extra heavy twelve-inch I-beam, as shown in the accompanying sketch.

By referring to the sketch it will be seen that the strain at the beam is mostly one of compression along the length of the beam. Bolts are passed through both timbers above and below the I-beam, and substantial cross pieces are fastened diagonally across the two legs to add stiffness. A heavy timber is notched out near each end, to keep the legs from spreading, and bolts are run through the ends of the bottom beam to prevent any tendency of shearing of the end pieces.

A carriage made up of four wheels with faces beveled off to fit the flange of the I-beam distributes the weight to be carried over the face of the flanges.

The hook block, which is below the I-beam, has two stiff cast-iron plates running up to carry the pins on which the wheels revolve.

A heavy chain block, fastened into the hook, completes the arrangement, which is of sufficient capacity to pick up any weight that the average station is called upon to handle.

The crane can be set up easily by four men in half a day and when not in use can be readily taken apart and stored away

A 20-foot, 12-inch I-beam weighing 40 pounds per foot costs \$24, and the carriage can be built at any machine shop for \$30, while a five-ton hoist of 12-foot lift will cost \$85.

With this arrangement a piece of apparatus can be picked up and moved along the length of the I-beam 15 to 18 feet in a very short time.

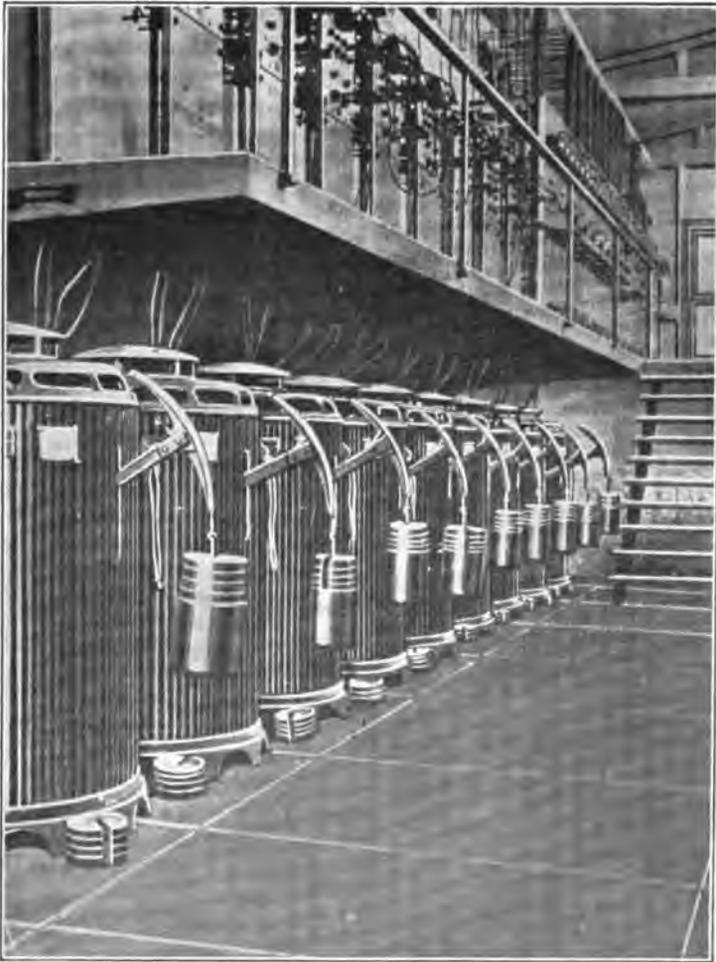
B. C. ADAMS, Madison, Wisconsin

## 9

### **Economic Arrangement of Alternating-current Series Arc Lighting Apparatus to Economize Floor Space**

The accompanying cut illustrates our arc-lighting outfit, which controls the lighting of some 400 city arcs in eight circuits. You will note that it indicates the switchboard panels

and the gallery just above the constant-current transformers, which gives us a very compact arrangement and enables us now



ARRANGEMENT OF TRANSFORMERS.

to use one corner of a building which was previously almost entirely occupied by arc machines.

H. SCHREIBER, Augusta, Georgia

## 10

**Switchboard Located to Facilitate Careful Watching  
Where One Man Operates the Plant**

Our plant being small, one man fires the boilers and looks after machinery, too, for the most of the time. Not owning a voltage regulator, and our switchboard not being as conveniently located as we could wish, we moved our voltmeter and rheostat into the boiler-room, where the engineer can have them right at his elbow all of the time, and we find that it enables him to keep the voltage almost exactly uniform.

W. A. THOMAS, Abingdon, Illinois

## 11

**An Electric Bell Used as an Alarm to Tell Where a  
Circuit-breaker Is Open**

We had trouble with our power circuit. The circuit-breaker would go out occasionally and the noise of the station usually prevented the attendants from hearing it, so the circuit would remain open until the ammeter was read or some consumer complained. To avoid this trouble we put a bell on the 110-volt circuit, with contacts arranged so that the bell circuit would close when the breaker was open. The noise of the bell could easily be heard by the attendants and the circuit-breaker was closed.

JAS. DAHLES, Lincoln, Nebraska

## 12

**An Electric Siren Used in Place of a Telephone Gong**

I take pleasure in inclosing herewith a wrinkle that we have had in use in our station for several years ; it has been quite a curiosity to people from other places who have visited us from time to time. You, no doubt, have experienced trouble in having telephone calls answered promptly by the operators in your central station. To overcome this trouble we made and put in several years ago what we call an electric siren. This piece of apparatus is nothing more nor less than a horn, operated on an alternating current of electricity. We have made out the

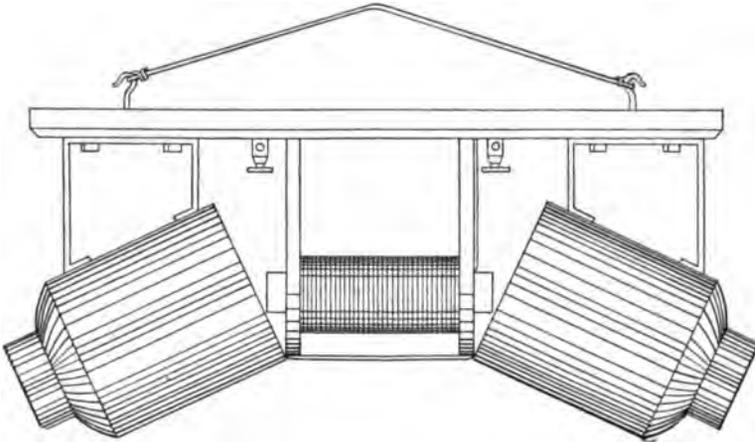
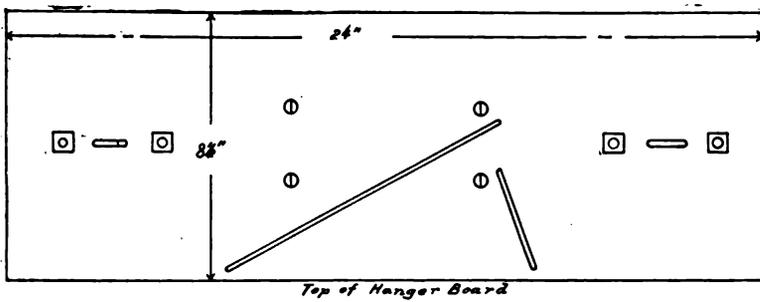


FIG. 1



Top of Hanger Board

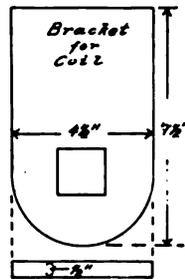
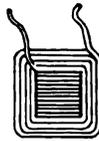
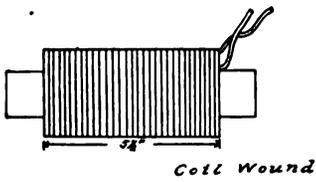
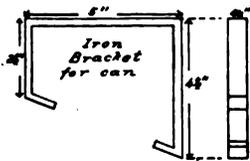


FIG. 2

DETAILS OF MAGNETIC SIREN

working drawings so that should any one be disposed to manufacture one it can be very easily done at an expense of five or six dollars, and the result will be that from the time it is

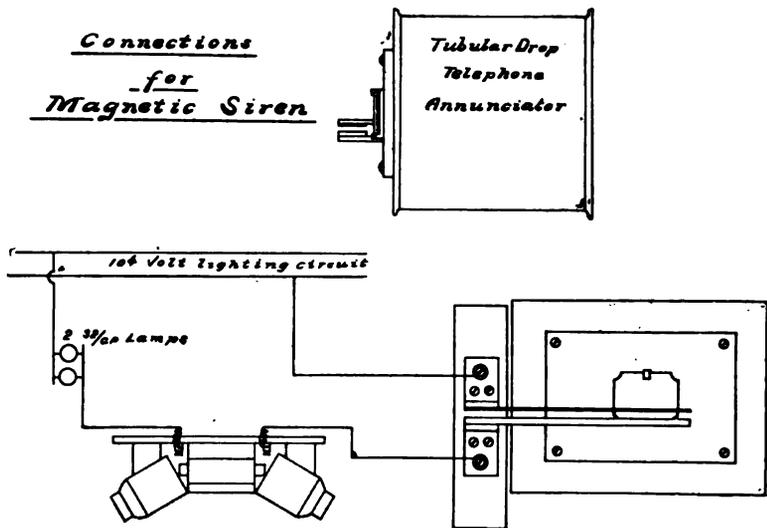


FIG. 3

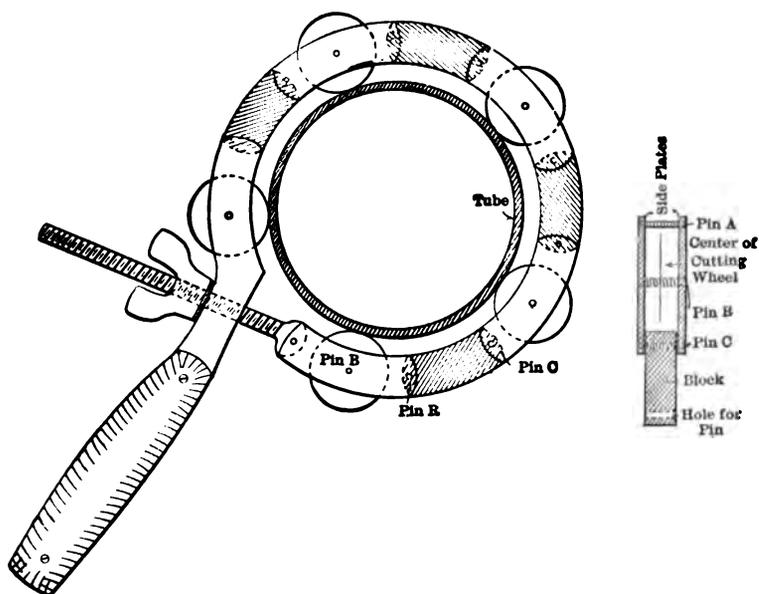
installed there will be no further excuse for not hearing the telephone ring, as a machine of this kind can be heard several blocks from the station.

F. G. PROUTT, Memphis, Tennessee

#### A Tool for Cutting Out a Boiler Tube from a Water-tube Boiler

Perhaps the accompanying diagram will give you a suggestion that some of the members of the association have not had in regard to cutting out a tube from a water-tube boiler. The principle is that of a bicycle chain made of alternate steel blocks and plates, the cutter wheels being set between the plates. With five cutters the tube can be cut out by moving

the handle one-fifth of the distance around the tube and then back again, etc. We have made these in our own shop for about \$3.00, buying the wheels. We find that we can cut out ten



TOOL FOR CUTTING OUT BOILER TUBE

times as many tubes from a water-tube boiler in a day as we can with the old method.

A. J. GODDARD, Freeport, Illinois

## 14

### To Change the Diameter of a Dynamo Pulley by a Small Amount When Necessary to Obtain Exact Synchronous Speeds of Alternators for Operation in Parallel

Where it is difficult to obtain pulleys of exact relative sizes for synchronous operation of generators, the diameter can quite easily be increased one-half inch by means of a paper covering. To do this, the pulley—no matter of what material it is made—should be thoroughly cleaned of all grease and oil, and the surface roughed up by scraping or draw filing. Heavy manila

paper cut to the right width is glued to this surface, care being taken to have the glue hot and not too thick. Press the paper firmly down upon the pulley face in starting, and then draw the paper tight as the pulley is turned, pressing and pounding the surface carefully as each additional section is glued.

When one complete cover is fastened to the face of the pulley, the glue is applied to the exposed surface of the paper, and the operation continued, being careful to see that no bubbles or wrinkles are left on the surface.

If it is desired to make a crown on the pulley, this can be done by gradually narrowing down the width of the sheets that are being glued.

This glued-paper addition to the pulley forms a substantial, lasting surface, and makes a very good surface for the belt to drive upon.

W. E. EMERY, Madison, Wisconsin

## 15

### Repairing a Defective Boiler Crown Sheet

We once had a cracked crown sheet in one of our boilers, due to a brace-rivet hole. It was cut out and patched repeatedly, until the hole grew to be eight inches in diameter. The rivet holes would crack out, due to unequal and violent expansion. We remedied the trouble entirely by placing a soft-copper gasket between sheet and the patch, cut from sheet copper, about three-sixty-fourths-inch thick, or less.

D. L. DAVIS, Salem, Ohio

## 16

### Keeping a Commutator in Good Shape Without Turning or Sandpapering

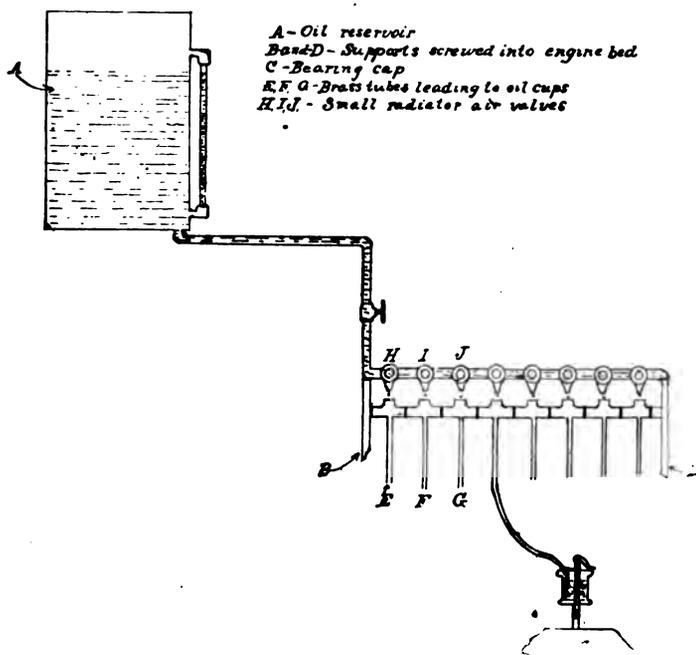
In taking care of a commutator on a D-62 generator, it was with much difficulty and turning that we kept it from sparking badly. We finally remedied the trouble entirely by taking a piece of soft sawed paving sandstone, about the width of the commutator, and holding it on while running. Even with current being generated the commutator was dressed up so that sparking ceased, and ran smoothly. The stone soon gets a concave shape to fit the surface of the commutator, and then does still better.

D. L. DAVIS, Salem, Ohio

## 17

**Arrangement of Oil-tank Valves, Etc., for Oiling  
High-speed Engines**

The accompanying cuts illustrate two schemes which our engineer, Mr. Samuel Beatty, has put in use in our plant here. The first is an arrangement of oil-tank valves, etc., for oiling high-speed engine. A ten-gallon tank is placed about five feet above the top of the engine bed. This leads to a framework in which is fastened horizontally a section of three-eighths-inch pipe.



ARRANGEMENT OF TANKS, VALVES, ETC., FOR OILING ENGINE

This pipe is drilled and tapped to receive a number of small air valves, corresponding to the number of oil cups that it is desired to feed. From these valves the oil drops into openings in the sides of a corresponding number of tees that are joined with short nipples and have the nipples soldered shut. From these tees the oil is carried in eighth-inch-bore brass tubes to the

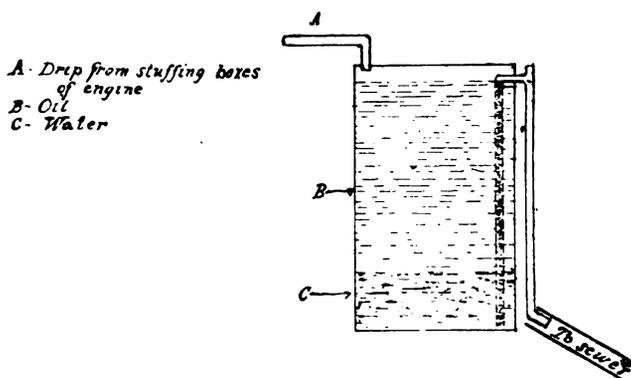
several oil cups. The small valves are set to allow the proper flow of oil, and in shutting down the engine all that is necessary is to close the globe valves in the supply pipe, leaving the small valves set at the proper opening. We have found this arrangement a great saver of oil and time and, in addition, it keeps the oil cleaner and gives an additional sight feed. The framework was made of quarter-inch pipe.

E. C. WARD, Washington, New Jersey

## 18

### Tank for Collecting and Separating the Drip from the Stuffing Boxes of an Engine

The second is an arrangement of a tank or can for catching the drip from the stuffing boxes of the engine. The oil and water fall into the can and are there separated, the water going to the bottom of the can. A pipe extends from the bottom of the can almost to the top, and from there down into the waste



RECEPTACLE FOR SEPARATING OIL FROM WATER

pipe. There is an opening in the highest part of the pipe, which acts as a vent and prevents any action as a syphon. As the oil reaches the level of the highest part of the pipe the water flows out, and continues to do so until the can is full of oil. We are thus able to save three or four gallons of oil per week, which would otherwise be wasted.

E. C. WARD, Washington, New Jersey

## 19

## A Winding Machine

Quite a satisfactory way to make a winding machine is to take an old sewing machine and saw off the arm close to the bearing at the drive end. Saw off the shaft at the desired length and run babbitt into the hollow shank, to make a bearing that will support the shaft. File the shaft down where it is cut off in order to make a head stock for the machine. The tail stock is made of a bolt threaded full length, and made to work through two nuts held in position at each end of a tee. The tee is made of iron piping, and the nuts are held in it by running babbitt around them after being put in place. The diagram shows the construction of the machine.

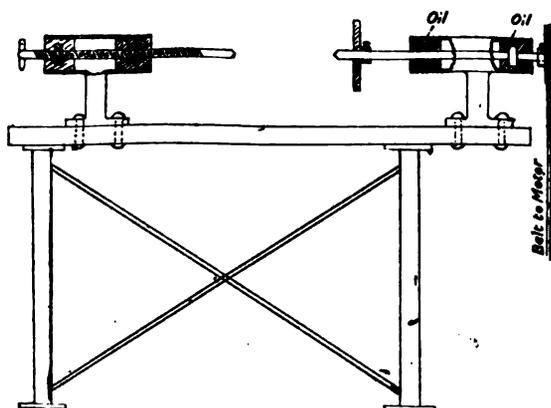


DIAGRAM SHOWING MACHINE AND CONNECTIONS

A piece of the old machine may be used for a face plate, and another for a dog. The machine may be operated either by foot, or by means of a small induction fan motor. The fan can be taken off from the motor and a grooved pulley substituted for it. A grooved pulley on the machine and a sewing-machine belt complete the apparatus. Retainer coils on starting boxes, small field coils, arc-lamp coils, meter coils, resistance coils in starting boxes, and other windings, may be wound with this machine. The device will be found very convenient and will afford a great saving of labor and expense.

WM. J. HUGO, Madison, Wisconsin

## 20

**Plugging a Small Break or Leak in a Steam Main While  
It Is Under Pressure**

This is probably a "chestnut." Whittle a plug on the end of a long stick, push the plug into the hole where the steam is escaping and then break off the remainder of the stick. In this way the man will be away from the escaping steam.

GEO. B. LAUDER, Concord, New Hampshire

## 21

**An Arrangement to Utilize Transformer-cooling Water  
for Boiler-feed Water**

The accompanying sketch shows a scheme we have adopted by means of which the consumption of city water on meter basis is materially decreased by turning the water used for cooling the station transformers into the boilers. The system of operation is as follows:

A large tank *A* is placed at sufficient elevation above the transformers to insure the necessary head of water to effect circulation in the cooling pipes of the transformers. The waste water of the transformers is carried to a smaller tank *B*, situated below the transformers, and from this tank the water is drawn into the pumps. The system of piping and valves is such that either pump may feed into the boilers or may feed back into tank *A*. The water level in tank *A* is maintained constant through a float valve on a pipe connected with the city water system, the city water system being also connected to the transformers for the purpose of flushing the pipes when necessary. It is also seen that the feed from tank *A* maintains a constant level in tank *B* through another float valve. Should the supply of water from the transformers exceed the demand of the boilers for feed water, the idle pump is started up and returns the water from tank *B* to tank *A*, thus using the transformer cooling water over and over. Should the demand of the boilers exceed the supply of water through the transformers, the float valve in tank *B* is open, demanding a supply from tank *A*, the level in which is in turn maintained at a constant point through the float valve on the city water system. There is also an arrangement, not shown in the sketch, whereby the pumps are operated condensing, in order to raise the temperature of the

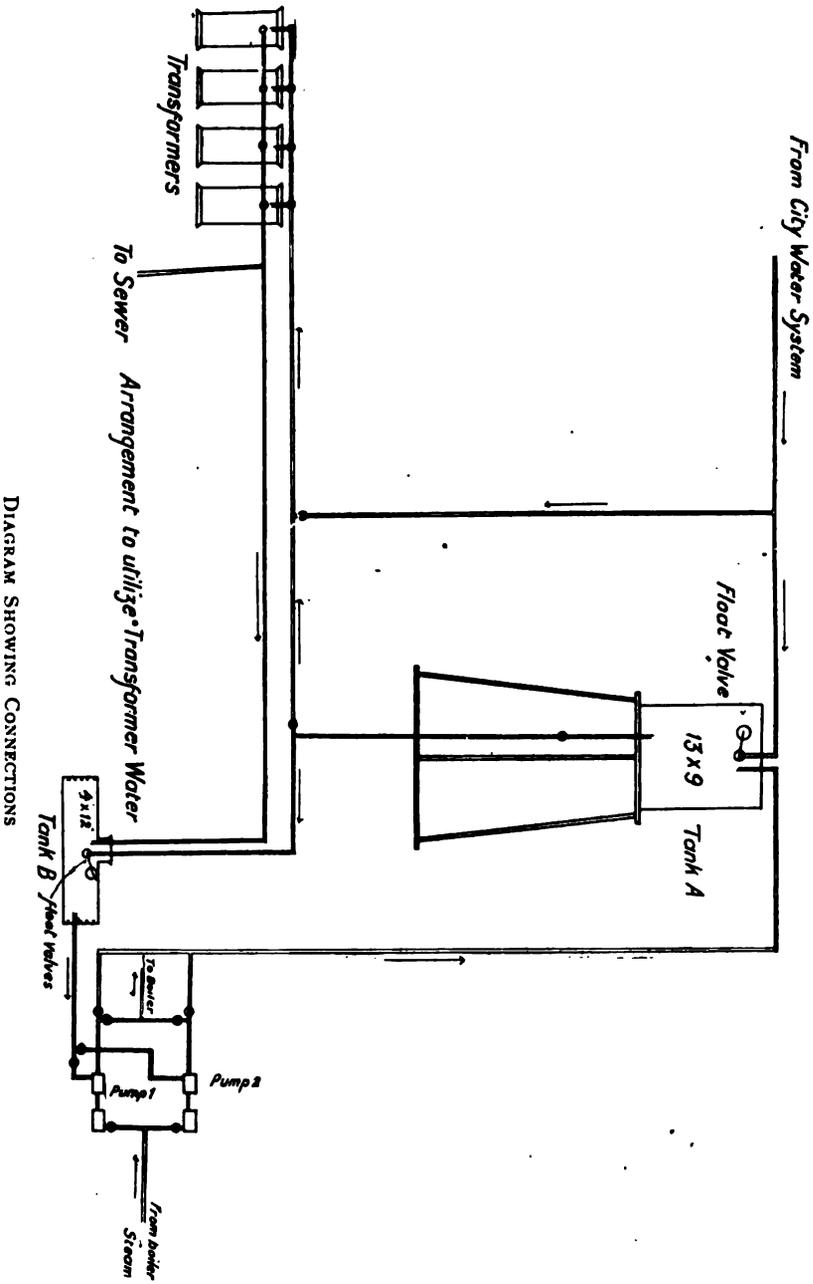


DIAGRAM SHOWING CONNECTIONS

feed water going to the boilers. This scheme was adopted for the purpose of reducing the supply from the city water system, which is sold to the company on meter basis, and the size of the transformers and boilers is such that the operation has effected a saving of more than 50 per cent in the consumption of water per month.

GEO. B. TRIPP, Colorado Springs, Colorado

## 22

### A Gas-engine Igniter

The accompanying sketch shows an arrangement for igniting gas in a gas engine. We use gas engines exclusively for operating our plant, having two 125-hp three-cylinder Westinghouse gas engines, belted to 90-kw alternating-current generators. We also have a 110-hp two-cylinder Otto gas engine.

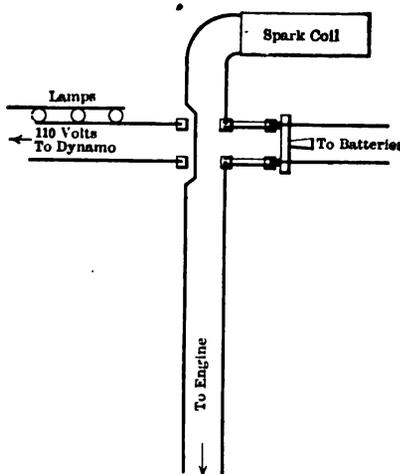


DIAGRAM SHOWING CONNECTIONS

We found it rather expensive to use the Edison-Lalande cells, and the small dynamos that the engine people furnish for the ignition of the gas did not seem to make spark enough; this was especially so when a little crank case oil would get on the points of the igniters, causing them to miss and give us all kinds of trouble. You will note in the drawing that we have

a double-pole, double-throw switch. We start the engine with the batteries, and as soon as the exciter builds up we throw the switch over on to the exciter current and use that throughout the run. By using the current from the exciter through the three lamps we never have a miss fire, and the platinum points on the igniter stems do not wear as fast as when we were using the 10-volt ignition dynamo. The wear of the platinum point on any gas engine with dynamo ignition will depend altogether on the clearance given the trip stem nut. If the clearance is too great the igniter points will remain in contact too long, causing them to heat and cut out rapidly. Our rule for setting igniters is to give not more than one-sixteenth-inch clearance between the igniter arm and the trip stem nut.

A. M. JONES, Sistersville, West Virginia

## 23

### **A Tell-tale Lamp Used to Keep Down the Expense of Current Used by the Company in Station Lighting**

It is customary among station engineers to go to great extremes to save the expenditure of a few watts wasted energy in designing or buying electrical machinery. After having secured the most efficient machinery possible in a plant, it is the common practice to put as many incandescent lights around the plant as can be conveniently installed. It is a fact that these lighting circuits probably consume more energy than was saved through buying more efficient machines; hence this wrinkle.

In lighting or wiring of stations, and in fact all company property, we make it a practice to control all circuits possible with switches at one central point, and insert in the circuit at the controlling point one standard receptacle into which is inserted a 25-watt incandescent lamp colored red. This lamp, of course, burns whenever the current is thrown upon the lighting circuit, and we find that it has resulted in a very material saving in the amount of energy required to light our various stations and properties.

A red lamp is not at all pleasant to look at, and men working within the vicinity of the lamp will almost invariably make it a point to pull all the switches possible. While this is a comparatively small matter, yet in the course of a year's run it amounts to a great deal of saving; and, as a matter of fact, the

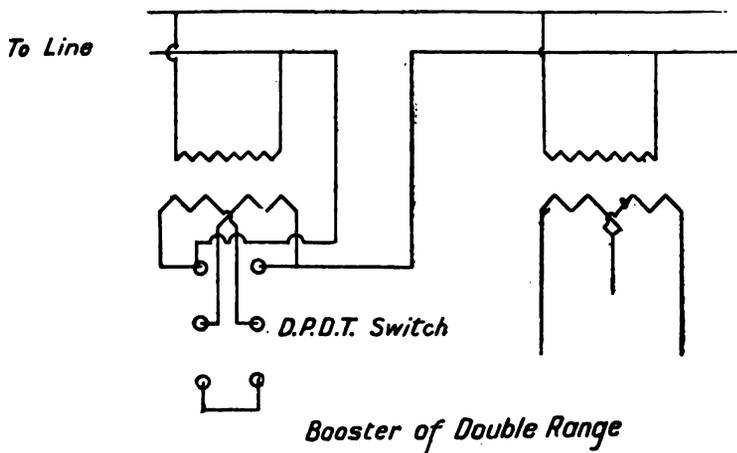
original cost of installing these red light tell-tales is almost insignificant.

L. G. WHITE, Columbus, Ohio

## 24

**Transformer Booster**

The use of a transformer for boosting the voltage on a primary circuit is well known, but the accompanying sketch shows the arrangement now in use for obtaining a boost of two ranges by means of a boosting transformer having a double secondary. The double-throw, double-pole switch indicated in



the sketch is connected to the secondary of the boosting transformer in such a way as to parallel or place in series the secondary coils, thus giving the two steps. It is also very easy to reverse the connections of the transformer and get the same range of choking effect if necessary.

GEO. B. TRIPP, Colorado Springs, Colorado

## 25

**Home-made, Oil-cooled Transformers**

Figure 1 shows a device for maintaining a low temperature in the oil of two heavily over-loaded booster transformers.

These boosters are connected to 1000-volt 'bus-bars, and are designed to transmit 50 kilowatts at 2000 volts. A rapid increase in business on the circuits fed by the boosters made it necessary for them to handle a load of two and a half times their normal capacity, and, in so doing, caused them to run dangerously hot. New apparatus was ordered, but the usual delay incident to ordering special apparatus from the large electric manufacturing companies caused some alarm lest the boosters burn out before the new apparatus arrived, so the

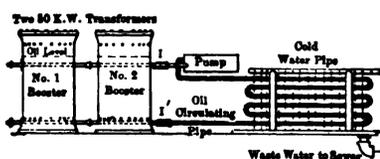


FIG. 1

above scheme was resorted to. It consists essentially of a small circulating pump which draws the cooling oil from the boosters near the top of the oil level, and forces it through the system of piping shown in the diagram. Water dripping from a pipe above the radiator keeps the pipes cool by running down on the outside, being caught at the bottom in a pan that drains to sewer. By adjusting the speed of the pump the oil can be maintained at any desired temperature above that of the cooling water. At the points *I, I'*, insulating joints, consisting of short pieces of rubber hose, are placed in the circulating system.

Previous to this arrangement, the temperature of the oil was 180 degrees Fahrenheit, whereas it is now maintained below 75 degrees Fahrenheit.

O. B. KOHL, Denver, Colorado

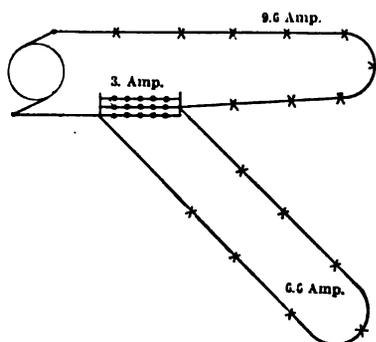
## 26

### To Run a Circuit of 9.6-Ampere Lamps and a Circuit of 6.6-Ampere Lamps on the Same Machine

When the city let the contract for gas street lighting, it left the number of our series arc lamps small enough to be carried by one machine. The arcs used by the city on the principal streets and by the railroads were 9.6 ampere open arcs, the series commercial lamps were of the 6.6-ampere inclosed-arc type.

To carry both circuits on one 9.6 ampere machine required

an arrangement to shut off part of the current from the commercial circuit. This was accomplished by putting a shunt across the terminals of the commercial circuit, consisting of three rows of 32-cp lamps, enough lamps in series in each row to



allow one ampere of current to flow. To reduce the actual loss due to this shunt, we put the lamps on the back of the switch-board where we could get the benefit of the light.

The accompanying diagram illustrates the shunt.

JAS. DAHLES, Lincoln, Nebraska

## 27

### A Serious Trouble and an Efficient Remedy

Last October, a disastrous flood visited us and submerged a large storage battery, replacing the electrolyte with muddy water.

To avoid the heavy expense and loss of time in cutting out all the plates, three barrow-like frames were devised, having iron hooks of sufficient number to lift all the plates forming positive and negative elements in adjacent tanks. By working one set of men in lifting out elements, and another set in washing plates and tanks, the whole battery was put in operating condition in a short time.

B. F. CRESSON, Easton, Pennsylvania

## 28

### A Floating Battery Used as a Water-wheel Governor

We have a water-power station delivering power at 2200 volts, two-phase, to synchronous motors, direct-connected to

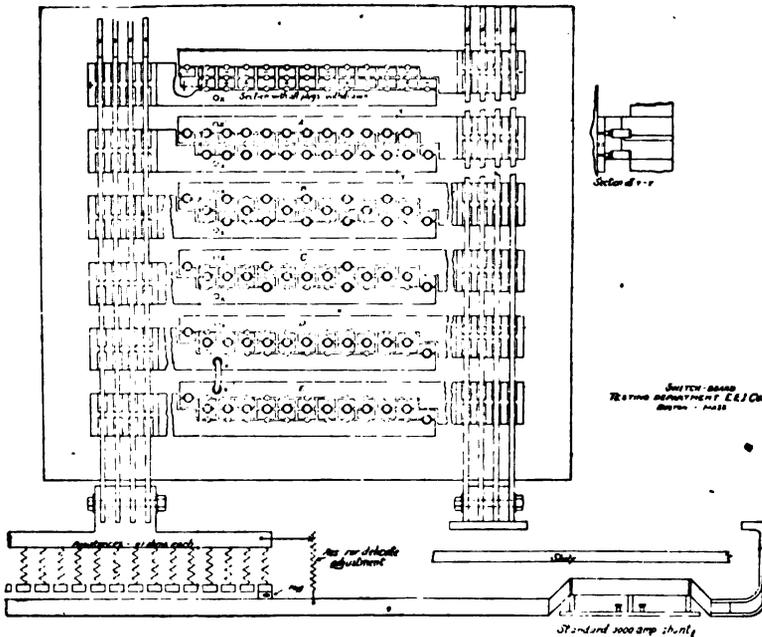
railway generators, working on a booster battery system. Water power also furnishes lighting load. It has been found that on cutting out water-wheel governors entirely, and running at constant gate opening, with battery floating across line, all variations in voltage at alternating-current switchboard are within the range of a voltage regulator, and a perfect alternating-current chart is obtained. The battery acts as a water-wheel governor, and booster losses are avoided.

B. F. CRESSON, Easton, Pennsylvania

29

Means for Obtaining Steady Current for Checking Current Instruments

The accompanying cut shows the battery switchboard used by the testing department of The Edison Electric Illuminating



BATTERY SWITCHBOARD AND CONNECTIONS

Company of Boston. This switchboard, as shown, is used for connecting up in various combinations 72 chloride accumulator

cells of 80 ampere-hours capacity each. By this means, station shunts of 2000 to 3000-ampere capacity are calibrated. The battery is also used in calibrating portable ammeters and all instruments for which it is necessary to have an absolutely steady current.

For most uses all the cells are in multiple, the switchboard being plugged as shown by *A* (see cut). *B* shows the arrangement of plugs for two cells in series and 36 in multiple; *C*, four in series and 18 in multiple. By drawing the bars *S*, *S'*, and putting in connectors at *X*, *X'*, it is a simple matter to put the whole battery in series, as is indicated in sections *D* and *E*. The board is plugged as shown in *D* and *E* for charging the battery.

C. R. BROWN, Boston, Massachusetts

### 30

#### Device to Get Reliable Records as to Load Curves, Etc., at Power Plants

Something that has been suggested to us previously seems to be a good idea, which we would be glad to have the associ-

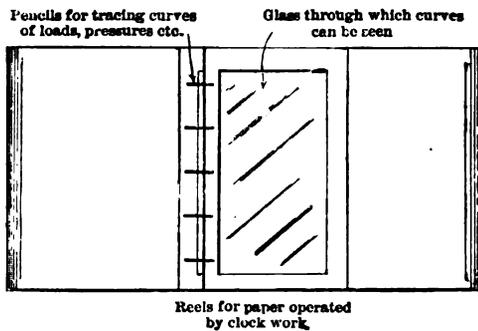


FIG. 1

ation bring up, and that is some form of automatic recording device to indicate the load curves on different circuits. Even though this device has a movement by clock and is operated otherwise by hand, it would avoid danger of record being fille..

in after time had been past. Such a device would have a sheet of paper, operated by a clock, with a number of points passing

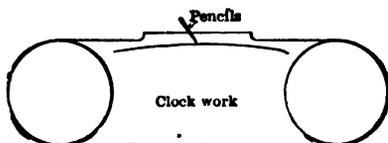


FIG. 2

over it and making drawing of line, which would be shifted back and forth in proportion to the load on each circuit.

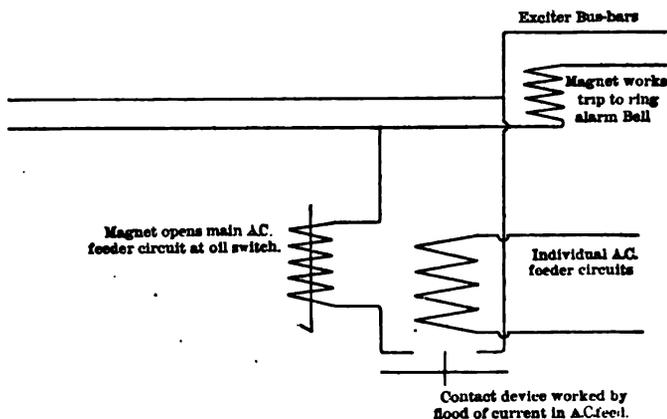
I inclose sketch of same indicating the idea more in detail.

H. SCHREIBER, Augusta, Georgia

31

Device for Opening Alternating-current Circuits

Another little item that may be of interest is the arrangement of automatic cut-out and alarm on alternating-current



circuits. This arrangement is explained by accompanying cut.

H. SCHREIBER, Augusta, Georgia

32

Running an Alternator with Two Coils Burned Out

One of our 700-light Westinghouse alternators burned two coils out of its surface armature windings. We cut them out,

and continued to carry its full load for several weeks until our extra armature returned from being rewound, which was a surprise to us.

D. L. DAVIS, Salem, Ohio

## 33

#### A Scheme to Reduce Stand-by Losses During Light Load

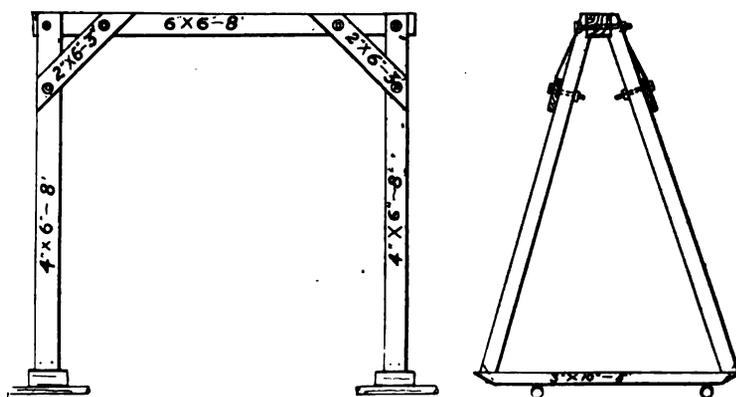
We are operating a three-wire, direct-current system for the down-town district and an alternating-current system for the outlying district. All of our units are direct connected. During the early evening, the units are fully loaded, but after midnight the load drops off very rapidly, and in order to operate everything on one engine and keep it fully loaded, we purchased a direct-current generator having two armature windings and two commutators, which were directly connected to the engine operating the alternating-current generator. After midnight we carry the entire load on this engine, thus increasing the efficiency of the engine and decreasing the cost of operation.

A. W. ZAHM, Mason City, Iowa

## 34

#### A Home-made Traveling Crane

This is an overgrown "saw-horse," made high enough to swing the upper half of the fields of a generator or motor, or



ELEVATION OF CRANE

other piece of machinery, with the chain blocks. The beam is long enough to allow of the legs being far enough apart to

straddle the machines we want to handle ; the feet are beveled to fit, and are toe-nailed to a three-inch plank, which is just long enough to take the two legs on each end of the beam ; each end of these planks are beveled from the bottom so as to take readily a two-inch roller, which should be about one-inch long.

We used for ours one piece of plank six inches by six inches by eight feet for the beam, four pieces four inches by six inches by eight feet for the legs, four pieces two inches by six inches by three feet for braces, and two pieces three inches by ten inches by five feet for the sills, all bolted together, except the tacking of the feet to the sills, so as to be taken apart and assembled as required.

Two men handle our fields and armatures very nicely with this, rolling them to whatever parts of the building desired, and when not in use it is stowed away, and is quickly assembled when needed.

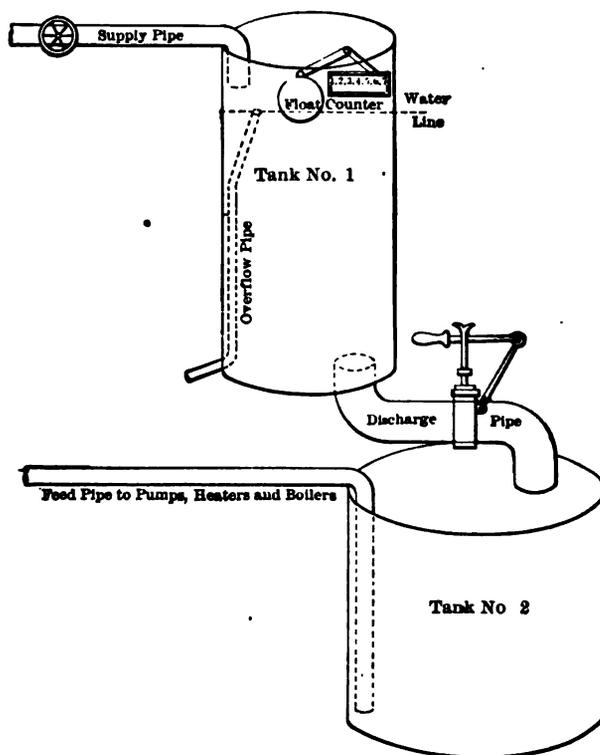
S. S. INGMAN, Georgetown, South Carolina

**A Simple Apparatus and Method for Measuring the Water Evaporated When Making Evaporation Tests of Fuel, Boilers, Etc.**

In the early years of my connection with the electric business, when making evaporation tests, we used to stand a barrel on a platform scale, fill it full of water, weigh it, and pump it into the boilers. We had to work lively at times to fill and empty the barrels fast enough to quench the excessive thirst of the boilers when working under rush conditions during the peak of the load. I conceived the idea of the following apparatus, which was connected up by our engineer. First, a wooden tank of about 300-gallon capacity, which we will call No. 1. The supply pipe was extended to the top of this with a valve placed conveniently for turning the water on and off. A discharge pipe was taken from the bottom of the tank fitted with a gate valve, the pipe and valve being of sufficient size to allow the tank to be quickly emptied. Inside of the tank was an overflow tank, open at both ends, the top of same being level with the water line when the tank was full, the bottom of the pipe protruding from the side at the bottom of the tank. On the side of the tank near the top was placed a counter, the lever of which was attached to a float in the tank.

A little to one side and below the first tank was a larger one, which we will call No. 2, set in the ground that received the discharge from the first tank. To this second tank was connected the feed-water pipe to the pumps, heaters and boilers.

I submit herewith a diagrammatic sketch of the complete apparatus.



APPARATUS FOR MEASURING WATER EVAPORATED

#### METHOD OF OPERATION

Open valve in supply pipe; when water first comes out of overflow pipe (indicating that tank is full), close valve in supply pipe and open gate valve in discharge pipe until the tank is emptied, the float falls and the numbering device automatically adds one to the number of times the tank has been previously

filled and emptied. The weight of a tank full of water is found by filling tank No. 1 a sufficient number of times for accuracy, carefully weighing same and taking the average.

This scheme has been in use in our station for over ten years, and during that time has been adopted by several other concerns. It is crude, but easy to install and operate, requires practically no repairs, and has proven very satisfactory. Being a permanent fixture, a test can be made at any time without the annoyance and delay of getting ready to do it.

WM. R. GARDENER, Pittsfield, Massachusetts

## 36

**Connections for Making Use of Two Transformers to Their Full Capacity When Two Sets Are Connected Y to the Same Primary When One Transformer of One Set Burns Out**

Where two sets of transformers are used with the same primary voltage and connected in Y, if one transformer burns

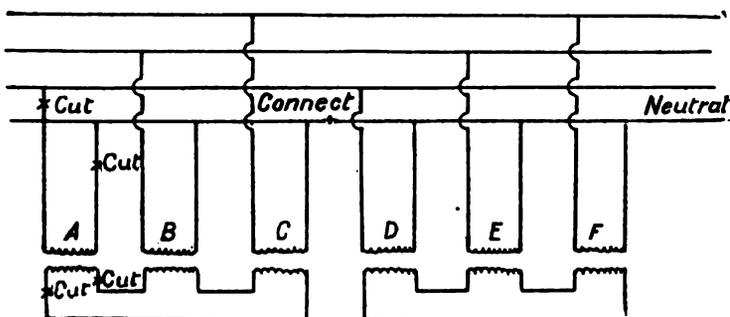


DIAGRAM SHOWING METHOD OF CONNECTION

out, the other two transformers can be used up to their capacity by connecting the neutral of this set of transformers to the neutral of the other set, and cutting out the burned transformer secondaries connected delta.

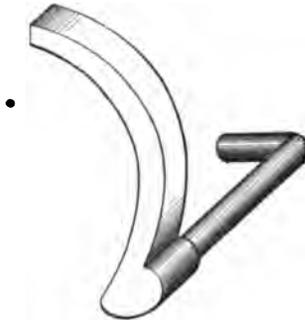
H. C. HOAGLAND, Kalamazoo, Michigan

**Re 125-Light Brush Arc Machine**

*Trouble experienced:* Regulator rheostat got dangerously hot under normal condition of load, and as a consequence machine would not regulate properly and good operation was out of the question.

*Method employed to overcome trouble:* Forcing a current of air through the regulator.

*Apparatus used:* A sheet-brass casing (see diagram) was so made as to fit over the armature coils and between the



magnet bobbins. This casing terminated in a brass pipe, which was brought to the side of the regulator box. Brass was used on account of its being non-magnetic.

*Method of operation:* The armature coils act like the blades of a fan and circulate the air confined in the casing with great velocity, finally blowing it out through the pipe and into the regulator box, with the effect of keeping the rheostat thoroughly cool.

S. R. INCH, Missoula, Montana

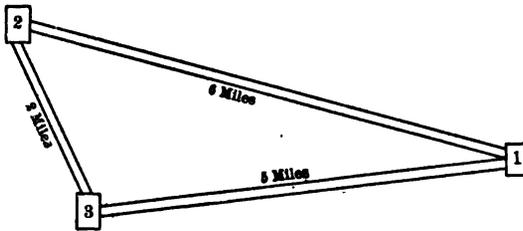
**Three Individual Properties Interconnected and General Arrangement to Insure Good Service**

In reply to your last appeal for information regarding our system we beg to state that, aside from the occasional blowing of a fuse in the premises of some customer, we have no trouble

to report during the past twelve months. All our mains are underground, and by using the best materials in the market we have escaped burn-outs, etc. What lines are overhead are inspected often enough to keep things in shape, and we keep the manholes free from water, etc., by frequent examinations.

We have three power-houses, two operated by water-power and one by steam, and they are connected as shown below. In case of any station trouble, which we have escaped up to date, the lines are so run that we can carry our load from any two of the three stations. Station No. 1 is the main distributing point, and the voltage on the transmission line is 6000, two-phase, 60 cycle. We step down to 1200 volts for the lighting circuits, and supply 110 volts to the customers from transformers located at central points.

By using care we prevent transformers from being over-



loaded without our knowledge and have no transformer trouble to report. The greater portion of our motor work is still on a 500-volt direct-current circuit, but we are gradually introducing the two-phase alternating. Our present motor load is over 1000 horse-power, and in the next month we expect to start a customer who has installed 700 horse-power in alternating-current motors.

All the men employed in the power-houses work on an eight-hour basis, and as they are paid higher wages than any other men in the same business we are never troubled with the "little things" that less able men would overlook long enough to produce trouble.

At the present time the voltage in our lighting circuits is all regulated by hand, and until such time as a good voltage regulator is put upon the market I think we can produce as steady a voltage curve as anybody. We believe in buying the

very best of material, and find that it pays in the end. We aim to give all our customers, large and small, good service and courteous treatment, and the complaints we receive are very few.

If we can tell you any more about our system and methods we shall be glad to do so.

W. L. MULLIGAN, Springfield, Massachusetts

### 39

#### **Line Transformer Used to Boost or Depress the Feeder Voltage to Help Out Temporarily**

I submit the following as a wrinkle that has sometimes been used successfully, although there are objections to its use for any length of time :

To compensate for a temporary drop in an alternating primary line feeder, a transformer whose secondary had the same current-carrying capacity as the feeder, was connected with the primary on the 'bus-bar side and its secondary in series with the line, thus boosting the primary feeder voltage. By reversing the secondary, the feeder voltage could be cut down. While this plan would not be recommended for regular service, it can sometimes be used to advantage to help out in case of urgent necessity, or to overcome excessive line drop on temporary feeders where expense would otherwise prevent the use of sufficient copper to obtain requisite voltage.

N. F. WILCOX, Lowell, Massachusetts

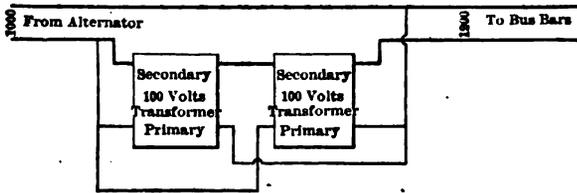
### 40

#### **Booster Transformer Used to Compensate for Drop in Line Voltage**

Having only a small plant it is not easy to find wrinkles unknown to every one, and if you think the following is too well known to be of help to any one please throw it in the waste basket :

In cases where it is desirable to boost the voltage of single-phase alternators we have several times had occasion to connect the secondaries of one or more transformers in series between

the alternator and 'bus-bars, the primaries being connected as is usual in the constant-potential system. The secondary winding of the transformers must be large enough to carry the primary current produced by the alternator without overheat-



METHOD OF CONNECTING BOOSTER TRANSFORMER

ing, and must be connected in such a direction that the secondary voltage of the transformers will be added to the primary voltage of the alternator and not deducted from it.

COLUMBUS (KANSAS) ELECTRIC CO.

Potential Booster

It is sometimes necessary for an electric-light company to run out a long circuit to feed a small neighboring town or a

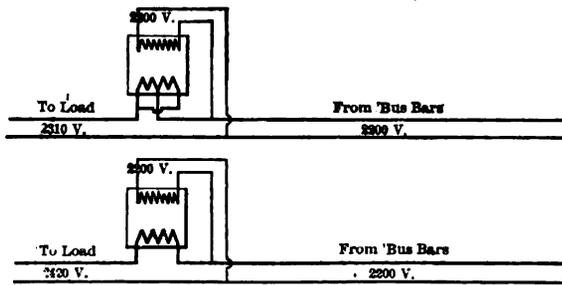


DIAGRAM SHOWING CONNECTIONS

few factories, the load on which is at times so heavy as to cause an excessive drop in potential on this particular circuit.

This difficulty can be easily overcome by installing a small

standard transformer (the size varying according to the load) with the secondary leads in multiple, or in series with each other, according to the increased voltage desired, and these leads in series with one side of the circuit; the primary winding in shunt across the circuit, as shown by sketch herewith. This booster, as it may be called, can be connected permanently in the circuit at the power station, or, by the proper installation of switches, thrown in and out as desired. Should conditions ever change so that the booster is not needed, it can be turned into regular stock.

E. H. MATHER, Portland, Maine

## 42

### Transformer Testing Set for Line Use

The occasional breakdowns of transformers in service, due to lightning or other electrostatic strains, or to normal depreciation of insulation between the primary and secondary coils or between the primary coil and the core of transformers, have resulted almost invariably in very serious, if not fatal, accidents to the unfortunate victim who may have been in the path of the high voltage circuit at the instant of such a breakdown. Such weakness or defect in transformers in service will not in any manner be indicated by interference of service conditions, or otherwise, therefore in such cases the trouble is not known or rectified until too late. Transformers that have been tested as all right are installed in service and most frequently are given no further attention, unless unsatisfactory service conditions, or some change in service, make attention necessary.

In order to guard against such accidents, and to take proper precautions to insure the reliability and safety of the transformers, the writer designed a "Line-testing Outfit," to be used for checking by test connected transformers in service, without the necessity of removing or replacing them from the primary lines.

This transformer-testing outfit consists simply of a choke coil of high resistance, which is secured in a stationary position in its case.

A movable core of soft-iron laminations is so placed as to partially surround this coil.

The terminals of the coil are connected to two single-pole fuse blocks, placed on the outside of the case.

To test a transformer connected on service lines, the method is as follows :

*First*—Open the circuit on the secondary of the transformer to be tested. This can usually be done by the main switch near the entrance of the building, or by the removal of fuses from the main secondary cut-outs.

*Second*—The testing set described is then placed at a convenient point to the transformer to be tested, and the free end of one fuse block is connected to one side of the primary supplying the transformer under test, and the free end of the other fuse block is connected to the secondary of the transformer under test. If a "dead" short circuit or cross between primary and secondary coils exists in the transformer under test, it will at once be indicated by blowing of the fuses. If the fuses do not blow, then slowly raise the movable iron core until entirely clear of the coil. If the fuses do not then blow or melt, it indicates that the insulation between primary and secondary coils of the transformer under test is all right, having withstood test of normal voltage of the line.

*Third*—A similar test is then made between one side of primary as connected and the case of the transformer under test.

This completes the test of the transformer in respect to one side of primary to which it is connected.

The connection of the testing outfit is then changed to the other side of the primary supplying transformer under test, and the same procedure as noted in paragraphs second and third is followed out.

The complete test as described requires but a few moments, and can be made with convenience and entire safety, and the results as indicated are absolutely reliable as regards existing breakdown or weakness in insulation between primary and secondary windings, or between the primary winding and the ground, that is, case of transformer.

As a precaution and safeguard against serious accidents and as an insurance of reliability of high-voltage transmitting devices, the line-testing outfit, as described, has been found to be of much practical utility and value.

G. WILBUR HUBLEY, Louisville, Kentucky



in sketch. The side of the street on which the pole is located is indicated by marking the card S or N, E or W, as the case may be.

As an example, take the card shown in sketch. On West Main street, between Webster and Butler streets, there are three poles on the south side of the street, each with three 6-pin cross-arms, one 2-pin cross-arm, and two 4-pin cross-arms. No. 1 primary occupies the end and middle pins of the top cross-arm on the sidewalk side of the pole; *C C*, or commercial power, the pole and middle pins of the second cross-arm. No. 6 arc, the end pins of the second cross-arm; the three-wire secondaries, the end pins, and the middle pins, street side of the fourth arm, and so on. There are six taps of the Wisconsin Telephone Company on the three poles, and there are two vacant pins on each pole.

In the sketch of the pole on the card, the pins are labeled with the circuit carried there, as shown, 1  $\phi$ =No. 1 primary circuit; *c c*=commercial power, etc. In blocks or streets where the same circuits follow the same direction, and occupy pins of same relative position on several poles, one card is used and the number of poles indicated.

By this method the exact number of poles, location of any circuit on any pole, and taps of other companies on your poles, and *vice versa*, also vacant pins on any cross-arm, are easily and accurately determined at any time, and it is a simple matter to keep the index corrected up to date.

G. W. FALLER, Madison, Wisconsin

## 44

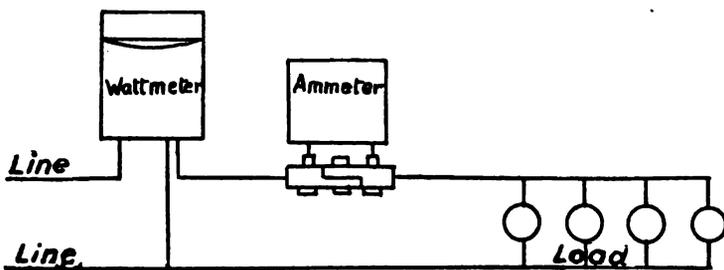
### A Method of Cutting In Ammeters for Testing Wattmeters in Place Without Interrupting the Service

When it is advisable to make tests on wattmeters without taking them to the testing department, the same may be easily accomplished when suitable connections are installed with each meter.

Referring to the accompanying sketch, it is seen that by inserting the ammeter leads into the lugs, and closing the circuit through the ammeter, and opening the circuit at the connectors, all the current is led through the ammeter, and when a portable voltmeter is connected across the pressure

wires, the wattmeter can be calibrated from the voltmeter ammeter readings at board.

Such an arrangement lends itself admirably to station



*To Ammeter*

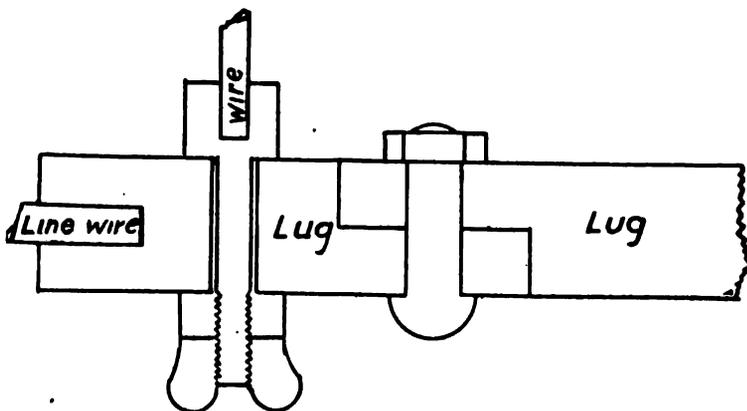


DIAGRAM OF CONNECTIONS

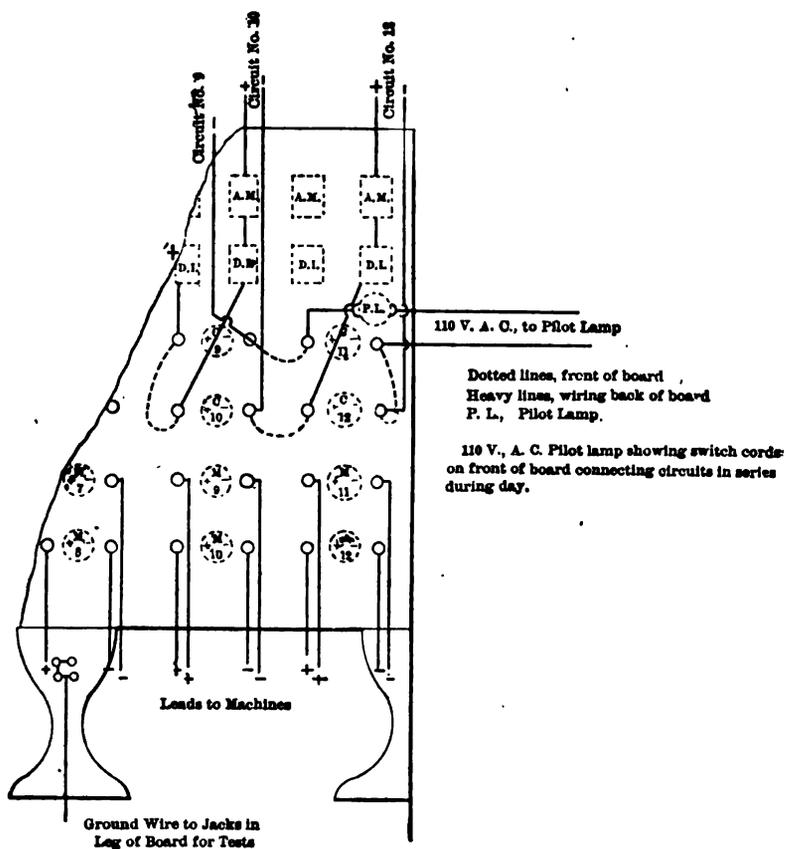
wattmeters, which can thus be readily checked without disarrangement of the circuits.

F. CUTCHEON, St. Paul, Minnesota

## 45

**Description of Alternating-current Pilot Lamp on Direct-current Arc Switchboard for Promptly Detecting Open or Grounded Circuits**

This is simply a 110-volt alternating-current lamp, wired on switchboard above arc circuits and connected with them in series during the day-time when the arc lights are not burning. A set of spare circuit jacks is made use of by us for the



purpose of this test. One side of the alternating-current circuit is connected to the (—) jack, the other side to the (+) jack through the pilot lamp, as shown in sketch herewith. All the arc circuits are connected in series by means of the plugs and cords and plugged into the above jacks. When the circuits are in normal condition the lamp will burn. It burns dimly with us owing to the drop due to about 35 miles of arc circuits.

## OPEN CIRCUITS

If an open circuit occurs in any circuit, the light will be extinguished, which will at once attract the attention of the engine-room attendant. With a cord and plugs he short-circuits each arc circuit in turn until the lamp lights up again, indicating the one in trouble, which he leaves open and reports immediately, thus giving the line repairs department very much more time than if a regular hour for testing in the old way were in vogue.

## GROUNDS

Test for grounds on circuits is made by means of a cord and plugs, and a grounded jack placed on leg of switchboard.

The lamp circuit is opened at the (—) jack above mentioned and grounded through the ground jack. If there is a ground on any of the arc circuits, the lamp will burn. The more perfect the ground and the nearer it is to the (+) jack, the brighter will be the light, up to full incandescence. The grounded circuit can then be located by opening the circuits one at a time until the light goes out. By the use of a voltmeter cut in with pilot lamp and grounded circuit, an approximation of distance to ground may be obtained.

J. CHAS. ROSS, Steubenville, Ohio

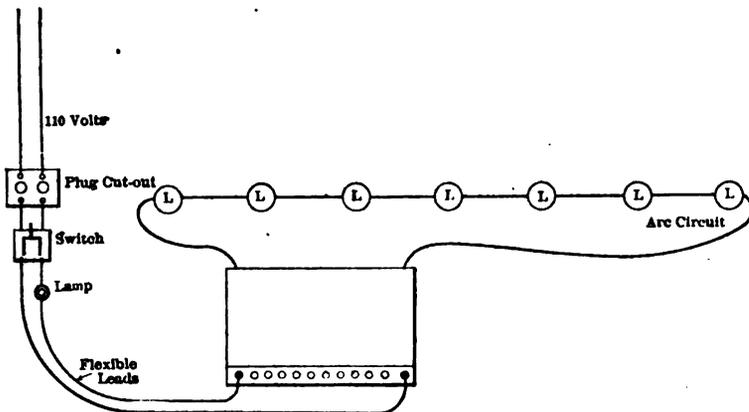
## Locating Breaks in Series Arc Circuits

The following is a simple method of locating broken wires or bad connections on series arc circuits. First, it is necessary to run two wires from a lighting circuit of 110 or 220 volts to a point at or near arc switchboard, connecting same to a suitable fused cut-out and switch; second, connect two flexible wires to switch, having them long enough to reach all circuits in board and placing a lamp of 16 or 32 candle-power in series on one of the flexible leads, as shown in sketch. In case of trouble, such as an open circuit, connect flexible leads to ends of circuit and throw in switch.

The lineman, in looking for trouble, should be provided with a test lamp of proper voltage, with leads long enough to reach across hoodboards and lamps. On placing the ends of test-lamp wires across lamps at doubtful poles, his lamp will light at once provided the break is at this point; if the lamp

should not light he will, of course, know that there is no trouble and will go on until he finds defective wire.

As soon as trouble is remedied, the lamp at station will at once light, showing operator at station that the trouble has been fixed.



CONNECTIONS FOR LOCATING BREAKS

The lineman will report to station before circuit is plugged in, or, if there is no telephone at hand, an understanding between lineman and switchboard operator allows a certain amount of time after light is lit before throwing circuit on line.

OLD COLONY STREET RAILWAY COMPANY  
Newport, Rhode Island

#### Reducing Transformer Core Losses

It occurs to me that a description of the method that we have adopted in reducing some of our core losses might be of interest. Our plant is located midway between the business and residence portion of our city and was at one time operated on the Edison underground three-wire system, although the bulk of our business is now handled on 2300-volt alternating-current system. There is considerable lighting in the immediate vicinity of our station, which was supplied by a number of moderate-sized transformers through three-wire overhead secondaries. A small amount of overhead wiring was thought sufficient to incorporate all of these secondaries, as well as the

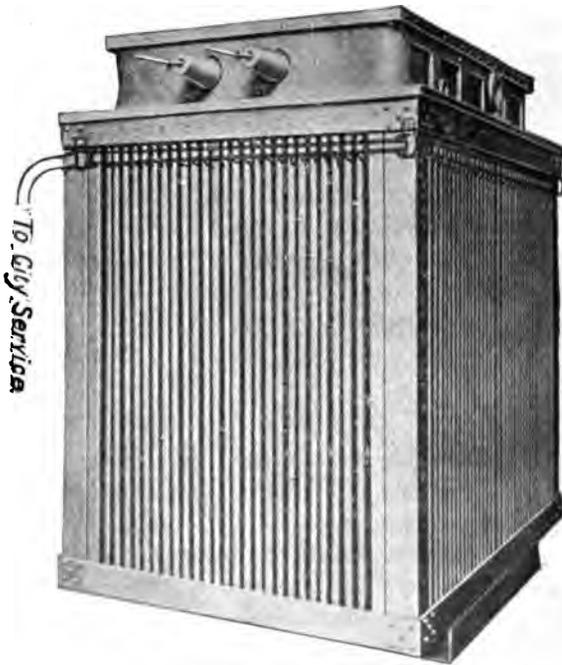
underground supply, into one system, which is now supplied by four 20-kw transformers located in our station. As the load on these is light during the greater portion of the day, we have arranged so that all but one is cut out during about 18 hours of the day, thus saving the core losses on these as well as on the number of small ones that were displaced by them. It may be that some stations are so located that they could take advantage of this method.

E. J. RICHARDS, Newburgh, New York

## 48

**Improvements in Self-cooling Transformers**

It became necessary to overload temporarily a pair of oil-cooled transformers of a well-known type to such an extent that



SELF-COOLING TRANSFORMER, SHOWING CONNECTION TO CITY SERVICE

the oil became offensive to the olfactory sense of propriety. A few lengths of inch pipe were secured to the cases as shown in Figure 1 after having holes bored along the sides of the pipes

at points corresponding to the indentations of the corrugated case. A connection was made to the city water service and a small stream allowed to trickle down the outside of the transformers cases. Temperature readings "before and after" were not made with a thermometer, but the temperature of the oil was reduced from "hot" as the dynamo tender understands this term to "quite cold."

A. A. DION, Ottawa, Ontario

## 49

### A Pole Puller

The wrinkle I submit is a pole puller, constructed on the same principle as is the stake puller used by the tent men with a circus, except that the wheels of the pole puller are made up of a pair of old 20-inch pulleys, mounted on a two-and-a-half-inch shaft; the lever is a six-inch by six-inch oak stick about 12 feet long, and the short end of the lever is provided with a strong steel hook.

In using the puller, a heavy log chain is given a half hitch about the base of the pole to be pulled, and the hook on the puller is hooked into the chain, then two or three men on the other end of the lever will pull out a 40-foot pole without much trouble.

This scheme can also be used to lower the same pole to the ground when it is out. Be sure to use as wide a face pulley as can be found, and see that the lever is a good stick, for something will happen if the lever breaks when the pole is being lowered.

L. E. WATSON, Kearney, Nebraska

## 50

### Cutting Down Outages on Arc Circuits

Our street railway has an average load of 25 amperes. We are arranged with a double overhead trolley, and have a 500-volt storage battery, so run 125-volt, 250-volt, 500-volt motor and trolley circuit from one 500-volt dynamo. The 125-volt is used principally for inclosed direct-current lamps in stores, which are practically all within 2000 feet of our plant. For 16-cp work we use 250 volts on the three-wire system. We have about 100 5-ampere, 125-volt inclosed arcs in stores, and insist on our customers doing their own trimming. This means, perhaps, more repairs on the lamps, and a greater number of

carbons used, but it saves complaint on account of our failure to trim.

We run 73 street lights, series. A penalty for outs is charged by the city. We set the year's penalty at about \$300 more than it will be this year, and gave two of our employees all they could save out of this estimate, and they will make about \$150 each. The object was to have them keep a close watch of the lamps, and at the same time we gave them a raise in wages which was due them.

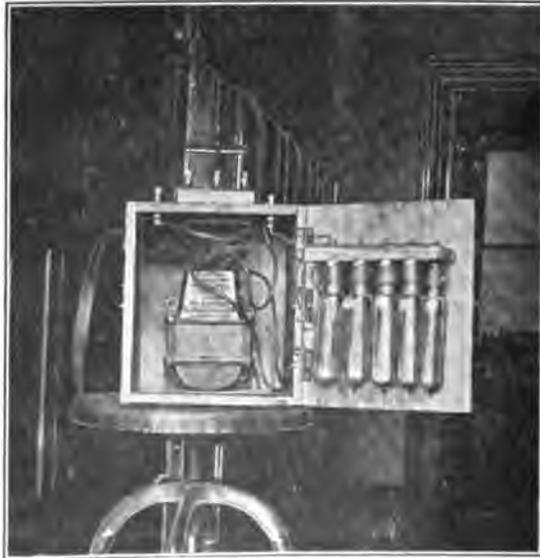
We also give return tickets on our street railway to those who ride before seven a. m.

E. S. KING, Merril, Wisconsin

## 51

### **Portable Load for Testing Alternating-current Recording Wattmeters Without Removing the Meter**

The accompanying photograph shows a compact, efficient and reliable portable load for testing recording wattmeters



**PORTABLE LOAD FOR TESTING ALTERNATING-CURRENT RECORDING  
WATTMETERS, ETC.**

installed on alternating currents. We have found this to be the simplest and lightest thing for this use that we have run across.

The box, ten inches by nine inches by eight inches, is made of three-eighths-inch cypress; the door attached by three small brass hinges, which also serve as a part of the three-wire lamp circuit.

A current transformer, with a ratio of 8:1, a five-ampere primary and a 40-ampere secondary are used.

Nine 16-cp bunghole lamps give sufficient current to test a 50-ampere meter at full load. Smaller meters are tested in the same manner, the current being controlled by the lamps in circuit and the resistance of the meter fields.

A three-pole, double-throw switch changes the lamps from multiple to series for 200-volt service, with a corresponding change in current.

The weight, complete, should not exceed 15 pounds.

J. N. BISSELL, Long Island City, New York

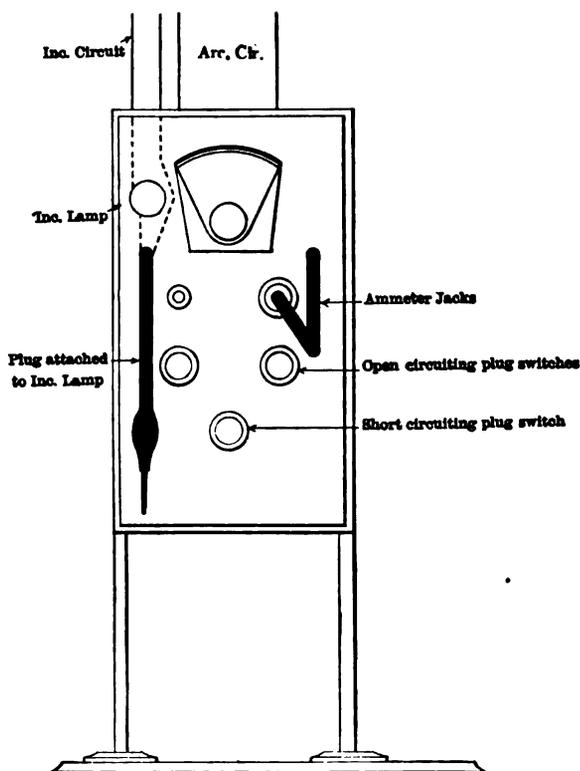


DIAGRAM ILLUSTRATING WRINKLE 52 TESTING OUT SERIES ARC CIRCUITS.

### Testing Out Series Arc Circuits

We have a very simple, ready and quick way of testing our arc circuits for open circuits.

We have the alternating-current series inclosed-arc system, using tub transformers.

For testing for open circuits we have an incandescent lamp connected to a cord and plug as per sketch, and by inserting short-circuiting plug on panel board to transformer, and by placing plug connected to incandescent lamp in ammeter jacks, it puts the incandescent lamp in series with the arc circuit, and if the circuit is all right, your lamp will light; if not, the lamp will not light.

C. J. SULLIVAN, Lyons, New York

### A Wrinkle to Prevent Burn-outs of Arc Lamps, Motors and Fans Where Direct Current and Alternating Current Are Substituted One for the Other

Some plants that operate both direct and alternating currents find it convenient after midnight to shut down their direct-current apparatus and furnish alternating current to their direct-current system. Again, sometimes alternating-current plants furnish a breakdown or light-load service to direct-current isolated plants. In either case should arc lamps, motors



FIG. 1

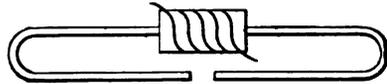


FIG. 2

or fans be left in circuit they will burn out through inductive action before the fuse will blow.

The writer obviated this by placing fuses in circuit, so constructed that the fuse would get the heating resulting from inductive effect as well as the C<sup>2</sup>R.

This was done by using a piece of soft-iron wire and insulating a part of the centre and giving the fuse wire a number of turns around it (see Figure 1), then bending the ends of the iron wire together to close the magnetic circuit (see Figure 2).

The whole device can be inclosed in asbestos to conform to the insurance requirements. This fuse was found to blow before the coils in arc lamps, fans, etc., could burn out.

P. H. KORST, Janesville, Wisconsin

## 54

### A Practical and Inexpensive Scheme to Prevent Open-arc Circuits

I have adopted a plan for hanging street arc lamps which is entirely new in some details, so far as I know, although it may be old to some.

Our street series arcs are hung in the centre of the intersection of streets. We formerly used No. 6 solid copper weather-proof from the pole to the lamp, but found it broke off very frequently. I next used a duplex No. 8 rubber-covered seven-strand cable. This worked admirably between the pole and the lamp cross-arm, but broke off between the lamp cross-arm and the lamp. I have now used for the past 18 months, without a single open circuit on 50-light circuits, No. 8 duplex rubber-covered seven-strand wire between the pole and the lamp cross-arm and No. 8 49-wire flexible strand between the lamp cross-arm and the lamp binding-post, which I have made standard with the above results.

R. P. STEVENS, Everett, Washington

## 55

### An Ounce of Prevention Worth a Pound of Cure

Last winter we had a great deal of sleet to contend with, and as we are using the open arcs for street lighting it made us a great deal of trouble during the first storm of this kind with which we had to contend, but after that we tried the experiment that solved the problem, and since that time we have never had a lamp out on account of sleet or ice.

Whenever the carbons begin to coat with ice, we take pieces of rather stiff manila paper, about four inches square, and fold them so that they are cone-shaped, then, after removing the ice from the ends of the carbons, we put this paper above the top of the lower carbon and fasten it in place with a small piece of magnet wire. This makes a complete break between the car-

bons and prevents the ice from forming on the upper end of the lower carbon. When the current is turned on the paper burns out and the lamp starts off as if there were no ice within a mile of it. There were quite a number of nights last winter when neighboring plants were unable to run on account of the ice, while we had no trouble at all after adopting this plan.

W. A. THOMAS, Abingdon Electric Company  
Abingdon, Illinois

## 56

**Money Saved by a Wholesale Renewal of Lamps During Peak Load**

In a station having a pronounced peak load for only a short period during the holiday season, a material saving may be brought about by making a wholesale renewal of all lamps on the line, substituting lamps of a high efficiency for the short time of peak load.

Assume the station running on 3.5-watt lamps to be full loaded, so that any additional load will require additional generating and distributing equipment, it is perfectly proper, then, to credit on one side of the balance the interest and depreciation on the investment, which will be saved by a substitution of, say, a 3.1-watt lamp, for with the same equipment of station and line, it will be possible to furnish current for 11.4 per cent more lamps; and against this must be charged the additional expense that will be incurred by the increased cost of lamp renewals for the short period.

Assume three per cent regulation on the line, and the 3.1-watt lamp gives a life of 263 hours before dropping to 80 per cent of its initial candle-power, while 492 hours' life is obtained from the 3.5-watt lamp; or there is a loss in lamp life of 229 lamp-hours per lamp for each substitution which is made. If a station with 42,000 connected lamps is considered, this will represent an additional cost corresponding to 9,618,000 lamp-hours, provided each 3.1-watt lamp is used to the extent of its useful life.

The cost of lamp renewals being made up of the cost of the lamp, which will be assumed at 17 cents, plus the cost of labor of photometering and changing at one and a half cents per lamp, gives a total lamp renewal cost of

$$\frac{17 + 1.5}{492} = .00037$$

per lamp-hour, and having lost 9,618,000 lamp-hours, the expense incurred due to additional lamp renewals would amount to \$3,558.66, provided all of the useful life of each lamp were used up, or the lamps burned 263 hours each.

In the station under consideration the actual average burning of each lamp during the month of December amounts to 45 hours, so, instead of an expense of \$3,558.66 for the increased lamp renewals that would be occasioned, the expense would be

$$\frac{45}{263} = 17.1 \text{ per cent of } \$3,558.66, \text{ or } \$622.76,$$

and to back against this there would be saved interest at six per cent and depreciation at six per cent, or 11.4 per cent of the investment of 42,000 lamps, which can be fairly taken at \$10 per lamp. This would amount to an annual expense of \$5,745.60 fixed expense due to interest depreciation, or by the substitution of the 3.1-watt lamp for the month there would be a net saving to the company of \$4,500.80 per annum.

Another factor should come into consideration at this point, and that is that the consumer is using a smaller amount of energy for a given amount of illumination during this short period, and he is benefited during this time by having a decreased bill, to which he will raise no objection, while the station will have its kw-hour sales curtailed by an amount equal to the difference in lamp efficiency, provided the consumer is paying for his current on a straight meter basis.

#### MADISON GAS AND ELECTRIC COMPANY

#### **Storage Batteries for Testing 500-volt Direct-current Power Meters**

It is quite undesirable, for various reasons, to test power meters on the connected or motor load, and on 500-volt lines the necessary resistance box or lamp bank becomes very bulky, and is, therefore, objectionable for mechanical reasons.

The storage battery offers a convenient and efficient method of testing this class of meters on direct-current systems. The nine A. K. storage cell manufactured by the Electric Storage Battery Company is one and a quarter inches by two and a quarter inches by five inches, and weighs approximately two

and a half pounds, and for meter testing, three cells connected in multiple are inclosed in a hard-wood box with hinged cover and external binding posts. The total weight is about 12 pounds, and the capacity approximately 25 amperes.

In testing a meter, it is simply necessary to disconnect the load wire from the meter and connect the storage battery with an ammeter in series to the two terminals of the current coils of the meter to be tested. The resistance of the two battery leads can be made such that together with the current coils of the meter the proper load can be obtained without further manipulation, although a short piece of resistance wire may sometimes be advisable.

**BOSTON EDISON COMPANY**

## 58

### **Special Transformer for Testing Alternating-current Power Meters**

For the purpose of accomplishing the same results in testing meters on alternating-current systems, as explained in the previous item, a special portable transformer is very satisfactory. Such a transformer should have its primary designed for the regular meter voltage and its secondary for about two volts potential and approximately 50 amperes capacity. The transformer is then connected to the line ahead of the meter, and secondary current is taken through the meter coils from the transformer with wattmeter in series, the adjustment of current being handled in the same way as with the storage battery previously explained. Such a testing transformer, inclosed in a portable wooden case with outside terminals, will weigh only about 15 pounds.

**BOSTON EDISON COMPANY**

## 59

### **Dummy Plug or Wire for Thomson Recording Wattmeters**

All two-wire Thomson recording wattmeters of small capacity are provided with binding posts for a double break in the wires of the circuit through the meter. In practice, however, a single loop and potential wire are frequently left in

in place of a double loop, so that one of the two inner inlet holes is frequently left open to vermin, dust and tampering.

This hole may be conveniently and cheaply closed with a

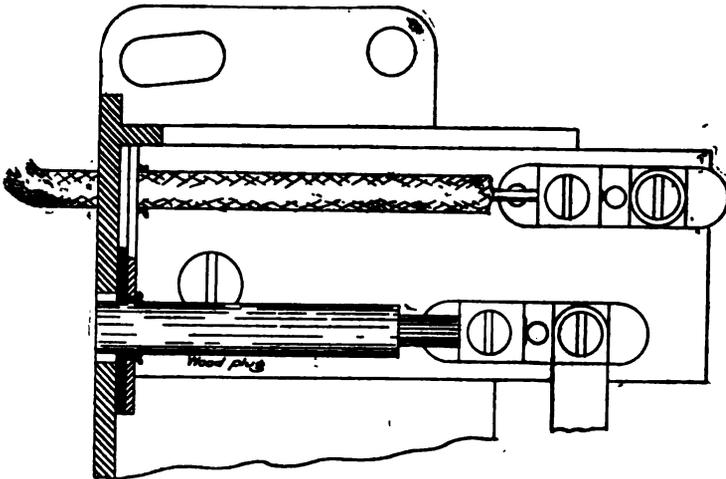


DIAGRAM SHOWING PLUG AND CONNECTIONS

wooden plug or wire, as shown in the attached sketch, secured under the set screw of the binding post not otherwise in use.

BOSTON EDISON COMPANY

## 60

### A Trouble Transformer

It frequently happens that it is necessary to install a transformer at some point on the distributing system where the delay due to the labor of getting a transformer out of the storehouse and hanging it, is a very serious matter. This may occur at the time of the burning out of one of the regular line transformers, or an exceptionally heavy demand may be brought upon some particular district, say for a day or two, which will require a considerable increase in transformer capacity over that which is normally demanded. Considerable expense and labor, as well as delay, can be prevented by having a transformer of a large capacity mounted upon a light wagon and housed in, so that it is impossible for people walking along the street to touch the transformer or lead wires.

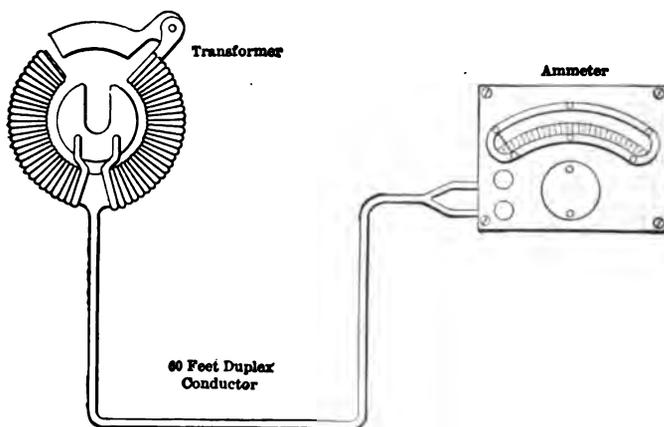
At the station where this scheme is put into service a 60-kw transformer is connected up with leads thoroughly insulated, which are taken out of the top of the housing covering the transformer ; a locked cabinet contains the switch and fuses for both primary and secondary sides, and the transformer leads are fitted with clamp connectors of large bearing surface. In case of a transformer burnout, but a few minutes are required to back the wagon up to the pole, clamp on the connections and close the switches, the regular trouble men doing the work without the assistance of the line gang. The housing is wired on the outside, and red lamps, placed in the sockets, guard against the wagon being run into at night by passing vehicles, should it be necessary to let the wagon stand in the street over night.

W. J. HUGO, Madison, Wisconsin

## 61

### A Line Ammeter

The accompanying sketch represents a "line ammeter," which is one of the most convenient instruments that has been brought to the attention of central station operators for some



METHOD OF CONNECTING AMMETER AND TRANSFORMER

time. The instrument is used to measure the current flowing in a conductor, although it is unnecessary to open the circuit to measure it. The great value of this instrument lies in its ability to determine instantaneous demands on transformers, and to

determine as to whether the loads are properly balanced on the two sides of three-wire secondary network.

The apparatus consists of a series transformer wound on a two-piece iron ring, so arranged that a small segment of the ring on which there is no winding acts as a hinge to be opened and closed over the conductor carrying the current. Connected to the transformer coil is a 60-foot length of duplex flexible cable ending in terminals that fit in the binding posts of a suitably calibrated ammeter, which reads the load in amperes direct.

To operate the instrument a lineman carries the small coil—weighing about two pounds—up the pole to the secondary leads and snaps it on, while a man on the ground reads and records the amount of current flowing.

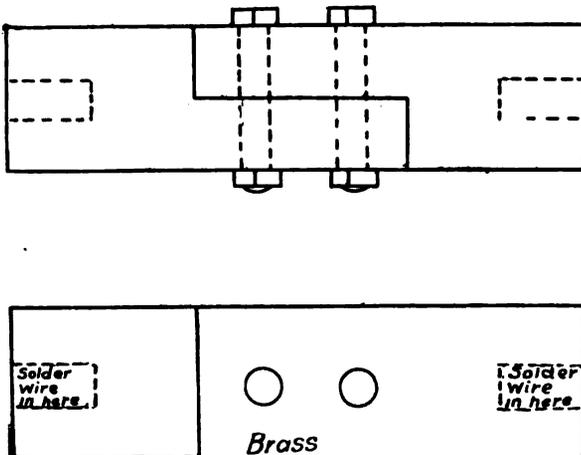
The use of this instrument is bound to show up miscalculations as to division of load, which takes place in secondary network, no matter how carefully it may have been estimated.

C. W. HUMPHREY, Denver, Colorado

## 62

### A Coupler for Transformer Connections

The accompanying sketch shows a brass connector for connecting up transformer leads. The leads and line wires are



soldered into the respective ends of the coupler, which is made of brass, and two screws hold the two parts of the connector in

perfect contact. This connector can be readily disconnected, but there is no danger of the connection becoming loose.

A. G. SANGSTER,  
Disraeli, Quebec

## 63

**Method of Furnishing Light for Substations in a Railway Plant  
After the Railway Is Shut Down for the Night**

Replying to your favor of February 17th, beg to say that when I wrote you on December 19th I expected to be able to give an account of one small "wrinkle" which might prove interesting. We have had this scheme in operation for some time, but as it has not been entirely satisfactory for some reason I think perhaps it would be better not to publish it. The "wrinkle" was briefly this:

We are operating a 13,200-volt, 25-cycle, alternating plant, furnishing power to approximately 100 miles of railways outside this town. Besides furnishing this railway power we are furnishing lights in Portsmouth and in some of the neighboring towns.

The railways with our substations are usually shut down from about one to five a. m., so that we have no means of lighting the cars in the various car barns for the purpose of cleaning them properly. For some time we ran a 200-kw synchronous motor-generator set from our lighting service here in Portsmouth, and from the 25-cycle end operated a rotary converter in one of the substations for the purpose of giving the lights. We found, however, that to get less than 200 lights we were using nearly 60 kilowatts in electrical energy. The writer conceived the idea of taking four standard lighting transformers and connecting them up with primaries in multiple and secondaries in series at the nearest substation, in which we also have a distributing substation for the lighting. After the railways were shut down for the night we would close a switch, throwing the secondaries of the transformers, which being in series approximated 575 volts on to the trolley; this in the nearby substations gave us first-class light.

In the substations 25 or 30 miles distant from there, however, the lights were very dim, and up to the present writing I have been unable to ascertain whether this was caused by the

feeders not being properly connected through, or whether we were getting some capacity effect from the system of the 500-volt feeders and trolleys which caused a serious drop. In view of this, I think it would be better not to publish the matter at the present time.

J. S. WHITAKER, Portsmouth, New Hampshire

## 64

**Connecting Two-wire Thomson-Houston Meter in Two-wire Circuit—Which Is a Pair of Three-wire Systems with Grounded Neutral**

The solution of a case in connecting a two-wire Thomson-Houston meter in a two-wire circuit from an Edison three-wire system might be a wrinkle to another company operating a three-wire Edison system with neutral grounded.

The neutral wire of the two-wire circuit was connected to the series field terminal of the meter; the shunt terminal was connected to the other wire; a ground developed in the customer's premises on the neutral wire. The result was that the meter operated sometimes forward and sometimes backward.

The solution is found in testing always before connecting a two-wire meter on a three-wire system when the neutral of the three-wire system is used for shunt purposes only in the meter.

ROBERT LINDSAY, Cleveland, Ohio

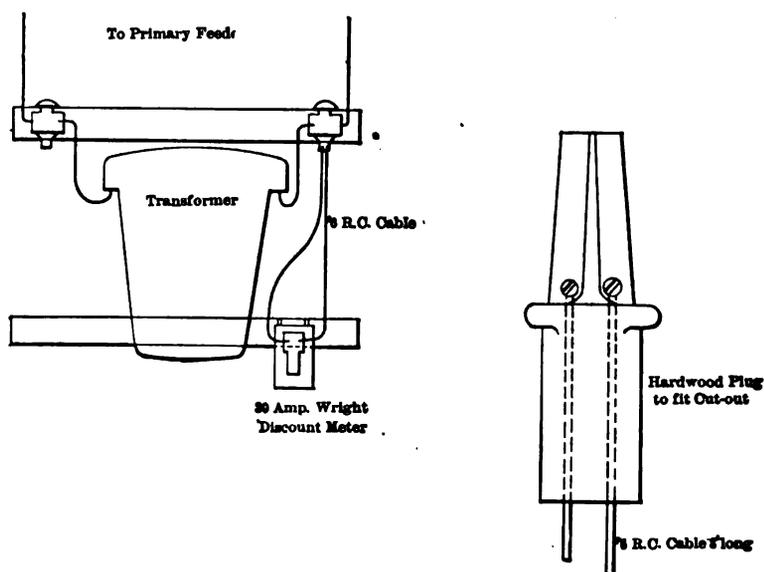
## 65

**A Simple Method for Determining the Demand Upon Individual Transformers**

It is oftentimes necessary to know the amount of current that a certain transformer is called upon, by the lamps or other apparatus connected, to deliver. The easiest way to obtain this is to measure the primary current passing to the transformer. The accompanying sketch and the short description following will give an idea of a simple arrangement that makes testing transformers very easy indeed.

We are using the insulator-type, primary cut-out manu-

factured by the General Electric Company. A duplicate plug was made of hard wood, with an extended handle six inches long and two inches in diameter. Two of the brass clips from an old plug were placed upon the wooden one, and through two holes in the handle, two No. 6 rubber-covered cables were connected to said clips. These cables are about eight feet long and connected to a 30-ampere Wright discount ammeter, which is mounted upon a board about eight by twelve inches. Upon



ARRANGEMENT OF TRANSFORMERS

the back of the board are two pieces of wrought iron of suitable size to hook over an ordinary cross-arm.

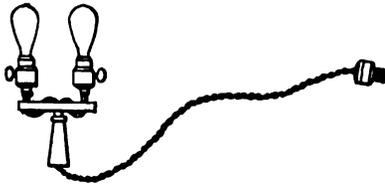
To test a transformer, it is only necessary to place the ammeter upon a convenient cross-arm, pull out the plug in one of the transformer cut-outs and insert the plug upon the end of the cable. We usually leave it in service for two nights, and then remove it to some other transformer.

GEO. S. HALEY, Rutland, Vermont

**Method of Showing Difference Between New and Old  
Incandescent Lamps**

With companies whose customers purchase their own incandescent lamp renewals it is frequently necessary to adopt some method to induce the customers to renew dim lamps before they burn out. The following has been used with good satisfaction:

Two standard lamp sockets are attached rigidly to a small strip of brass and wired in multiple to a lamp cord that is connected to a standard attachment plug. Upon receiving complaint of poor lights, an inspector takes this two-light device and a voltmeter to the house or store making the complaint, and after ascertaining to his own satisfaction, by the use of the



voltmeter, that the potential is all right on the secondary wires, shows the complainant the difference in illuminating power between an old and a new lamp. To one socket of the two-light device he attaches a new lamp, and to the other socket one of the lamps complained of; then, after turning out all lights in the room, the two-light device is held over a newspaper and the old light turned on, then cut off and the new light turned on; this repeated two or three times shows the difference between the two lamps.

The illustration is more effective to the layman than a voltmeter test, and, ordinarily, it is not difficult to convince a customer that the discolored lamps need to be replaced by new ones.

E. H. MATHER, Portland, Maine

### A Method of Testing Arc Systems for Open Circuits

With a view of shortening the time consumed in closing arc circuits, the following device has been used in making tests for open circuits :

Having any standard transformer in primary circuit, connect the secondary winding in series so as to secure about 220 volts, then connect one of these terminals to the ground and the other to one side of the arc circuit, having previously disconnected both sides of the arc circuit from tub transformer or arc machine.

The lineman then starts out from the station to close the circuit, following the leg that is connected to the transformer

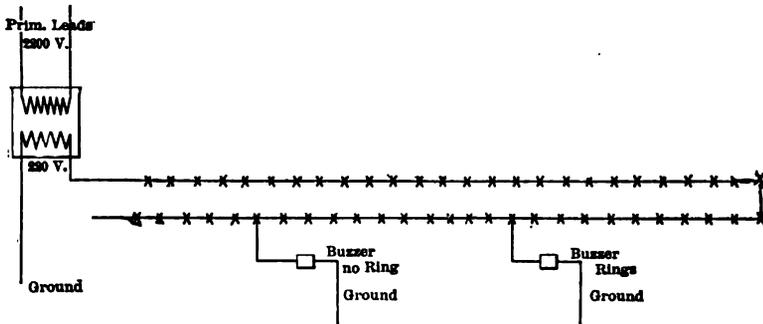


DIAGRAM ILLUSTRATING CONNECTIONS

secondary lead. Instead of a magneto, the lineman carries with him a common telephone extension-bell, or "buzzer," of about 80 ohms resistance, and as he proceeds along the circuit he occasionally grounds one end of the buzzer and touches the other to a lamp terminal. If the buzzer rings upon contact with the lamp terminal the circuit thus far is closed, and he proceeds in the same manner until he finds the point at which the buzzer will not respond to connection. The "open" is then quickly located and closed.

The sketch herewith more clearly illustrates the method followed.

E. H. MATHER, Portland, Maine

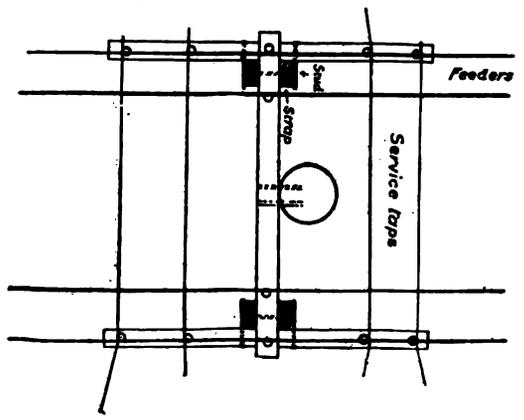
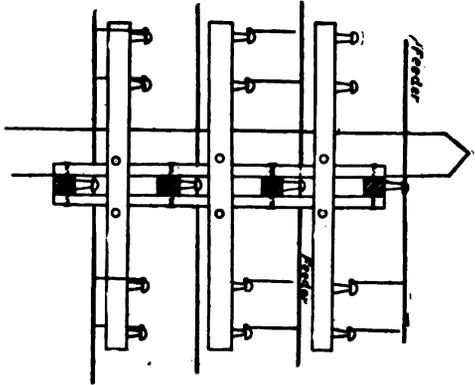
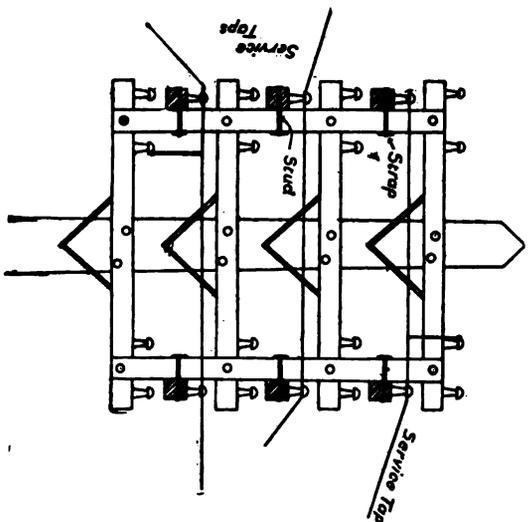


DIAGRAM SHOWING METHOD OF CONSTRUCTION  
WRINKLE 68

## 68

**A Construction of Cross-arming Whereby Service Connections Can Be Tapped from Any Feeder, and Run in Any Direction from Vertical to Perpendicular and Irrespective of Sidewise Direction**

By observing the method of construction, it can be seen that the connections are made and run with absolute safety from contact with other wires, and, moreover, without the use of knobs or any like substitute.

There are four feeder arms, which are used as follows :

Top arm—arcs—both city and commercial.

2d arm—two 500-volt private power circuits.

3d arm—2000-volt primaries, alternating-current lighting.

4th arm—three-wire secondaries.

To these four feeder arms, four pieces of "two by fours" (two on each side) are bolted. These act incidentally as braces for the feeder arms, and as supports for the service tap cross-arms. These cross-arms are clamped, by means of studs and strap, to the "two by fours" midway between the feeder arms. The top connections run perpendicular to the direction of the feeders, and half-way between them, thus insuring safety from contact and a jumble of wires, the evil of which is too well known to mention. This construction is especially adaptable to line work on junction poles, where it may be used to excellent advantage. By using only four of the six pins, a lineman has a space free from live wires in which to climb and work.

This construction, however, is limited to southern latitudes, as in the north the network of cross-arms would offer too much surface for the accumulation of sleet and ice.

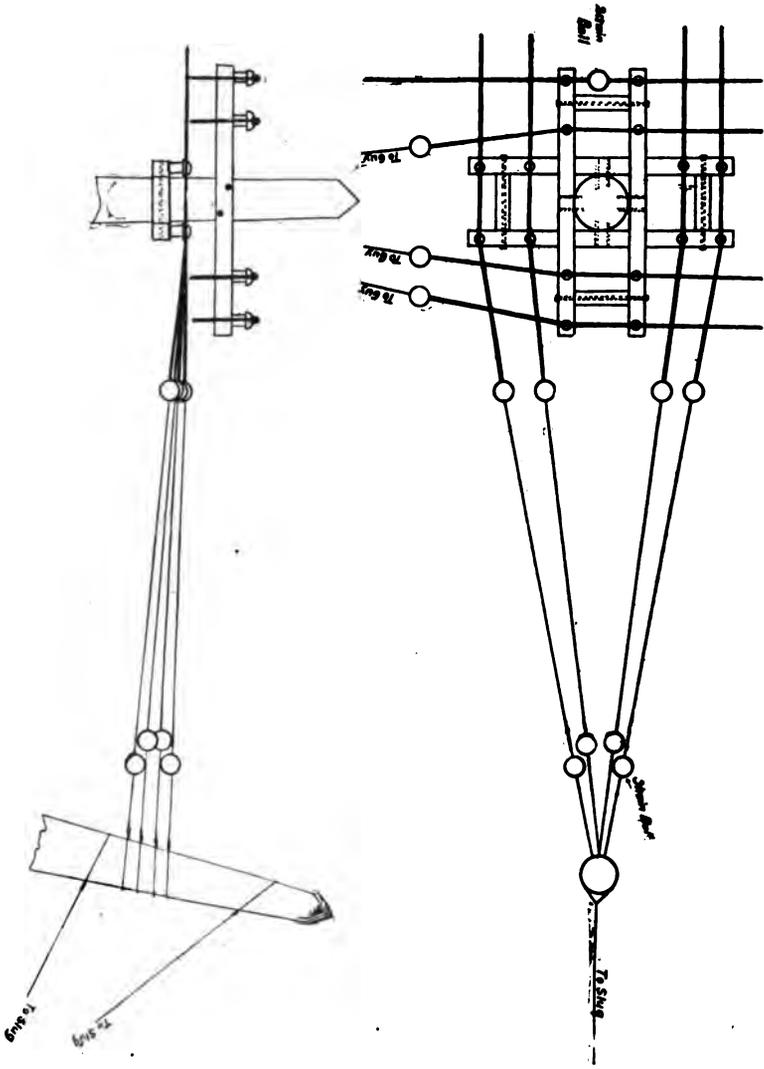
GEO. CUSHMAN, San Antonio, Texas

## 69

**A Method of Dead-ending Heavy Feeders**

When large numbers of heavy feeders are supported by the same pole, the strain on the pins, cross-arms and the pole is considerable. This is especially true in the case of junction poles on which the strains usually act at right angles to each other, thus tending to pull the pole over and eventually cause it to buckle. By relieving the pin, in a proper manner, of the undue strain, the whole trouble is obviated.

METHOD OF GUYING FERRERS



The accompanying drawing shows a neat and simple method of dead-ending heavy feeders.

The feeder, instead of being dead-ended at the junction pole or first pole beyond, is run past the junction pole and tied onto a strain ball of good design, which in turn serves as the connecting medium to an ordinary guy wire, which is tied to the guy stub in the regular way, a second strain ball being inserted near the guy stub to prevent any possible leakage. The guy wire and guy pole thus receive the strain, and the pin, arm and pole are not overburdened.

Each feeder is treated in the same manner, extra precaution being taken that the guy wires are attached to the guy pole so that they do not touch each other. In case the strain balls do break down, no feeders will be tied together through the guy wire. The guy pole is then guyed to a slug in such a manner as to prevent buckling.

The feeders running at right angle are run past the buck arm, and dead-ended in the same manner as above described. Connections from feeders on upper arm to those on the buck arm are made in the usual manner where the buck arm is used.

Where feeders run in opposite directions (such as shown) the guy is dispensed with, a strain ball being inserted, thereby splitting up the feeders.

J. S. RULEY, San Antonio, Texas

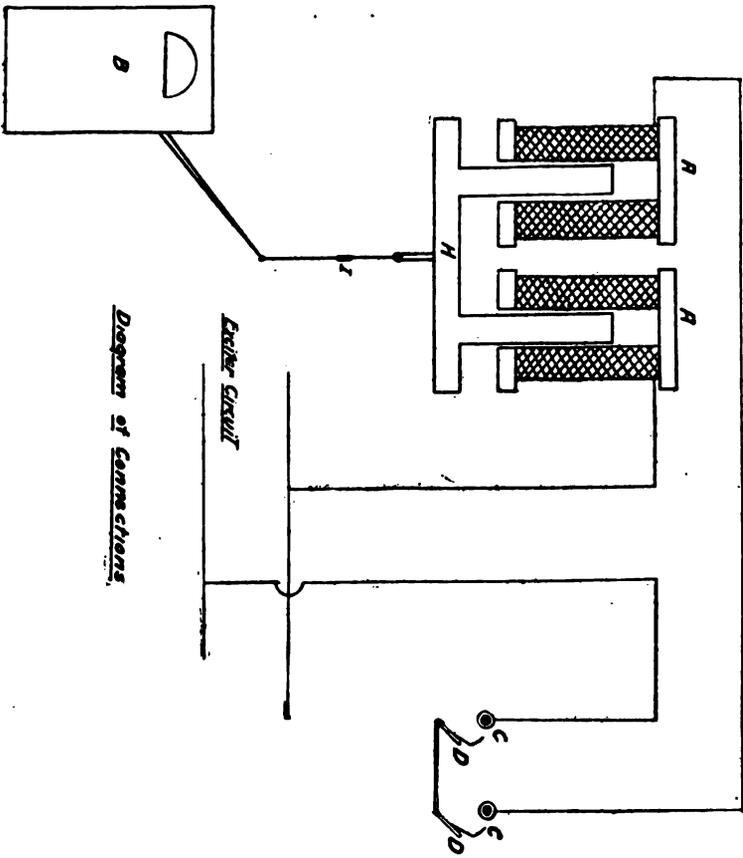
#### **An Effective Telephone Gong**

In electric plants where the noise of the machinery would drown the ring of the bell on a telephone the above scheme may be used to notify the subscriber that he is wanted at the telephone.

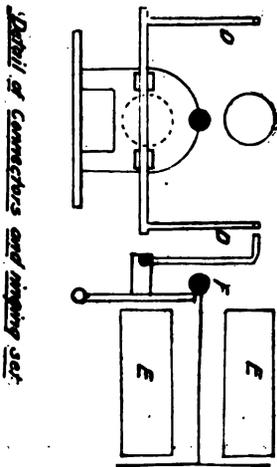
The apparatus consists of a pair of electromagnets *AA* with soft-iron armature *H*, a steam whistle *B*, two mercury cups *CC*, two curved connectors *DD*, a bell-ringing set from a telephone.

The ringing set is inserted in the circuit between *CC* and *DD*.

When Central calls the subscriber the bell clapper *F* begins to move up and down; on the up stroke the frame work attached to the curved connectors is released, falling in the mercury cups, thereby closing the circuit. This causes current to flow



*Diagram of Connections.*



*Detail of Connectors and wiring set.*

through the coils *AA*, pull up the armature *H*, which in turn pulls the lever opening inlet steam valve to whistle. The announcement of the whistle calls subscriber to 'phone, the whistle continuing to blow until the jack on which the curved connectors are soldered is again thrown behind the clapper *F*.

The current is obtained from a 150-volt exciter circuit supplied by a 25-kw dynamo, and the electromagnets were taken from a Brush lamp, being re-wound to suit this voltage.

A precaution must be observed in that an insulator *I* of some kind is placed between the armature *H* and whistle, to insure safety in case the magnet winding becomes grounded on its frame.

GEO. CUSHMAN, San Antonio, Texas

### A Handy Method of Determining Side of Three-wire System on Which a Two-wire Meter Loop Is Attached

In order to maintain an accurate record of the connected

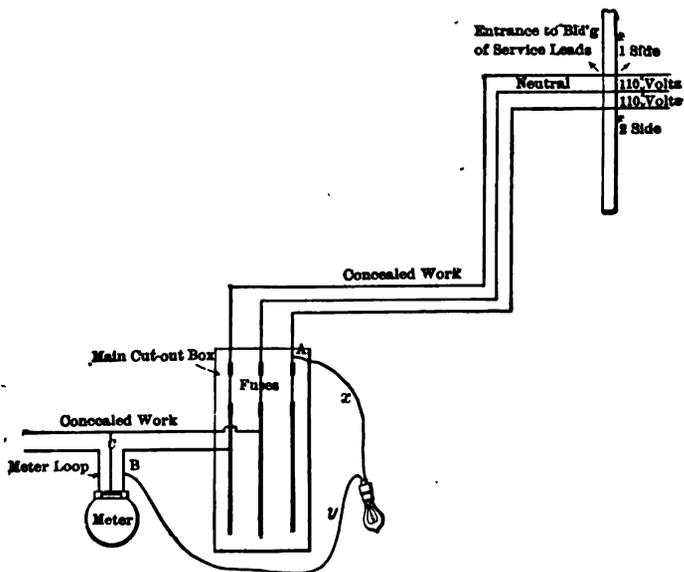


DIAGRAM OF APPARATUS

load on a three-wire Edison system, it is necessary to know on which side of the system each meter is set. In a large building

in which there is a three-wire system this may be determined as follows :

Assuming that, according to underwriters' rules, the wires of a 220-110-volt three-wire Edison system in a building do not cross after entering a building, that is, remain in the same relative position as the service wires, from the place of entrance to building to main cut-out in meter-room, the side on which the meter loop is placed may be easily determined as follows :

Apparatus necessary : a 110-volt incandescent lamp, socket, and two short pieces of lamp cord connected to socket as leads. Attach one lead *x* (see sketch) to one side of line *A* at main cut-out ; touch quickly the other lead *y* to line side of meter loop *B* ; if lamp does not light, the meter loop is on same side of circuit as the first lead ; if it burns brightly, the loop is on the other side of the circuit.

By touching the second lead *y* to the pressure wire *c*, whether or not the proper voltage of the pressure connection is obtained, is easily determined. This eliminates any possibility of burning up pressure coils of a meter due to wrong voltage.

G. W. FALLER, Madison, Wisconsin

## 72

### A Testing Device

In central-station practice it is necessary to be able to locate open circuits and grounds where a magneto has not given satisfactory results. Take enough lamps to take up the line voltage on which operates the machine or apparatus to be tested, and place them in series with one side of the line. Take a tap from the other side of the line, then with the live open ends, test as with a magneto. The number of amperes is regulated by the size of the lamps used.

W. J. HUGO, Madison, Wisconsin

## 73

### Arrangement for Series Arc Circuits

It is convenient where possible to have "jumper switches" or some equivalent installed where portions of the same circuit come near each other, as at the beginning and end of a loop. The switch or device is so arranged that by closing it the loop can be short-circuited. If the line opens, a man can be sent around and close the switches one at a time, and in a compara-

tively short time the loop in which the open circuit is will be discovered. The loop may then be entirely disconnected and the rest of the circuit operated until the break is repaired, when the switch may be opened. If the number of lamps on the circuit is too many it may not be possible to do this when the circuit is "alive," on account of the high voltage involved.

GEO. B. LAUDER, Concord, New Hampshire

## 74

**Stringing Several Wires on One Cross-arm**

We had occasion to run five No. 6 wires on the top cross-arm of our pole line a distance of several miles. We did this with one hitch, by having a wooden bar to which the five wires were fastened. The bar was pulled along by a horse with blocks and tackle, five poles at a time. There was a man on each pole and all each man had to do was to lift the bar over the top of his pole as it came along. In this way the five wires were strung in about the same time it would have taken to run one wire, had they been strung separately.

GEO. B. LAUDER, Concord, New Hampshire

## 75

**Method of Fireproofing High-tension Cables in Manholes**

High-tension cables in manholes, unless protected by some fireproof covering, are likely to be damaged in case of a manhole fire. When these cables are allowed to rest on iron brackets and where they are of considerable length and there is no break in the lead sheath of the cables there is liable also to be considerable damage from electrolysis at the point of contact between the lead sheath and the iron bracket. The Chicago Edison Company is now using split clay tile for covering these cables in manholes in all cases where it is practicable. Two light angle irons are installed to carry the weight of the cable and the tile, and from the end of the angle iron to the ducts a piece of light galvanized sheet iron is used to support the tile until the cement has had time to set.

Forty-five-degree elbows are used for covering the bends on the cable. This method of covering the cables is expensive, costing in the case of a run of six cables, three on each side of the manhole, about \$35 per manhole. It is, however, as near a fireproof job as can be obtained, and experience has shown that the fireproofing of all high-tension lines that may carry several thousand kilowatts each is of vital importance.

Where there are only one or two cables in a manhole and where it is not possible to use split tile on account of the way the cable is trained, we use two layers of heavy asbestos paper for a protection. This paper is held in place by brass tape one inch wide and .025 inch thick, the tape being wrapped close together so that the asbestos can not disintegrate from the effects of water or other causes.

W. G. CARLTON, Chicago, Illinois

## 76

### **An Ingenious Arrangement of Available Generators to Help Out of a Difficulty**

We had occasion last summer to exercise our ingenuity in order to take care of an unexpected load at one of the beaches (Bergen Beach) in the neighborhood of Brooklyn, which may be of interest.

We had supplied Bergen Beach previously from our 2400-volt, 60-cycle, two-phase system, but during the summer immediately preceding that of 1903 the Beach did not open at all, and the question of opening again last year did not come up until the last moment.

We did not have sufficient capacity on our two-phase system, and a 400-kw, two-phase motor-generator on order was not due until the middle of summer. We had, however, the following apparatus that was not in use: Two 250-kw, 500-volt, 25-cycle rotary converters, three 150-kw, 25-cycle, 6000-volt transformers for same, and one 180-kw, 66-cycle, 2400-volt, two-phase Stanley alternator, speed 666 r.p.m. We belted the Stanley alternator to one of the rotaries by substituting a pulley for the starting induction motor on the rotary. The set was started by a 10-hp, 230-volt, direct-current motor belted to a second pulley on the alternator and operated from the 230-volt Edison direct-current system.

Owing to the fact that the alternator was intended to be driven by two belts, one on either end of the shaft, we were unable to carry more than 150 kilowatts on the single belt. The

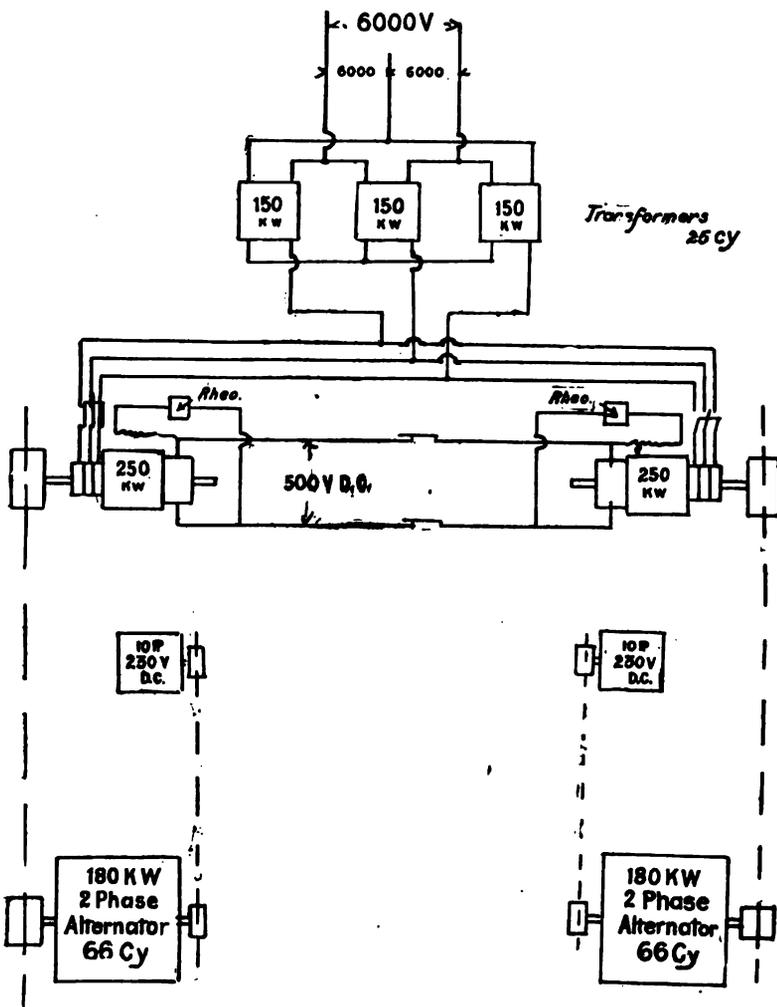


DIAGRAM OF THE CONNECTIONS

load at Bergen Beach increased rapidly and soon got beyond the capacity of the single machine. We therefore obtained a 150-kw, 66-cycle, 2400-volt Stanley alternator, speed 1000 r.p.m., and

belted it to the second 250-kw, 500-volt rotary. By running the second rotary as a direct-current motor from the first rotary we were able to operate the two alternators successfully in multiple and to divide the load as desired by adjusting the field strength of the second rotary.

The method of starting was as follows: Start the first set by means of a 10-hp, 230-volt, direct-current motor from the Edison system and synchronize on the alternating-current end of the rotary with our 6000-volt, 25-cycle, three-phase system. The second set was started in the same manner and also synchronized on the alternating-current end of the rotary. Then the 500-volt, direct-current circuit was made between the two rotaries and the alternating-current switch of one opened, leaving it running as a direct-current motor, after which the two alternators were synchronized with ease. The maximum load carried in this manner was about 225 kilowatts.

It was also possible to run the alternators in multiple with both rotaries running as synchronous motors; but this was not so satisfactory, as the division of the load could only be adjusted by the slip of the belts.

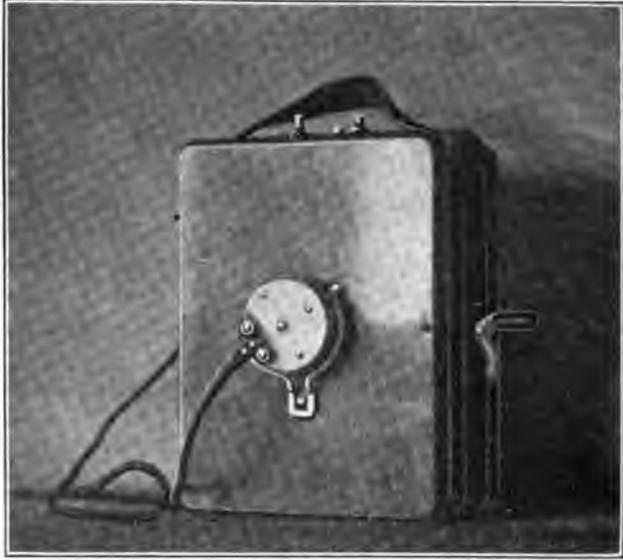
I inclose a diagram of the connections.

CABOT STEPHENS, Brooklyn, New York

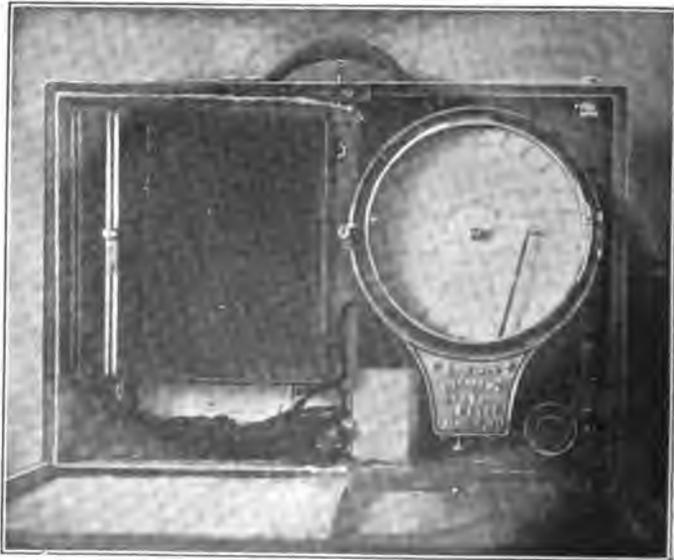
In cases where we have complaints of either poor voltage or poor regulation we use a recording voltmeter mounted in a case like a suit case. This is placed at the entrance of the building and a record of the voltage taken for 24 or 48 hours. From this we can tell whether the trouble is inside the building or on the line. This gives much better results than testing with indicating voltmeter.

FULTON COUNTY GAS AND ELECTRIC  
COMPANY, Gloversville, N. Y.

Our linemen when looking up line trouble carry a portable telephone as shown. This is like the set used by the telephone trouble men and can be used at any point where they



RECORDING VOLTMETER  
WRINKLE 77



PORTABLE TELEPHONE  
WRINKLE 78

can get on the wires. In case the lineman wants to talk with the station he puts this on the first service he comes to and calls central and gets the station at once. This is of great use at night, when it is hard to get the use of telephone in stores or hotels.

FULTON COUNTY GAS AND ELECTRIC  
COMPANY, Gloversville, N. Y.

#### A Trouble Preventer

In answer to yours of January 25, 1904, beg to advise that our memory for wrinkles is limited, but we had a rather peculiar case this winter which may be of interest.

We furnish power to two grain mills, and, as you probably know, they are very cold places in winter, and we had considerable trouble in getting them started on cold mornings, as they were continually blowing fuses in trying to get their machinery in operation. After the machinery was up to speed they had no trouble.

The last time we sent a man there to help them out he left a set of fuses in their office on a shelf just back of the stove, and the next morning they had the same trouble, so put in the warm fuses, and everything started all right. They now take the fuses out at night and keep them in the office and they have no trouble whatever.

The fuses used were inclosed.

RALPH D. SMITH, Hoosick Falls, New York

#### Testing Set for Low-tension Cables

Those who have to do with high-resistance measurements by means of a voltmeter are familiar with the following principles of the test:

If  $R$  is the resistance of the voltmeter,  $X$  the resistance to be measured,  $V$  the total drop,  $V_1$  the drop across  $X$  (see Figure 1), it is evident that  $R : X = V_1 : (V - V_1)$ ,

$$\text{or } X V_1 = R (V - V_1)$$

$$X = R \left( \frac{V}{V_1} - 1 \right).$$

Figures 2 and 3 show a convenient arrangement that is used by the testing department of the Edison Electric Illuminating

Company of Boston for testing low-tension cables. The box contains 60 silver-chloride cells, a 75-volt Weston voltmeter of 100,000 ohms resistance, and well-insulated leads wound on a spring reel.

To operate, the ends of the leads are first placed on the lead sheath. This gives  $V$  on the voltmeter and also insures good contact of the terminal that is to be in electrical connection with the cable-sheath. One of the leads is then placed

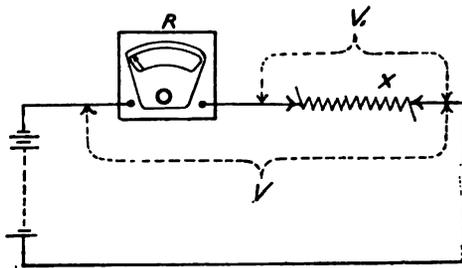


FIG. 1

upon the copper core of the cable.  $V_1$  is then read from the voltmeter. The resistance of the voltmeter  $R$  is made 100,000 ohms for convenience in testing and calculation.

The box is weatherproof. The spring-reel is released by a button, and a glass window in the cover admits of reading the voltmeter without opening the box.

Insulation resistances up to 10 megohms can conveniently be measured in this manner.

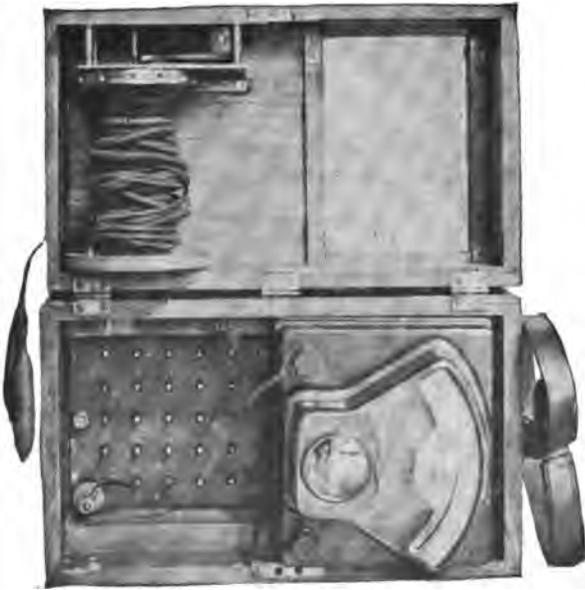
C. R. BROWN, Boston, Massachusetts

#### Gln Pole for Hoisting Transformer

A few issues ago I saw in the *Western Electrician* a notice of "Wrinkles" to be edited by you, with request for additions. I inclose illustration of a handy device I used a few years ago,



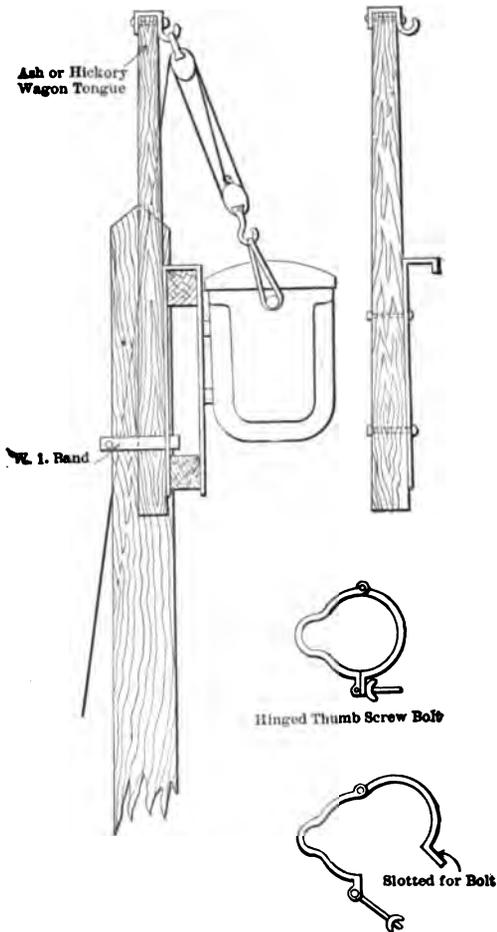
**FIG. 2**  
**WRINKLE 80**



**FIG. 3**  
**WRINKLE 80**

and, no doubt, you have seen it before. Anyhow, I thought it no harm to send you a sketch of same.

The pole is cut from the end of a sound wagon tongue. It



GIN POLE FOR HOISTING TRANSFORMERS

comes in handy when the transformer is placed on the upper cross-arm, and we have hoisted 300-lighters with it.

W. B. VOTH, Sheboygan, Wisconsin

#### **A Water Rheostat Used as a Starting Box**

A water rheostat may be used as a starting box in case of an emergency where it is necessary to start a motor when a starting box is not at hand, or in case of a starting box burning out.

Take a wire from one side of the line and connect to motor as with an ordinary starting box. Then, take a wire from the other side of the line and connect to the field connection on the motor. Next, take a wire from the same side of the line as the field connection and connect to an iron or copper plate in a pail of water. Connect a wire to the armature side of the motor, then connect the other side of the wire to another plate, and the motor is ready to start.

To start the motor, place one of the plates in the pail of water; lower the other plate in the water until the motor is up to speed, then put the plates together so as to cut out all of the resistance. It is advisable to use a little salt in the water.

W. J. HUGO, Madison, Wisconsin

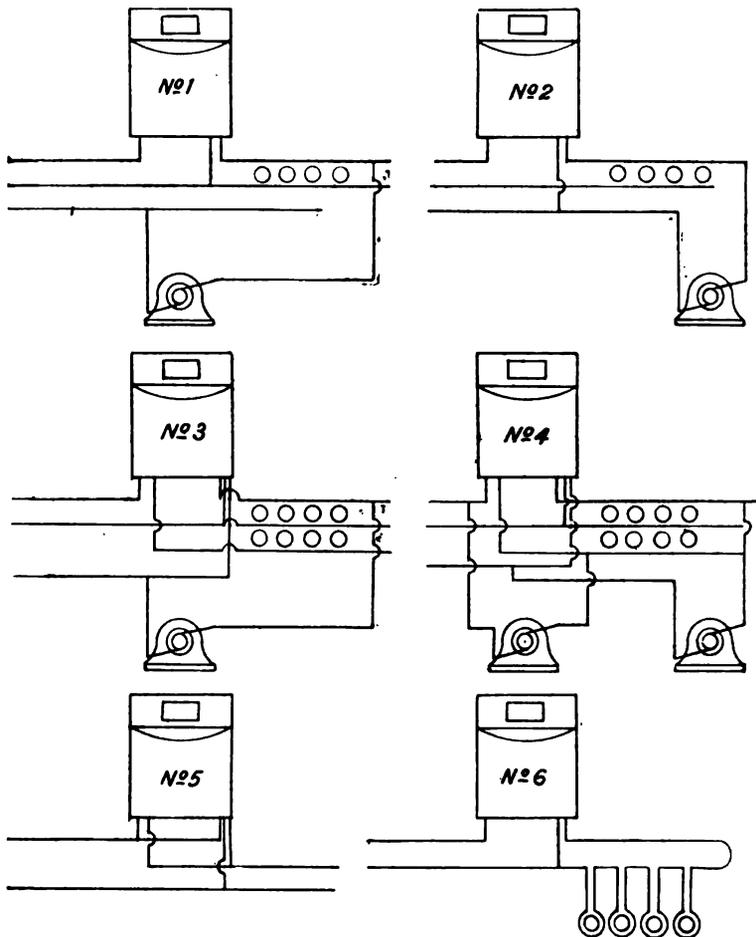
#### **Method of Connecting Thomson Recording Wattmeters on a Three-wire Edison System**

*Number One*—Showing a 110-volt meter carrying 110-volt incandescent lamps and a 220-volt motor so connected that the meter records the energy required for the lamps and the energy required for the motor at half potential or half value, thereby giving the customer a lighting and power rate with a ratio of two to one, or to, say, a 15-cent rate for incandescent lamps and 7½-cent rate on the motor.

*Number Two*—Shows a 220-volt meter connected for power where a customer desired a few incandescent lamps. In this case the meter records the energy required by the motor and doubtless the kilowatt reading on the lamps, which makes it appear that the lamp and motor current is being sold at a motor rate but in reality a double motor rate is being charged for the current used by the lamps. This being the reverse of No. 1, the current in amperes is being recorded in the meter at 220 volts

while in reality the lamps are being furnished with 110 volts, thereby recording twice their actual consumption.

*Number Three*—Shows a 220-volt, three-wire meter connected



DIAGRAMS SHOWING DIFFERENT METHOD OF CONNECTION

in the ordinary manner for lamps, while but one lead of the motor is connected to the house side of the meter and the other is connected to the line side of the meter, thereby recording the

current used by the motor at half its value and giving the customer power at one-half the lighting rate.

*Number Four*—Also shows a 220-volt, three-wire meter connected for lighting load for two motors connected as in No. 3, except that the connections are reversed so that the motor load may be divided on the series coil of the meter, also recording but one-half the energy used by the motors as in the case of Nos. 1 and 3.

The above methods of connecting Thomson recording watt-meters have sometimes been found convenient where light and motors are furnished to small consumers, in order to save the necessity of two meters, one for light and one for power, for the same customer.

*Number Five*—Shows a method of connecting up a three-wire, 220-volt meter or a two-wire, 110-volt service paralleling the series coils, thereby combining the ampere capacity of the two coils of the meter and doubling its capacity for an emergency call, as might occur in an alternating-current, two-wire service, thereby making a 15-ampere, three-wire meter take the place of a 30-ampere, two-wire meter.

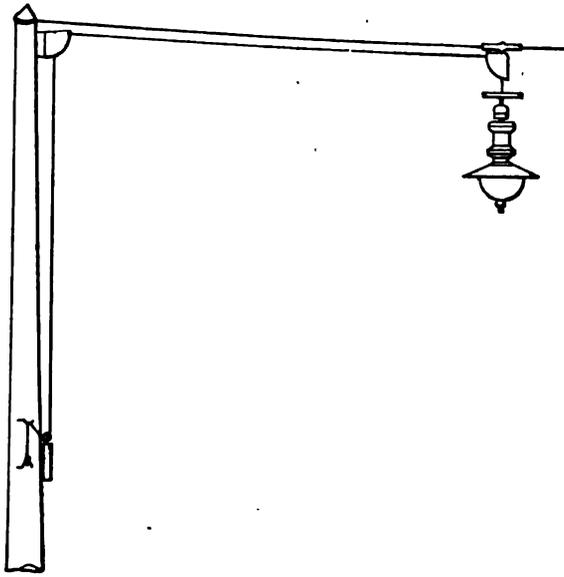
*Number Six*—Shows a 10-ampere, 220-volt, two-wire meter connected up on a series arc circuit, and may be used for one, two, three or four arcs of 50 volts each, in place of the regular series arc meter. While we have used this meter in several cases, we should not advise such a practice except as an emergency, as there is no cut-out to protect the meter in case of an accident to an arc-lamp lead or anything else that might open the arc circuit on the house side of the meter.

JAMES E. PYLE, West Chester, Pennsylvania  
R. L. PETERMAN, West Chester, Pennsylvania

#### **Method Adopted for Keeping Ropes Tight in Connection with Cross-suspensions for Arc-lamps**

The accompanying diagram shows method adopted for keeping ropes always tight in connection with cross-suspensions for arc lamps where the weight of the lamp is borne by an automatic pulley and hook-knob. The practice of having lamps swinging on the rope is dangerous, and, on the other hand, automatic suspension pulleys leave the rope alternately too

tight and very slack in wet and dry weather respectively. The method shown herewith has been found very satisfactory, not only for the reasons noted above, but also because the rope does not have to come within 10 or 12 feet of the ground, so that unauthorized persons can not readily lower the lamp



out of the supporting pulley, as had previously been of common occurrence, and because the weight very materially assists the lamp trimmer by partially balancing the weight of the lamp.

The trimmer uses a pole provided with a hook to catch into the ring at the end of the rope.

S. R. INCH, Missoula, Montana

#### **A Special Transformer Used for Thawing Frozen Water Pipes**

We have been doing a rushing business in thawing out frozen water pipes, and up to the present time we have not used over six kilowatts of current on any of the jobs.

The transformer we are using is a five-kw, which is wound

for 100-200 volts primary and 24 volts secondary; but the secondary voltage can be raised to 48 by connecting up in multiple across the 200 volts. The reason we use a transformer of this capacity and voltage is that five kilowatts is our standard size of transformer on incandescent distribution, which is all three-wire, 100 or 200 volts secondary, and there are places where the drop between transformers will throw the load almost entirely on one transformer.

The outfit is all put on a light wagon, and includes the special transformer, a regular five-kw transformer, used where primaries are nearer than secondaries, 400 feet of 00 flexible weatherproof conductor, 1000 feet of No. 6 weatherproof wire for primary connections, and the usual switches and cut-outs.

We do not use a water rheostat but adjust the voltage by changing the connections to the length of pipe to be thawed, and we get the water running in about 20 minutes on the average. The shortest time thus far has been three minutes and the longest time two hours. We could work faster, of course, if we used a larger outfit, but what we have is inexpensive and economical and does not require any special care in handling.

H. A. FEE, Adrian, Michigan

## 86

### **A Wrinkle for Thawing Water Pipes by Electricity**

The recent severe winter has made the wrinkle I am about to describe of great value to our company, as well as a source of considerable "easy money." The writer, in his work, finds that there is a good profit in the price charged for such service—\$10—and that all who have a chance to get the service are glad to pay that price rather than wait until Nature does the work or have the frozen ground dug up along the whole line of pipe.

We have used mostly direct current of 550 volts, although alternating current might be used to better advantage—provided a transformer of adequate capacity be available—for the reason that it is the ampere factor of the electrical energy imparted that does the heating, and by reducing the voltage to the lowest degree possible on the transformer connections, a greater amperage—consequently greater efficiency—is secured per kilowatt of power.

The idea is, briefly, the insertion of the frozen pipe in an electrical circuit, with an ammeter to tell the flow of current and a water rheostat to regulate same. As the electrical formula for heat generated in a conductor is, heat = square of current X resistance, and as resistance of both wrought-iron pipe and inclosed body of ice is high, this, together with a fairly large flow of current—at least 200 amperes—will develop a large amount of heat.

I note in issues of the *Scientific American* of March 5 and March 19, in experiments conducted by Mr. E. B. Greene, of Altoona, Pennsylvania, and Mr. T. D. Bunce, of New York city, the following results:

Mr. Greene, using alternating current, with 50 volts on secondary wires.

Pipe length	Diameter	Time	Kilowatts	Amperes
250 feet	1 inch	20 min.	18-20	360-400
40 feet	.75 inch	5-8 min.	11-15	220-300

Mr. T. D. Bunce, using 48 200-ampere-hour storage-battery cells and regulating both voltage and amperage by various series-multiple connections.

Pipe length	Diameter	Time	Kilowatts	Volts	Amperes
70 feet	0.5 inch	15 min.	4.5-5	16	300
20 feet	2 inch	3 min.	10-12	6	2000

Experimenting further, Mr. Bunce found that on connecting terminals of a four-volt battery circuit, 185 amperes flowing, to 20 feet of three-quarter-inch pipe, drop at terminals was one and one-half volts, and at end of 10-minute run, water rose from 39 to 41 degrees Fahrenheit, while pipe was not uncomfortably hot. On connecting up another cell, however, adding two volts, and raising amperage to 260, the result at end of 10-minute run was that temperature of water was raised to 59 degrees Fahrenheit and pipe was uncomfortably hot.

So much for the general idea; now for the specific application. The connections made by this company, if on a 550-volt circuit, direct current, were: tap made from positive wire to a floor stand or single-pole knife switch; from other side of switch to some wedge-shaped piece of iron or copper (we used an axe), which is immersed in the water of the rheostat. A wedge-shaped metal is preferable, for the reason that if it should be necessary to break the circuit at the rheostat, it will be easier and the current will generally flow off better. For the water-resistance box we used an ordinary wash-tub made of wood and holding perhaps seven or eight pailfuls, and if

flow of current was not sufficient when terminals of rheostat were as close as they could safely be brought, we introduced a quantity of salt to increase the conductivity of the water. For the other terminal of the rheostat, we used a copper or iron plate, and this terminal was made fast to the end of frozen pipe, with an ammeter introduced between terminal and pipe. Then connection was made from a nearby hydrant, spigot in neighboring house, or to water main itself, and from there to return conductor. On closing circuit at switch and adjusting movable wedge of rheostat until desired current is flowing, the circuit is from positive wire to switch, to rheostat, to ammeter, to end of pipe, through pipe to water main, to hydrant, to return conductor. If alternating current is used with transformer, put rheostat on primary side, as thereby a smaller volume of water may be used.

Of course, the element of time is an important factor in this work, as often a smaller current will do the work in a longer time than the examples given above. It is also, of course, difficult to determine the exact distance the pipe is *frozen*. In a recent case we had a current of 190 amperes flowing for 15 minutes and got a full flow of water at that time, where pipe circuit was over 100 feet of three-quarter-inch pipe. Diagram of circuit would be :

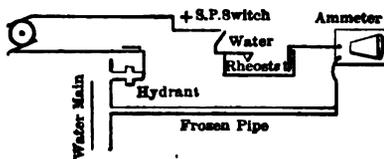


DIAGRAM OF CIRCUIT

EDWARD S. GOLDTHWAITE,  
Suffield, Connecticut

#### A Novel Electric Sign

An effective electric sign for advertising coke is made up in the following way :

A skeleton frame, three feet square, is covered with wire screen of about one-inch mesh. This box frame is placed in the

window, or on the sidewalk where such is allowable, and filled up with coke.

A dozen automatic red Hylo, 16-cp to 1-cp lamps are stuck in with the coke in such a way that the lamps can not be seen, but the light given out by them is cast onto the sides of the coke. This can be done by careful placing of the individual pieces of coke. The automatic Hylo lamps give an excellent imitation of a burning coke fire, and passers-by will almost invariably stop and look at the display, generally trying to warm their hands.

Such an advertisement is inexpensive to rig up, and it is easy to find a coke dealer in nearly any town who is willing to make a long-hour contract for its use.

Another but less effective advertisement may be made by placing red lamps under a glass in a window and spreading coke upon the glass in such a manner that the light will find its way through in places; but this scheme will not deceive many people, although it will attract attention.

ANONYMOUS

## 88

### **Electric Fans for Keeping Windows Free from Frost**

During sudden changes of temperature, when much moisture is in the air, a great deal of trouble may be experienced by merchants in their display windows on account of the frost forming on the glass and thus hiding the window display. The frost may be easily removed by directing the blast of an electric fan against the window, which will clear away the frost and keep it away, besides pleasing the consumer and adding a long-hour user to the company's list of patrons.

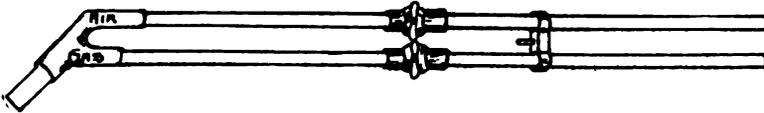
L. BEMIS, St. Paul, Minnesota

## 89

### **A Handy Tool for the Dynamo-room**

Very often a great deal of difficulty is experienced in removing a pulley from a shaft after the pulley has been on the shaft for any length of time, and pulling and pounding and forcing will only batter up the shaft and pulley, without accomplishing anything further.

Where gas is piped into the dynamo-room, a bunsen burner made up of half-inch gas pipe, connected up by a flexible tube to the gas supply and to an air compressor, or some means of supplying air under a slight pressure, will be found very effective in removing a pulley that sticks, as an intense heat can be



applied to the hub just where it is wanted by means of the bunsen, and the hub heating up rapidly expands before the heat is conducted to the shaft, which allows the pulley to be easily removed without any dangerous pounding or straining.

T. CRAWFORD, Dallas, Texas

#### A Made-over Electric Sign

When trying to introduce electric signs into a small town, the first cost of the sign sometimes scares out a prospective consumer. A good deal of long-hour business can sometimes be taken on by arranging with parties who already have large painted plain letter signs in use, to place sockets upon the sign already installed, fastening the sockets on the back of the sign, and boring holes through the sign for the lamps to stick through. At night it looks like a straight electric sign, and during the day-time the appearance of the sign is not damaged.

A flasher can be rigged up and added to the equipment at a small cost, and it makes a good advertisement for the electric company, for every sign that is put up helps to sell more signs, and the sign business pays well on the investment necessary for it.

W. DAVIS, Chicago, Illinois

#### Dummy Slips to Insure the Performance of Work Ordered

I have to say that no strictly electrical or technical wrinkle in use by us, that is original with us, occurs to me just at

this time. However, as a wrinkle applicable to the office end of an electrical plant, I am inclosing you herewith a little slip with attached stub which we have had in successful use for a year or more. They have in some way acquired the title "dummies" with our office and working force, and it has become more and more the thing to "make a dummy" to cover any instruction, request or question passing between the various principal employees of our company.

These dummy slips are bound with their stubs in books of 100 each. They are used mainly by the manager in his dealings with the principal employees of the company, but each of our principal employees (or heads of departments, as you would call them in larger plants) has one of these books to use in his dealings with the others and with the manager.

<p>No. 2001</p> <p>TO: <u>Edwards</u> DATE: <u>1/30</u></p> <p><u>Put fusible plug in #1</u></p> <p><u>File # 2</u></p> <p><u>by 2/10</u></p> <p>SLIP RETURNED <u>7/10-04</u></p>	<p>No. 2001</p> <p>TO: <u>Edwards</u> DATE: <u>1/30-04</u></p> <p><u>Fusible plug should be placed in</u></p> <p><u>Box #1 and plug in #2 should</u></p> <p><u>be refilled as per Hartford</u></p> <p><u>recommendations</u></p> <p>SHOULD BE DONE BY <u>10 - Jones if convenient</u></p> <p>WHEN DONE, user has returned slip to place per- sonal on desk, and return to the sender, or to last of a telephone instruction, with address, and not return to desk.</p> <p><u>Jones</u></p>
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DUMMY SLIPS WITH STUB

Of course, in the case of instructions or requests that call for immediate compliance, verbal communication is sufficient, provided the party addressed is present; otherwise we find the dummy well worth the trouble of a hurried and sometimes considerably abbreviated written instruction. Where a dummy can not well cover a matter fully, we add to the abbreviated instruction "see me first"; then in conversation the matter in all its phases can be thoroughly covered.

To make the dummy system efficient, insist that every slip be returned as soon as the instruction is complied with, but not before the instruction is complied with.

The slips as made out can be dropped in the stenographer's basket, and be delivered by him, or mailed, as the case may require.

As the slips are returned they are filed after the corresponding stub is checked and the date of return entered if desired.

By glancing over the unchecked stubs, all instructions not yet complied with are at once apparent; and where the delay in returning a slip becomes improperly long, a "because why" dummy can be sent out as a tracer, referring by number to the original slip.

The principal advantages of the "dummy system" are:

*First*—Instructions can be issued at whatever instant their expediency becomes apparent. It is not necessary to "wait to see" a certain person, nor to go and see him either.

*Second*—The matter being once decided on, it keeps itself constantly before you and the employee delegated to attend to it until it is done. Neither of you can forget, and it is harder for him to procrastinate. He knows you have not forgotten and he knows you know *he* has not forgotten. Likewise, when he sends you one, he knows whether his request is attended to or not and you are compelled to grant the request or indorse the dummy with the "reason why not" and return it. Likewise, in sending questions, requests, suggestions, etc., to other employees, he either gets compliance or a prompt answer.

*Finally*—There is no "shenanigan" about the dummy—it is strictly business.

E. L. WELLS, JR., Marshall, Texas

## 92

### A New Business Proposition

Why would it not be good policy for electric companies in small towns that are trying to work up a load for their stations to wire and connect up houses free of charge and then charge a somewhat higher rate for current until the wiring is paid for? In some places this would be the only way you could get the houses wired, and once wired the people would be more apt to use current than they would if the houses were not wired.

C. G. KNODE, Long Branch, New Jersey

## 93

### A Scheme for Cutting Off the Neck of a Bottle at a Predetermined Point

I had some bottles from which I wished to cut off the tops. I tried several schemes, but found that by taking a string and

soaking it in turpentine and tying it around the bottle where I wished to cut it was the best method to pursue. Fill the bottle with water up to the string, light the string and let it burn, and the bottle should then break off evenly and smoothly.

C. G. KNODE, Long Branch, New Jersey

## 94

### A Wrinkle Remover

There is a season when the kick department deserves all the sympathy that can come its way. It begins December 1st, passes the critical point March 1st, ends about April 1st, and comes as surely as the tax schedule. The cause of this season of misery appears to be inability of the public to appreciate the exact difference between summer and winter burning. Most electrical men will admit that such a thing as a kick in spring, summer and autumn is almost unheard of. The meters—those infernal robbing machines, just and peaceful the rest of the year—break loose and aim to make a record in this one remaining period. Argument may appease for a moment, but a conviction of robbery too often survives, and confidence is forever shaken. Since we can not change human nature, and seldom feel disposed to adjust meters to conform with customers' ideas, I offer this suggestion: A little observation will show that the trouble begins with the meter reading for the month of November (bill December 1st). Now, suppose it has been your custom to read meters in a certain locality on the 24th of each month: Begin in September and read on the 26th; in October, on the 28th; in November, on the 24th; in December, on the 20th; in January, on the 18th; in February, on the 18th; in March, on the 22d; in April and remaining months, on the 25th. Conditions vary so much in different places that dates of reading could be changed to suit. This scheme, which may be common to many, is only intended to convey an idea, the results of which will be satisfactory—particularly to the victim in the kick chamber, who often grows wrinkles to give away.

CHAS. H. PETERS, Durango, Colorado

## 95

### A Strong Argument Used to Force the Settlement of a Bill

A certain manager of a small electric-light company in one of the northwestern states advertised the fact that his company

stood ready to serve the public by thawing out frozen water services at \$10 each, and as the cold was unusually severe numerous orders were soon placed on his books.

Including the time necessary for making the connection, etc., about two hours was usually consumed in completing a thaw. On one occasion he had just finished thawing out a service when an old German, living in the adjoining house, made up his mind that it would be cheaper to pay the \$10 than borrow water until spring, when the frost would leave of its own account, so the connection was quickly changed, and about three minutes after the current was turned on the water began flowing from the faucet. It did not seem just to the old man that he should be required to pay \$10 for this service when barely 15 minutes had been consumed in the entire operation, and he entered a decided protest against the payment of the bill. After the old man had finished his abuse of the electric company, the manager asked him point blank if he refused to pay the bill now that the work was done, to which he answered in the affirmative. Turning to his assistants, the manager said, "Reverse those connections and freeze him up again." But the old man wouldn't stand for that, and the bill was quickly paid.

L. STRONG, Champaign, Illinois

**Several Wrinkles from Different Departments of the Boston  
Edison Company, Boston, Massachusetts**

*First*—No person connected with a company furnishing light and power to the general public should allow any stress of circumstances to make him forget, even for a moment, that his rule of conduct to every one, whether rich or poor, powerful or humble, should be one of unfailing courtesy and politeness.

*Second*—Most business men who operate an isolated plant admit grudgingly, if at all, any item for its administration. All lighting and power companies pay salaries for equivalent work.

*Third*—When a solicitor can be made to see that he must redouble his efforts when a prospective customer says "no" he begins to be a valuable man.

*Fourth*—Consideration for his customers, a cheery and affable manner, combined with plenty of diplomacy, should be part of the qualifications of a solicitor. In the great majority of cases the impression created by the solicitor is the only one the customer has of the company.

*Fifth*—There are two ways of saying the same thing to a customer. One way will leave the impression that the solicitor is doing all he can for the customer under his instructions from his company. The other way will make the customer feel that the solicitor's treatment is unjust and that he is personally overbearing and discourteous. It is part of a solicitor's business to leave a customer in such a frame of mind that he is glad to see him again personally, and also ready to talk business with him as representative of his company.

*Sixth*—Every solicitor knows the unreasonable and overbearing customer; the one who talks loud, swears, and calls the company a "gang of daylight robbers," etc., *ad libitum*. The solicitor feels like giving him as good as he sends, and without doubt there would be a great deal of personal satisfaction in so doing. The company is paying the solicitor for business obtained, however, and does not consider personalities. Here is a chance for diplomacy. The loss of your temper only handicaps you for final results.

*Seventh*—Solicitors are apt to feel that the company's prices are high and that it would be much easier to sell current if reductions could be made or certain conditions could be modified. This is a narrow view of the subject, for the reason that prices have been fixed by the company on the basis of necessary income and must therefore be maintained. Any one can sell current at very low rates, but it requires a man who is considered valuable by his company to sell current at its established rates.

*Eighth*—Liberality toward the customer counts largely for a company's success. No "peanut policy" can, or will, bring permanent success. Competition from isolated plants and the possibility of still worse competition in the shape of a rival company or a municipal plant may be the result of lack of attention to details through which liberal treatment can be shown to the customer.

*Ninth*—"The supply from an isolated plant is always limited in capacity. The supply from the Edison company is unlimited."

*Tenth*—The different departments of electric light companies are constantly asking for data and information in regard to special classes of business.

Wood, Pollard & Co. 170 Summer St., Business		FORM 497—28-11-09—E. I. CO., OF BOSTON			
Pass or Freight	K. W. H. per year				
No of Floors	H. P. H. per year				
Sq. ft. in Bld'g	K. W. H. per mile				
Make of Elevator	Cost per K. W. H.				
Capacity: lbs.	" " H. P. H.				
Speed per min.	" " year				
Travel of Car	" " day				
Counterbal Drum or Car	" " mile				
Make of Motor	" " trip				
Horse Power	" " 1000 sq. ft.				
Hours per day					
Miles per day					
Miles per year					

LIBRARY BUREAU C10311

The form of card attached will offer a suggestion in this direction. This card the Edison company of Boston uses in collecting information upon directly-connected electric elevators and, I think, explains itself.

#### GENERAL USE OF ELECTRIC ELEVATORS IN MODERN OFFICE BUILDINGS

In seeking business for new buildings, particularly the modern office building, it has been our aim to induce the owners or trustees, as the case may be, to install electric elevators, as this insures us a steady business for our day load factor.

After considering the low price of installing same, as compared with the hydraulic type, together with the economy of space, etc., comes the cost of operating. We have found that by offering a flat sum per year per elevator for a term of not less than three years, provided we also have the entire lighting of the building, it has appealed to the customer so favorably and

proved so satisfactory to both parties, that nearly all of the new buildings erected since we adopted this plan have put in electric elevators and taken power from the central station. In a great many instances this has been the means of getting the electric elevator installed where the hydraulic type was seriously considered, and we believe this is one reason why so few hydraulic elevators are now being put in here; for in the past 12 months there have been contracted for and installed in newly erected buildings alone, some 90 electric elevators, which are operated from the central station.

We claim that our efforts in this direction have helped the owners of these large buildings in reducing their operating expenses, as the expense for elevator service and public lighting is an item that is borne by them, and as there is always the question as to whether they can not install their own electric plant and produce current for less than by taking it from the central station, we think the above results answer the question as to which is the cheaper.

#### EDISON ELECTRIC ILLUMINATING COMPANY OF BOSTON

Mr. Robins, of Sherbrooke, appreciates the fact that a kicker once converted generally makes the strongest kind of a friend, and it always pays to go to no small amount of trouble to attend to the complaint of a consumer, whether the complaint is real or imaginary. Nothing so angers the kicker when he comes in to take the price of his bill out in a good, healthy kick to the complaint department, as to be told that the electric business and its meters is something that he knows nothing about. Under those circumstances the kicker will leave, a confirmed kicker, and will do his kicking to the public and through the press, instead of at the company's office.

#### A Help to the Complaint Department

The accompanying card is something that I use, when possible, with a dissatisfied customer. I give him enough to cover a month's daily readings. If he can be induced to

follow up the suggestion, he disappears from the list of kickers. Our rate being ten cents per kw-hour, our meters read directly in cents, so that makes it easy figuring. There are lots of

Maximum ..... Amp. Acc. No. ....

Name .....

Address .....

Meter No. .... Minimum Bill, \$, .....

Mkts. .... Capacity .....

1000,000 100,000 10,000

10,000,000 100,000 10,000 1000

DATE ..... READING .....

1000,000 100,000 10,000

10,000,000 100,000 10,000 1000

DATE ..... READING .....

1000,000 100,000 10,000

10,000,000 100,000 10,000 1000

DATE ..... READING .....

1000,000 100,000 10,000

10,000,000 100,000 10,000 1000

DATE ..... READING .....

1000,000 100,000 10,000

DATE ..... READING .....

kickers whom you could not hire to read their own meters, and with one of this class you are "up against it," unless you can induce one of the converted kickers to reason with him.

R. N. ROBINS, Sherbrooke, Quebec, Canada

### Thawing Water Pipes by Electricity

Referring to the accompanying diagram, a simple method of thawing out frozen water services by means of electricity is shown.

From the 2000-volt primaries taps are led to a primary fuse box, from which the primary wires are connected to a 20-kw

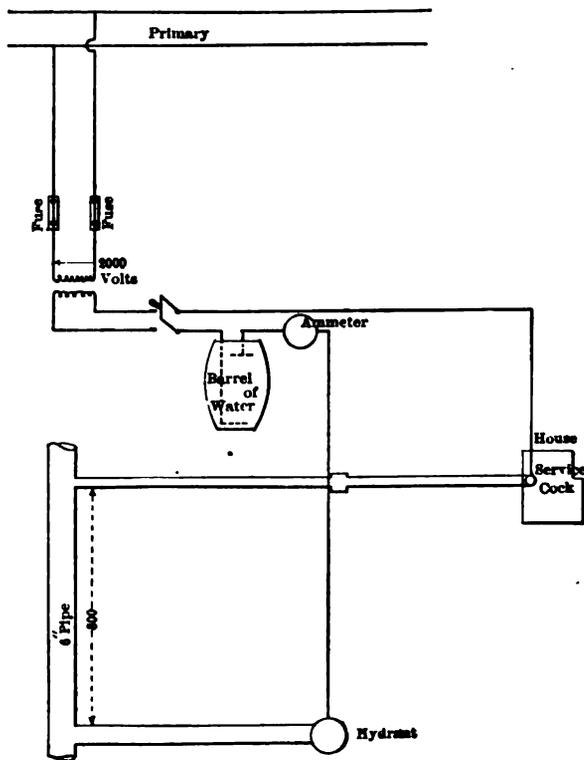


DIAGRAM OF CONNECTIONS

transformer. In the leads of the secondary transformer is placed a secondary switch, from which one lead is carried to an iron plate at the bottom of a barrel of water. In the upper part of the barrel is placed a movable iron plate from which the current is conducted through an ammeter, thence through a lead of heavy wire to a nearby fire hydrant. The secondary current is

then conducted through the iron branch pipe, thence through an eight-inch or six-inch cast-iron main, then through the service pipe to the service cock in the house. At this point a heavy copper wire is connected to the service cock, and this wire, leading back to the transformer, completes the secondary circuit. This is the connection that is necessary if a service pipe is frozen between the main and the house. If the pipe is frozen between the service cock and the house connect an iron wire on to the service cock instead of connecting the wire on to the hydrant, as shown in the sketch, which arrangement will place only that part of the pipe in circuit which lies between the service box and the service cock in the house.

By means of the movable plate in the barrel the amount of current used can be regulated from zero to the capacity of the transformer. The lower the secondary voltage that will force a sufficient number of amperes through the pipe, the greater the economy. From 200 to 300 amperes will be needed.

The transformer may be loaded on to a wagon and left standing close to the house where the pipes are frozen, and it will be necessary, then, to use but a small amount of heavy wire, as No. 6 wire will be of sufficient capacity to carry the primary current from the primary leads to the transformer.

Where two services in adjacent buildings, or in buildings in the same block, are frozen, the two may be thawed at the same time, by making the connection to the surface cocks or faucets in the two houses, instead of making one connection to the service cock and one connection to the hydrant, as shown in the sketch.

A. G. SANGSTER,  
Disraeli, Quebec

## 100

### Meter Card

I inclose one of our meter cards, which is not unlike many that are used by others, but we record our readings *backward*, from bottom up, for the reason that the last number is then always on top. This reduces the chances of errors very materially. We make out our bills from these cards on the





run to the repair shop, where the bell, or ringer, may be installed near the work bench. The two leads from the ringer coil may be long enough to reach to any part of the bench or rack, and at the same time, not be in the way when not wanted. In this way, since the magneto is always in operation, all that is necessary in order to ring out a circuit is to pick up the two terminals and make the required contact without reserving one hand to turn the generator.

JOHN CORSCOT, JR., Madison, Wisconsin

## 102

### A Ventilating Device

Good ventilation in the office is as important as a good heating system. Poor ventilation means less work done in the office. Offices located in the same building or on the same property with the power-house or generating department are often rather small and poorly ventilated. This is especially true among the older plants. The usual plan of running a ventilating shaft from the side of the room near the floor to a chimney or flue leading to the top of the building is sometimes unsuccessful on account of poor draught.

A very economical and easy way of overcoming this difficulty is to pass the feed pipe for one of the radiators through the ventilating shaft. One coil of one-inch pipe extending up in the shaft (about four feet) is usually sufficient. The radiation of heat from this coil is great enough to create an upward draught in the shaft, thereby removing the foul air from the room. The quantity of steam condensed in this coil is small, and is more than compensated by the pure air gained.

JOHN CORSCOT, JR., Madison, Wisconsin

## 103

### Data Pertaining to the Electrical Process of Thawing Water Services

While the thawing of water services by electricity is not new, and there seems to be more or less controversy in our electrical journals as to who instigated the system, there have been no data published, to our knowledge, giving information regard-

ing cost, etc., thereby opening up a new field for electrical companies, and adding greatly to the comfort of the people in general, as the one thing next to light and heat that the residence community can least afford to do without, is water.

The Rutland City Electric Company has given valuable assistance for the past three winters to the superintendent of the water-works, and the result has been that, while a great many services have been frozen up, none of our citizens have been without water for more than two or three days at the most. The amount of this work done during the past year has been very much greater than heretofore, owing, of course, to the extreme cold weather we have had, the ground having been frozen in some parts of the city to a depth of seven feet.

We began this work about the middle of January, and it has lasted until the middle of March. Seventy-five per cent of the services thawed out were done in the month of February, and it is from this month that the data, which are given below, have been compiled. From the middle of February until the fifth of March, two wagons were kept busy. Each wagon was equipped with two 10-kw transformers, ammeters in the primary circuits, fuses, switches, etc.

The water rheostat was applied to the secondary side. While the amount of current handled would be much greater, it was considered much safer for our employees than if the resistance were cut in on the primary. In each case two linemen, one helper and driver constituted a gang. The work that has been done has been all charged to the city water-works, with the exception of two or three private services that were supplied from springs and used by one or two residences only. Our city is well covered with primary feeders, but in some cases it is necessary to run them for a quarter of a mile, and in one or two instances for half a mile.

During the extreme cold weather the primaries were allowed to lie on the frozen ground; ordinary triple-braid No. 10 weatherproof wire was used, with little regard for bare connections. Owing to the liability of accidents, which should not be lost sight of, we charged a good fair profit upon this work. We furnished the use of transformers and instruments without charge, and also stood the wear and tear of the wire that was used. The rate of 10 cents per kw-hour was charged for the current, except in one or two instances in the thawing of some six-inch mains, when both wagons were used upon the same main and the price cut to five cents per kw-hour.

The city supplied the drivers and wagons at a cost to them of \$2.50 per day for each. Our charges were as follows: Linemen 40 cents per hour and helpers 30 cents per hour; the former we paid 25 cents and the latter 15 cents. Our bill to the city water-works for the month of February for the thawing out of 125 house services, seven hydrants and four 6-inch mains, not including teams and drivers, was about \$600. Just what it would cost the water-works to have done this work in any other way could hardly be estimated, and with the men that were obtainable at that time of the year it would have been utterly impossible to have given the citizens of Rutland anything like good service during the months of January and February. Information regarding time and current consumed and the cost for different services is given below.

Thawing 125 house services in February, 1904:

Average current consumed.....	17 amperes at 2200 volts
“ time “	27 minutes
“ cost of current, 17 amperes, 27 minutes, at 10 cents per kilowatt..	\$1 68
“ cost of labor ...	1 85
“ “ teams and drivers.....	58
Cost per services.....	<u>\$4 11</u>

Actual time and current consumed thawing a few “tough” ones:

1 service.....	2 hours, 14 amperes
1 “ .....	2½ “ 15 “
1 “ .....	1½ “ 20 “
1 “ .....	2¾ “ 20 “
1 “ .....	1½ “ 17 “
1 “ .....	1½ “ 21 “

One day's work for one outfit, Thursday, 18th:

J. Barney, Grove street .....	25 minutes, 16 amperes
79 Cleveland avenue.....	23 “ 16 “
17 Watkins avenue.....	26 “ 17 “
447 West street.....	17 “ 15 “
451 West street.....	17 “ 15 “
379 West street.....	11 “ 16 “
383 West street.....	11 “ 16 “
387 West street.....	10 “ 16 “
Mr. Moriarity.....	10 “ 16 “

Thawing seven hydrants, February, 1904:

Average current consumed..	18.5 amperes at 2000 volts
“ time “	1 hour 15 minutes

Average cost of current, 18.5 amperes, 1¼ hours, at 10 cents per kilowatt.....	\$5 08
“ cost of labor.....	2 20
“ “ teams and drivers.....	71
Cost per hydrant.....	<u>\$7 99</u>

Actual time and current consumed :

1 hydrant.....	10 minutes, 20 amperes
1 “ .....	1¼ hours, 20 “
1 “ .....	4½ “ 18 “
1 “ .....	35 minutes, 18 “
1 “ .....	25 “ 18 “
1 “ .....	30 “ 19 “
1 “ .....	1 hour 10 minutes, 17 “

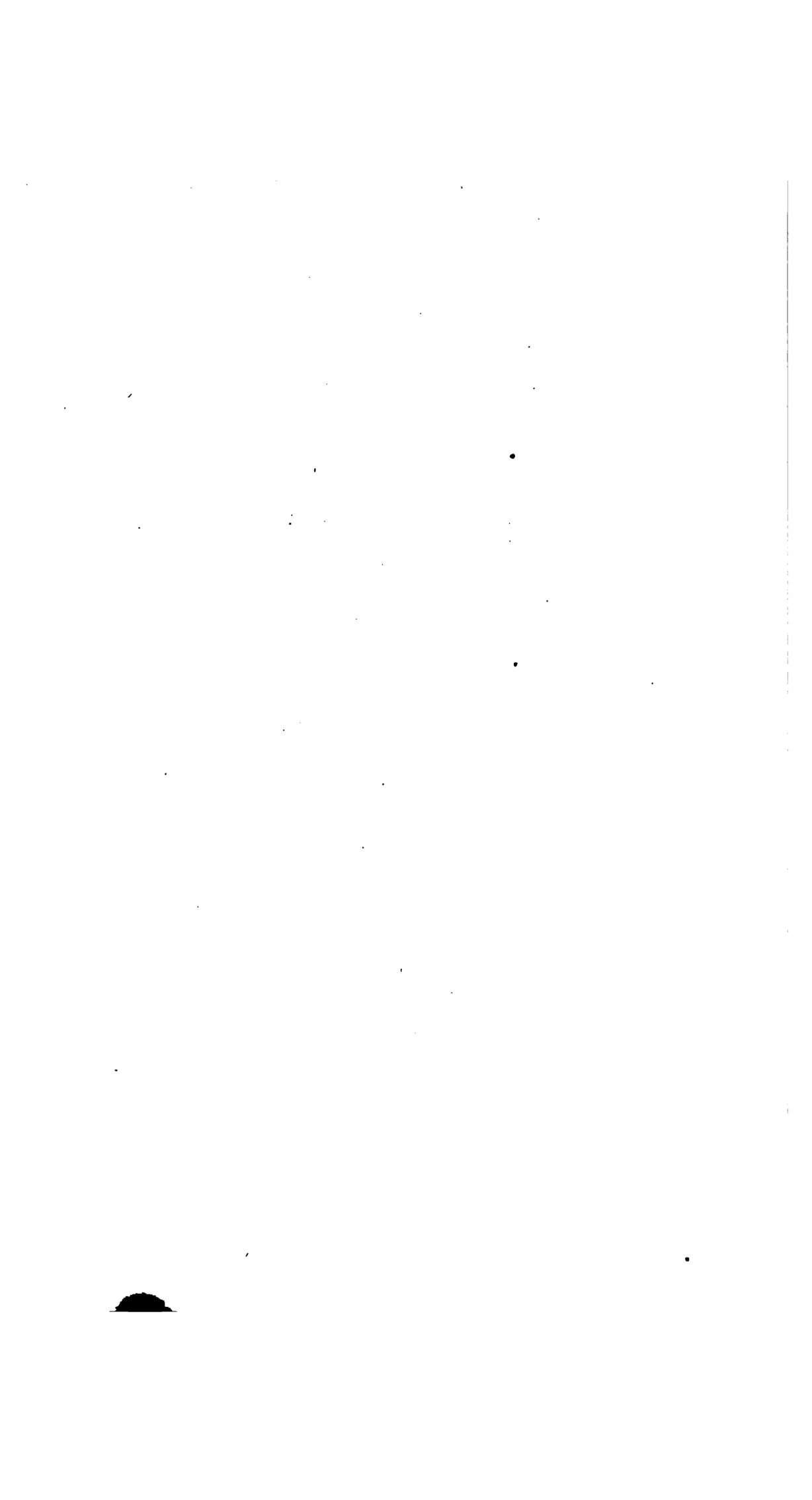
Thawing four 6-inch mains, lengths from 100 feet to 300 feet. Amount frozen unknown :

Average current consumed....	33 amperes at 2200 volts
“ time . “	3 hours 24 minutes
“ cost of current, 3 hours 24 minutes 33 amperes, at 5 cents.....	\$19 60
“ cost of labor.....	7 70
“ “ teams and drivers . . . . .	3 75
Cost of each.....	<u>\$31 05</u>

Actual time and current consumed :

1 6-inch main, 200 feet long,	6 hours, 22 amperes.
1 6-inch “ 300 “ “	3 hours 20 minutes, 38 amperes, 2 outfits.
1 6-inch main, 100 feet long,	5 hours 15 minutes, 36 amperes, 2 outfits.
1 6-inch main, 200 feet long,	7 hours, 36 amperes, 2 outfits.

GEO. S. HALEY,  
Rutland, Vermont





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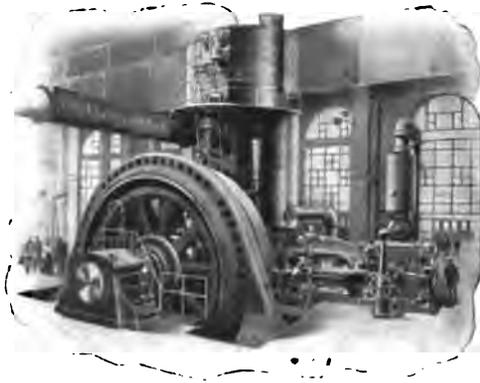
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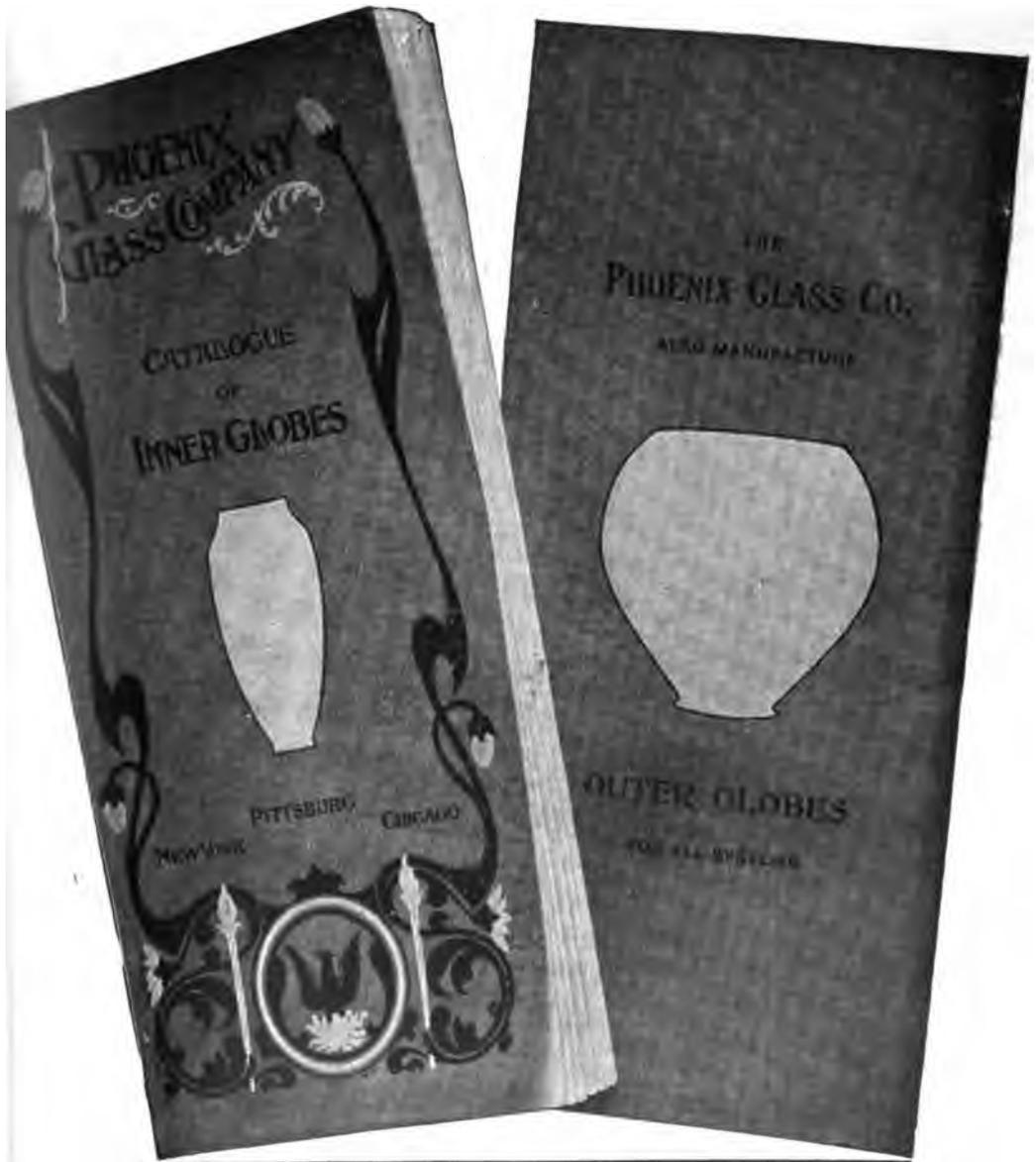
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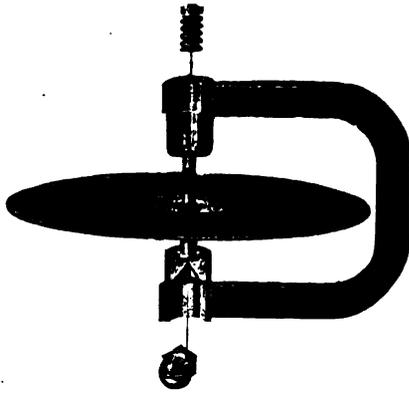
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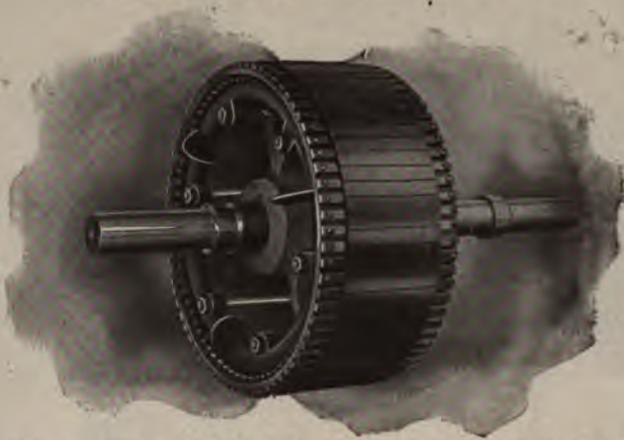
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### TYPE B MOTOR

In this type the starting current is kept low by introducing starting resistance within the secondary circuit. This motor does not possess the same simplicity of construction as the type A, owing to the fact that the armature has a polar winding and a device for conveying the armature resistance is a necessary adjunct in its construction, but it has this advantage—it will start a given load with a current materially less than that taken by the type A. Therefore, it is recommended where the motor must start heavily loaded and where a large current, such as the motor with short-circuited armature takes when starting at full load, would be objectionable.

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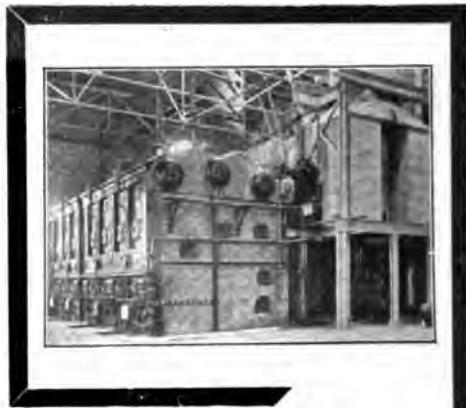
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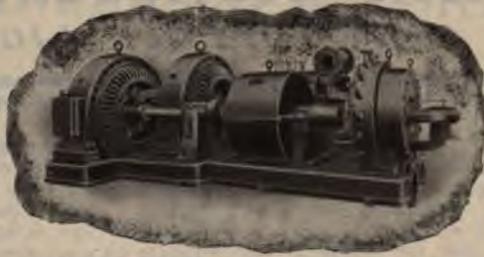
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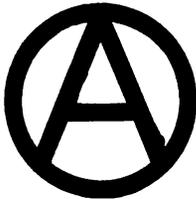
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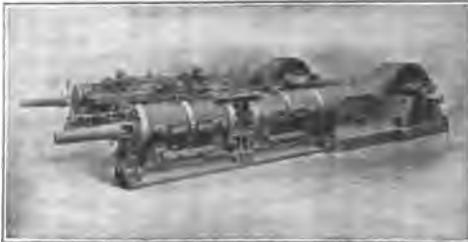
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