

## ELECTRIC LIGHT AND POWER STATIONS

**Census Bureau Issues Bulletin Giving Interesting Account of Growth of This Important Public Utility Up to Close of Year 1902—Illinois Leads.**

The bureau of the census has just published a report on central electric light and power stations for the year ending June 30, 1902, prepared under the supervision of W. M. Steuart, chief statistician of manufactures. It is the third of a series of reports on the operation and utilization of electric current. In addition to the text, which was prepared by Thomas Commerford Martin, of New York city, expert special agent, there are elaborate tables and an interesting series of illustrations.

The chapters of text discuss, respectively, the scope and method of the investigation, financial operations, employment, salaries and wages, physical equipment, output of stations, franchises, and the history and development of electric lighting.

The statistics do not include isolated electric light and power plants installed in manufacturing establishments, hotels, office buildings, etc., for the purpose of furnishing light and power primarily for the use of the individuals, firms, or corporations operating such establishments.

### History of Electric Lighting.

Electric lighting dates back only to the beginning of the last century, while the history of central stations proper belongs only to the second half or, more strictly speaking, to the last quarter of the century.

The development of electric lighting was marked by the work of a series of discoverers and inventors, by whom the evolution of arc lighting from an expensive laboratory experiment to its present cheap and useful form was accomplished.

The progressive success of arc lighting imparted a great impulse to experimentation with the incandescent lamp. Many distinguished inventors devoted their attention to this subject, but the incandescent lamp was not commercially a success until about 25 years ago, when Edison's first lamp was produced.

To Mr. Edison the development of the incandescent lamp was associated with the creation of a complete system of electric lighting, a current to be furnished from the central station to a large number of buildings in a manner exactly analogous to that in which the supply of gas is furnished. In 1880 he installed such a system in Menlo Park. The introduction of the Edison "Jumbo" dynamo soon followed.

The estimated useful life of a 100-Watt 16-candlepower lamp made today is over 10,000 hours, about 29 times as long as it was 25 years ago.

In the last quarter of a century a total of over 250,000,000 lamps has been produced, or not less than 10,000,000 a year.

Then came the attempt to unify arc and incandescent lighting, the development of the use of the alternating current, the evolution of the later arc lamp, the change from open to inclosed lamps, the production of lamp globes, lamp supports, series and multiple methods, appliances, fixtures, fuses and cut-outs, methods of wiring, modern conveniences, and novel types of lamps, including the Nernst incandescent, the mercury vapor, and vacuum tube lighting.

### Growth of the Industry.

For convenience in study the various electric stations have been divided into two grand classes. First, those operated by individuals or corporations; and, second, those operated under municipal control. Each of these classes is subdivided into, first, those doing a purely electric business; and, second, those operated in connection with other industries. The latter are designated composite stations.

Further subdivisions have been made, one being based upon the population of the place in which the station is located, and the other upon the horsepower capacity of the generating apparatus of the station.

The growth of this industry is shown by the following figures: From eight stations beginning operation in 1881, the number rose to 100 in 1886, to 208 in 1889, and to 247 in 1892. During the following years of depression the number of new stations fell; but in 1895, though a time of financial stringency, it rose again to 239. In 1898 it reached 277, or more than the number beginning operation in the entire period from 1881 to 1886, inclusive.

The number for 1901 was 250, and for five months of 1902 it was 146. In the 20 years from 1881 to 1901, inclusive, an average of 165 private and municipal stations have begun operation each year. The spread of the agitation for municipal ownership of public service enterprises is illustrated in a somewhat striking manner. Of the 815 municipal stations enumerated, only 68 had been installed up to 1889. In that year 40 were introduced, and in 1895 the number of new stations reached 73, increasing in 1898 to 82. The returns for 1902 indicate that the ratio was fully maintained in the census year.

In 1902 there were in the United States 3,620 central electric stations, with a cost of construction and equipment of \$504,740,352. Employed were 6,396 salaried officials and clerks with salaries amounting to \$5,663,580; and 23,339 wage earners with wages amounting to \$14,983,112. The gross income was \$85,706,605, comprising \$84,186,605 from sale of current and \$1,514,000 from other sources. Total expenses were \$68,081,375. The total output of stations for the year, in kilowatt hours, was 2,507,051,115. The number of arc lamps was 385,698 and of incandescent lamps 18,194,044.

There has been a striking change in the character of service in these stations. In the earlier days of the industry nearly all the stations were installed for the purpose of furnishing current for arc lighting, while today the bulk of current is supplied for incandescent lighting, motor power, and miscellaneous service. This last includes charging telephone exchanges, batteries for boats and automobiles; pumping; hot water, steam, and electric heating; electric current; and nickel plating and electroplating.

### Comparison of Private and Municipal Stations.

Private stations form by far the largest portion of the industry, constituting 77.5 per cent of the total number of stations in operation during 1902. Their income from sale of current was \$76,735,500, or 89.5 per cent of gross income; the expenses of operation \$23.3 per cent of the total, while they gave employment to 89.5 per cent of the total number of wage earners engaged in the industry, and paid 90.5 per cent of the total amount of annual wages. The primary power plant equipment of these stations formed 91.3 per cent of the total horsepower of all stations, while their generating equipment formed 90.6 per cent of the total horsepower of all dynamo. The kilowatt hour output of private stations formed 92.2 per cent of the total, and the arc lamps in such stations formed 86.8 per cent of the total number wired for operation.

The comparison of the income of the two classes of stations is not a fair indication of their earning capacity, because of the gross income reported for municipal stations. Of this gross income \$6,836,856 resulted from the sale of current and included income from public service which was necessarily largely, if not wholly, a matter of estimation.

The private stations employed 20,863 wage-earners, who were paid \$13,569,771, and 6,046 salaried officials and clerks with salaries amounting to \$5,206,199; while the municipal stations employed 2,467 wage-earners who were paid wages amounting to \$1,422,341, and 950 salaried officials and clerks, who were paid \$457,381.

The cost of construction and equipment of the municipal stations was only 4.4 per cent; their income from sale of current, 8.1 per cent; their expenses, 7.7 per cent; and the horsepower capacity of their power and generating plants, 8.7 and 9.4 per cent, respectively. The output of such stations was 7.8 per cent of the total kilowatt hours produced by all the stations, while their arc lamps were 13.2 per cent and their incandescent lamps, 8.7 per cent of all the lamps reported for the country.

In addition to controlling practically the entire industry, the average private station is much larger than the average municipal station. Considering the total of 2,805 private stations, it appears that the average total expense per year per station was \$22,401, as compared with \$6,437 for municipal stations. The private stations gave employment on the average to 7.4 wage-earners; while the municipal stations gave employment to 2.3. The average private stations reported 823,938 kilowatt hours per year, as compared with 240,373 for the municipal stations.

It is found that 732 municipal stations operated in that number of communities in which there was no competitive private service. It would appear that in all probability a great many if not all of these places would have gone without electric lighting had the supply been left to private enterprise seeking a return upon its investment. The population served by these stations was 2,052,485, an average of a little over 2,800 per station, and towns of this size rarely offer inducements to private capital, regarded from the per capita basis of consumption of current. These stations also represent a total cost of construction and equipment of \$15,369,382, or about \$21,000 per station, whereas the average cost of construction and equipment for the 3,620 central stations of all classes was slightly short of \$140,000. The largest average population per community is

shown for Massachusetts, having 17 stations, with an aggregate population of 151,407, or an average of 8,906. The smallest population per community is shown for Colorado, with two municipal stations supplying 1,402 people, or an average of 701 for each station. An average of 5 persons to a family or house would give barely 140 houses.

### Distribution of Stations.

The largest number of stations was in Illinois, followed by Pennsylvania, New York, Ohio, Michigan, Indiana, Iowa, and Wisconsin in the order named. No other state reached the 150 mark. The New England states were well supplied with stations. Massachusetts reported the largest number, then came Maine, Vermont, New Hampshire, and Connecticut. Among the southern states Texas led, with Kentucky, Tennessee, and Georgia following. Of the western states, California reported the largest number of stations, Colorado, Washington, Oregon and Montana being next in order. Of the 1,892 places reported at the 12th census as having a population of 2,500 and over, 1,511 had one or more central electric lighting stations. Of the places with a smaller population, 1,960 had similar stations.

### Long Distance Transmission Stations.

A number of companies supply areas of many square miles in which are located scores of cities, towns, incorporated villages, and mere hamlets, all enjoying the benefits of electricity and constituting a source of income for the enterprise. The extreme limit of such work at the time of this report was marked by the long distance power transmission on the Pacific coast, where current from the Sierras was actually delivered for general consumption in San Francisco and Sausalito, and was also delivered from the same plants over lines which ramify into half the counties of the state of California. The whole aspect of central station current supply in its relation to population has in reality been utterly changed by the development of polyphase power transmission plants. There are at least a thousand such plants, with lines frequently 15 or 20 miles long, in many cases 40 or 50 miles, often 60 or 90 miles, and sometimes even 150 or 200 miles.

These transmission enterprises are peculiarly typical of the far western states, but are by no means concentrated there, being scattered all over the union.

### Financial Operations.

The total capital stock and funded debt authorized amounted to \$743,296,266, but the amount issued was considerably less, being \$627,515,875. Of the total amount authorized, \$435,178,372, or 58.6 per cent, was capital stock, and \$192,337,503, or 41.5 per cent, was funded debt. Of the total authorized capital stock, \$372,951,952, or 85.7 per cent, had been issued at the end of the year covered by the report. Of the capital stock issued, \$23,871,671, or 6.4 per cent, was preferred stock, and \$349,080,281, or 93.6 per cent, was common stock.

Private stations expended \$10,050,613 and municipal plants \$1,741,834 in construction and equipment during the year covered by the report. The total for private stations from their origin until 1902 was \$182,719,879, giving an average outlay of \$328 per horsepower of dynamo capacity. It is interesting to compare these figures with those for municipal stations, which show a cost for construction and equipment of \$22,020,473, and an average of about \$145 per horsepower of generating capacity; it is not safe to accept this average as a basis of comparison, on account of the wide variations revealed in the different states, which range from \$114 in Ohio to \$844 in the state of Washington.

Although the practice of supplying current for motive power and other uses had grown rapidly, the supplying of current for light was still preponderantly the business of both private and municipal stations. Of the total income, \$70,138,147, or 81.8 per cent, was directly derivable from lighting. The private stations obtained 80.5 per cent and the municipal stations 96.9 per cent of their income from this source. This income from sale of current for lighting purposes was derived from 385,698 arc lamps and 18,194,044 incandescent lamps. The average income per lamp for arc lights in private stations and used for commercial or other private lighting was \$48.88; used for public lighting, \$83.20. In municipal stations, for commercial or other private lighting, it was \$41.46; for public lighting, \$69.98. The incandescent lamps in private stations in commercial use earned an average income of \$2.40 per lamp; in public service, \$6.06. In municipal stations these lamps earned \$1.92 in commercial service and \$5.93 in public service.

The total expenses for private and municipal stations were \$68,081,375. Of this, \$20,646,692 was for salaries and wages; \$22,915,932 for supplies, materials and fuel; \$11,895,206, for rents, taxes, insurance, and miscellaneous expenses, and \$12,623,545, for interest on bonds.

### Physical Equipment.

This subject is considered under the three heads: Power and generating equipment, line construction, and service line equipment. The power plant equipment showed 5,830 steam engines with 1,379,941 horsepower, and 1,390

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water wheels with 438,472 horsepower; and the generating plant equipment, 2,823 direct current constant voltage dynamos with 442,146 horsepower; 3,539 direct current constant amperage dynamos with 195,531 horsepower; and 5,122 alternating and polyphase current dynamos with 987,003 horsepower. The line construction had 107,265 miles of mains and 17,880 miles of feeders. For the service line equipment, meters, lamps, and motors are the important items. There were 582,689 meters

575,004 of these were mechanical and 7,685 chemical. The aggregate of arc lamps of all classes was 385,698, of which 334,903, or 86.8 per cent, were operated from private stations. In addition to these 385,698 arc lamps connected to the circuits of central stations, the street railways operating electric lighting stations reported 35,863 arcs, making the total for the United States 419,561.

### Output.

The main function for which a cen-

tral station exists is the generation of current, for the measurement of which the kilowatt hour is the unit now universally accepted. Using this as the unit, the average output of current per day for all stations was 6,960,733, making a total for the year of 2,507,051,115. For private stations the output was 2,311,146,676 kilowatt hours and for municipal stations, 195,904,439. Among the private stations the totals for New York are at the head of the list; among the municipal, Illinois.

Electric lighting, street railway, and other analogous corporations derive their charters, which give them the right to exist and which regulate in a general way their internal government, from the state through the medium of either a general or special statute. Usually further definite authorization is necessary before wires may be run along a specified street or highway, and it is this authorization that is designated by the term "franchise" in the more limited sense.

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