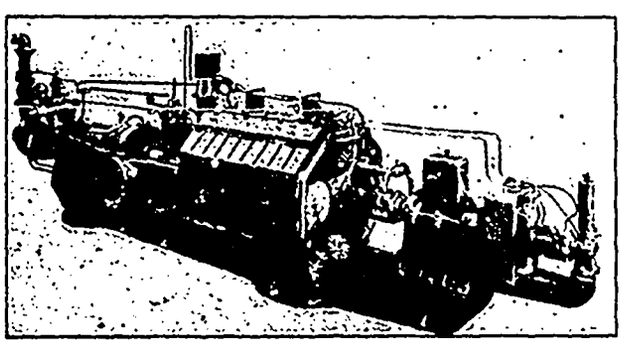
cost to compete with water power. In the turbine engine, as in the compound triple or quadruple reciprocating engine with which we are more familiar, it is essential for the most economical results, that the capacities of the cylinders should be proportioned to the various stages of the expansion of the steam between the boiler and the condenser. In the ordinary triple-expansion engine this is very incompletely obtained. In the mercantile marine, the ratio of expansion seldom exceeds 10-fold, and in war vessels 9-fold. In the compound turbine any ratio of expansion can be obtained without a material increase in weight or bulk, and in the larger condensing turbine motors, being constructed for driving dynamos, or for marine propulsion, the ratio of effective expansion within the engine is between 100 and 200-fold. It is to this exceptional ratio of expansion, and the economy of the engines themselves, that the satisfactory results which have been obtained in the larger engines are attributed. In the steam turbine the advantages of working expansively are obtained by increasing the length of the blades and diameter of the turbines; and therefore, of course, increasing the area acted on by the steam In this way, what corresponds in some degree to compounding in a reciprocating engine is obtained, though of course there is not the need to divide the expansion up into stages, as in a reciprocating engine, the expansion being continuous and gradual. So long as the initial pressure is kept constant, the temperature of any one ring of blades will not vary.

The plants, when completed in the machine and erecting shops, are transferred to the testing shop, where they are put under steam, and undergo the usual tests of full and emergency load; the steam consumption being accurately measured. At present the boiler and condenser capacity of the shop is sufficient for prolonged tests up to 500-k w. output, but this will shortly be increased to 2,000 k.w., when plants up to this size will undergo a full series of tests before being sent out from the works. New large machine-shops, erecting-shops, pattern-shop and offices are at present in course of erection, and will be specially equipped for the production of the larger turbine plants of standard sizes and design for continuous current and single, two, or three-phase alternating current.

We do not propose in these articles entering into the construction of various types of generators made by Messrs. Parsons, as that would take us too far afield, but any description of the works would hardly be complete without some notice of the product. There are thirteen 350 k.w. turbo-alternators now in use for lighting London at the Metropolitan Company's stations at Manchester square and Sardinia street. In the illustration we show a 75-k.w. turbo-generator of another type, four of which have been installed at the Hotel Cecil, London.



STEAM TURBINE.

The central station of the Newcastle and District Electric Company at Forth Banks, is one of the most important installations undertaken by the Heaton works. A 500 k.w. turbo-alternator has been more recently erected in the same station.

This company obtained powers to supply energy in 1889, and on January 10, 1890, the works were opened with three Parsons turbo-electro generators of 75 k.w. capacity each. The company has been a success in every respect from the first, paying a dividend which has increased every year from 2 per cent. in the first to 8½ per cent. in the last year of working.

The small cost per unit for repairs and renewals—and this figure includes all plant, cables, buildings, etc.—is worth noting; as also is the moderate figure which represents the amount required per unit sold to pay interest on capital at 5 per cent. This is important in view of the results obtained. The works are near the River Tyne, from which water is drawn for condensing purposes. The water pipes are laid in a brick lined tunnel about 100 yards long, and terminate in a condenser chamber sunk to mean tide level. There are two sets of plant, one for surface condensation, dealing with light loads, the other for jet condensation, and capable of condensing 48,000 lbs. of steam per hour. The works are peculiarly formed, being placed on the side of a hill, and the various rooms are as it were terraced out. The place originally formed part of Messrs. R. and W. Hawthorn, Leslie and Co.'s marine engine works, and at present is bounded on one side by that company's locomotive shops. As is well known, Messrs. Hawthorn's marine engine department was, some time back, transferred to St. Peter's, lower down the Tyne, and the electric light company thus were able to find a site well suited for its purpose. Advantage could hardly have been taken of the position, however, had it not been that the Parsons steam turbo-generator occupies so small an amount of space, and also on account of the absence of vibration, no foundation being required for the machinery. With regard to the latter feature, it is of interest to point out that Messrs. Hawthorn's drawing office wall forms a continuation of the engine room retaining wall of the electric lighting station; a fact which, in itself, would prohibit the use of ordinary reciprocating engines. The total area of the engine room is only 400 square yards, and in that space there are at present fixed turbo-generators representing nearly 1,720 k.w., with provision for a total of 3,200 k.w.

The use of the steam turbine for actuating electric generators has hitherto created the chief demand for this motor, but there are some other applications of the steam turbine; amongst these that to fan and pump machinery is of considerable importance. It has been found that a centrifugal pump when somewhat modified, is equally efficient whether it is run at 1,200 revolutions, as it generally is, or at 3,200 revolutions. An ordinary 6-inch pump at 1,200 revolutions will give a lift of about 40 feet, but we learn experiment has shown that the modified pump running at 3,200 revolutions will give a lift of about 200 feet, with proportionately greater output. This equals a discharge of about 1,000 gallons per minute, and gives about 60 water h.p. When this is combined with a 100 h.p. turbine, a very compact arrangement is obtained, suitable for mining purposes. A plant was recently erected at Messrs. Storey Brothers', Lancaster, for 850 gallons per minute, at 160-ft. lift, when run at about 3,200 revolutions per minute, and is reported to have given exceedingly good results. For low lifts, the centrifugal turbine pump is not so suitable, and propeller pumps with screws, somewhat like those of a ship's propeller, are adopted. These are suitable for lifts of from 10 to 40 feet.

Another department of these works is devoted to the manufacture of fans for ventilating purposes, and also for induced and forced draught. For the last three years, a fan 3 feet in diameter has been running at Mr. Cookson's works, Howdon-on-Tyne, drawing hot gases, and exerting a pressure of 7-inch water gauge with 2,000 revolutions per minute. It has practically run day and night since the start. Fans have also been made at the Heaton works for forced draught on board ship, and for land purposes. At the time of our visit one was being erected to give induced draught at 3-inch water gauge to two marine boilers capable of evaporating 25,000 lbs. per hour.

Another application of the fans is for colliery ventilation. Engineering describes a 5-foot fan which has now been running for nearly three years at the Clara Pit, Wylam-on-Tyne, a large colliery in the Tyne district exhausting 120,000 cubic feet per minute at 2½-inch water gauge; and another fan has just been erected at the Tredegar Coal Company's pit in South Wales for 300,000 cubic feet of air per minute at 3 inch water gauge.

Both fans and pumps are reported to have given good results for economy. One advantage is that practically no foundations are required; in one case the total cost of fan, brickwork and foundations amounted to one-third that needed for an ordinary slow-speed fan. This was largely on account of the small quantity of brickwork and foundations which were necessary. Although we are not entering into many details of construction reference may with advantage be made to the interesting feature of the governing of turbines. It may be effected by an electrical governor, or by a centrifugal governor, as may be found most suitable for the special work. If constant speed is required, as in alternators which have to run in parallel with