

## SOME POINTS FOR THE ELECTRICAL ENGINEER.

BY HORATIO A. FOSTER.

Although it is the province of this Institute to consider largely the more theoretical side of electrical engineering, and rightly so, it is perhaps well that it should occasionally have brought to its attention that outside practical part, only for which theory would have no backing and therefore could not reach its proper development.

It has been the fortune of the writer during the last ten months to visit and inspect, both technically and financially, considerably more than a hundred central lighting stations.

Taken as a whole, it really seems as if much of the ordinary commercial common sense and the usual keen judgment of self-interest had been on a vacation when these plants were erected. In many cases this traces back—first, to the wiles of that slickest of all individuals, the agent, who is always willing to assure the buyers that his system of lighting will virtually run itself, and then to the fact that people were formerly so doubtful of the prospective profits that on going into the business they invested the smallest amount that would start the work. The consequence was, bad construction, bad machinery, bad lines, and, of course, an entirely unreliable service. Oftentimes the man put in charge was a novice, and that worst of all novices for the business, the local amateur electrician; and is it any wonder that the business was a failure for the first few years?

In some localities this condition still obtains, nothing having been done but to patch up the bad work of the past.

In a few cases the administration has been changed by putting at the head some substantial and tried business man,

very much to the benefit of the concern. While, in many instances, even the large city plants suffer from the above causes, they also suffer from other conditions inherent in the size of their field.

The pioneers were so timid about the outcome, that the city station was invariably very much too small, and inside of two years had become so patched up and crowded, that rebuilding became necessary, and this in many cases was repeated two or three times.

There is probably no business extant which has been built over so many times and that has had the same quality and quantity of brains applied to it that is in such chaos as to the proper design of building and arrangement of machinery. In cotton or any other weaving industry, machine shops, foundries and similar establishments, it has long been determined which is the best form of building to erect, and those put up in the last ten years or so of a similar industry are planned in the same lines, differing only in size to suit the special case. Now, this not only fails to be the case in electric lighting, but outside of the two prominent systems of connecting the dynamo to its power—that is by direct belting to fast running engines, or by counter-shaft to larger slow running engines, there are scarcely a half-dozen stations in the state built on the same or similar lines.

So much diversity of opinion is shown in designing these stations, and oftentimes by those whose opinion should have no weight, but unfortunately does, that it has the effect to convince some of the investing public that the electrical engineer does not know his business and they might as well go it alone.

If some action could be taken by this Institute through a committee which should examine into proper station design and report on some few general plans and suggestions as to lines to be followed, it might go far toward establishing a better backing for our members who are in that branch. As it is I think it will be acknowledged, that far more electrical engineering skill is applied to the larger isolated plants; and that the central stations are enlarged or rebuilt under the management of the local superintendent or board of directors, who frequently lack technical knowledge or even familiarity with recent improvements elsewhere. Quite often this is owing to the fact that the only experience they have had with an electrician has been the generally young inexperienced expert who was sent out to install the first plant,

and they think they can make better use of their money by controlling it themselves.

The method of distribution should also have consideration, especially in reference to the amount and style of underground work which certain sizes of city will be able to stand.

This may seem a large question, but you can be assured it is one of the most vital to the future welfare of the industry. It may be said that it is not well to interfere in private business, and that electrical engineers can be trusted to remedy the evil. I assure you the electrical engineer individually "is not in it," to use a vulgar phrase, and sad to say, has never been in it to any extent. Quite often officials of the electric lighting companies take a jaunt through the country visiting different stations for models for a new one for themselves. This often results in a worse muddle than ever, as they seldom find two stations at all similar, and they return resolved to use their own judgment.

This leaves the real electrical engineer out in the cold, at a point where if known he could by consultation do much good but many of these company officials never heard of the American Institute of Electrical Engineers and need to have it brought to their notice in some way.

Some may think that in time the electrical engineer will be called in and consulted, as are engineers of other works, but at the present rate I am afraid many will be angels or worse before the majority of electrical central station companies come to that point.

Perhaps if instances be mentioned under the following heads a better understanding can be arrived at, viz.: Location; foundations; construction of station; motive power; arrangement of machinery, and location and construction of lines.

#### LOCATION.

The location of plants is not now so generally bad as in the past, although we occasionally find a station in a location for which no excuse is apparent, as, for instance, one located in the basement of a carpenter shop at a long distance from fuel supplies, and only plenty of condensing water to recommend it; insurance rate, three per cent. or more. Another located nine miles away from a village of two thousand people to take advantage of water power never surely available all the year, and since destroyed entirely for the greater part of the year. An-

other placed so low down in reference to its water power as to be flooded in freshets. Another located more than a mile from fuel supplies, and the center of distribution at the top of a long, steep hill, with not even free water to recommend it. Another so located in relation to a very intermittent water power as to be unable to take advantage of the water for condensing purposes and now running the poorest kind of a slide-valve engine. Another located in a rickety, old, uncared-for part of a gas-house, where coke is scarce, and apparently plenty of water power available within a half mile.

Another located a long distance from center of distribution and coal supplies, to take advantage of cheap land and cheap fuel, the last of which has since proved very unreliable, when seemingly land could have been had much more central, with a much surer supply of cheap fuel, and to cap all, the value of that land has since increased enough to have paid the entire cost of the station at any moment it be desirable to sell.

One advantage of some of the older centrally located stations has since been learned in the increase in value of such real estate. One such station visited will enlarge and rebuild soon, and will sell its present real estate for enough advance to go far toward paying for the new station, and there are others which can, I think, tell the same story. In fact, in the present problematical growth of the future, a well-selected piece of ground may prove a very valuable part of the investment.

#### FOUNDATIONS.

Foundations are now much better than in the past, and some of those now placed under dynamos would sustain almost anything that could be put on them. Poor foundations are occasionally seen though, as for instance those under a large bank of boilers in a station which was erected and started in six weeks. The boilers have since lunched forward until the fronts are some two or three inches out of plumb. In fact too little attention seems to have been paid to boiler foundations as a general thing.

Engines have fared better and when the ground has been good the foundations are to be little criticised.

One station has very large Corliss engines and owing to water soaked ground and limited time in which to build the brick foundations, they were placed wholly above the floor level of the dynamo room, and belts run both ways from the fly-wheels to shafting on either side of the room.

Very few bad dynamo foundations are now met, but many unbalanced armatures are found which no amount of foundation would hold steady.

#### STATION CONSTRUCTION.

In station construction there has been no settled design, therefore the promoters have generally built as they saw fit, occasionally following suggestions of the agent. Of course many plants are located in buildings already up, in which case the machinery had to be made to fit.

In many of those built especially for the work, no attention has been paid to designing for a low insurance rate, and brick stations are found sheathed all over the inside with pine, the one thing that insurance inspectors always criticise. A couple of coatings of whitewash or paint would have been much cheaper, safer, and looked quite as well.

When stations have been remodeled, very little improvement has been made in the smaller ones, but those in large cities have generally taken advantage of all the improvements to date, if not too strongly attached to some one parent company.

#### MOTIVE POWER.

The selection of motive power has of course been governed by local conditions; in the northern and northwestern part of New York state, water power is abundant and is largely used as motive power for stations, but almost invariably with steam reserve.

Water power alone has been found very difficult to govern for uniform speed, and some of the devices used for that purpose are to say the least ingenious.

When the load is large enough to use part steam there is no trouble whatever, as the wheel takes a steady load and the engine does the governing.

Plants are sometimes placed a long way from the work in order to take advantage of water power and in some cases it seems as if all else had been sacrificed to that one point.

Of engines there is no end to the different design, style and size used. Some use high speed, belted direct to dynamos, others slow speed belted to counter, some simple non-condensing where compound condensing would be decidedly best.

I know of at least three plants located in water works pump-

ing stations, using high speed simple non-condensing engines on a practically steady load, all of which have been erected during the past three or four years.

Two stations I remember having an all night and every night load of arc lights and situated on a lake shore which run high speed simple non-condensing engines.

To offset this there is one station that deserves mention as it embodies many points of value. The building is substantial, of brick, two stories high and on a river bank. The boilers are very efficient and well set, the engine is a moderate speed compound condensing, with shaft extended for three dynamo pulleys, and one for the power condenser. There is a heater between the exhaust and condenser and a power pump attached to one side of the condenser. The flow to the boilers is governed by a bye pass valve, as the pump is of course in motion all the time the engine is running. This station has only an arc load and runs all night; it was built entirely under the supervision of a local mechanical engineer with the exception of connecting the lines and dynamo terminals to the switch-board, and would, I think, be hard to beat for results.

#### ARRANGEMENT OF MACHINERY.

The arrangement of machinery is as diverse as the style of motive power; when direct belting is used the arrangement is generally simple and plain, but oftentimes so crowded as to be very inconvenient.

There seems no end to the arrangement of shafting, some have a line shaft through the middle of the dynamo room and belt both ways to dynamos, others a shaft on either side of the room belting to dynamos in the center, others the shaft under the floor belting up to dynamos and occasionally to engines also, others have the shafting overhead, in fact, there is no end to the styles, some good and some bad. In most cases friction clutches are used with shafting for stopping individual dynamos and some few may use loose pulleys on independent sleeve for the same purpose.

The length of belt centers varies greatly, some apparently thinking if long belts are better than short, very long ones must be much the best.

The improvement in switch-boards seems to me more marked than in any other one department, which is probably owing to the

pressure of insurance men who look at the switch-board as the most dangerous fire risk of all.

#### LINE CONSTRUCTION.

In line construction I cannot see that any very marked improvement has been made, excepting in some cases, the substitution of larger and better poles for the older ones.

The use of black covered wire in place of white has perhaps made the lines a trifle less conspicuous but that is about all. The lines still have the apparent aimlessness of direction mentioned by Prof. Thomson at Buffalo.

People in the larger interior cities are already agitating the question of underground wires and it seems probable that unless something is done soon by the companies themselves to rid the streets of the more conspicuous of these wires, there will be very costly trouble for them to contend with.

It can no longer be denied that wires are working well every day in sub-ways and the only valid argument against them is extreme cost. Nevertheless when the general public learns this fact, cost will have little to do with the argument.

In many places wires can be removed from the main streets to alleys back of the shops, and the extra cost will be decidedly cheaper than underground work. In such few places as this has already been done, wires are inconspicuous and the underground question is never raised.

In street lighting the favorite method is the cable suspension across the street. Where the work is neatly done this serves very well but it would be difficult to find a more unsightly thing than some of the lamps so suspended.

Considerable trouble is occasioned in the above method by breakage of the wires at the joint with the line, and at the cross bar over the hood. There is no apparent reason why twin or duplex wire should not be more used for this purpose, instead of the kinked and straggly single wires.

There are many other methods, some of them good in principle but bad in the application, and so it goes.

It seems to me that if some action was taken by a non-partisan association like this Institute, an advance toward better engineering might be made, if a few general laws could be suggested to be followed in laying out the different parts of a lighting station. Perhaps it may be said that much of the above work should

more properly come before the National Electric Light Association, but as many of that society are members of this Institute, I feel sure they would individually appreciate its backing in the future when the time comes for enlargement, and they have need of combined expert opinion.

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#### DISCUSSION.

MR. H. WARD LEONARD :—Mr. Chairman, I think the points that Mr. Foster has made in his paper are very good ones, and that they will be appreciated by all who have contact with central stations that have been constructed in the past. I know that in my own case I have quite recently had it forcibly impressed upon me in the case of two central stations of considerable size. In one case I remember that a very large central station was to be erected, not a thousand miles distant from here, and considerable time was spent in the selection of a proper site. At that time I remember personally taking sufficient interest in the matter to make calculations as to what would apparently be the best site for a central station to meet the proper demand. The question of the value of the real estate was a matter which proved to be quite important in determining upon the selection, and the first selection had to be abandoned very shortly and a second selection was made, and a very excellent and a very profitable central station was established. But it is a little gratifying to learn, as I have recently, that the central station is about to be moved to within one block of the site that seemed to me personally to be the best, and it could have been placed there originally at a very large saving over what it can be now.

The second instance that has come to my attention recently is one in which a central station has expended something over a quarter of a million of dollars, has made two changes of location, and finally the parties owning the station called me in with the view of learning as to whether certain changes and improvements could not be effected, and it was almost sad to notice that so much money had been expended, and that they were still so very far from economical results. The station was one which had ample space to place apparatus sufficient in capacity to run all of the electrical service for a town of three or four times the size of the one in question. They had abundance of space originally, but they had failed to utilize it advantageously. The building was full of the very long belts which Mr. Foster has very forcibly called attention to, occupying a tremendous amount of space, a large number of friction clutches were used, long steam pipes, and very poor arrangement of all kinds of apparatus—in fact, so perfect a disregard had been evidenced of the proper condensation and arrangement of machinery that although they had but slight capacity they found themselves in such a position that they



could scarcely enlarge their facilities without entirely remodeling the station. That was relative to the station itself.

Outside of the station I found that a circuit had been established originally for a very contracted area, and that the system of conductors had been introduced at moderate loss and with a very slight cost in copper, no survey having been made originally that would enable them to judge fairly well as to the location of the probable load. It appears that they got loads at entirely unexpected places, and consequently they got very bad distribution of current relative to the copper which they have installed, with a consequent very bad condition of pressure throughout the system. At this time the question might have been submitted with very beneficial results to some competent engineer. But as soon as they realized that it meant either a readjustment of matters or more copper they came to the conclusion that there was no difficulty about putting in more copper because the territory was limited, and if they got in more copper they realized they would equalize the pressure. Consequently a large number of loops were placed all around their system which made the loss of the system one-third or one-half, perhaps, what it originally had been. In fact, so perfect a disregard had been shown of the question of feeders in that system that they ran out from the station a distance of about 300 feet, three wires of 0000 guage that they didn't have use for, and connected directly on to the mains. Probably the maximum loss of that line did not exceed two or three per cent. Now they want to enlarge. Of course enlarging a direct current plant, as this was, and extending a considerable distance on a basis of two or three per cent. loss in feeders, made the cost of copper prohibitory, and they are now facing the problem of remodeling the entire system in order to put in sufficient loss in those feeders to enable them to operate at reasonable distances with fair economy.

I think that there is one point that Mr. Foster has already touched on which is one of the most conspicuous fallacies in this business. He called attention to the fact that the ordinary purchaser realizes that long belts are better than short belts, and comes to the conclusion that a longer belt is better yet. That seems to be equally true as regards conductors and engines and a good many points. The ordinary purchaser has an impression that you cannot make the engine too large and you cannot make the conductors too large; that the bigger they are the better. But they find that such a plant is operated at very poor economy. They find themselves operating under conditions which make it impossible to enlarge, and altogether find themselves very much restricted as regards their extensions in the future and the profits from their system because of the impression which is so prevalent that it is impossible to make the apparatus you use too large.

There is one thing which I think is essential for any first-class station in starting out which seems not to be considered except by

a few, and that is this :—Any gentlemen who are contemplating the investment of money in a central station should have a great deal of money spent under the supervision of a thoroughly competent and experienced person to determine exactly where such a station should be placed, exactly what extent of demand there will be, judging by the existing establishments to be supplied, how large the plant should be to start with, what the arrangements should be for extension, and all such matters as that. But in practice we find that where gentlemen are going to build a station they have a lot that they have selected that is a little ways out of town and they have rented a building, or have made arrangements to do so, perhaps put it in an old factory or an old foundry or something of that kind, and they want a plant of about a thousand lights to start with. The town is about two miles square, and they don't know where the lights are going to be, and they only want to provide in the beginning for conductors, lamps, and so forth, for about two hundred lamps, but they would like dynamos and engines for about a thousand lights, and ask for figures. That is the way they figure at the start. They show a total disregard for the location of the load with reference to the station. They do not care anything about the distance, whereas they would have got far better results in economy had they located centrally.

PROF. ROBERTS :—Because I am not now in construction work I desire to speak in this matter of obtaining proper engineering and paying for it. Architects, as you know, charge  $3\frac{1}{2}$  per cent. for plans and 5 per cent. for plans and supervision. How few companies pay such a percentage to a consulting electrical engineer.

With reference to the erratic arrangement of buildings, it is not very long since I had occasion to look at a plant that had been under three different managers, and each manager had put in a boiler room and the boiler rooms were in different places. They started in with an engine room, dynamo room and a boiler room. They had it on the corner of the lot. The next manager wanted more boiler room and put a boiler over here, and the next man put a boiler room down here (indicating) and they had three boiler rooms, three engine rooms and three dynamo rooms; they had no scheme drawn up originally as to what they would do when they extended.

MR. T. C. MARTIN :—Mr. President, I think it is due to Mr. Foster to state that one reason for the somewhat general terms in which he has couched many of the statements in his paper is the fact that he is at present an officer of the government. He has been investigating these things as an agent of the Census Office, and he is not at liberty to go into details as he will at some later time. The paper is certainly as remarkable for that which it does not state as for that which it does state. One of the remarkable features of this paper is that after visiting a hundred central stations, of which I believe nearly the whole were in New York State, there is not the slightest mention made of the use of

the storage battery in a single one of them. It seems to me that in that respect at least we must be very much behind our compeers in Europe. As nearly as I can ascertain, at least 10 per cent., if not more, of the central stations in Europe are equipped with storage plants, some of which have been running four or five years. There are not a great many central stations in Europe, but still the fact that so large a percentage of them should have found it profitable to employ storage batteries must convey some suggestion to us. There are some gentlemen on the floor who have had sad experiences in the days gone by with station storage batteries, but it seems to me that we must have advanced a little bit since the days of our pioneer work, and that the time has arrived when we might learn something from what is being done in Europe.

A point Mr. Foster alluded to was painting in stations, and I believe it was once stated by a distinguished expert that dynamos might be painted any color without increasing their efficiency. I believe that the color that the central station is painted is apt to make a great difference in its efficiency. I have heard of one station, I think it is in this state, at Jacksonville or Dixon, where the interior is as sumptuous—well, at least as that of the office of the average electrical engineer. The whole of the interior, is a dazzling, glittering white; and even the engines have been touched up in a style that equals in gorgeousness the splendor of Barnum's circus wagons. Now I understand that that station is paying as much as any station in the state. I have been told, in fact, that its dividends have exceeded those of any other station; and it seems to me that there may be a connection between the cleanliness of that station and the dividends which it pays.

On motion duly seconded and carried, the President appointed as a committee on acknowledgment of courtesies extended to the Institute, Dr. Charles E. Emery, Prof. E. P. Roberts and Dr. E. L. Nichols.

[Recess.]