from no load to full load that is necessary for parallel operation.

It is worthy of notice that all Westinghouse-Parsons turbines installed are running alternators in parallel, and their operation in this connection is guaranteed to be satisfactory.

Looking at the disadvantages, it must be noticed that, with some types of turbines, it is difficult to get the shaft through the case. All, for reasons referred to above, must have excessive speeds that do not permit of belt drives. Where many rows of vanes are used, the clearances must be small, causing expense because of the accurate workmanship required. In the De Laval type, however, the clearances may be very considerable—are, in fact, from two to five millimetres. It would be surprising if, for a time, the initial cost of turbines were much below that of reciprocating engines. The experimental work of years undertaken by the producers has undoubtedly involved great expenditure, and it is only right that they should receive remuneration in proportion to the incurred expense and to the risk involved. Speaking generally, the first cost of a turbine and its alternator will not differ much from that of a cross compound Corliss engine with its alternator of good manufacture. When, however, the cost of foundations, engine room capacity, and floor space is taken into account, any advantage in price is probably with the turbine. The cost of attendance, repairs, oil, etc., should be less in the case of a turbine than of a reciprocating engine.

As regards economy, it will be seen from the following tables of results of trials that the consumption is not much different from that of the best reciprocating engines when running at most efficient loads. At light loads the turbine ought, from its construction, to have an advantage over the reciprocating engine.

The turbine is admirably adapted to the use of superheated steam, the smaller fluid friction, due to the use of a rarer gas and the elimination of water, having a marked influence on the economy. Just how great a reduction in the consumption superheating will ultimately effect is not known, but the trials already made to determine this show very satisfactory results.

The best economy recorded in the annexed results of Parsons turbines occurs in the trials of a 1,000 kilowatt machine, built by C. A. Parsons & Co., for the Newcastle and District Electric Lighting Company. The trials were conducted by Mr. Hunter, engineer for the company. The vacuum was 26.5 inches, the initial steam pressure 145 lbs. per square inch (gauge), and the superheat, 237 deg. F. The lowest consumption recorded, 17.7 lbs. of steam per kilowatt hour, is equivalent to 13.2 lbs. per E.H.P. per hour, or expressed in B.T.U. is 268 B.T.U. per E.H.P. per minute. Taking the combined efficiency of turbine and dynamos (there were two placed tandemwise), as 83 per cent., the calculated consumption of steam per I.H.P. per hour is 11.0 lbs. This corresponds to a thermal consumption of 223 B.T.U. per I.H.P. per minute. This same turbine using steam at 138 lbs. per square inch initial pressure (gauge), superheated 71 deg. F., with 26 inches vacuum in the condenser, took 21.5 lbs. steam per kilowatt hour. This corresponds to 16 lbs. per E.H.P. per hour, or 300 B.T.U. per E.H.P. per minute.

The best results at hand of trials on a Westinghouse-Parsons machine show a consumption of 12.4 lbs. of steam per E.H.P. per hour. Taking the efficiency of the combined plant, as above, the calculated steam per I.H.P. per hour is approximately 10.3 lbs. This corresponds to 246 B.T.U. per E.H.P. per hour. These trials were made on a 1,500 kilowatt machine, with an initial steam pressure of 150 lbs. (gauge), 140 deg. F. superheat, and a vacuum of 28 inches.

The trials giving this very low consumption were made by the Westinghouse Machine Company, who vouch for their accuracy, and the results are substantiated by three distinct tests.

The trials for the 1,000 kilowatt turbo-alternator, built by C. A. Parsons & Co., for the city of Elberfield, were made by W. H. Lindley and Professors Schroter and Weber. A complete account of these trials, which were very exhaustive, may be found in the Revue de Mécanique for November, 1900. The best consumption recorded—19.43 lbs. per kilowatt per hour—is equivalent to 14.43 lbs. per E.H.P. per hour, or, assuming an efficiency of 83 per cent. for turbine and alternator, the calculated steam per I.H.P. per hour is 11.8 lbs. The steam pressure was 129 lbs. per square inch (gauge), with 18.4 deg. F. superheat and the vacuum 28.2 inches. The consumption expressed in B.T.U. is 270 B.T.U. per E.H.P. per minute and 264 B.T.U. per I.H.P. per minute, a result agreeing very closely with the previous one.

In the trials made by Professor Ewing on the 500 kilowatt Parsons turbo-alternator, at the Cambridge Electric Supply Co.'s plant, with a steam pressure of 145 lbs. per square inch (gauge), vacuum 25.4 inches, the consumption was 24.4 lbs. per kilowatt per hour, corresponding to 18.2 lbs. per E.H.P. per hour, or 274 B.T.U. per E.H.P. per minute. With the same assumption as above, the calculated consumption per I.H.P. per hour is 15.1 lbs., corresponding to 225 B.T.U. per I.H.P. per minute. It is to be noted that in these trials the turbine was driving its own air and circulating pumps. The trials were made after the turbine had been in operation for one year. In the maker's tests, when the turbine was not running the air and circulating pumps, the consumption was 24.1 lbs. per kilowatt per hour—i.e., practically the same as after one year's operation.

The guaranteed efficiency of the turbines for the Metropolitan Railway Co.'s plant, referred to above—17 lbs. of steam per kilowatt hour—is equivalent to 12.7 lbs. per E.H.P. This corresponds to a consumption of about 10.5 lbs. per I.H.P. per hour, or 213 B.T.U. per I.H.P. per minute.

There is very little data at hand concerning the economy of the Curtis turbine. A test made by the makers on a 600 kilowatt machine shows a consumption of 19 lbs. of steam per kilowatt hour. The initial steam pressure being 140 lbs. gauge, the vacuum 28.5 inches and no superheat. This is equivalent to 14.2 lbs. per E.H.P. per hour, or, expressed, in B.T.U., 269 B.T.U. per E.H.P. per minute.

In trials on a 10-h.p. De Laval turbine at Purdue University by Professor Goss, the best consumption recorded is 47.8 lbs. of steam per B.H.P. per hour, corresponding to 805 B.T.U. per B.H.P. per minute. The initial pressure of the steam was 138 lbs. per square inch (gauge), and the brake horse-power of the turbine, 10.33.

In a trial on a 50-h.p. De Laval turbine by Professor Cedarblom, of the Royal Polytechnic College, at Stockholm, Mr. Andersson, assistant at the Royal Polytechnic College, at Stockholm, and Mr. Uhr, inspector of the Board of Trade, Stockholm, a consumption of 19.78 lbs. of steam per B.H.P. per hour was obtained. The initial pressure was 122.3 lbs. per square inch (gauge), and the vacuum 26.4 inches. The thermal consumption is 352 B.T.U. per B.H.P. per minute.

In trials on a 300-h.p. De Laval turbine by Dean and Main, an average consumption for six trials is recorded of 14 lbs. per B.H.P. per hour, corresponding to 272 B.T.U. per B.H.P. per minute. The initial steam pressure was 207 lbs. per square inch (gauge), the vacuum 27.2 inches and the superheat 84 deg. F.

All things considered, it looks as if the steam turbine had made a permanent position for itself as a prime mover, and that it only needs time to extend its sphere of action. Probably the steam engine is the prime mover for nine-tenths of all the power that is developed, and any improvement producing a greater economy in its operation will have a powerful commercial influence. The reciprocating steam engine has apparently nearly reached its limits of economy. Although the turbine is not a perfect heat engine, it probably will when those improvements are applied that experience alone can suggest, prove itself a more efficient machine than the reciprocating engine, and will mark one more step in the advancement of steam engineering.

There is a wide difference between the heat engines at present in commercial use and the perfect heat engine; and although the thermal efficiency of the turbine is not as great as some internal combustion engines, the turbine, as it stands to-day, is a very simple and highly efficient steam engine. It is peculiarly adapted to the performance of certain kinds of work, and there is every reason to expect that those bright prospects for the future, which are indicated at present, will be more than realized.