entire clean space for brushing out the boiler tubes, although at the same time they provide a flexible steam jet similar to that supplied with the Wolf set.

In the Garrett "Overtype" engine arranged with inverted superheater the joints in the pipes connecting the superheater to the boiler and to the engine, are situated outside the smoke box where they can readily be disconnected and withdrawn from the chamber in a very easy manner.

Fig 8 shows a horizontal section through the cylinders of the Garrett side by side compound engine. From this figure the construction of the engine will be clearly seen, and it should be noted that the cylinder casing forms a steam

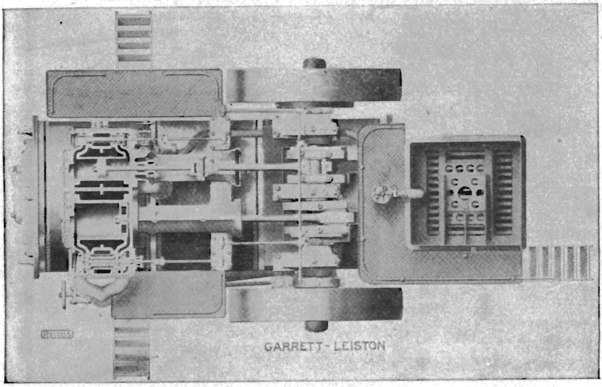


Fig. 8

jacket for both cylinders, the actual working barrel or liner of the cylinders being made of a special cylinder metal pressed into place hydraulically. The main safety valves of the boiler are so placed with regard to the steam jackets that any excessive steam passing away from the boiler must first surround the cylinder valves. A question which is often brought up is the unequal expansion of the boiler plates and the cast iron cylinders. It has been stated that with this type of engine, if it is well under steam, the co-efficient of expansion being unequal for the two metals, throws the piston valves out of proper adjustment. Both Messrs. Wolff and Garrett provide for this by lining up their engines with steam in the boilers. After a considerable amount of experimenting with this method, it was found to be very satisfactory, and perfect alignment was assured, and the engine, when under normal working conditions, has accurately set piston valves which, owing to unequal expansion, might otherwise have been thrown out of adjustment. Messrs. Wolff have also in some of their plants provided tie-rods between the main bearings and the cylinders, and have allowed the main bearings to have a certain amount of end play on the boiler shell.

Figure 9 shows a Robey Superheated Steam Overtype Engine, Uniflow type.

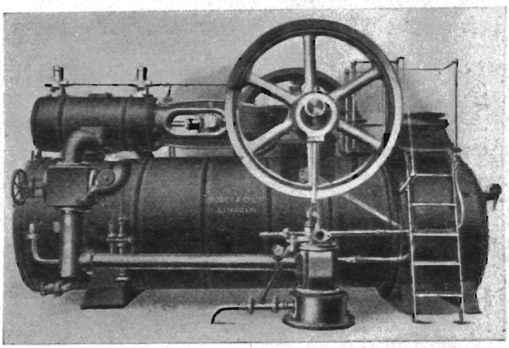


Fig. 9

Figure 10 shows a 140 to 180 B.H.P. Garrett Engine running a flour mill in Aldershot, near London. This engine was installed for the purpose of driving the entire flour mill. The consulting engineer upon whom fell the task of choosing the most suitable plant, originally installed a suction gas engine and producer plant. It was found, however, that a great deal of valuable time had to be spent in overhauling and cleaning, in order to obtain a continuous run with it, and that even with this attention it occasionally failed during the week's run. It was also found that the speed was liable to vary considerably, and in spite of the heavy fly wheel supplied, the drive was somewhat irregular. None of these difficulties are experienced with the "Overtype" engine that the consulting engineer eventually installed to replace the suction gas plant, and since it has been at work it has actually

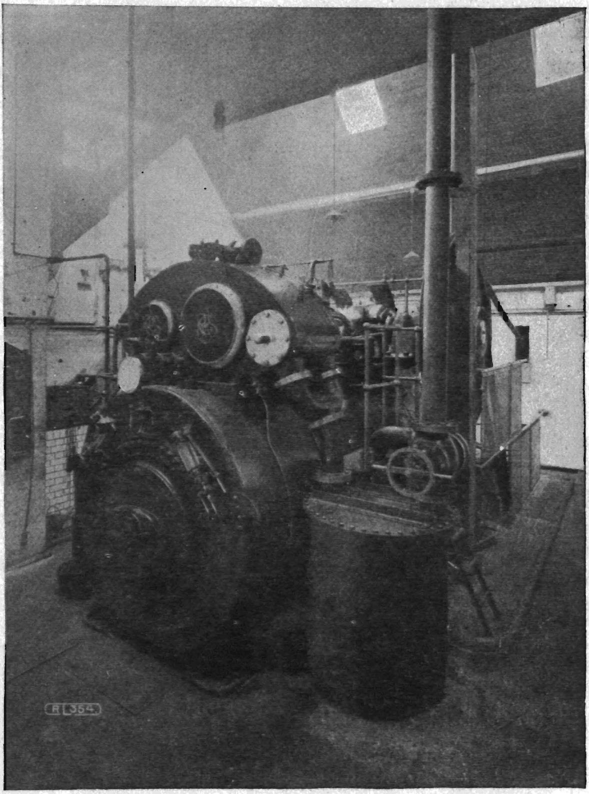


Fig. 10

been found that the cost of fuel per sack of flour made, is lower than was obtained with the suction gas plant. This is certainly a very praiseworthy result, especially when it is taken into consideration that the steam engine is at present running only about .65 of its full load, owing to the additions to the mill not yet being complete.

Table 1 shows the actual figures taken from a day's run of this flour mill in ordinary work, and they show that the high economy obtained on the test bed is still maintained under running conditions.

TABLE I.

Test of Garrett Compound Superheated Steam Semi-Stationary Condensing Engine, of 140-180 Brake Horse-Power Capacity Continuous Working Load, installed in a Flour Mill.

Duration of trial	12 hours
Total coal used	2150 lbs.
*Coal for heating	336 lbs. to 450 lbs.
Net coal for power	1814 lbs.
Coal per hour for power	164·5 lbs.
Temperature of steam	540 deg. to 550 deg. Fhr.
Vacuum	24 in. to 24½ in.
Speed	170 r. p. m.
Calorific value of coal used	12,404 B. Th. U. per lb.
Moisture in coal	10·29 per cent.
Mean indicated horse-power	115·8 h.-p.
Mean brake horse-power at 92 per cent. efficiency (60 per cent. of full load) ...	106·5 h.-p.
Coal per indicated horse-power per hour ...	1·42 lbs.
Coal per brake horse-power per hour ...	1·55 lbs.
Corresponding consumption per brake horse-power per hour of dry coal of 14,000 B. Th. U.'s per pound Calorific value ...	1·24

* This steam is used for conditioning purposes. The lower figure was ascertained on a previous trial. On actual day of trial more steam was being used owing to the class of wheat which was being ground, but the lower figure has been taken.

Table 2 shows a test taken by Messrs. Burstall and Monkhouse, Consulting Engineers, of London. The engine was driving a dynamo by means of a belt off one of the fly-wheels —a loss of 5 per cent. was allowed for the power absorbed

TABLE II.

General Description and Dimensions.

Engine driving dynamo by belt off one flywheel.

Type:—Horizontal, tandem, single crank, with high pressure in front; superheater between high-pressure and low-pressure cylinders. Both cylinders in base of fuunel, and surrounded by waste gases.

Valves of piston type, both driven by eccentrics. High-pressure cut-off variable by governor.

The feed to boiler was measured; as there were no external feed-pipes and no leaks of steam or water, this was equal to the steam supplied to engine.

Power.	Trial A.	Trial B.	Trial C.
1. Date of trial	March 3, 1909.	March 4, 1909.	March 4, 1909.
2. Duration of trial	7 hours	2 hours 59 min.	3 hours
3. Steam to high-pressure cylinder per hour ... ... lb.	1324	1637	982·8
4. Pressure of steam to engine ... ,,	217·8	218·6	219·7
5. Pressure of steam to engine (absolute) ,,	232·5	233·3	234·4
6. Temperature of steam to engine ...deg. F	601	604·5	552
7. Temperature of high-pressure exhaust ... ... ,,	334·4	356	277
8. Temperature of steam to low-pressure cylinder .. .. ,,	431·5	437	378
9. Temperature of steam, low-pressure exhaust ... ... ,,	145·5	143·7	126·5
10. Pressure of low-pressure exhaust (from cards) (absolute ... ... lb.	2·8	2·95	2·35
11. Corresponding temperature of saturated steam ... . deg. F.	139	141	134
12. Mean vacuum in condenser inches of mercury	26·9	26·7	28·5
13. Mean absolute pressure in condenser pounds per square inch	1·5	1·6	0·7
14. Mean effective pressure in high-pressure cylinder... ... ... lb	71·7	85·3	53·9
15. Mean effective pressure in low-pressure cylinder... ... ... ,,	14	18·1	9·7
16. Mean pressure referred to low-pressure cylinder... ... ... ,,	31	38·3	22·4
17. Mean area of low-pressure cylinder sq. in.	255·8	255·8	255·8
18. Mean revolutions per minute (by counter)	212	209·5	212·9
19. Piston speed ... . ft. per min.	640	632	643
20. Total indicated horse-power	153·4	187·7	111·6
21. Mean output of dynamo kilowatts ...	92·8	112·9	61
22. Efficiency of dynamo ... per cent.	86·8	88	83·6
23. Brake horse-power (calculated)	150·2	180·6	102·7
24. Mechanical efficiency... ... per cent.	98	96·2	92
25. Steam used per brake horse-power hour ... ... lb.	8·81	9·06	9·57
26. Steam used per kilowatt-hour .. ,,	14·27	14·50	16·11
27. Coal per brake horse-power-hour ... ,,	1·05	1·06	1·12
28. Coal per kilowatt-honr ... ... ,,	1·70	1·70	1·88
29. Thermal efficieney of whole plant (on brake horse-power) ... per cent.	16·8	16·5	15·8
30. Thermal efficiency of engine (broke horse-power) ... ... per cent.	22·5	22	21·1

by the belt. The test was carried out by the most elaborate and careful method. The calorific value of the coal fired was 14,473 B.T.U. The author had reason to believe that these low steam consumption figures of 8.81 lbs. per b.h.p. per hour had since been improved upon unofficially in this city.

Figure 11 showed a power installation of a Garrett's engine, which was running a brush manufacturer's works near London. It would be seen that there was an automatic stoker arranged in front of the furnace. By means of this

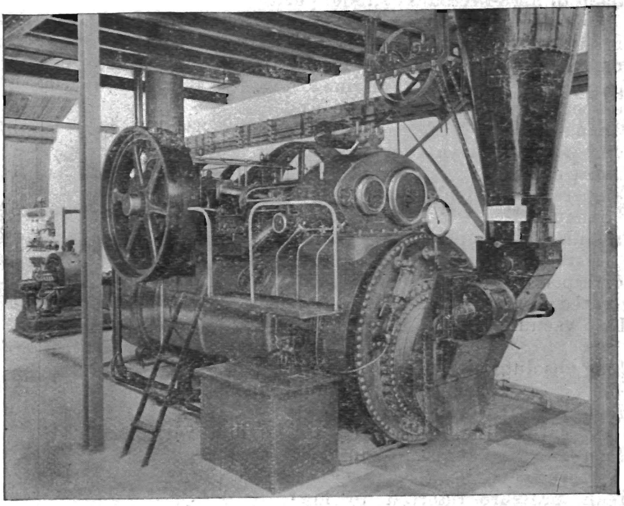


Fig. 11

apparatus refuse in the form of shavings, chips, and sawdust, etc., from the factory, which had been pneumatically conveyed from the various points throughout the works were delivered into this hopper from the floor above, and were automatically fed or blown into the furnace by a small fan worked off the counter shaft from the engine.

Table 3 was compiled after testing the above engine, and from which it would be seen that only 4.9 lbs. of wood refuse per B.H.P. per hour was necessary, with slight addition of under ½ lb. of coal per B.H.P. per hour for the purpose of

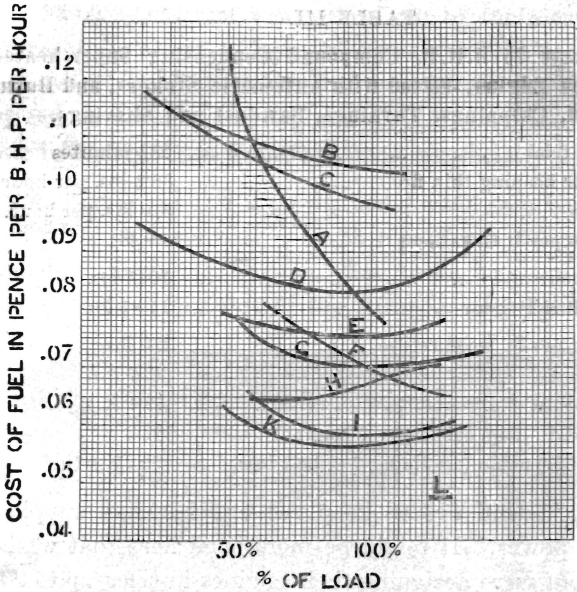
TABLE III.

Test of Garrett 75 B.H.P. Compound Condensing Super-heated Over Type Engine, Fitted with Automatic Stokers, and Burning Wood, Chippings, Turnings, Sawdust and Shavings.

Duration of trial	283 minutes
Coal used for keeping thin fire	38·2 lbs. per hour
Wood refuse	310 lbs. per hour
Wood refuse per B.H.P. hour	4·9 lbs.
Water per hour...	1045 lbs.
Water per B.H.P hour	11·84 lbs.
Evaporation per lb. wood refuse	2·5 lbs.
Average I.H P.	93 7 lbs.
Average Output of Dynamo	48·4 K.W.S.
Average B.H.P. (94% efficiency of Engine)	82·2
Efficiency of Dynamo (assuming 7 % belt loss) ...	79·25 % (low)

maintaining a thin fire to keep the entire works supplied with ample power. It might be mentioned here that whilst Messrs. Wolff were designing their engines in sizes up to 800 B.H.P., Messrs. Garratts had limited their designs to 300 B.H.P. At the beginning of this paper it was pointed out that heretofore the larger power installation was the most economical, but that the Overtype Superheated Steam Engine had now placed the smaller user in a position equal, if not to a better advantage, to generate power more cheaply.

In Figure 12 the author had shown a few curves which would allow it to be seen at a glance the relative costs for running various types of prime movers. Unfortunatelyl, one of the most important competitors of the engine being described particularly, namely, the Diesel oil engine, was not represented on these curves. The author had no data at his disposal at the time but he could assure members that the "Overtype" superheated engine would class very favorably with this imposing rival, not only in actual running costs, but, as would be universally admitted, the steam engine was more reliable and more capable of performing its duty continuously without involuntary stops or bad starts than any internal combustion engine.



CURVES SHOWING COST OF FUEL CONSUMPTION IN RELATION TO CAPACITY

PRICE OF STEAM COAL 10/- PER TON
PRICE OF ANTHRACITE 20/- PER TON

A	65 B H.P. SUCTION GAS PLANT	(TESTED BY MATHOT)
+ B	150 B H.P. STEAM TURBINE	
o C	300 B H.P PARSONS STEAM TURBINE	
- D	200 B.H.P COMPOUND STEAM ENGINE	(PROF SCHROETER)
E	200 B.H.P WOLF LOCOMOBILE	(PROF GUTERMUTH)
F	45 B.H.P. WOLF LOCOMOBILE	(PROF JOSSE)
G	65 B.H.P. GARRETT OVERTYPE ENGINE	(CAPT SANKEY)
H	500 B.H P WOLF LOCOMOBILE	(MAGDEBURG BOILER ASSN)
I	100 B.H.P WOLF LOCOMOBILE	(PROF GUTERMUTH)
K	150 B.H.P WOLF LOCOMOBILE	(BURSTALL & MONKHOUSE)
L	100 B H P WOLF LOCOMOBILE	(BERLIN BOILER REV ASSN)

+ B STEAM PRESSURE 176 LBS PER SQ IN SUPERHEAT GOOD VACUUM

o C STEAM PRESSURE 183 LBS PER SQ IN TEMPERATURE 250 DEGREES CENTIGRADE

- D STEAM PRESSURE 132 LBS PER SQ IN TEMPERATURE 300 DEGREES CENTIGRADE VACUUM 27·6"

Fig. 12

Figure 13 showed three (3) large Wolff Locomobiles running in the City Electric Power Station of Oranienburg of a total capacity of 414 B.H.P., and driving four different electric generators. It would be interesting to note the arrangement of belt drives off an overhanging pulley, or fly-wheel. The shafts of these engines were very strongly made, and the

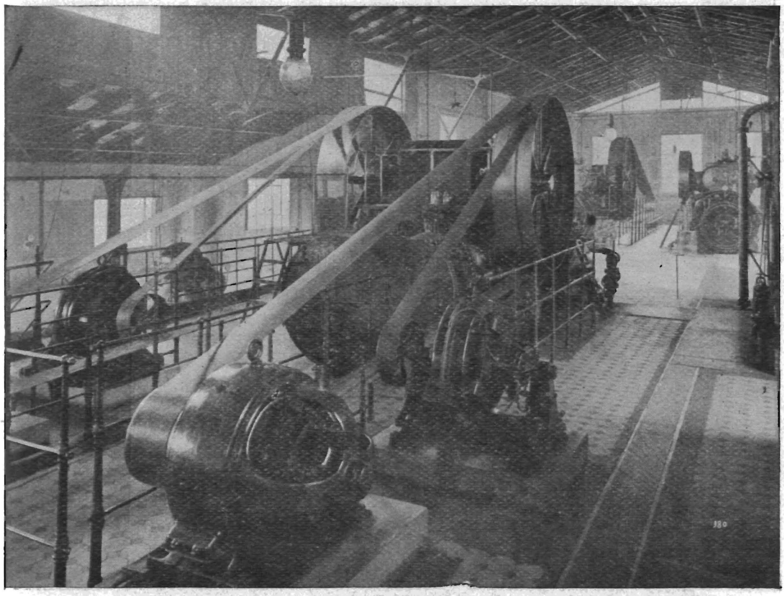


Fig. 13

bearing surface was ample to take care of any undue stress which might otherwise be transmitted to this portion of the engine

The curves shown in Figure 14 had been roughly drawn up and recalculated so that the conditions of steaming were as nearly equal as possible, and they demonstrated the steam

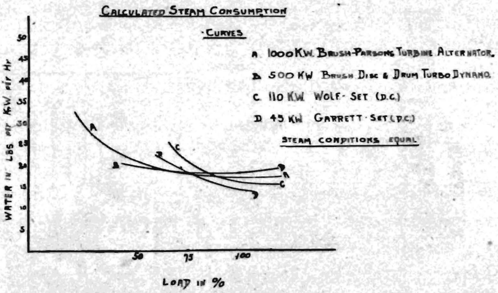


Fig. 14

consumption of a Brush Parsons turbine, a Brush Disc and Drum turbine, a Wolff and a Garrett Superheated Steam Overtype Engine.

Figure 15 showed two large Wolff sets running in Germany, each driving electric generators off the main fly-wheels.

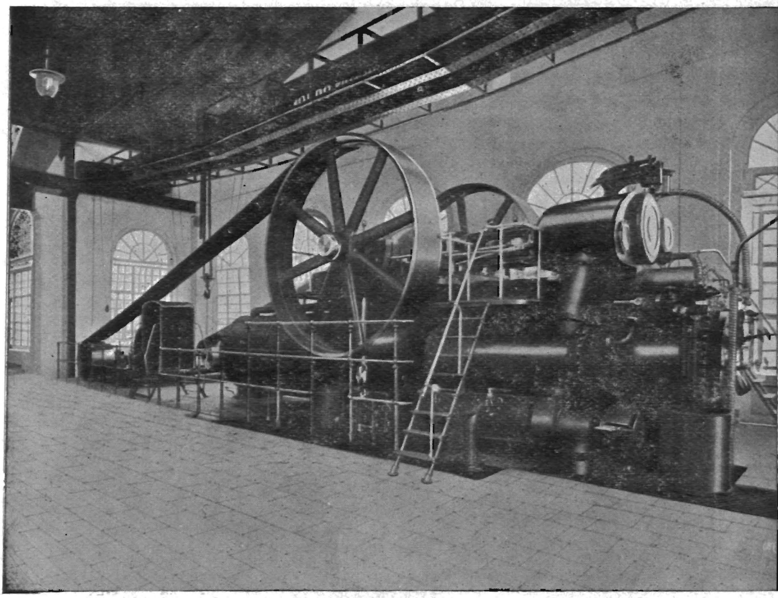


Fig. 15

The principal of placing the engine on the top of the boiler as applied to stationary engines was, of course, an old arrangement, but as a matter of interest the author was able to show a photograph, Figure 16, of the first Wolff's

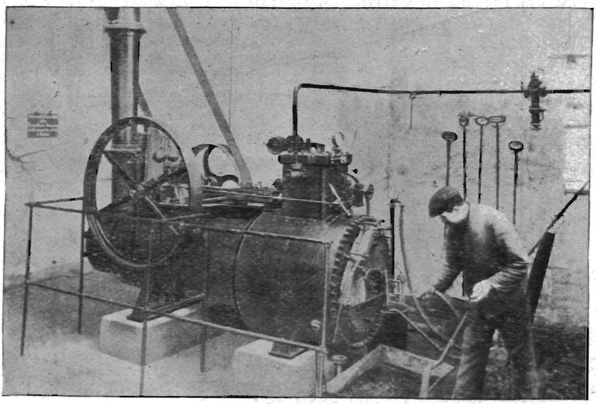


Fig. 16

Overtype Engine ever constructed. This engine was sold some 56 years ago, and was re-purchased by the makers purely as a matter of sentiment, and was now running in Messrs. Wolff's works at Magdeburg.

Figure 17 showed the Testing Plant at Messrs. Garrett's works in Suffolk. It would be observed that all loads were obtained electrically, the efficiency of the dynamos having

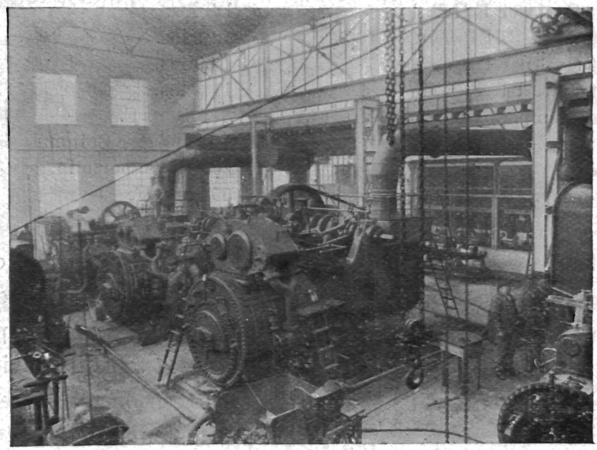


Fig. 17

been accurately tested and frequently re-checked. In the foreground would be seen the scales for measuring the coal before the same was fired.

Table 4 gave the results of trials of a 55 H.P. Garrett Superheated Steam Engine when using low grade Japanese coal.

TABLE IV.

Test of Garrett 55 B.H.P. Cbmpound Super-heated Steam Over-Type Engine, using Low Grade Japanese Coal.

DATE OF TRIAL APRIL 19TH, 1912.

Japanese Coal used, calorific value ...	12,232 B.T.U.'s per lb.
„ „ moisture	2·8 per cent
„ „ ash	16·7 per cent.
Duration of trial...	312 minutes
Load	58·14 indicated H.P.

Load	54·66 Brake H.P.
Mechanical Efficiency	94·2 per cent.
Total Coal used	616 lbs.
Total Water used	3444·3 lbs.
Evaporation	6·72 lbs. of water per lb. of (net) coal
Clinker and Ash	104 lbs.
Nett Coal used	512 lbs.
Nett Coal per hour	98·4 lbs.
Water per hour	662·3 lbs.
Nett Coal per B.H.P. hour	1·8 lbs.
Water per B.H.P. hour	12·1 lbs.
Nett Coal per I.H.P. hour	1·69 lbs.
Water per I.H.P. hour	11·3 lbs.
Mean Temperature of Steam	511 Deg. F.
Draught	¼ in. Water Column
Speed	200 Revs. per min.
Condenser Inlet Water Temperature...	55 Deg. F.
„ Outlet „	113 Deg. F.

Up to the present he had said everything in favor of the engine being discoursed upon. Like any other engineering device, it was by no means immaculate, and there was plenty of room for discussion upon the subject. It was often said that the engine in question placed undue stress on the boiler, but the makers could prove by a series of calculations that these stresses were not so serious as they might appear. Then again, they had to contend with the nuisance of combining the stoke-hole and the engine-room in one, and there was a chance of grit finding its way into the working parts of the engine. The great difficulty of cleaning the tubes of a locomotive type of boiler was overcome in this design, and no special care need be given to the chemical analysis of the water, owing to the ease with which the tubes were scaled. In summing up the disadvantages, which were comparatively few, it was surely apparent that they are overshadowed by the many advantages gained by the installation of this type of prime mover.

The author would like to thank Messrs. Haes and Eggers and Messrs. Gilbert Lodge and Company for the courtesy they have snown in placing at his disposal the material for composing what he feared had proved to be a somewhat incomplete and fragile paper.