

similar decrease is going on in the isolated plant, both from the increase in knowledge of the requirements, and the increase in the uses of electrical apparatus, uses which are largely stimulated by the cheap supply. I also believe that there are very few plants, that would not welcome the central supply of steam.

A continued erection of large buildings in a congested area will inure to the advantage of the central steam supply and for the reasons above given, to the disadvantage of the central electrical supply.

Only one office building in ten, of modern construction, takes its current from the central station, and with the large loft buildings, the story will be the same, as soon as these buildings pass into the hands of investors.

The department stores, hotels, large restaurants and apartment houses (where light is given free) have already found the isolated plant to be the cheaper and the continued disappearance of small buildings will increase these conditions, unless the central station companies can discover elevators that will take care of themselves, or incorporate with the supply of electricity, a cheap supply of steam for heating.

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#### DISCUSSION.

THE PRESIDENT:—The paper is now before the INSTITUTE for discussion.

MR. H. WARD LEONARD:—This subject of the isolated plant is a very old one and has a good many points in it pro and con. There has been no very radical change in the cost of production of energy in isolated plants over quite a period. I remember about twelve years ago I secured a great abundance of statistics covering probably three hundred isolated plants in the west, and although the cost varied, as, of course, such figures always will, the statistics were based upon answers to a very large number of questions that were framed with the idea of getting accurate figures, and the owners in those days were I think perhaps a little more interested in the results than they are now; at any rate they very gladly went to considerable trouble to give me the figures. I remember that the cost at that time, that seemed to be attainable, in a well installed plant was about a quarter of a cent for 75 watt hours, which would be in the neighborhood of about  $3\frac{1}{2}$  cents per kilowatt hour, and it seems to me that about 3 cents per kilowatt hour is pretty close to what can be done in an isolated plant to-day if the same consideration be given to the factors of the cost that I gave at that time. Personally I believe that an allowance of five per cent. for depreciation is insufficient.

While you can borrow money at five per cent. you can't borrow money at five per cent. on the ordinary isolated electric light plant, and if you are going to invest money in an electric lighting business as a speculation you would not be apt to invest your money when the maximum return possible would be five per cent., in view of the risk. My own opinion would be that 15 per cent. would not be at all too much to allow for the interest and depreciation charge on a modern isolated plant.

Another point which has always struck me as of very great importance and which is not sufficiently allowed for, is the value of the space that the plant necessarily occupies. While it may be true that in some instances plants will be found where there is no other use for the space, I don't think that is the rule by any means and I remember that without considering at all the question of space for a storage battery I have frequently been much puzzled to find room enough for the electric plant and it is very often a very serious problem. In the modern tall office buildings the space that the plant occupies in the basement is an important matter, and although the owner may not appreciate it fully, I consider that a continual charge should be made against the operating cost, for the maintenance of that plant in that space, because if he had not used the plant in that space he would have used something else there. So that it seems to me that with an allowance of ten per cent. only for interest and depreciation, and in disregarding entirely the value of the space occupied, the present paper leans too strongly in favor of the isolated plant. Of course, it is incontestable, at least I think so, that under favorable circumstances a large isolated plant can produce electricity at a price such that the central station company would have difficulty to compete with it, but I do believe that a great many isolated plants are being operated at a higher cost than the central station company could afford to take for the service. In some of the cases here quoted, even with this rather small allowance for interest and depreciation, and no allowance for the value of the space occupied, you will find 4.7, 4.3, 8.06, per k. w. hour, and figures of that character. I believe the central station would provide electric energy at those figures if they saw what the load was. These curves are particularly favorable as compared with the average curve of the central station, and the load factor being high, a low rate could be made for such service. I have always felt that there was quite a field in the direction of supplying energy from the central station at a flat rate per kilowatt for a 24-hour service, allowing the customer to have his own storage battery and thus purchase his power at the minimum rate. But as the author stated, there are many instances in which the economies which might be derived from a storage battery are not realizable because of the lack of space, and I also feel that a person who installs a storage battery in connection with an isolated plant necessarily adds or should add

almost a dollar a day to the value of the expert labor if he is going to keep his plant to the degree of minimum maintenance that he had before he put the storage battery in. And I personally think that the percentage allowance for depreciation, on the storage battery even to-day, is not such as compares favorably with that of a plant that has no battery.

It seems to me that the whole question boils down to the value of the heat of the exhaust steam as against the economy of production on a very large scale by a central station, over a small plant. Where the value of this heat is large the isolated plant would necessarily have an advantage. But certainly a central station plant should be able to, and I believe it does, produce a kilowatt hour at a very much lower rate than it could be produced by an isolated plant if we disregard the exhaust steam. Frequently figures of this character are largely a question of methods at arriving at results but there is every reason to expect that under skilled guidance a large central station should be able to produce energy at a rate such that nothing could compete with it except for this factor of the value of the heat for the exhaust steam. And since instances seem to be developing where the owner of an isolated plant finds that he can purchase from a central station, steam to operate an isolated plant, cheaper than he can operate his plant by himself, it would look as though in an average case the question of cost would be in favor of the central station, provided that the central station were able to sell its current for a twenty-four hour service and consequently sell it at a low rate. It seems to me that the central station ought to be willing, and I presume they are in some instances willing, to sell a steady load at about  $3\frac{1}{2}$  cents per hour for annual service, and I believe that energy bought at such rates and stored and used as required will compete quite favorably with the average isolated plant case.

But of course this question of elevators is a factor that nearly always is an important one, and the introduction of any means of equalization, such as a storage battery, would I believe operate elevators at an advantage as compared with the rates which would have to be charged by the central station if the current were so excessive at times, as the direct load of the average elevator demands, when operated by the ordinary methods in use to-day.

It seems to me that in this kind of a case the greatest saving can be effected by the owner making use of the service of a thoroughly competent and unbiased engineer, because each problem is one which must be studied by itself, and the various factors of electric light, heating, elevator service, etc., vary so widely that what in one case might result in a saving would in another case be a serious disadvantage.

MR. ARTHUR WILLIAMS:—Nothing, perhaps, could more clearly illustrate a point I wish to make in regard to the use of the exhaust steam of a private plant for heating than the curve which Mr. Moses has drawn—the characteristic load curve of an office

building. During the early part of the day, and in the early morning hours especially, the need for heat is at a maximum, whereas there is very little demand for artificial light in the late afternoon, when the demand for lighting, and therefore, the supply of exhaust steam is at a maximum; the necessity for heating is at a minimum.

Mr Moses' paper is based almost entirely upon conditions as he understands them in New York City, where he believes the possibilities of the near future for the central station are relegated to the supply of current for small customers and breakdown connections for isolated plants. The field of comparison selected is so local that I feel you will justify a reply, also local. I did not succeed in getting a copy of the paper until just before leaving New York Saturday and am not able, therefore, to make a statement in regard to each of the buildings to which it refers, but a number may be identified, and having been connected closely with that branch of the New York Edison company, I am able to show, to some extent, the side that has not here been presented. I learn in answer to a telegraphed inquiry, that of 118 large buildings erected in New York City in 1898, in the plans of which the isolated plant for both lighting and power was a factor, all but 22 decided to use the Edison service; of 66 such buildings erected in the first half of 1899, 60 have decided to use the Edison service.

There were several buildings in connection with which we submitted figures of cost, where in view of the low average use and the coincident local and system maxima, we felt that even at best prices the very large investment which the company would be compelled to make would leave us at the end of the year a considerable loser, and, while we desire to have it understood that our company is prepared to supply electricity in any building for any of the established uses, we did not regret the conclusions of the engineers and owners. It must be apparent, however, that in an instance where the company finds that its established rates subject it to loss, the conclusions of the engineer who encourages his principal to make very large and costly investments in generating and other electric machinery must be subject to serious question.

While attending the second electrical show in New York, an agent, in attempting to sell me an isolated plant, stated that the cost of operation was approximately half the cost of central station service supplied in New York. I said as central station service costs approximately one cent a 16-candle lamp hour, that of his plant would cost approximately one-half cent, to which he answered in the affirmative; I then asked him that if the central station service cost only one-half cent—an amount much in excess of the average price paid by the large buildings in New York—could the plant be operated at one-fourth cent. To this he made no reply, feeling, evidently, that he was getting into deep water.

The same motive that, in many instances, leads a consulting engineer to recommend the private plant actuates the operating engineer in keeping it in operation. An instance occurred not long since in which the engineer of a large down-town building stated to the committee in charge, who were considering a proposition we had submitted to them, that he was making electricity at "one cent per k. w. hour or a little less," upon which statement, and without further investigation, the committee decided that it could not afford to substitute the local Edison service at five cents per kilowatt hour. It should be said that our own estimates, most carefully and, we believe, most accurately, prepared, showed a very large percentage of saving, with much greater satisfaction, in abandoning the plant.

Our experience with a large club taking central station supply, might be interesting: We were receiving approximately \$8,000 a year from an installation of 1,200 lamps. The house committee felt that this was more than the club should pay, and authorized one of the prominent engineers of New York to prepare the necessary plans and specifications, upon which bids were obtained. These bids for the electrical and mechanical plant amounted to \$35,000, to which the architects thought \$10,000 should, or might, be added for the necessary building alterations. The engineer had stated to the committee that when installed, this plant would save enough each year to repay its cost in two or three years, after which the club would get its light for nothing, and this statement was repeated in all seriousness by one of the members of the committee at another meeting which I attended. It took little consideration on the part of the committee to find that far from saving anything by installing a plant they would in all probability increase their annual charges by as much more as they were then paying the Edison company; the fixed charges alone, including interest, depreciation, taxation, insurance, and "up-keep" expenses, amounted to very nearly 20 per cent. of the investment, or approximately \$7,000 and they had been paying us only at the rate of \$8,000 for everything.

One can hardly disagree with Mr. Leonard that the author's 10 per cent. is not enough for the fixed charges of a plant. Our New York practice is to include the interest value of the money invested at about 6 per cent.—it is worth much more when taken out of one's business—the depreciation at 8 per cent. allowing about twelve years' efficient life of the plant, taxes at 2 per cent. the actual rate being about 3 per cent. and  $1\frac{1}{2}$  per cent. for insurance, this item on steam and electrical machinery, being subject to variation. It will be seen that a very small addition for "up-keep" repairs, rent, accident insurance, or any of the other many items usually forgotten but still incidental to plant service, would bring the annual fixed cost to 20 per cent. of the first, or installation cost.

The statement of the writer, that the expense of operating a

private plant is the difference between the cost of the mechanical service of the building before and after its installation, should be qualified. And if the costs are given on the kilowatt basis, owing to the tendency to over-rate plant output, this statement or definition could become very misleading. The tendency, even in our own stations, where our people have no possible incentive, is to read the indicating instruments on the high rather than on the low side, and the average plant engineer, desiring to support and increase the importance of his position in every possible way, is certainly as cautious in this direction. In addition, the tendency of all consumers where not under the moral influence of the meter, is toward a very wasteful use of light or power.

Not long since, while the family were at dinner, we found three electric lights burning in the small parlor of an up-town apartment supplied by a private plant and the use of light in the halls and elsewhere seemed equally extravagant; and I recall an instance in which by placing a meter on an apartment where light was included in the rent, it was found that the cost of current used wastefully and for ornamental, in addition to the proper purposes, amounted to more than the landlord received from the tenant. It is safe to say that in either instance, and without reference to the source of supply, a meter would have cut down the use of current fully one-half, if not more—in fact in the second instance, when the tenant learned that the landlord had a meter on his circuit, though even then not paying directly for light, the consumption became about normal, which was less than one-fifth the previous consumption.

Another instance in our experience, showing that the tendency is to overstate private plant output, arose in connection with a large building for the supply of which the owner had asked our annual costs on the basis of the number of k.w. hours reported by his engineer. On finding that our first estimates greatly exceeded the cost of running the plant, we were led to make an investigation, which revealed the fact that the ampere meters were reading almost double the current generated, and that several items of expense properly charged to the generating plant had been charged to other parts of the building. The true figures of consumption showed that the central station supply offered a large saving, and the plant has since been idle. Many additional instances could be cited, showing conclusively that the k.w. consumption of a building is a very unsafe factor to determine the relative cost of central station vs. private plant supply.

For the large hotel of which Mr. Moses speaks, the Manhattan, of New York, the annual cost of electric light is placed at \$13,000. These costs are estimated deductively by determining the difference in the cost of fuel and other supplies during a period in which the hotel was supplied with current from the local dynamos and for one in which the local Edison service—for lighting only—was used. It should be remembered that the building has ten or

twelve electric elevators, which, owing to the difference of voltage required, compelled operating the plant, notwithstanding our station supply of light during the entire period of the test.

That the sum given does not fairly represent the real cost of electric light is readily shown by the fact that the hotel last year consumed 6,000 tons of coal, costing \$20,000, of which only 1,400 tons, costing \$4,500, is allowed for light. Two thirds of the coal consumption, or 4,000 tons, it must be evident, are to be charged to both lighting and elevators; the elevators alone, therefore, if the statements made are accurate, would have consumed 2,600 tons, when certainly much the "smaller half" of the power generated was required for that purpose. The only fair test of this character would be to shut down the entire plant, supplying elevators and auxiliary motors, as well as lights, from the Edison service, crediting to that service in a comparative estimate the resultant saving that would be accomplished in labor, fuel, supplies, etc.; the space occupied could be utilized for other purposes and doubtless has a high rental value. The fact is that instead of costing \$13,000 annually, the lighting of this building is probably costing more nearly \$20,000, or, including the elevators, more nearly \$30,000, whereas our estimate of Edison service for all purposes has never exceeded \$25,000, and, under proper control, I doubt if the cost would reach that amount.

The apartment house mentioned by Mr. Moses offers another instance in which instead of showing a saving through plant operation we believe that there would be a very considerable advantage to the owners by adopting Edison service. I have no estimate of the present cost of running this building, but, taking another building, a hotel very much like it as to size, but where the conditions of service are much more onerous, the bills for the entire supply last year were something under \$3,000. The proprietors recently considered the installation of a plant, but on investigation became satisfied that their existing service could not be replaced at a cost much below \$6,000 annually, which agrees with the figures given by Mr. Moses, amounting to about \$7,000 for the apartment house in question. Allowing a little more fairly for labor and taking a more conservative view of the investment value, even this high relative cost for the apartment house becomes nearly \$10,000, undoubtedly a more accurate estimate.

The electric elevator supplied by meter is the cheapest service a central station can give. The average cost of 15,000 h.p. supplied by our company last year was \$18 per h.p. installed or approximately half the estimated cost of delivering coal at the doors of New York boilers. Only last week the proprietor of an apartment house found that his elevator service, continued through twenty-four hours daily, was costing approximately \$3,800 per annum, whereas we have never supplied an elevator of that type at a cost exceeding \$500, and the average is very much less. He

has abandoned the use of his plant, and is now arranging to substitute an electric for the hydraulic elevator. When the change is perfected the lighting and elevator service together will hardly amount to the former costs of the elevator alone.

On the basis of the estimate Mr. Moses has given, the electric light and power supply of the office building referred to on page 316 costs \$7,000 per annum. It will be observed, however, that only 10 per cent of the installation cost, or \$1,500 is allowed as covering interest, depreciation, and I presume, insurance, taxes and rental, though these items are not mentioned, while 20 per cent., as has been shown, is more nearly on a not too conservative basis, the proper charge, increasing in this one item, the estimated cost by \$1,500. Another indication that the estimate is insufficient is found in the item allowed for lamps; \$200 represents 1,000 incandescent lamps at 20 cents each, and as the reported consumption for the year was in excess of two million lamp hours, the average life of each lamp would be in excess of 2,000 hours. It is questionable whether any plant, using efficient lamps, where the standards of light are fairly maintained, secures a life of more than 600 hours. Either the item understates the cost of lamps, or the reported consumption of current is largely overstated.

Four hundred dollars has been allowed for "sundry supplies and ash cartage," an item which must include the water supply which last year cost more than \$600, and the oil supply which amounted to more than 650 gallons; and according to the estimate presented to us, one man, receiving \$18 weekly, runs this plant of four high-speed engines and dynamos, the necessary controlling and regulating apparatus and a storage battery. The estimate given, by fairly allowing for items mentioned, could easily be increased to \$10,000, and it is extremely doubtful whether even this item represents the cost to which the proprietors of the building are subjected; on the other hand, I am certain that, supplied from our station at the usual rates, the cost for both lighting and elevator service would not exceed \$7,500 per annum.

A storage battery is considered a medium of saving, and the cost of making the current, which I presume means its delivery at the switchboard or at the battery, as might be desired, is placed at 4.37 cents per k. w. hour. Our storage battery prices in New York start at 6 cents per k. w. hour, and descend on a graduating scale to 3 cents, a price with which I have yet to know of any isolated plant competing, operating charges alone, but fairly, considered. But even at 3 cents we have found it very difficult to convince anyone of the economy of the storage battery for which the central station supply is certainly more regular and better assured than that of a plant.

The writer's reference to the New York Wool Exchange, and its comparison with a large loft building, (page 322) brings out clearly the point I have made as to the wasteful tendency of engineers and tenants where current is supplied without direct



charge. The loft building with a plant consumed last year 100,000 k. w. hours, or 2,000,000 lamp hours; annually; the Exchange, having the same cubic contents, supplied through meter by the Edison company consumed only 822,000 lamp hours. The Exchange building has a comparatively high load factor while a loft building, such as that of which the author speaks, has the lowest load factor of any class we supply. As no complaint of an insufficient supply has been received from those in charge of the Exchange, we assume that they have had all the electric light and power required.

Allow me to draw your attention to the conclusion of the author regarding the Sohmer building of New York City. From his paper it is evident that the cost of electricity for lighting and power last year was \$3,900, to supply which he now intends to install an isolated plant at a cost of \$10,000, and expects to obtain current at about 4 cents a k. w. hour. The consumption for all purposes last year was 45,000 k. w. hours, which, at 4 cents, would cost \$1,800. The fixed charges at 20% of the installation cost amount to \$2,000, in addition to which it will be necessary to provide fuel, labor, incandescent lamps, engine room supplies, etc., as well as an auxilliary source of supply consisting of either gas or electric light service. Two men added to the labor force would at least add \$1,500 to the fixed charges of \$2,000, leaving a margin of \$400 for coal and everything else required to replace the present service for the lighting and elevators.

The author's distinction between the practice of the speculative and the investment builder is to be taken, curiously, very much in the favor of the side he does not advocate. The speculative builder of New York erects the most substantial building that can be designed, usually with the expectation of filling it with tenants and of selling it at any time within two or three, or more years, basing his price at that time upon the investment value as determined by the net return which he is able to show as a result of the year's operation. It is an investment of the highest class, with every possible incentive on the side of the temporary owner to the highest economy—the far sighted economy. I do not remember at the moment of a single builder of that order who installed a plant last year; it was toward that class of builders that our first missionary efforts were directed, and their present practice is at extreme variance with that of three or four years ago, when for every such building a private plant was contemplated and usually installed.

Contrast this with a building erected by a permanent investor, in which a plant costing \$35,000 was installed, to provide the electrical supply for about 6,000 incandescent lamps. The full service for both tenants and owner, who provided the public lighting, was supplied by the Edison company for something more than a year at an annual cost slightly under \$6,000; 10 per

cent. of the investment cost, the amount which the writer of the paper thinks should be allowed for fixed charges, is \$3,500 and 20 per cent, which we think should be allowed, is \$7,000 or, in itself, more than all the charges of the Edison company. The plant has been recently started, and I understand that the single item of labor requires the addition of four or six employes in the engine and boiler room. In its operation it is expected to make money and supply current to the tenants at less than the amount of their payments of the last year to our company.

The central station requires machinery for about 30 per cent of its connected installation and finds this provision ample. The isolated plant, if properly installed, must provide from 100 per cent. to 150 per cent.; at the first figure, you have three times the machinery, installed under much more expensive conditions, upon which to base the fixed charges. Then consider the number of employes. Our company requires a man and a half to operate a 2,500 H. P. engine, while the 800 private plants of New York, aggregating probably only half our supplying capacity, will average at least three men to each. I think the entire city south of 10th street is operated through the night with a force not exceeding a half-dozen men, a number not greatly in excess of the force that would be required in one of the large buildings were night as well as day service supplied.

The author suggests that a discussion on the subject of gas engine plants would be interesting. I recall two instances of a number that have arisen in our experience. The first one is of a restaurant of considerable size, in which a gas engine and dynamo combined, of the latest type, were surreptitiously installed—I say surreptitiously, because the proprietor feared to communicate with us, thinking we would oppose his plans. We, however, learned of the matter before actual operation, and, on going over the contracts, found that the guarantees as to the consumption of gas, on a minimum basis, placed their cost alone at \$3,500 (gas at \$1.15 per thousand feet), whereas our Edison bills had amounted to only \$2,700 for the preceding twelve months. The plant has never operated for more than a test run, and is one of a number which I think could be purchased at a very low figure.

The second instance is of a large hotel, in which the dynamos were operated by gas engines. Question having arisen, we installed Thomson meters on the dynamo leads and found that in a month, in which the gas meter showed a consumption of \$206, the electrical meter at our published rates, recorded only \$204. Notwithstanding recent reductions in the price of gas, I think all of the gas engine plants in the district lines of the New York Edison company can be counted on the fingers of the hand.

That the superiority and relative cheapness of the Edison service is becoming more and more highly appreciated by engineers, architects and owners, is shown by the number of plants that are

abandoned, as well as by the relation existing between the plant and central station supply of the new large buildings, as indicated by the telegram I read a few moments ago. Several of the largest hotels in New York have plants idle in their cellars because of the saving in favor of Edison service, (and yet hotel service is the most difficult to compete with) and one of the largest down-town printing houses also abandoned its plant something more than a year ago, finding that the Edison service, which has never failed them, costs no more than the direct operating charges of the plant service, which gave a great deal of trouble. I speak of operating charges only, in each of these instances, as in the abandonment of a plant for competitive service, fixed charges of all character must be ignored, the investment having been made and the plant once installed possessing very little intrinsic value.

MR. STEINMETZ :—There is one reference in the paper recurring a number of times, regarding the fluctuating load imposed by electric elevators, and the hope is expressed that storage batteries may be used to equalize this load.

There may be some doubts whether storage batteries are advantageous in such isolated plants or not. They undoubtedly have been a very great success in large low tension direct current systems, but just as undoubtedly they have been an entire failure in street car propulsion and similar applications.

It is true that the elevator load is a severely fluctuating load. I doubt, however, whether in installing electric elevators due care has always been taken to make this load as little fluctuating as possible. There must always remain the fluctuation between the power consumption when running, and the absence of power consumption when standing still. It follows thus that the problem of the electric elevator in its relation to the power supply system is to make the power consumption as uniform as feasible during the time the elevator is running.

This means first that the starting current of the elevator should not be greater, but rather less than the running current. This can be accomplished by the use of a shunt motor of fairly low magnetic density with a powerful series coil which in starting remains in circuit until all the starting rheostat is cut out.

Second, to use power as uniformly as possible when running makes it obviously objectionable to use gravity for the descent, since thereby the power consumption during ascent is doubled. On the contrary, the car should be overbalanced for the average load of the elevator so that at the average load the motor supplies only the work of friction, more work when ascending with heavy or descending with light load, and less work in the opposite case. While this consideration really appears self-evident, yet I doubt whether it is always taken into consideration when installing electric elevators.

MR. MOSES :—Replying to Mr. Leonard, I wish to emphasize the point made in the paper, that the cost of electricity in a build-

ing plant is in no ways comparable to the cost in electric lighting plants out west. In an electric lighting plant, labor, coal, rent, taxes and insurance, are directly and solely chargeable to the electricity. In a building plant on the other hand, only the labor additional to that required for supplying other functions of buildings and only such coal as is additional to that required for the heating and for other apparatus (which can be equally well supplied by exhaust steam) are properly chargeable to the electricity. Rent, taxes, insurance, depreciation and interest charges are also quite different in building and in isolated plants. This brings me to the question of interest and depreciation charges. My figure of 10 per cent. has been strongly objected to. I still adhere to it for the following reasons: while I would not advise any client to invest his money in an electric plant unless more than 10 per cent. clear was assured, yet I consider five per cent. or even four per cent. as ample to allow for interest charge, as this is in excess of the actual amount an investor or owner of a building would pay for the money required to replace the capital invested in plant. As regards depreciation charge, I allow an average of 5 per cent. per annum (which with interest at five per cent. will equal original capital in fifteen years), for depreciation on the whole installation, which includes boilers, piping, pumps, engines, dynamos, foundations, alterations to existing building, boiler setting and alteration to wiring. This allowance is excepted to, on the ground that no plants last fifteen years. I can cite dozens of existing plants where boilers have been in daily operation for over twenty years, and are still allowed to carry from sixty to eighty pounds pressure, and many engine plants have been running for the same length of time. Direct current electrical machinery has only recently been standardized, and as electrical building plants are dependent on the existence of large buildings they are, of course, of comparatively recent growth.

Judging from the construction of the engine and of the dynamo, the latter should last at least thirty years with but little repairs. I am safe therefore, I think, in considering fifteen years as the average life of a plant. It has been objected, also that the continual changing of design should involve a larger depreciation charge. This I do not think will bear investigation.

The investor can continue to produce current from the plant he installed at the rates stated in the paper. If large improvements are made in machinery, he may find it worth while to completely change his plant. In this case, however, the cost of producing current will evidently be very much lower, so that, though his depreciation charge may have increased, his cost of operation will have decreased in greater proportion, as in any other event the change would not have been made. The rental value of the space occupied by the plant has been dwelt upon. Generally this value is not calculable, as the greater part of the space used is required for elevator, pumps and other machinery,

boilers and motors, and the space actually used by the electric plant is of no consequence. In some cases the added space is valuable, and must be taken into account. In general this is not so. Mr. Leonard states that the question depends on the comparative value of the heat obtained from exhaust steam vs. the increased efficiency of the large engines in the central stations. This is not the case. The value of the heat from the exhaust steam, while important, is not the deciding influence. A few of the reasons why the building plant can manufacture and deliver electricity cheaper than the central station, in addition to the benefits of use of exhaust steam for the heating, are that in the building plant little or no additional labor is necessitated by the addition of an electric plant, and such labor is always cheap. In the central station; labor for firing, for running engines, keeping books, collecting bills, inspecting outside and internal constructions testing meters, and selling current are direct charges on electricity. In the building plant there are no legal expenses, no treasurers or officials with large salaries, no increased insurance or taxes, no rent of subways (and generally no rent at all); besides which, interest and depreciation are reckoned on actual cost and only on the additional apparatus required for supplying electricity, and there are no patented distributing rights for which large sums are payable annually. In the central station all these items, which constitute more than two-thirds total cost are direct charges on the electrical current.

Mr. Williams intimates that because the Edison company installs generating apparatus and mains for but 30 per cent. of the total connected installation, that therefore, their investment is less, per unit of current delivered than in the isolated plant, where a capacity of from 100 to 150 per cent. total connected installation is installed. This is not the case. It is true that the capacity of the Edison stations is only 30 per cent. of the total connected installation, but the average load is only one-seventh of this capacity. In this building plant, on the other hand, the average load is from one-half to one-quarter the total capacity installed. That is, the cost of the plant in the Edison stations for a given load is from two to three times the cost of the building plant. The fixed charges are at least twice those of the building plant. Replying to the criticisms on the use of the storage battery; the battery merely takes the fluctuating load, the integral of which is comparatively small. The allowance for loss in passage through the storage battery is about one-fifth of this and is not to be compared with the benefits derived from the steady load on the engine. Generally, however, its chief claim is based on the fact that it takes care of the night service.

With the storage battery in use on the Edison system the conditions are quite different, as in this case all the power and light are passed through the battery, and with the same percentage of loss the benefits from reduced rates are swallowed up in low

efficiency. Besides, the cost of a battery to take the whole load is very many times that of one to take the fluctuation of the load only.

Mr. Williams states in his discussion of the figures from a large hotel "that it must be evident that two thirds of the coal used in this hotel is chargeable to the electricity" and has evidently misunderstood my meaning in the paper. The "1400 tons of coal costing \$4,500" are all that are actually chargeable to light and power not to light alone. To anyone familiar with hotel work it must be patent that heating the building, cooking and running laundry and ice machinery use more than half the steam required in the building, and it is this amount of steam or coal that I have called "the constant requirement" and which I have approximated by taking periods with nearly constant conditions of weather and service in which equal amounts of electricity were supplied. By subtracting the coal used in the first period from that in the second period a difference was obtained, which, as the electricity supplied in each case was the same, was roughly that required for the other uses enumerated above. This difference divided by the difference in the number of days in the two periods would give the "constant requirement" per day. His suggestion to throw the entire plant of lights and elevators on Edison circuit for a test was impracticable as the elevators are wound for 120 volts. Mr. Williams also criticises my figures on the office building and brings up a figure of \$600 for water supply which he assigns to the plant. Most of this is used by the tenants through the building for other purposes, but I charge water to the plant at the rate of 25 cts. per ton of coal burned, which is the equivalent of 8 lbs of water evaporated per pound of coal, making due allowance for the fact that in winter the water evaporated is returned nearly wholly to the boiler and reused. The "lamp" and "oil" terms are taken from the records and it is not therefore necessary to discuss them.

In the hotel spoken of by Mr. Williams where the plant has been shut down for one year and three months, the owner has stated to me that he reckons the increased cost of the Edison service at about \$100 a month. This is about the actual money increase over what it cost them when they ran their own plant, but as about \$2500 was paid for current from an outside source at retail rates, the cost of operation of the plant (present cost \$6660 a year) was about \$3000. The plant installed was too small for the work and the breakdown connection was a necessity. The owner does not care to invest the necessary money now for putting in a proper sized plant, as the old hotel business is, to a certain extent, uncertain. In the Grand Union Hotel, where I installed a plant, and where no breakdown service is used, the cost of operation this year, excluding all saving due to decreased cost of gas, is over \$5500 less than it was last year. One-half of this saving was due to the use of small coal, but the remainder is

the difference between the cost of electricity \$4558 from the central station and the cost of electricity from the private plant. In reality, the saving effected was greater, as the hotel has increased its use of steam. The total cost of installation was \$8000 and cost per k.w. hour, everything included 2.19 cents.

Mr. Williams refers to the moral influence of the meter and objects to my basing costs on the k.w. hour supplied. Where light and power are furnished free to the tenants the meter will have no moral effect. Where they pay for it themselves it has a decided effect. In one building of the same size as the Wool Exchange, cited in the paper, and with similiar conditions, current is sold to the tenants by meter at Edison rates and the profits pay the expenses of operating the whole building. In this building the cost per killowatt hour is five cents.

Mr. Williams criticises my statement that in the Sohmer Building current at four cents per killowatt hour can be produced. I have taken up the question of interest and depreciation charges already, and therefore deduct \$1000 from his estimated annual cost, and the remaining \$1,500 which he charges to labor and extra coal, may properly be divided in half, as the labor charge, is not increased in any way. The coal will be increased by about \$500 per year and \$250 is sufficient to allow for oil, waste and supplies. That gives a cost of \$1,750 to which should be added cost of repairs, of lamps, ash cartage, boiler insurance, extra water and contingencies, not more that \$500 or a total annual cost of \$2,250.

The kilowatt hours supplied, as stated, are 5,000 for light and 30,000 for power, exclusive of the light used and paid for directly by the tenants of the first seven floors. I am perfectly safe therefore, in assuming that the total kilowatt hours supplied will exceed 60,000 which at four cents gives \$2,400—that is \$150 more than the total arrived at above, making all allowances for contingencies. Mr. Williams cites figures of comparative number of new buildings erected with and without plants and I, of course, presume them to be correct. Such general figures are extremely misleading as is shown in this instance, for it must be a matter of common knowledge that no large office building, properly so-called is erected without its own plant, unless the controlling officer of the erecting company happens to be also strongly interested in the lighting company. The speculative buildings were frequently erected without plants, but where the building is 50'x200' or larger and 10 or more stories high this practice is antiquated and the owners of the buildings already up are rapidly installing plants. No large hotel is erected without a plant and the only large buildings that do continue to use street current are apartment houses, where light is paid for by the tenants directly and old houses where the owners do not feel warranted in spending more than is absolutely necessary.

If the present methods in building plants and in central stations

were those of five or three years ago, the answer as to the comparative value of the two services would be more difficult.

A few years ago all the trained engineers were employed by the central station or trolley companies, and every advantage of technical skill and large capital was on their side, while the building owner dependent on his stationary engineer fell rapidly behind in the march of improvement. Nowadays the owner of the large office, hotel or loft building has a first class progressive engineer in charge or employs a consulting engineer to keep a general control over the staff and operation. In some instances the complete plant is run for a fixed sum per year by a contractor who is able to make money himself and save the owner money as well, by purchasing large quantities of material at a time. This method while it renders many of the central station economies of both material and labor available to the isolated plant is only to be recommended when the contract is for such a length of time that the contractor will see that proper repairs and additions are made, whether he is momentarily financially the sufferer or not. It is these facts, that repairs are seldom made by the contractor until the plant breaks down, and that no improvements are possible on account of the short term of the contracts that have brought the system of contracting into serious disrepute. The same results can be obtained by placing the operation of a number of plants the purchase of their supplies and the employment of labor in the hands of a technical engineer, who should be paid a fixed sum per month by each owner. This will give the owner the benefit of the best engineering, improvements and all economies possible to large buyers, while at the same time the plant will not suffer through neglect of proper repairs.

MR. STEINMETZ:—In this paper, the depreciation is estimated on the basis of a 15 years life of the station. I like to ask the question whether any one of the gentlemen present knows of any station where apparatus and machinery installed 15 years ago are still in satisfactory operation. I need not ask the question whether you know of stations where apparatus installed less than five years ago has been thrown out as antiquated and unprofitable, since such stations are numerous.

MR. WILLIAMS:—That question is answered by Mr. Moses himself where he refers on page 306 to the plant of the Manhattan Hotel as being even now "slightly old-fashioned." This plant was installed in either 1896 or 1897 under the supervision of one of the most competent engineers in New York. And would you allow me to say, correctively, of the Broadway hotel mentioned, that the books were carefully gone over, and there can be no question as to the figures which have been given.

Of the large office building, the point made was that the entire expense of lighting and power service supplied from the Edison station did not substantially exceed \$5,000, while the fixed charges on the investment alone were fully \$7,000, again omitting the



question of rent, which in that neighborhood is very considerable. In our discussion one side of the question has been entirely overlooked, the extent to which provision for a large mechanical plant increases the cost of constructing the building. In the Manhattan Hotel, I have not the slightest doubt, the necessity for providing for the engine and boiler-room in connection with the foundations and building structure, increased the cost fully \$50,000, incidental to which there are fixed charges which must be considered in one way or another, an expense of the hotel.

The storage battery losses, as Mr. Moses says, are confined to but a percentage of the total output, but on the other hand this percentage must bear all fixed charges of the battery.

MR. C. W. RICE:—I am familiar with a plant that originally cost \$50,000 four years ago. It is stationed underground, out under the sidewalk and they pay \$250 a month rent. This plant costs about \$17,500 a year to operate and I was authorized recently to offer to sell the plant. The prospective customer would not give \$20,000 for the plant and operate it himself. He prefers to pay \$17,500 a year and let others operate it.

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[COMMUNICATED AFTER ADJOURNMENT BY MR. CHAS. BLIZARD.]

I desire to reply to Mr. Leonard's statements concerning storage batteries in isolated plants. I was not present at the Boston meeting and base my reply upon Mr. Leonard's remarks as reported.

Mr. Leonard expresses the opinion that the operation of a battery in an isolated plant does, or should, cause an increase in the cost of engine room labor. With the exception of the Edison companies and street railway companies operating batteries on a very extensive scale, and having two or more installations, I do not know of an instance in which the installation of a battery has added one dollar to the labor item. On the contrary, batteries in many cases have effected a very material reduction in the engine room force.

The modern storage battery in an isolated plant does not require the attention of a so-called expert, it needs only such intelligent care as can be given it readily by a competent engineer or his assistants. Seventy-five per cent of the plants in New York City are being operated with entire success by engineers who are now in charge of their first batteries. None of the more important electrical or steam apparatus in large isolated plants receives or requires so little of the engineer's time as the battery. It is safe to state that the time devoted to successfully operated batteries in isolated plants does not exceed an average of an hour per day per battery.

Instructions covering the proper care of a battery are simple and can be followed by any man who is competent to give intelligent care to a dynamo and engine.