different circuits. On these maps each transformer was located by a small square stamped on the map, and within this square was written the name of the customer being served from this transformer, the number of lamps installed, the revenue per year, the revenue per lamp per year, the estimated number of hours burned per lamp per day, and the probable number of lamps burning at any one time. There is also indicated on these charts the size and length of secondary wires from the transformer to the customer's cutout. All this information was found necessary for the proper "bunching" of customers on the transformers and for the loading of the transformer. Wherever possible, secondary systems were established, to which several transformers were connected in parallel, in which case the size of the secondary mains between the transformers was such that the drop in these mains was small compared to the drop in the transformers themselves; in this way the transformers were made to share, more or less, the load equally between them. When a secondary system of distribution was not economical, single transformers were located. In determining whether a customer was to be included in a bunch of customers, all of whom were to be fed from one transformer, or whether it was more economical to place a separate transformer, it was necessary to make an approximate estimate of the cost of locating the transformer for each case. When the interest on the cost of placing a separate transformer plus the cost of maintenance of the transformer, was more than the interest upon the cost of connecting a customer to a transformer, feeding other customers, the connection in question was made to the transformer feeding the "bunch." However, even if the difference in annual cost was small in favor of a separate transformer, connection was made to the "bunch." In making these calculations, a fixed drop in the secondary mains was allowed, and the load, *i.e.*, the probable number of lamps burning at any one time, for calculating this drop was determined from the records on the transformer charts; of course, the character of the service goes a great way in making this last determination. A separate transformer was placed only when the total annual cost for the placing and maintenance of such transformer did not exceed the sum of the two following costs—the interest on the cost of placing and maintenance of wire necessary to connect the customer to the nearest "bunch" transformer, and the increased cost due to necessary increase in size of transformer. The annual cost of a transformer on the lines was considered to include the cost of the iron losses, figured as costing the electrical lighting station at an assumed rate of one-tenth (.1 cents) per lamp hour of 55 watts, a 5 per cent. interest on the cost of the transformer, and the high rate of charge of 10 per cent. depreciation.

At the beginning of the reconstruction herein referred to there were 1,160 transformers on the lines, with approximately 53,000 lamps wired. There had been 473 old transformers removed, 229 new ones had been put up. The lightest load registered during the year preceding the reconstruction was 380 amperes. Ten months later, with about 8,000 more lamps wired on the service than at the time of the 380 ampere load, above referred to, the lowest load recorded was 245 amperes, or a decrease in the load line of 135 amperes, this decrease in leakage load being due to the transformer changes just mentioned. The leakage of the 229 new transformers was 19 amperes, which means that the 473 old transformers had a leakage of 154 amperes, or an average leakage of .325 amperes per transformer removed, which figure has been verified by leakage tests made on the old transformers which had been removed from the lines. Thirty-six of the 135 amperes reduction was due to the removal of the 110 old transformers, and placing the customers served from these on other old transformers, making secondary distribution systems. From this is deduced the fact that by replacing the 345 old by 187 new transformers, a saving was effected of 99 amperes. The average saving for the 187 changed is then .529 amperes per change, which, with coal at $2.75 per ton, means an annual saving of $25.58 per change in coal alone. The average cost of the 187 changes, including the cost of new transformers, all extensions of wiring for secondary mains and all labor, crediting these orders with old transformers as scrap only, was approximately $65. As stated above, an annual saving per change in cost of coal would be effected of $25.58, therefore at this rate the new transformers will pay for themselves, if the saving of coal only is considered, in about two and a half years.

The reduction in leakage load so far obtained in the reconstruction under consideration has not been accompanied by any sacrifice of transformer regulation. The type of new transformer used is one giving the best all round results, that is, one in which regulation and leakage are so proportioned in its construction as not to benefit one at the expense of the other. In thickly populated or central business portions of the city, where an extensive secondary distribution is possible, and where large transformers may be connected in parallel at different points, it would be an advantage to use transformers of very small leakage current and high "all day efficiency," as in this case the transformers share the load between them, and regulation can be sacrificed to gain diminished leakage current. However, as it is only in very large cities, and only in the most thickly populated centres of these, that the secondary distribution system can be economically used, the make of transformer giving the best all round results should, in general, be selected. To further improve the regulation beyond that to be obtained by improved transformer regulation, it is intended to change the primary distribution from 1,000 to 2,000 volts, thereby decreasing the copper losses on the existing circuits to one-quarter of the present losses, and reducing the feeder drops so that good service and regulation will be obtained without the use of feeder regulators or the erection of additional copper. A source of additional improvement in regulation will be the use of generators with very close regulation. The necessity of transferring the circuits from one dynamo to another makes close inherent regulation in generators an imperative feature if satisfactory service be desired. Transformers with good regulation, feeders having small drops, and generators of close regulation, mean that the ordinary changes of load and transfers of circuits from one generator to another can be made without materially affecting the voltage on the lamps in service. When this reconstruction has been completed there will have been installed five 300 KW generators, two on one engine, two on a second engine, and one on a third engine. The two generators running from the same engine will be run in parallel when the load requires it, making the units on two of the engines 600 KW, with the advantage of having a more flexible system and a possible saving due to running a 300 KW when a 600 KW would be but partially loaded. The construction and location of the engines was such as to make it impracticable to put 600 KW generators on the two large engines, had it been so desired. It will be found that the most economical and certainly the most convenient unit of power for operation is one that has the capacity to carry the day load, the remainder of the dynamos being of a uniform type and size.

In the search for economy the lamp should come in for attention. Lamps with long life are found to be inefficient; very efficient lamps are usually short lived. Using an efficient lamp increases the earning capacity of a plant and permits of using higher candle power lamps with a proportionally less increase in cost. An increase in candle power either by high candle power incandescent lamps of high efficiency or small incandescent arc lamps, seems to be the best way to meet competition from gas.

It has been found that running a 50-volt lamp at 52 volts, or increasing the voltage four per cent., increases the candle power about nineteen per cent., while the life of the lamp is decreased about forty three per cent. Running the lamps at a pressure of 55 volts, or a ten per cent. increase of voltage, increases the candle power of the lamp about sixty-six per cent., while the life of the lamp is decreased about eighty-three per cent., from which it would seem that to a plant supplying current to a large number of incandescent lamps and furnishing renewals, running them above the rated voltage, means a large increase in the lamp renewal account, both for material and labor. Run the lamps as near their rated voltage as possible, and the lamp renewal account will be a minimum. Good regulation on the circuits goes a long way towards keeping this account down. A daily rise in voltage from three to four per cent. above normal for a short time will reduce the life of a lamp of good economy about one half.

To determine what lamp is best suited for any electric lighting station, it is necessary to know the cost of producing current per lamp hour, and having established this for any special make of lamp, the following formula will permit of a comparison of different makes of lamps and the determination of the best lamp for the conditions under which they are to run. In considering the cost of production per lamp hour in connection with the lamp question, the cost of service may be divided into three parts: A. That portion of the service per lamp hour that is practically not affected by the average efficiency and life of the lamps and such portion of the maintenance, operating and general expenses, as is practically not increased by increasing the current consumption per lamp hour. B. The cost per lamp hour, coal, water, interest and depreciation on the lines, dynamos, engines, etc., and such part of the expense of the service as increases proportionately to the amount of current served per lamp hour and as the maximum station output. C. The cost of the lamp per lamp hour, and the expenses per lamp hour for replacing exhausted lamps. This is equal to the cost of one lamp, plus the cost of exchanging one exhausted lamp, divided by the average life of the lamp.