tions than did the independent systems, but the latter operated nearly twice as many public exchanges as the former. The average amount of line controlled per exchange was considerably greater for the American Telephone and Telegraph Company's systems, being 902.7 miles, as compared with 221.3 miles for the independent systems. The independent systems operated exchanges in all the States and Territories with the exception of the District of Columbia and Utah, and the American Telephone and Telegraph Company's systems operated exchanges in all save Indian Territory. There were twenty States and Territories in which the exchanges controlled by the American Telephone and Telegraph Company's systems predominated, forming 76.2 per cent of all exchanges operated in these States and Territories.

It is impossible to make an exact segregation of the statistics so as to show the number of lines, the wire mileage, and the number of telephones devoted primarily to telephone work in the country as distinct from the urban districts. Approximately, however, there were 21,577 such lines, of which 72.3 per cent were owned and operated by commercial systems, 4.6 per cent were the mutual systems, and the remaining 23.1 per cent were independent farmer or rural lines. The total length of wire was 259,306 miles, or an average length of about 12 miles per line. The total number of telephones was 266,968, giving an average of about twelve telephones to each line and a little less than one mile of wire per telephone. Considering the figures by main geographic divisions, it appears that the North Central States again held first rank. Of the several States, however, New York and Pennsylvania were no longer high in rank, the first five places being divided among the States of Ohio, Indiana, Illinois, Iowa, and Missouri, all in the North Central division. Illinois ranked first in number of rural lines and wire mileage, and Iowa first in number of telephones.

The commercial telegraph systems numbered 25 in 1902, as compared with 77 in 1880. This striking decrease is due, however, to the number of consolidations which have taken place, the magnitude of the equipment and business showing a great increase. At the present time the telegraph business is practically controlled by two companies, yet the number of miles of wire in operation in 1902 was more than four times, the number of messages almost three times, and the receipts from messages more than twice as great as in 1880. The average rate per message in 1902, after deducting the number of cable messages and the receipts therefrom, was 31 cents, as compared with 43 cents in 1880.

The total receipts of the commercial telegraph companies in 1902 amounted to 40,930,038, of which 86.2 per cent represented the gross receipts from operation. The operating expenses amounted to \$26,592,411, the net income to \$9,982,004, and the net surplus for the year to \$3,725,311.

The commercial telegraph companies reported 1,318,350 miles of wire in operation in 1902, but also made a report of 1,307,046 miles as owned or leased. Of the latter mileage, 62.5 per cent was operated by the single or Morse system, 14.1 per cent by the duplex system, 22.6 per cent by the quadruplex system, and the remaining eight-tenths of 1 per cent by machine or automatic systems.

The commercial telegraph messages sent during 1902 numbered 91,655,287, of which 820,498 were cable messages.

There were 684 railway companies that reported the operation of telegraph or telephone lines in connection with the transportation business. Along their right of way these companies had 1,127,186 miles of single telegraph and telephone wire, of which they owned 21.5 per cent.

CONTEMPORARY ELECTRICAL SCIENCE.*

DAMPING OF CONDENSER CIRCUITS.—A condenser circuit whose proper wave-length is sufficiently great in comparison with the length of the closing circuit, and whose plates are a sufficiently small distance apart, sends hardly any electric lines of force into the space outside. Therefore, according to Poynting's theorem, it radiates no Hertzian energy, and its damping is solely conditioned by the resistance of the whole circuit, which, if the wire is not too thin, consists practically in the resistance of the spark-gap. P. Druide follows up this consideration, and deduces some rules of great importance to the practice of wireless telegraphy. For every condenser circuit there is a certain length of spark which gives a minimum damping. In the neighborhood of that value the damping does not vary much with the length of the spark-gap, and however much the inductance and capacity may be varied, the damping can be brought to nearly the same value, if the supply of energy from the induction coil is not excessively large or small, and provided the condenser shows no hysteresis or brush discharges. By a careful adherence to these conditions, the author succeeded in reaching the extremely low value of 0.05 for the logarithmic decrement. The length of the spark gap was between 1 millimeter and 2 millimeters, and the ratio C : L had the high value of 17. It was found essential, however, to attach the supply wires as near the spark-gap as possible, as was the uniform practice of Hertz himself. Righi's method of introducing spark-gaps in the supply circuit has to be avoided, at least when the sparks pass in air. An exciting con-

denser without hysteresis or brush discharges may be obtained by using metal plates in petroleum, and not connecting them by solid insulators. Zinc electrodes preserve the small damping factor for a considerable time, though a decrease of the damping is noticeable after every fresh cleaning. A Tesla coil can only be recommended for very small capacities. The integral effect of the exciting circuit in a resonating circuit increases at first with the sparking distance, and then decreases. It is considerably enhanced by increasing the supply of energy, which increases the partial discharges. The length of gap giving the greatest integral effect lies somewhat below the value which gives the minimum damping. If, therefore, a good resonance is aimed at rather than a far-carrying range, the spark-length must be slightly increased. If the energy supplied is small, the two critical spark-lengths are sensibly identical. The integral effect depends much more upon the spark-length than does the logarithmic decrement. That in wireless telegraphy much larger spark-lengths have been hitherto employed than those given by the author is due to the employment of the coherer, which reacts, not upon the integral effect, but upon the maximum amplitude. The author would not exceed 5 millimeters even with a capacity of 36,000 and a strong supply.—P. Druide, Annalen der Physik, No. 14, 1904.

NEW PHOTOGRAPHIC METHOD FOR N-RAYS.—H. Bordier has devised a method of registering N-rays which is not open to the objections urged against the spark method, and at the same time gets rid of the difficulties attending the ocular observation of the effect upon a fluorescent screen. The author uses a calcium sulphide screen, but instead of observing the increase of luminosity under the action of N-rays direct, he records it photographically by a prolonged exposure. On a thick piece of paper he drops two groups of collodion drops containing a little of the sulphide in suspension. These are allowed to dry and are kept in the dark over night. The paper is then exposed for five or ten minutes to dull daylight, and is then placed, with the drops underneath, on a photographic plate enveloped in tissue paper. It is left in the dark for 24 hours, a source of N-rays, such as a file, being placed over one group of patches, and a piece of lead of the same weight and the same outline being placed over the other group. After this prolonged exposure the plate is developed. It shows a number of black patches corresponding to the drops, each surrounded by a halo. But in every case the halo surrounding the patches covered by the file is larger than that surrounding the patches covered by the lead. In another experiment, a cardboard box containing pieces of tempered steel was substituted for the file, and another box containing an equal weight of lead was substituted for the lead block. Exposure was made as before, and the plates were sent to the director of the photographic laboratory of Lyon University for measurement. His measurement showed that the patches produced under the steel had a diameter of 6.4 millimeters and a halo 11.7 millimeters in diameter. The other patches had an average diameter of 7.1 millimeters and a halo of 10.8 millimeters. Therefore the patches exposed to the N-rays, although having a photographic image of smaller diameter, produced a wider halo. The author describes a further experiment, which is even more conclusive. A line of sulphide is traced on paper with a capillary tube containing the emulsion. After drying, the line is cut in two, and the halves are exposed to lead and tempered steel, as above. On developing, the image from the steel appears first, and its edge is shaded by a wider halo.—H. Bordier, Comptes Rendus, December 5, 1904.

PRACTICAL DATA ON EUROPEAN PRACTICE WITH STEAM TURBINES.*

By FRANZ KOESTER.

THE remarkable development of the steam turbine in this country in connection with power plants makes it of interest to discuss European practice, which has covered a period beginning perhaps ten years before active work was started here. The lowest steam consumption under actual working conditions in Europe is 9.11 pounds per indicated horse-power-hour, although this does not include the power required to operate the condenser outfit, which in this country is usually considered not over 5 per cent. The lowest record for reciprocating engines is 9.41 pounds (including condensers), which is attained both at one of the street railway power plants in Berlin and in Vienna.

Although there are some half-dozen different types of turbine in use on the continent, the Brown-Boveri-Parsons is the most popular, being installed in some 150 plants throughout Europe.

The rapid increase in the use of the turbine during the past five years was due very largely to the successful operation of the municipal plant in Elberfeld, Germany, for running the suspended railway between Elberfeld and Barmen. Here they have two 1,000 kilowatt Parsons turbines, which operated even at the early date of their installation with a minimum steam consumption of 12.3 pounds per indicated horse-power per hour for one, and 12.1 pounds for the other.

The steam turbine, like the reciprocating engine, may be run both condensing and with free exhaust, and the jet condenser, the surface condenser, the siphon condenser, or a central condensation system may be employed. As there is no oil used in the steam

chambers of the turbine, the water from the condenser may be used directly for boiler feed or for other purposes, and it is not necessary to filter it and thus lose a large portion of its heat. The absence of oil in the condensed steam is of special advantage when surface condensers are used, as in this case the cooling water does not mingle with the condensed steam, and the feed water returned to the boilers is thus always pure and free from sediment. It is for this reason that surface condensers are specially appropriate for turbine plants. Quite contrary to the practice in this country most of the condensers and pumps in these plants in Europe are driven by electric motors.

A turbine lends itself much more readily to the advantageous use of superheated steam than a reciprocating engine, on account of the absence of pistons, stuffing boxes, and cylinder lubrication. As the economy due to superheated steam increases directly with the temperature, the turbine presents another advantage, because there is practically no limit to the superheat it can stand.

The steam consumption of the Parsons turbine, used on the continent, as already shown, will compare favorably with that of the best compound engine built to-day. The accompanying table gives some data regarding the steam consumption of Parsons turbines furnished by Brown, Boveri & Co., of Baden, Switzerland, and installed in a number of different plants. All the turbines are run condensing and the steam consumption given in the table includes that required for the auxiliaries, except those cases marked *, where this

TABLE SHOWING PERFORMANCES OF BROWN-BOVERI-PARSONS TURBINES, DIRECT-CONNECTED TO C. E. L. BROWN ELECTRIC GENERATORS.

Location of Plant.	Output, Kw.	Output, H. P.	Loss, steam pressure, absolute.	Temp. steam, degs. Fahr.	Steam, lbs. per I. H. P. hour.
Refrigerating plant, Berlin*	100	133	129	312	15.6
Electric plant, Chur	200	267	184	412	13.6
French navy yard*	420	558	216	413	8
Nord-Deutscher Lloyd, Bremen	300	400	147	414	0
Street railway, Linz, Switzerland	300	400	132	414	3
Cellulose factory, Villach	350	467	169	432	1
Shipyards, Kiel*	400	533	110	413	0
Celling mill, Antonienhitte*	400	533	132	413	0
Shipyards, Kiel*	400	533	132	413	0
Spinning mill, Colmar*	400	533	169	445	11.7
Mine and pottery, Tschoppe	400	533	110	409	13.0
Iron and steel works, Duedenhofen	470	600	118	432	11.3
Iron and steel works, Hirsch*	500	667	110	458	12.5
Schlieper and Baum, Elberfeld	500	667	147	432	11.6
Municipal plant, Frankfurt*	3,000	4,000	162	572	9.11

* Steam for power to operate condenser not included.
† Saturated.

work is not included. The table shows clearly the decrease in steam consumption as the size of the turbine and degree of superheat increase, and from the data here given it may safely be expected that in the 10,000-horse-power turbine, which is at present being constructed by Brown, Boveri & Co., the steam consumption will be considerably less than 9 pounds per indicated horse-power per hour.

In comparing the results of the turbine tests with those of reciprocating engines it must be borne in mind that it is usual to make special preparations before testing reciprocating engines, while there being no parts of the turbine subject to excessive wear, there is no necessity for special preparation at the time of test; indeed, tests made several years apart will show the same results.

As an example of the stability and slight wear of the turbine, it may be interesting to refer to the 500-horse-power Brown-Boveri-Parsons turbine in the Carlshuette at Duedenhofen, Germany, which was in service 5,800 hours continuously, except for a single stop of ten minutes' duration. At the end of the run the turbine was taken apart by the company's engineers and examined carefully for evidence of wear, of which not the slightest could be found.

In comparing performances of reciprocating engines with those of turbines, it is necessary, not only to take into consideration the steam consumption of the engine and turbine, but also to consider the wear and tear on the engine and the oil required.

The Bavarian Inspection Society thoroughly investigated this subject of oil and found that in compound and triplex expansion engines of 100 to 1,500 horse-power the oil consumption was about 2 grammes per horse-power-hour, costing 1.40 cent. In the Parsons turbine the oil consumption is practically negligible as compared with reciprocating engines, the figures being 0.1 to 0.3 gramme per horse-power hour in units of 100 to 1,500 horse-power. With the reciprocating engine the cost of the oil consumed amounts to 7 to 15 per cent of the cost of the coal used, while with the Parsons turbine the cost of the oil ranges from 1/2 of 1 per cent to 2 per cent of the cost of the coal.

The attendant delay due to the preparation of an additional reciprocating unit for service is entirely avoided with the turbine, for it is equipped with a by-pass valve by means of which steam at full pressure may be admitted to the second or low-pressure steam chamber; and the capacity of the turbine is thus largely increased. This by-pass is also of great advantage in case of an accident to the condensing apparatus which would necessarily decrease the power of the turbine, just as it would in the case of an engine. The use of this by-pass, however, means a less economical steam consumption.

* Compiled by E. E. Fournier d'Albe in the Electrician.

* Engineering Record.