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A Symposium on High Pressure Boilers.
(including the Atmos, Benson, La Mont, Loeffler, Sulzer, Velox and Wagner Boilers).

HELD

On Tuesday, March 12th, 1935, at 6 p.m.

CHAIRMAN: Mr. J. HAMILTON GIBSON, O.B.E., M.Eng. (Chairman of Council).

The Atmos Revolving Boiler.

By J. VIKTOR BLOMQUIST.

THE latest development of the Atmos boiler consists in the burning of the fuel within the cage rotor in order to reduce the brickwork. Any combustible material may be used, the supply of the material being modified correspondingly.

Whether the fuel be gaseous, liquid or pulverized, it is fed into the rotor through burners in the front wall together with the combustion air.

The accompanying drawing (Fig. 1) shows a steam generator for a capacity of 20,000lb. of steam per hour at a working pressure of 1,425lb./sq. in. and a steam temperature of 840° F., arranged for firing with lump coal or nuts.

The coal is supplied through a rotating drum and falls through an aperture in the front wall into the rotor (not shown in the drawing). The air is supplied to the coal bed through cast iron bars between the steam generating tubes of the rotor. The grate bars are efficiently cooled by the tubes. The combustion gases escape to the superheater through the grate at the upper part of the rotor, and from there over the economiser to the chimney. The superheater is of the combined convection and radiation type, securing a practically constant steam temperature at all loads without any regulation by injection water.

For preventing any leakage of the primary air to the superheater chamber, air of a somewhat higher pressure is directed tangentially to the rotor tubes against the direction of rotation.

For forcing all coal into the rotor, the aperture for the coal supply is surrounded by a channel through which secondary air is supplied. On account of the rotation, the coal is distributed in an even layer over the whole length of the rotor and is in constant motion which should prevent the formation of big cakes of clinker. The clinker falls over the furnace bridge at the end of the combustion chamber, and from there through the openings between the tubes into the ashpit.

The quantity of coal burnt per sq. ft. of grate area per hour is about 50lb.; this is very moderate for a revolving grate, so that the steam generation may probably be increased considerably. The number of revolutions of the rotor is 10/12 per minute.

The course of the steam generation is the same as in the ordinary Atmos boiler with cage rotor. The preheated water is fed into the central tube, from where it is distributed through six radial tubes to a torus and from there to the steam generating tubes. The steam escapes from the end of these tubes to the central tube and from there to the superheater. Protective measures are arranged for preventing the water from flowing out of the tubes during a high sea.

The Atmos boiler is very insensitive to the quality of the feed water. A boiler for 1,425lb. working pressure, erected in a pulp mill in Sweden, is fed with non-degassed water, having a pH-value of 5·6 - 6·4. The boiler was started in October, 1931, and has worked perfectly since that time, day and night with the exception of Sundays. At an inspection of the boiler last summer not the slightest trace of corrosion could be observed.

As is well known, it is impossible to feed a modern boiler, designed for even a rather low pressure, with water containing acids or gases, because of severe corrosion at the water inlets to the tubes, as proved for instance by a modern boiler for a pressure of 500lb./sq. in. erected in another pulp mill in Sweden. This boiler was fed with carefully degassed water at a temperature of 250° - 280° F. The pH value was 5·2 - 5·6. After working for only two and a half months, including interruptions for repairs, about one hundred tubes were so much corroded at the inlets that they had to be replaced by new ones. By increasing the pH-value to at least 10 by the addition of chemicals to the feed water in suitable quantities according to the quality of the water, the trouble was overcome.

In the author's opinion the primary cause of the corrosion was not the gases or acids, but the eddies existing at the inlets, as the corrosion appears solely at those spots. In these eddies a slight partial vacuum exists; the gases and acids accumulate there and have opportunity to attack the material.

The better behaviour of the Atmos boiler is due to the fact that no eddies can remain at any point in the connecting tubes between the steam generating tubes and the central tube, since those tubes, during every revolution of the cage, are alternately filled with steam or water.

The steam generating tubes of the Atmos

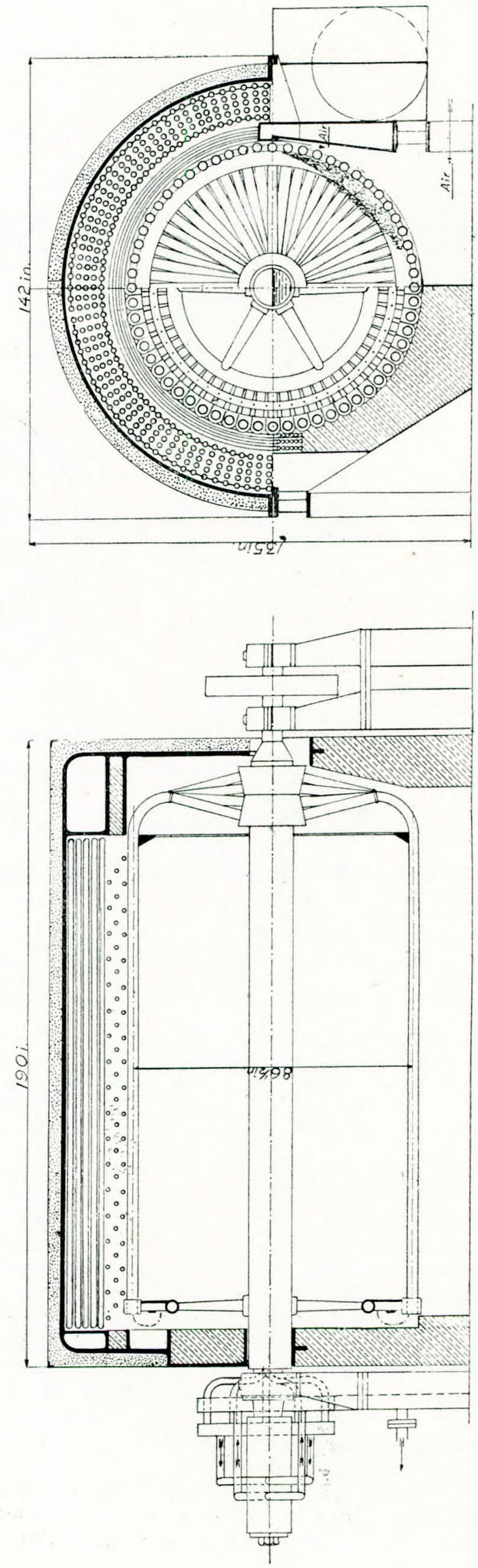


FIG. 1.—Atmos steam generator (20,000lb. of steam per hour; 1,425lb. per sq. in.; 840° F.).

boiler are provided inside with loose 1in. by $\frac{3}{8}$in. flat bars of soft iron, which constantly scrape off impurities arising from the feed water. It is probably possible to feed with raw water, since the scale incrustations are scraped off as soon as they are formed and are constantly blown off with the water necessary for the regulation of the feed. Trials in this direction will be executed.

The Benson Type of Super-pressure Steam Boiler.

By Dr. Ing. E.H. E. Goos.

The only super-pressure steam boiler installed in a merchant vessel up to the present time, as far as is known, is the Benson boiler designed and constructed by Messrs. Blohm & Voss, Hamburg. This boiler has now been in continuous service on the S.S. "Uckermark" for about four-and-a-half years and has worked to the entire satisfaction of all concerned*. In view of this, the Hamburg-Amerika Linie decided to have the new turbo-electric driven ship now in course of construction at the yard of Blohm & Voss for their service to the Far East fitted with four Benson boilers.

As is generally known, the Benson boiler consists entirely of tubes and has no drums, and these constructional features render it very suitable for use on board ship.

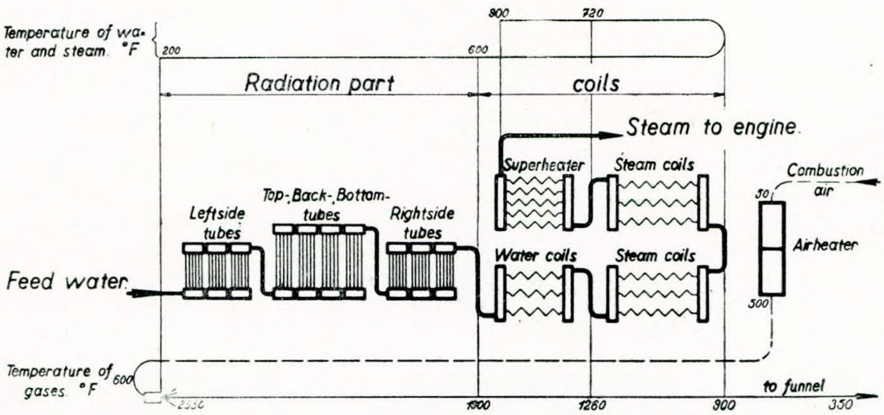


Fig. 1.—Benson boiler.
Diagram showing Temperature and flow of feedwater and steam
Temperature and flow of air and combustion gases.

The boiler has a comparatively large combustion space, entirely surrounded by tubes, through which water passes in continuous flow so that no stagnation can take place in any of them. The flow of water and steam is shown diagrammatically in Fig. 1, together with the path of the combustion gases. The heat transmission from gas to water or steam in the radiation part as well as in the convection part of the boiler can be exactly calculated, because the question of heat transfer has been thoroughly investigated and accurate coefficients have been established by numerous trials. For this reason it is possible to determine that part of the boiler where the water is converted into steam and where salts or other impurities of the boiler water are deposited. The temperature of the combustion gases in this part of the boiler must be low to prevent the formation

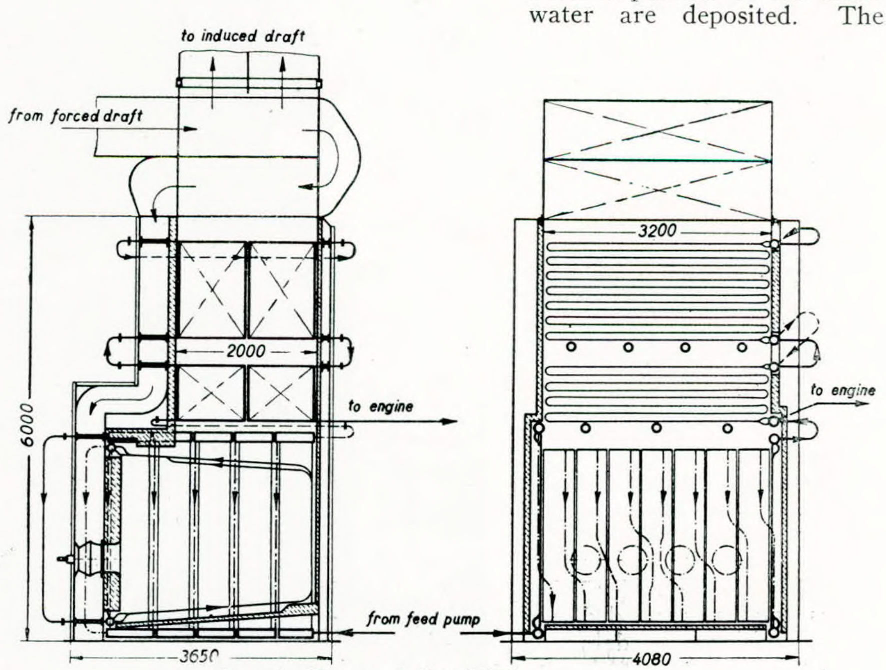


Fig. 2.—Benson boiler "497".

* See "Shipbuilding and Shipping Record", Nov. 26th, 1931, page 685; "The Steam Engineer", Vol. I, No. 5, Feb., 1932, page 194.

of hard scale inside the tubes. By this simple but ingenious measure it is possible in the case of a leaky condenser to maintain full power for several hours without danger of tube failures. As, also, the working principle of the boiler prevents the occurrence of priming, the boiler can be considered as especially suitable for marine purposes.

Originally the Benson boiler on the "Uckermark" worked at the critical pressure, but it has been shown that the boiler can also be worked at variable pressures as long as the conversion zone is situated in the region of low gas temperature. On this account the boiler pressure is virtually subject to no practical limitations and may be kept as high as 3,000lb. per sq. in. according to the type of turbine selected or the power temporarily necessary. The temperature of the superheated steam is automatically kept constant by an apparatus of special design and is, by considerations of the material available, limited to about 900° F.

One of the boilers for the before-mentioned new vessel is shown in Fig. 2, and the design will be readily understood by reference to the diagram, Fig. 1. The weight of this Benson boiler is only 3 tons and the space 100 cubic feet per ton per hour of steam at 1,500lb. pressure and 900° F. It should be particularly pointed out that in special cases, where the saving of weight and space is of vital importance, these values can be reduced to 0·7 tons and 35 cubic feet respectively. The combustion space is rectangular, and with this formation excellent mixtures of the highly preheated combustion air and the atomised fuel is secured so that the combustion at all loads is complete and nearly smokeless. With properly arranged high-class oil burners 340,000 B.Th.U.'s per cubic ft. of combustion space can be generated and 260,000 B.Th.U.'s per sq. ft. of radiation surface have actually been transmitted.

The tubes of the combustion space are of special steel containing 0·4 per cent. molybdenum; their diameter is 1in. and the thickness $\frac{5}{32}$in. The number of tubes in one nest depends upon the capacity of the boiler. The tubes or coils are welded on to upper and lower headers, each upper head being connected to the following lower head by one downpipe of suitable diameter. Around the boiler are the air trunks provided to carry the combustion air from the pocket type air heater to the oil burners, and in view of this arrangement the boiler does not require elaborate insulation.

In Fig. 3 the boiler is shown as photographed in the shop and this picture gives a clear idea of the boiler construction.

At the works of Messrs. Blohm & Voss one Benson boiler, complete with all the necessary instruments for exact measurements, has been installed and tried under conditions approximating to the severest seagoing service. It has been demonstrated that the Benson boiler is capable of responding immediately to the required alterations of the load. Manœuvres of the turbine from stop to full ahead and vice versa can be carried out in a few seconds. The fuel pumps were regulated by the thermometer for superheated steam and relays, the number of burners, the feed pumps and the boiler fans being hand regulated. As will be seen from Fig. 4 showing the test results, all the interdependent data, steam pressure, steam temperature, etc. are subject to little variation and only within the limits permitted. The efficiency is very good, being on an average 90 per cent., the same as that obtained on the "Uckermark". The tubes can be

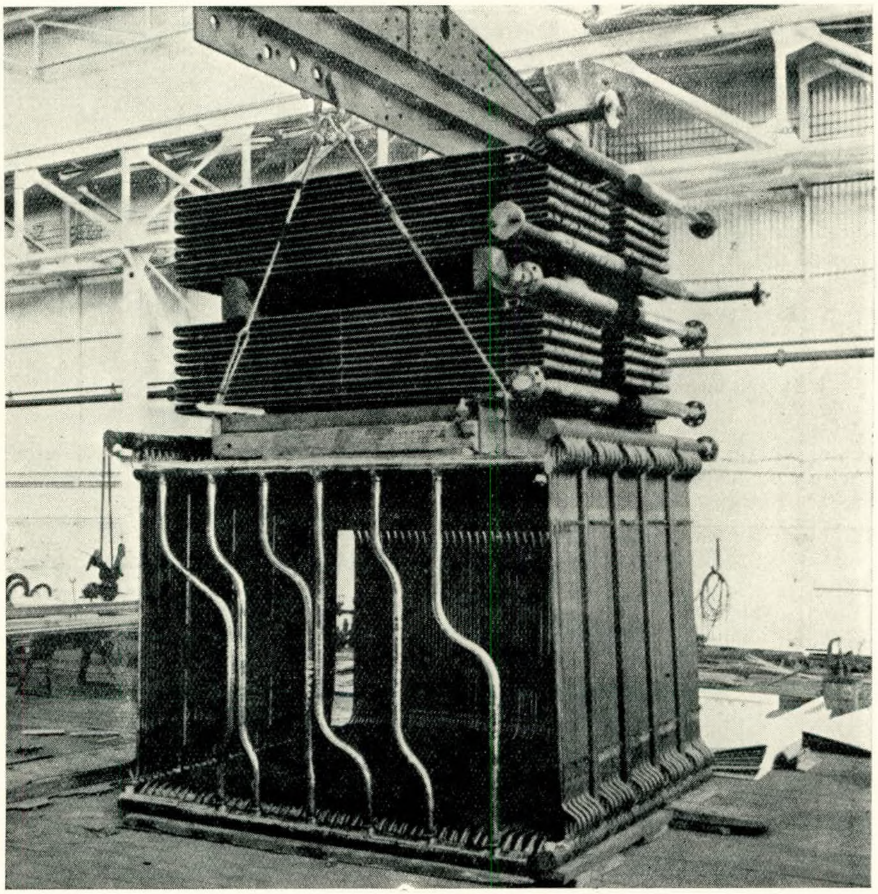


FIG. 3.—Boiler as erected in the shop.

kept clean easily by steam blowers; therefore the efficiency is nearly always at the same level. The oil burners used are of Blohm & Voss design, ranging in capacity from 100 to 1,700lb. per hour. The combustion is nearly smokeless at all loads, and the CO_2 content of the combustion gases uniformly recorded at 14 to 15 per cent.

From these trials the Hamburg-Amerika Linie, as well as the manufacturers, have every reason to anticipate that the Benson boiler will work as satisfactorily on the new ship as it did on the "Uckermark" and more recently in the shop. As the machinery of this ship has many additional new features, her voyage results will be awaited with the greatest interest.

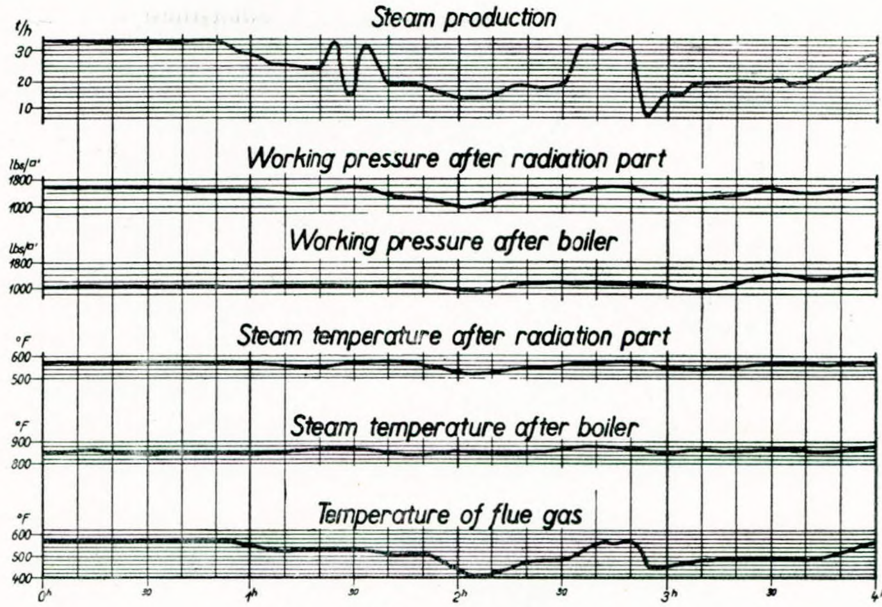


FIG. 4.—Diagram of test results.

The La Mont Boiler and Its Application to Marine Plants.

By D. W. RUDORFF, Dipl.Ing.

The outstanding characteristic of the La Mont boiler is the use of forced water circulation through the boiler tubing. Fig. 1 shows diagrammatically how this is accomplished. The boiler water passes from the boiler drum into the suction side of the circulating pump supplying the differential pressure required to overcome the friction loss in the boiler circuit. This friction loss includes that caused by the orifices situated in the tube inlets. These orifices (Fig. 2) with which each boiler tube is equipped serve the purpose of apportioning the water supply to the tubes in accordance with the heat absorption of each tube.

As a rule, the water circulation through the individual boiler tube is so adjusted by proper dimensioning of the orifice that at normal boiler load each tube receives eight times as much water as steam generated in the tube. By this ratio, high velocities of the steam-water mixture in the boiler tubing are ensured at all loads so that overheating of the tubes is made impossible even under the most severe conditions.

Following the boiler circuit we see that the water-steam mixture issuing from the boiler tubing is discharged into the boiler drum, where water and steam are separated. While the steam is drawn off into the superheater, an equivalent quantity of feed water is supplied to the boiler circuit by the feed water pump. Control of the feed water supply is accomplished by any of the standard types of feed water regulators used to maintain a constant water level in the boiler drum. Therefore no special types of feed water regulators are required and the cir-

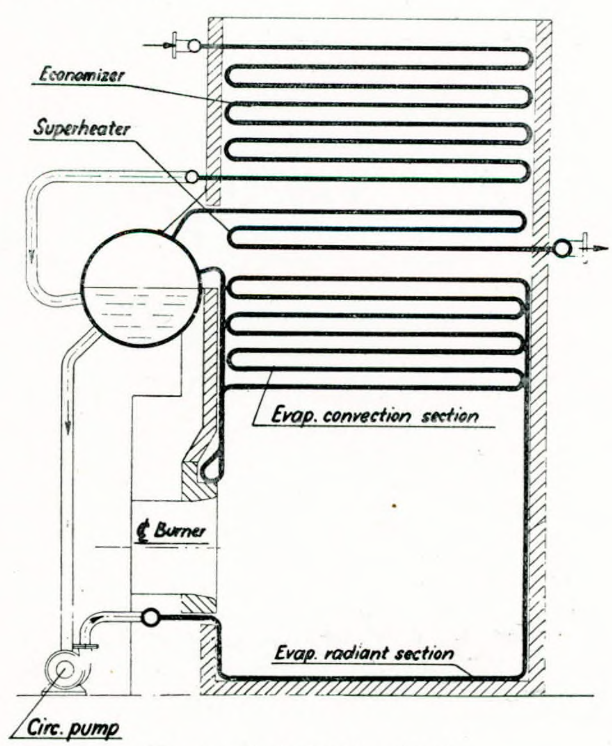


FIG. 1.—Typical boiler circuit.

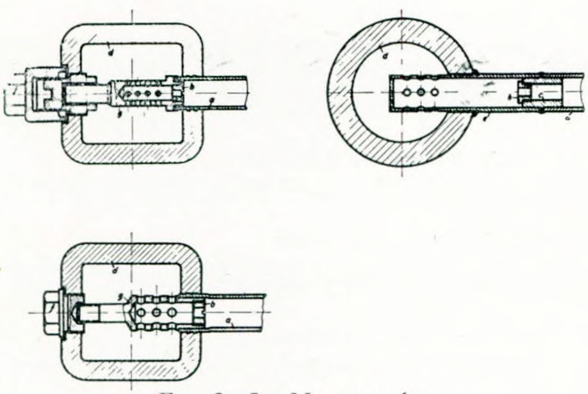


FIG. 2.—La Mont nozzles.

culating pump remains the only feature which distinguishes the operation of a La Mont boiler from

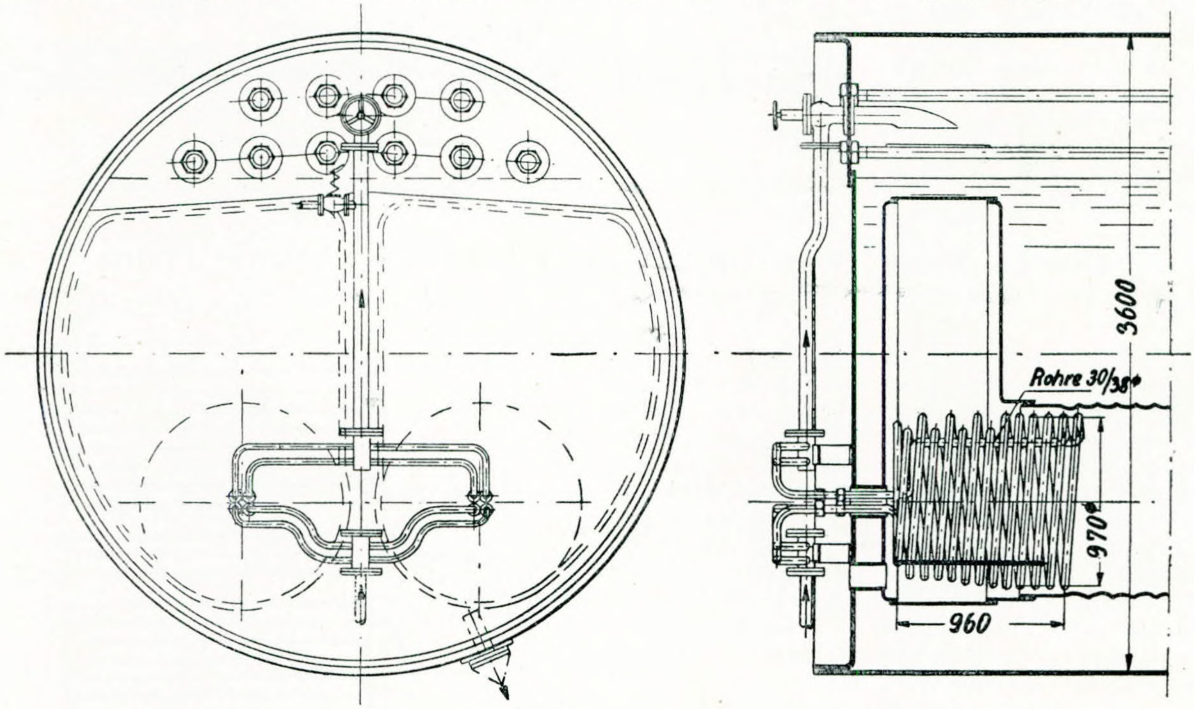


FIG. 3.

that of an ordinary boiler either of the Scotch marine or watertube type.

Besides preventing overheating of the tubes, the high velocity of circulation also acts as an efficient agent against the accumulation of scale, a point which will be discussed later.

As to the pressure drop which must be overcome by the circulating pump, this does not exceed 35lb./sq. in., so that in the average boiler the power consumption of the pump drive amounts only to about one-half per cent. of the energy output of the boiler.

Other advantages are also claimed for the La Mont system of forced circulation besides those just mentioned. With regard to the operating characteristics of the boiler it remains to be added that the starting time of such boiler from cold is extremely short, an advantage mainly due to the equalisation of metal temperatures throughout the boiler and the consequent suppression of expansion stresses; this results from the constant circulation of the boiler water, whereby a uniform warming-up of boiler tubing, headers, pipe connections, etc. is achieved.

The principle of natural boiler circulation has hitherto imposed a number of important restrictions upon the designer. Those relating to boiler-tube diameter, tube inclination and length are in the case of the La Mont boiler practically eliminated. Small tube diameters and great tube lengths as they are used in the design of the La Mont boiler are known to have highly beneficial effects upon heat transfer, cost of construction, and boiler weight; the latter feature is of special importance in the

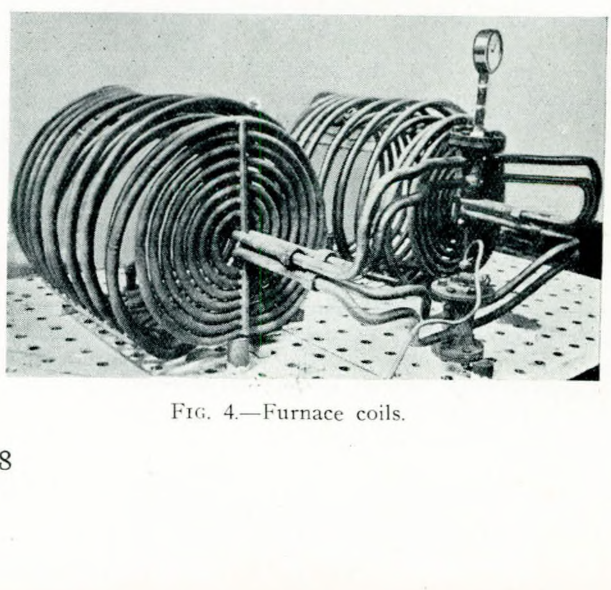


FIG. 4.—Furnace coils.

design of naval boilers. These two features combined with the unimportance of the tube inclination allow a wide latitude of design when it becomes necessary to adapt the boiler layout to specified conditions and restrictions of space, such as often occur in the conversion of ship propulsion from Diesel to steam, and the replacements of old boilers by others of higher output and pressure, etc.

As to the low boiler unit weights obtainable with the La Mont system, the claim of the manufacturers that they obtain these low weights without any sacrifice of either boiler efficiency or service dependability or by resort to radical departures from standard boiler practice has to be admitted. It is particularly fortunate that forced circulation of the boiler water is not confined to any particular boiler pressure, so that it is applicable over the whole range of pressures from the most conservative in marine plants of yesterday and to-day to the most extreme pressures for which the plant of the future may be built.

A few examples may serve to show the various kinds of marine installations in which La Mont boilers are in use. Figs. 3 and 4 show how the La Mont system can be employed to facilitate the conversion of cylindrical boilers to firing with pulverized coal. In this case the La Mont cooling coils serve to reduce the furnace temperature. The surprising feature of this arrangement is that, as continuous operation for a period of more than a year has shown, no scale formation takes place in the cooling coils although untreated river water is used as feed. The water used for the boiler in this and in another boat of the same type is taken from the river Rhine. Average analyses show the water to be of approximately 10·6 English degrees of permanent hardness and 50 degrees of total hardness. Fig. 5 shows how La Mont water walls can be used to increase the capacity of existing marine boilers. The installation shown is identical with those placed in the auxiliary boilers of the Hamburg-American liners "Albert Ballin" and "Deutschland", which had been found to be of insufficient capacity for the supply of steam to the auxiliary equipment such as turbo generators,

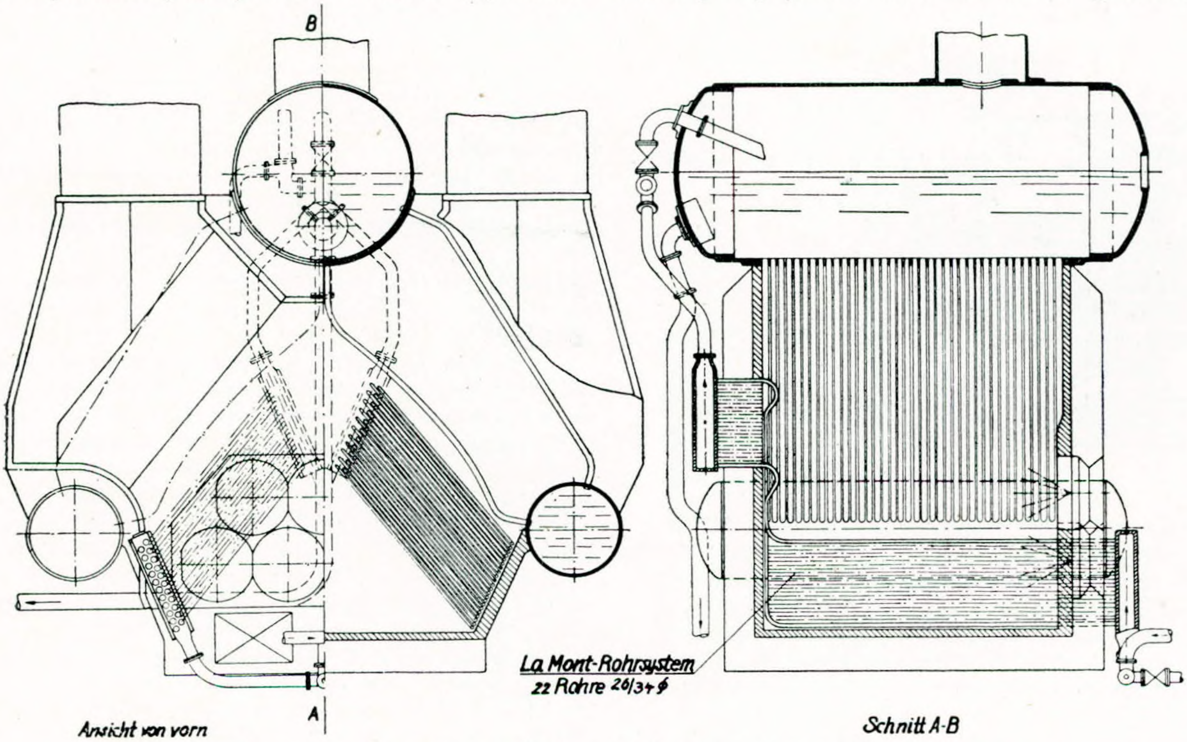


FIG. 5.—La Mont water walls installed in a watertube marine boiler.

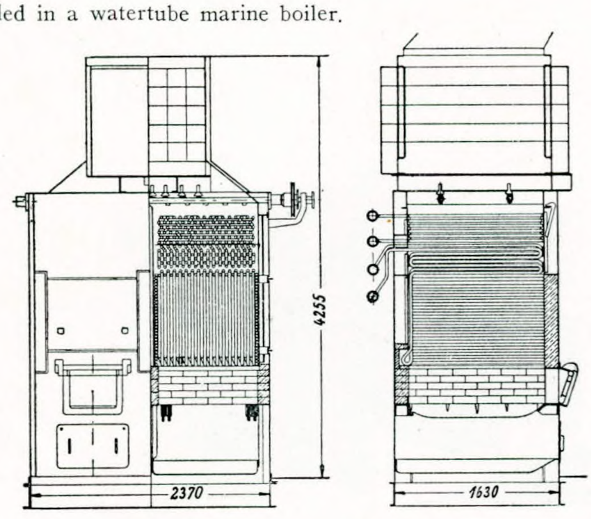


FIG. 6.—Small marine boiler.

winches, refrigeration equipment, etc. while the steamer was in port. Due to overloading of the boilers prior to installation of the water walls, boiler uptake temperatures as high as 930° F. had been observed, but the La Mont installation caused a drop to about 570° F. These water walls have given satisfactory service since the date of their installation in 1931.

As to complete La Mont boiler installations, Fig. 6 shows a small plant installed in the steamer "Juno". Operating pressure is 180lb./sq. in., the steam output is 5,500lb./hr., the heating surface of the boiler 540 sq. ft. Fig. 7 shows how the tube

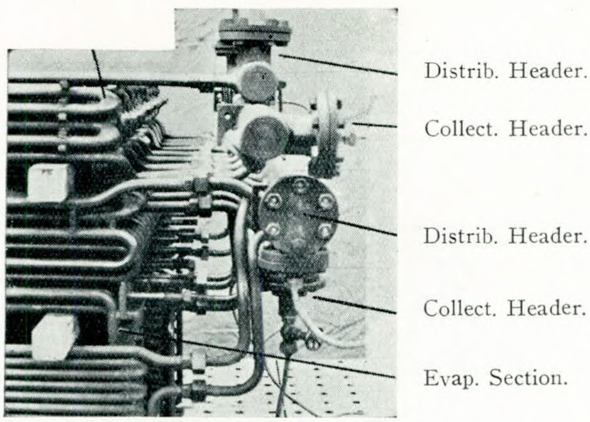


FIG. 7.—Tube connections of boiler shown in Fig. 6.

connections between tubes and headers are made and arranged, while Fig. 8 gives a picture of the assembly of the tubular part of the boiler.

A somewhat larger installation is that of two powdered-coal fired boilers for the steamer "Nicea". Fig. 9 illustrates the design of these boilers which are equipped with ample radiant evaporating surfaces followed by coil-shaped evaporating surfaces of the convection type. The firing arrangement is that of the inverted flame type which is similar to that frequently used in land plants. The most important data of these boilers are :—

Steam output of each boiler : 11,000lb./hr.

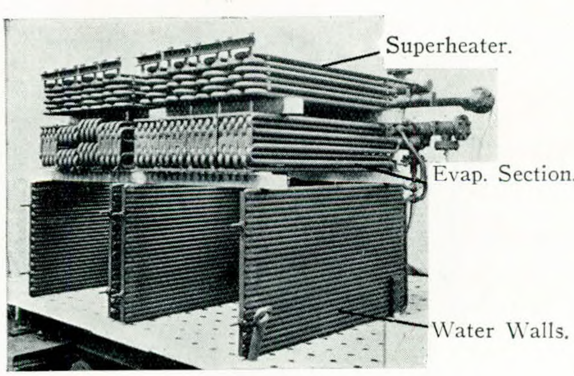


FIG. 8.—Assembly of tubular parts of boiler shown in Fig. 6.

Steam pressure 255lb./sq. in.
Steam temperature 626° F.
Evaporating surface 710 sq. ft.
Superheating surface 312 sq. ft.
Average rate of evaporation 15·5lb./sq. ft./hr.

This rate of evaporation is comparatively low and by no means represents the upper limit obtainable with La Mont boilers, as can be seen from that data appertaining to the design shown in Fig. 10. The operating data are :—

Steam output 88,000lb./hr.
Steam pressure 750lb./sq. in.
Steam temperature 806° F.
Evaporating surface 2,320 sq. ft.
Superheater surface 1,830 sq. ft.
Economizer surface 2,580 sq. ft.

The total service weight of the boiler including water content amounts to 52,800lb., which is equivalent to 0·6lb. of boiler weight per lb. of steam generated per hour or to a specific output of 1·66lb. of steam per hour per lb. of boiler weight. It is remarkable that in spite of this low weight the boiler efficiency amounts to 86·2 per cent. at full load, although the average evaporation is no less than about 38lb. of steam per hour per sq. ft. of evaporating surface.

Another somewhat different application of the La Mont system is that relating to waste-heat boilers in conjunction with marine Diesels. Fig. 11 shows the typical design of such an exhaust gas boiler. Exhaust boilers of this type are installed in several Diesel-propelled ships of which the M.S. "Toulouse", "Modjokerto" and the M.T. "Svithiod" may be mentioned. In this type the boiler surface is composed of a number of stacked-up flat coil spirals, each receiving an apportioned water supply from the distributing header.

Scaling, priming, and foaming of watertube boilers used in ships have always presented a serious problem to the marine engineer, particularly as these phenomena can become rather serious whenever condenser leakage or other circumstances demand a boiler emergency operation with feed contaminated with salt water or even with pure salt water. As a matter of fact the inferiority of the watertube boiler in this respect to the cylindrical boiler has for a long time presented a serious obstacle to its introduction in smaller marine plants. It may therefore be of interest and value to relate the results of a recent test made on a La Mont boiler which was fed purposely with contaminated water in order to study the effects of such operation. The boiler tested had been guaranteed by the manufacturer to give trouble-free operation with a water containing 2 per cent. NaCl. The water used for the test contained 3·82 per cent. total solids by evaporation, of which 3·64 per cent. were salt content. A series of tests run at full boiler load proved that it was possible to operate the boiler with salt concentrations as high as 15 per cent., a result which was in excess of the most optimistic expectations. Samples of the saturated steam taken periodically during the tests contained salt concentrations of 2·8 - 29·0 parts per million and total solids of 16·8 - 48·4 parts per million, the variations being due to the gradual building up of a higher boiler water concentration, which was gradually increased from 3·6 per cent. to 15·0 per cent. salt content. These figures indicate that the moisture content of the steam delivered by the boiler remained very low even under the most severe conditions.

After the boiler had been in operation for twelve hours it was shut down and the inner surfaces of headers and tubing were examined. As was to be expected, some scale accumulation could be found in the boiler tubing. A portion of the scale formed on the tube walls had already cracked off during operation and had accumulated in the headers where it had been retained by the strainers with which each tube nozzle is equipped. Where the scale still adhered to the tube walls, its thickness varied between 0·1 - 0·2mm. After inspection the boiler was put back into service again, the feed being changed to the fresh water supply available, which was treated with caustic soda and tri-natrium-phosphate. Another inspection of of the boiler tubing made after 100 hours operation showed that the scale on the tube

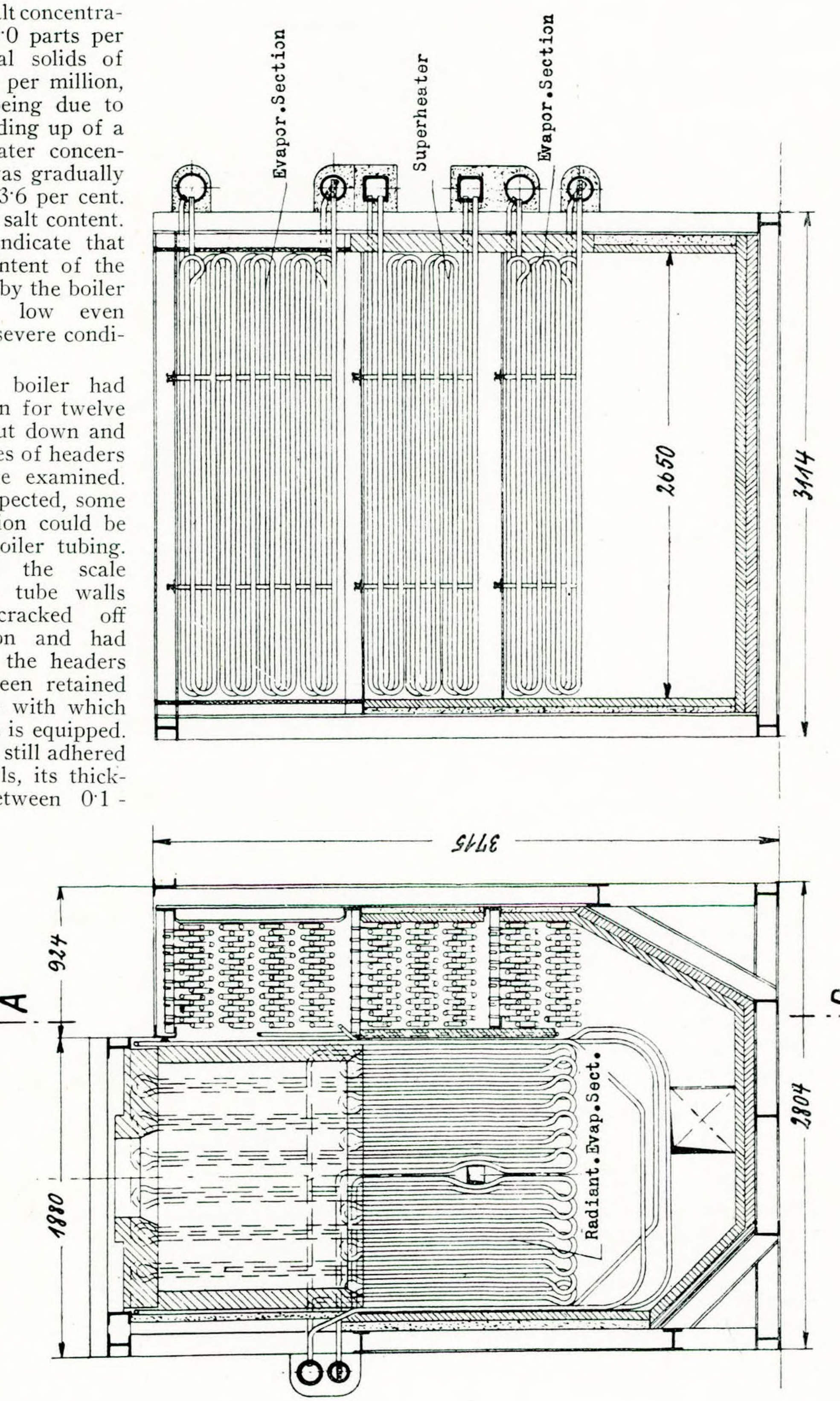


Fig. 9.—Boiler for s.s. "Nicea".

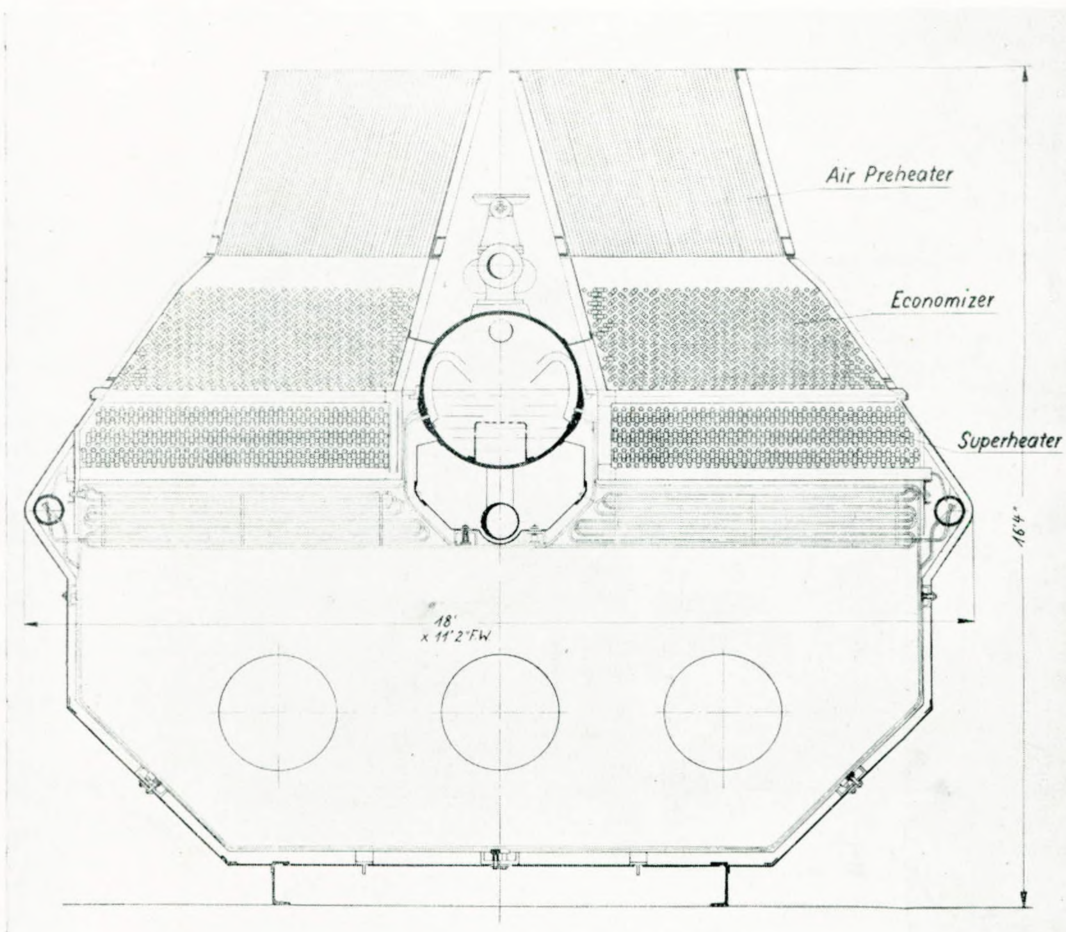


FIG. 10.—Marine boiler.

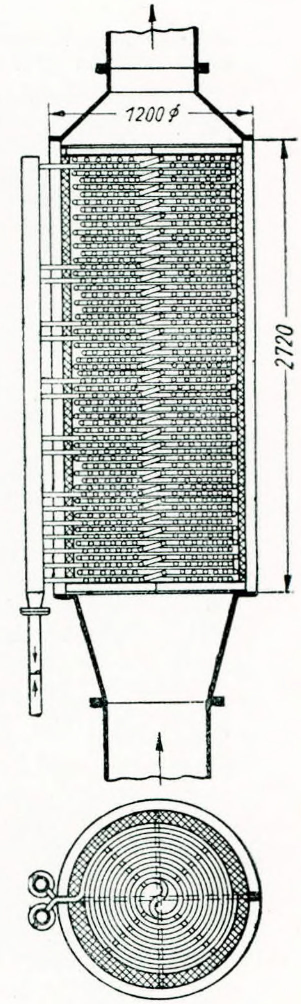


FIG. 11.—Diesel exhaust boiler.

walls had now almost entirely disappeared, its place being taken by the exceedingly thin film typical of boilers fed with chemically-treated water.

It need hardly be pointed out that the purpose of this test was merely to ascertain whether emergency operation of a La Mont marine boiler with salt water was feasible for a reasonable length of time. It must be admitted that the outcome of these tests was highly satisfactory. A permanent operation of this type of boiler or of any other type of watertube boiler with salt water is, of course, out of the question and was not attempted. For such periods of emergency operation, however, the La Mont boiler is seen to be in no way inferior to a Scotch marine boiler, and the manufacturers are justified in claiming that the La Mont boiler shows characteristics far superior to those of ordinary watertube boilers.

The Loeffler Marine Boiler.

By S. McEWEN.

The adoption of higher steam pressures and temperatures in marine practice has been progressive but, for reasons well known to marine engineers, it has not been considered practicable to develop in this direction to the same extent as has been found to be both possible and advantageous in land practice.

Considerations of weight and space occupied by equipment impose their particular limitations in marine as compared with land practice, and, further, the nature of the demands made on a marine power plant for the purpose of reversing and manœuvring have tended to check the adoption of highly superheated steam.

The developments which aim at improvement in power generation in marine practice may be divided into two groups, one embracing the means of securing higher rates of heat transmission

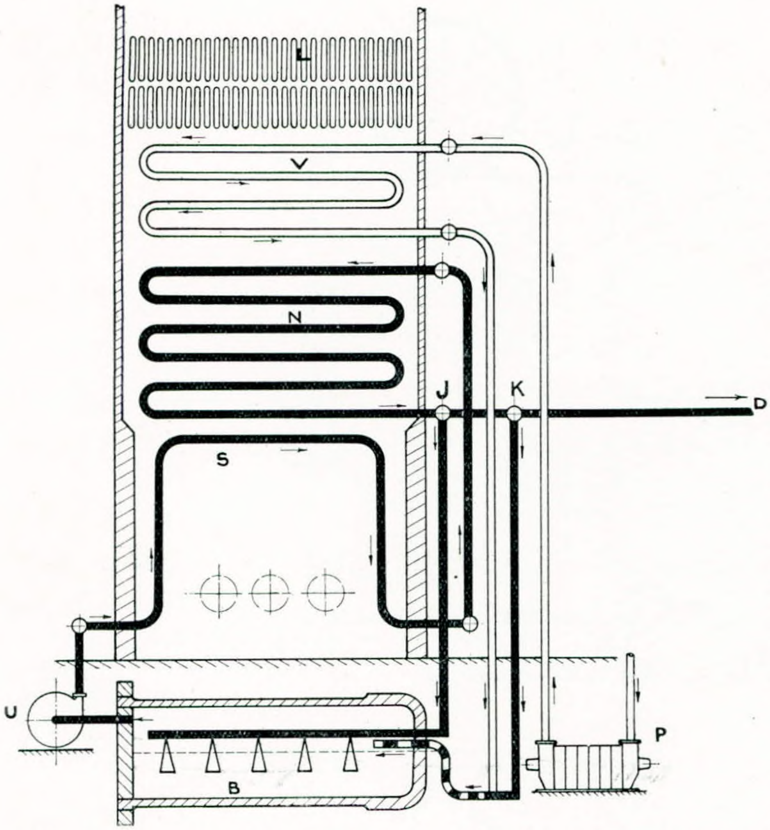


FIG. 1.—Diagrammatic representation of Loeffler system applied to marine boilers.

through heat absorbing surfaces with reduction of weight and space occupied by equipment, while the other deals with the efficiency of the power plant as a whole and seeks to reduce the large proportion of heat imparted to and lost with the circulating water.

Boiler and furnace efficiency have already reached a high degree of perfection in marine practice, and the Loeffler system, while maintaining this high efficiency and securing reductions in weight and in space occupied, applies itself to the better utilisation of heat contained in the steam, in which field there is the greatest scope for improvement. It achieves this purpose by making it practically possible to generate and utilise steam at a pressure of 1,900lb. per sq. in. and at a temperature of about 900° F.

It is necessary to realize that the conditions requisite for high rates of heat transmission are opposed to the objective of the generation of steam at high pressure and temperature. In each case the limiting factor is the stress, due to pressure and to the temperature gradient, which the metal of the tubes can withstand. It is obviously impossible to adopt both high external and internal temperatures with relation to the wall of a tube, and, at the same time, secure a high rate of heat transmission. Since the greatest scope for ultimate economy lies in the direction of high steam pressures and temperatures, the Loeffler system adopts a medium rate of heat transmission and the highest practicable internal temperatures.

The essential principles of the Loeffler system may be readily understood by reference to Fig. 1 which represents the system diagrammatically: (S) is a radial superheater enclosing a combustion chamber; (N) is a convection superheater; (B) is a boiler drum placed in any convenient position outside the boiler setting; the feed pump is represented by (P), the economiser by (V) and the air heater by (L). A steam circulating pump (U) extracts steam from the evaporator drum (B)), forces it through the radiant and convection superheaters up to the points (J) and (K) beyond which a part of the steam passes to the steam main while the remainder is returned to the evaporator drum (B). Superheated steam from the point (J) is

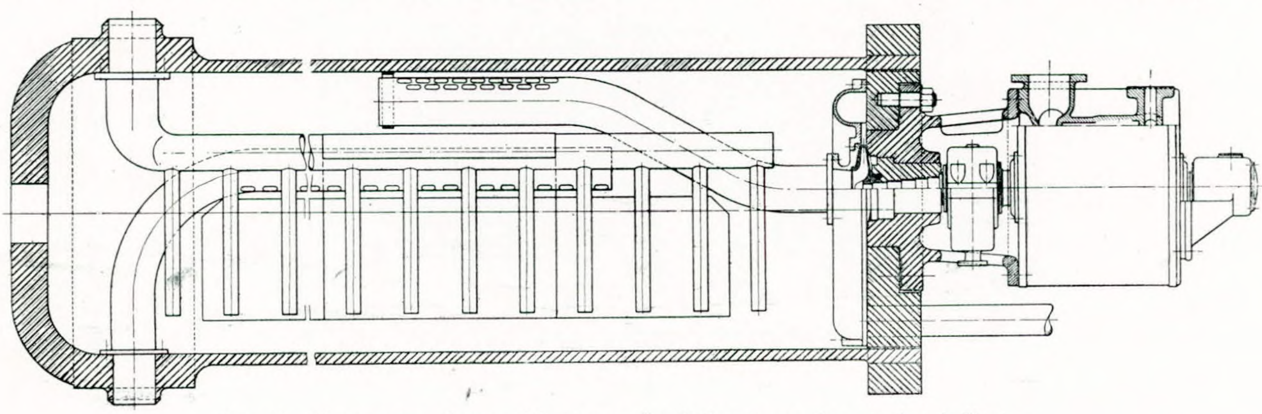


FIG. 2.—Evaporator drum with steam circulating pump for marine boilers.

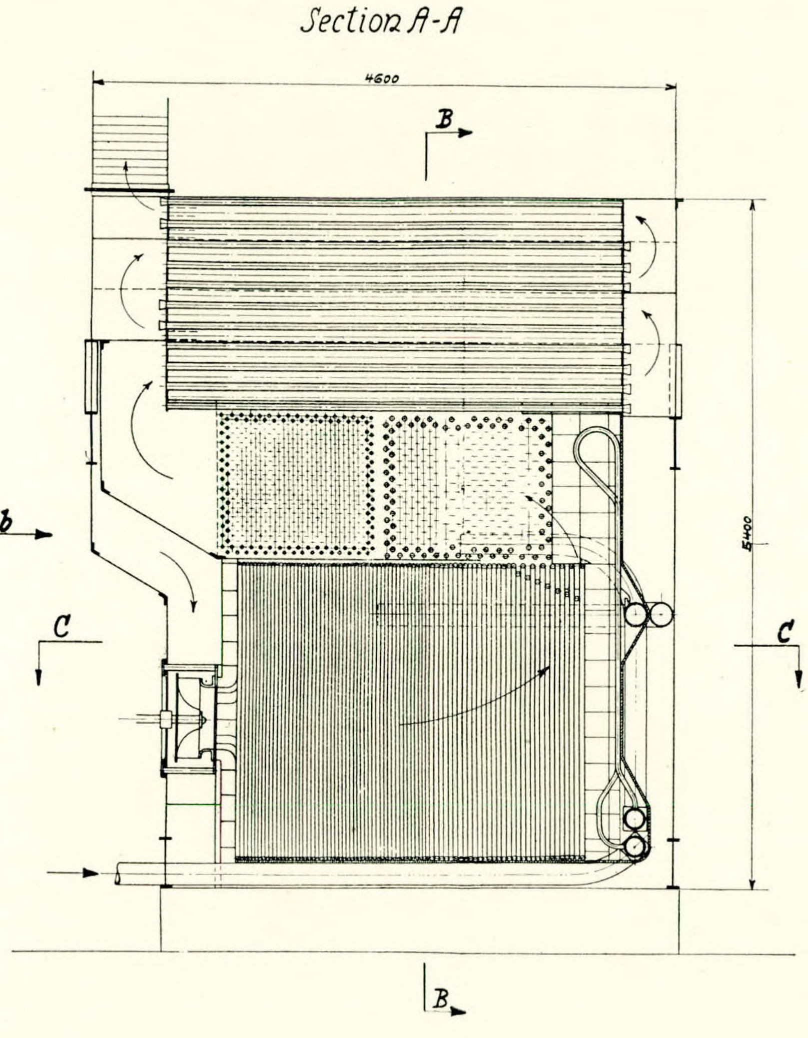


FIG. 3.—Sectional elevation of marine boiler—40,000lb. evaporation.

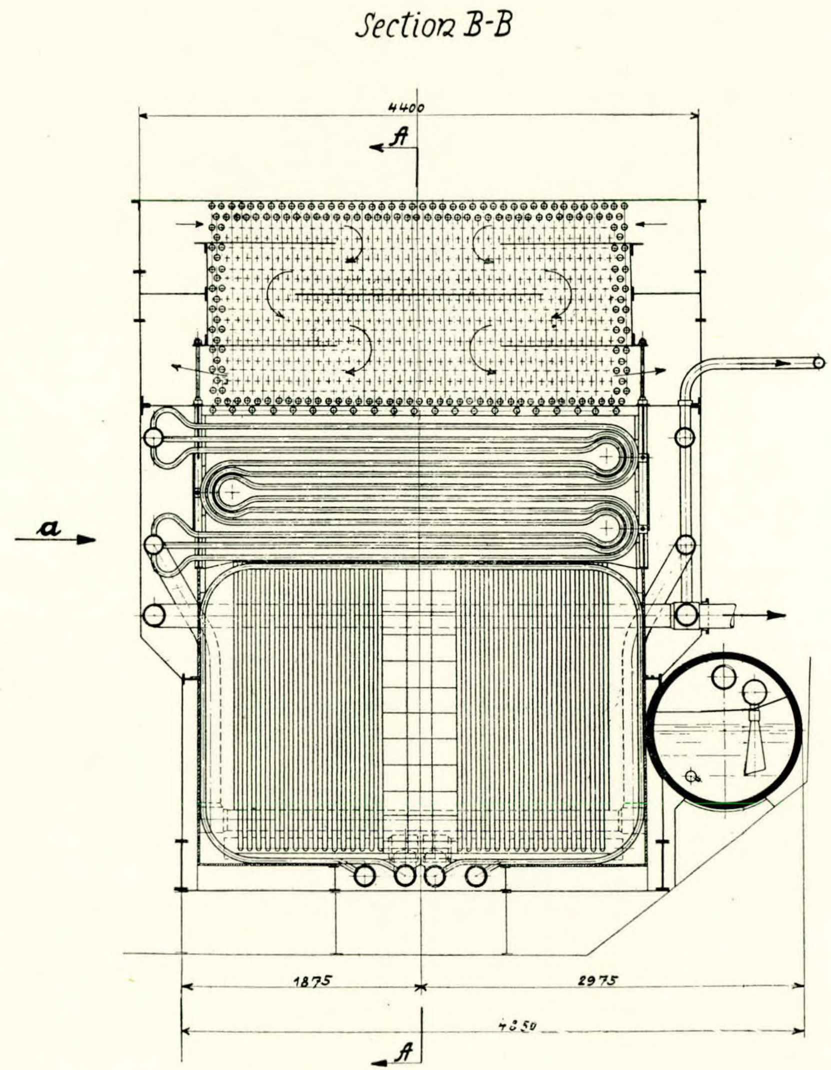


FIG. 4.—Sectional elevation of marine boiler—40,000lb. evaporation.

forced to pass through the water in the drum (B) giving up its superheat and producing an additional supply of saturated steam. Feed water from the economiser or, in the absence of an economiser, from the feed pump direct, is forced into the steam line from (K) wherein some evaporation takes place and a mixture of saturated steam and water enters the drum above the water level.

With the aid of this brief description the following features of the system may be appreciated. All the steam is generated in vessels not exposed to any external heat while the tubes which are heated externally contain only clean, dry and dense steam. Steam at a pressure of 1,900lb. per sq. in. has a specific volume of 0·21 and it is this low specific volume which makes it economically possible to circulate the steam by means of a pump. The velocity at which the dense steam is passed through the tubes is such as to ensure a small differential in temperature between that of the steam and the metal walls of the tubes. This velocity is of the order of 65ft. per sec. for maximum capacity and under these conditions 40,000 B.Th.U.'s can be transmitted per sq. ft. of radiant superheater surface per hour without any risk of overheating the metal. The entire absence of scale or deposit on the interior surfaces of the tubes ensures constant conditions for heat transference. In the absence of water circulation problems, the heating surface may be disposed to provide the best conditions for heat transmission and to conform with any reasonable limitations imposed by nature of space available. For this system the purity of feed water assumes secondary importance since all solid constituents are retained in the drum which is not subjected to external heat.

Steam Circulating Pump.—The steam pump is quite simple in construction and, for marine installations, is mounted on one end of the evaporator drum as may be seen in Fig. 2. A single impeller rotates within a housing formed in part by the drum end. The main purpose of the pump is to circulate steam at the desired velocity through the system and, by variations in that velocity, to maintain a uniform final temperature of steam for delivery to the turbine at all loads. The control of temperature by pump speed is based on the principle that a given quantity of heat transmitted through a heat absorbing surface may be imparted to a large quantity of steam at a low temperature or to a smaller quantity at a higher temperature. The quantity varies instantly with the pump speed and a constant temperature may be maintained at the expense of a variation in quantity. Variations in demands for total heat must ultimately be met by combustion control but the heat stored up in the metal of the tubes may be made quickly available by an increased velocity of steam, the tubes acting as a heat accumulator serving to compensate for lag in combustion control.

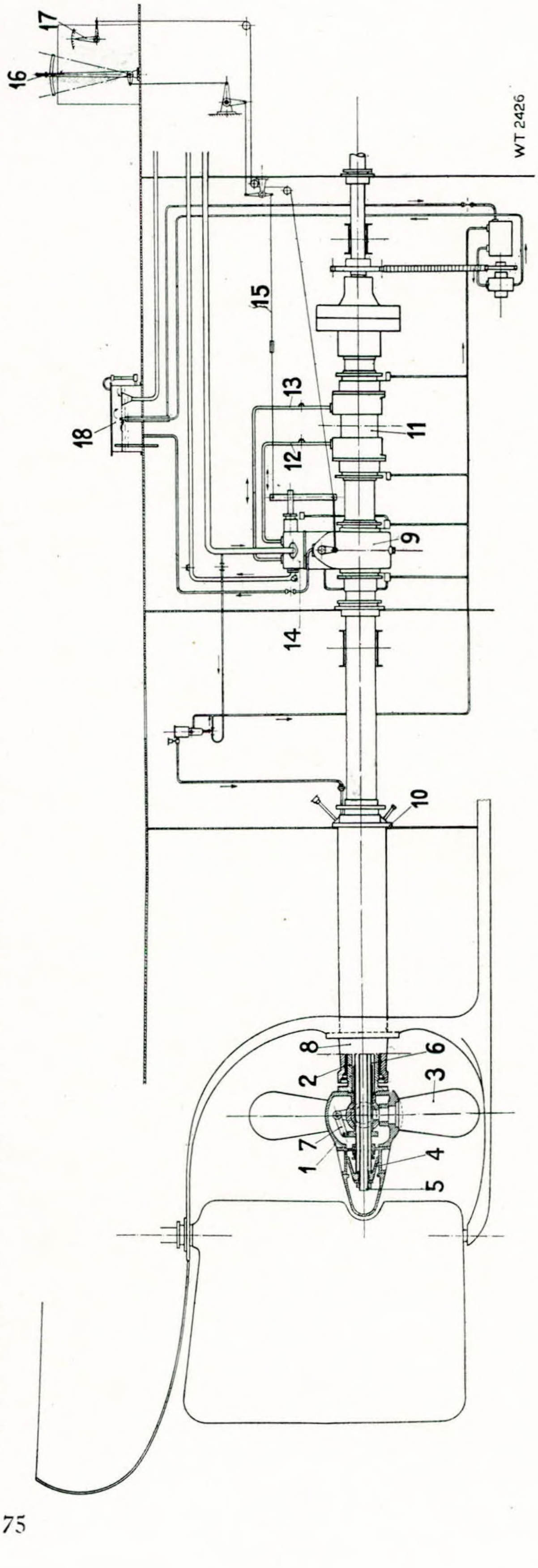


Fig. 5.—Diagrammatic representation of reversing propeller and controls.

Arrangement of Heating Surface.—The heating surface can be arranged in a variety of ways to suit conditions. Figs. 3 and 4 show in section a small Loeffler marine boiler having a capacity of 40,000lb. of steam per hour which can be installed in the space normally occupied by a Scotch marine boiler with a capacity of 16,000lb. per hour. The compact disposition of the heating surface is apparent.

Marine Power Plants.—The use of steam at temperatures and pressures considerably higher than those which have hitherto been adopted is not merely a problem of steam generation but demands material changes in the design and arrangement of steam turbines. Provision for reversing and for variable speeds with new conditions of steam supply requires close co-operation with turbine manufacturers, and the development of the Loeffler system for marine practice has been favoured by such co-operation with Messrs. Escher Wyss of Zurich who have been responsible for many developments of the greatest importance. Before dealing with their latest development it is interesting to compare the estimated performance of a Loeffler-Escher Wyss power installation, with cruising turbines and reversing stages in the main turbine, with the published data relating to the power plant of a torpedo-boat destroyer.

Full particulars of the trials of H.M. Destroyer "Acheron" are given in "The Engineer" of June 26th, 1931, and Table I gives some comparative figures.

Table I.

	Loeffler Boilers and Escher Wyss Turbines.	H.M.S. "Acheron".
S.h.p.	34,000	34,000
Steam pressure	1,900lb.	500lb.
Steam temperature	897° F.	750° F.
Oil consumption at full power and including auxiliaries per s.h.p. ...	0·561lb.	0·608lb.
Oil consumption at cruising power per s.h.p.	0·627lb.	0·92lb.

It will be seen that at full power the fuel consumption of the "Acheron" is 8·3 per cent. higher than that of the Loeffler-Escher Wyss plant, while at cruising speed the fuel consumption of the "Acheron" is considerably higher.

Reversible Propeller.—The knowledge that many of the limitations to the use of steam at high temperatures and pressures have been imposed by the necessity for provision for reversing, for variation in speed, for manœuvring, etc., has led to the perfection of an adjustable and reversible propeller by Messrs. Escher Wyss. Since this device removes the limitations to the use of high pressures and temperatures above referred to, it has been decided to advocate the use of the reversing propeller with Loeffler installations wherever practicable.

Fig. 5 is a diagrammatic representation of the propeller with its operating mechanism and controls. The pitch of the blades can be adjusted to any desired angle while the ship is in motion. The mechanism for adjustment is contained in the boss and is operated by an oil pressure servo-motor piston. If desired, the blades may be set in a neutral position while the turbines are started and brought up to full speed; then a gradual adjustment of the pitch of the blades will secure a smooth acceleration either forward or reverse. These propellers have been designed for all sizes up to 50,000 s.h.p. at 450 r.p.m. The advantages secured by these propellers may be briefly stated as follows :—

(1) Elimination of the reversing stages in the turbine and the saving of steam used for heating these stages.

(2) All stages are continually under steam with any speed of the vessel, when reversing or at rest.

(3) The turbine being always under pressure, steam may be bled to drive the auxiliaries.

(4) Increased braking power of the reversing propeller.

(5) Turbines not subjected to sudden changes in temperature.

In the space available it has only been possible to deal very briefly with the Loeffler system as applied to marine practice, but the author will be pleased to give supplementary information to anyone who may be interested.

In conclusion, the author wishes to thank Messrs. Mitchell Conveyor & Transporter Co. Ltd.; the Loeffler licensees, for permission to give the foregoing particulars and Messrs. Escher Wyss for much valuable information.

The Sulzer Mono-tube Boiler.

By J. Calderwood, M.Sc. (Member of Council).

That there is scope for improvement in boiler design is shown by the number of manufacturers who have carried out extensive research during recent years in the development of new designs in an attempt to overcome the limitations of the drum-type watertube boiler with natural circulation. It is evident that in the normal types of watertube boiler further development to higher pressures and steaming rates is limited firstly by the increasing weight and cost of the drums for higher pressures, and secondly by the liability to poor circulation due to the higher density of the steam. A drumtype boiler is further limited in the possible arrangement of tubes and consequently it cannot be adapted to the varying space requirements that have to be met for different services. It is largely for these reasons that pressures have not exceeded about 500lb./sq. in. for marine services and have only risen to about

1,000lb./sq. in. in exceptional cases on land, and then only for very large boilers. It is evident that in many cases both on land and sea there would be a gain in efficiency by the use of higher steam pressures, but even more important in the search for new types of boiler is the requirement that they should be lighter and more compact than existing types and should be adaptable as regards shape to meet the space available for various services.

Some years ago the author's firm started research on high-pressure boilers. The first boiler built was a single-drum boiler with hair-pin tubes. With this arrangement the difficulties of circulation in a high-pressure boiler were largely overcome, as each separate tube had its own circulation and there was no uneven distribution between the risers such as is liable to occur with multi-drum boilers or boilers in which the tubes are connected to headers. This boiler was designed for a pressure of 1,500lb. and proved very satisfactory. The design, however, was not proceeded with for these high pressures on account of the fact that it still suffered from the disadvantage of having the expensive high-pressure drum and also from some restriction on the tube arrangement that could be adopted, although this restriction was perhaps not so marked as with many drum-type boilers. It was evident that some more flexible type of boiler as regards arrangement must be adopted, and it appeared that the most promising line was to attempt to develop what has in the past been known as the flash boiler, viz., a boiler consisting simply of a long coil of tube into which water is pumped at one end and from which steam at the required conditions issues from the other end. The troubles experienced with these boilers were, however, well known, and it was necessary to start on extensive experiments to determine how these troubles could best be overcome. For this purpose test boiler plant was laid down in 1927. The test boiler was oil fired, as it was evident that oil firing lent itself most readily to adjustment for the purpose of experiment, but the experiments were undertaken with a view to the boiler eventually being designed for coal firing.

From the experiments on this boiler were evolved the conditions necessary to ensure satisfactory operation of the single-tube boiler. These were found to be:—

(1) Tube length of the order of 30,000 times the internal diameter of the tube, or roughly half a mile per inch tube diameter.
(2) A high velocity through this tube giving considerably higher feed pump pressure than steam pressure.
(3) Thermostatic regulation of the rate of feed from the steam temperature.
(4) Secondary feed injected at a point in the long tube about that at which the steam becomes dry saturated.

Considering the above (1) and (2) are obviously bound together, the pressure drop through the pipe being largely dependent on the length of pipe. The best relation of length to diameter and the consequent pressure drop for a given rate of steam raising was settled as the result of experimental tests, and was the length which gave the highest efficiency. The need for (3) is obvious, as for a given rate of firing the quantity of water passing through the boiler will determine the steam temperature. The reason for the auxiliary feed near the beginning of the superheater is to avoid the time lag which will occur between the time of the water entering the tube and the time when it influences the steam temperature. Actually, the time of flow of the steam through the superheater is very short so that the secondary feed at the beginning of the superheater immediately influ-

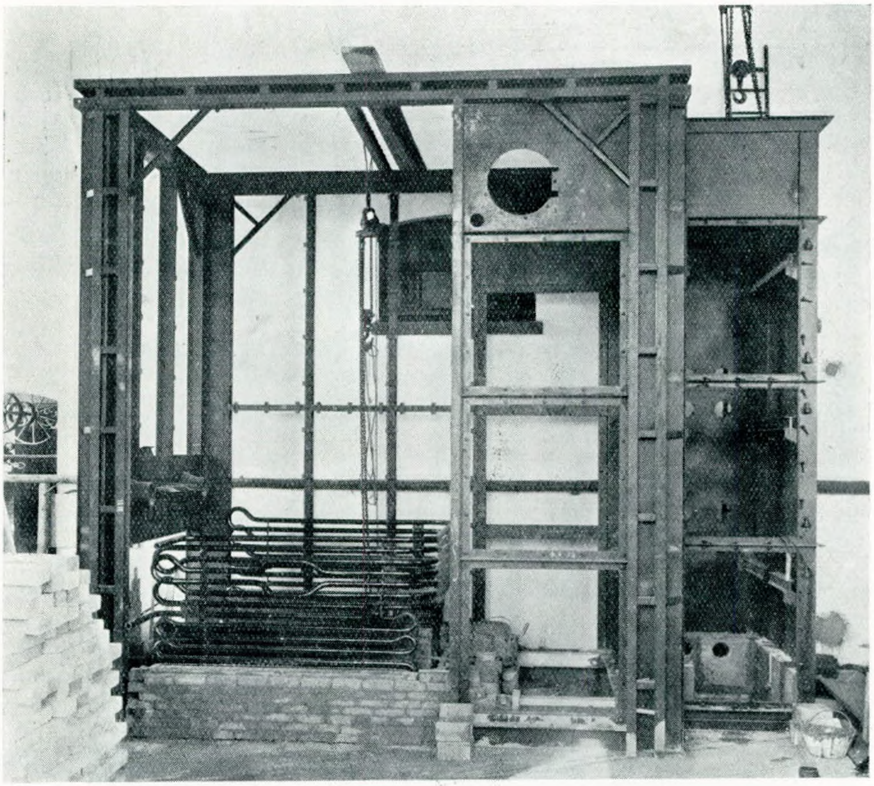


FIG. 1.—"Monotube" boiler under construction. Designed for 17,000lb./hr. at 1,500lb. per sq. in.

ences the steam temperature. Normally about 10 per cent. of the total feed is injected at this point and should the steam temperature rise, both this auxiliary feed and the main feed would be increased, the auxiliary feed having an immediate influence on the steam temperature and the main feed giving a permanent regulation. In cases where delicate regulation is required two thermostats can be employed, one on the superheated steam regulating the auxiliary feed injection and one shortly before the auxiliary feed point regulating the main feed pump.

Objection is sometimes raised to themostatic control on account of the delicacy of the instruments sometimes involved and it was, therefore, necessary to evolve a very robust type of thermostat which would be completely reliable in operation. The thermostat eventually developed consists of an oil valve box which is mounted on the steam pipe. The valve in this box is connected by an Invar metal rod to a point about 8ft. distant on the steam pipe, so that the expansion or contraction of this length of pipe controls the opening of the valve. The whole of the controls are oil operated and this valve acts as the regulator. It will be appreciated that this is a very robust equipment which cannot be subject to the troubles that may occur with a more delicate type of thermostatic regulation.

Combined with the themostat control is a differential regulator. The object of this is to give a certain amount of anticipating action in the control of the feed, i.e. it is evident that, if the temperature is set for say 700° F. and the feed quantity is increased throughout the period, the temperature is above 700° F.; the boiler will then be over regulated and there would be a tendency to hunting in the control equipment. The differential regulator works on the rate of change of temperature so that if the temperature rises above normal the rate of feed only continues to increase so long as the temperature is rising. As soon as it starts to fall the rate of feed begins to diminish thus anticipating the time when the temperature falls to normal.

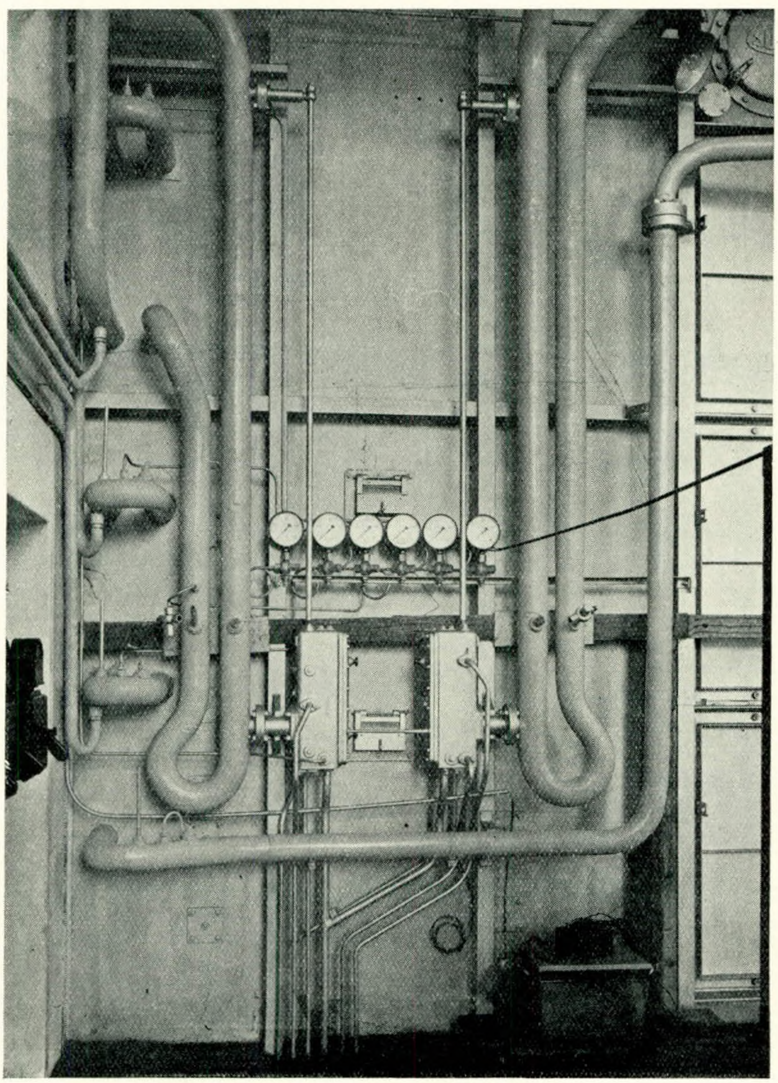


FIG. 2.—View on side of 17,000lb./hr. boiler showing thermostat controls.

For pressure regulation of the boiler an automatic valve is provided, which in effect is an inverted reducing valve, i.e. the pressure is kept constant before the valve instead of after the valve as in the normal reducing valve. Combined with this is a byepass which allows the steam to pass direct to the condenser in case the steam using equipment is suddenly shut down. This latter is, of course, an arrangement which has been used on many highly-rated drum-type boilers. With fully automatic control the regulating device is connected with the forced draught and, in the case of an oil-fired boiler, with the oil firing equipment so that the rate of combustion is automatically modified to suit the load on the boiler.

In the above the main features of the boiler have been briefly described. It is quite impossible in the course of a short paper to attempt to describe in detail these various controls, but it may be mentioned that they were very fully described in an article by Prof. Dr. A. Stodola which was published in "The Engineer" on the 17th and 24th November, 1933. Although on paper this control mechanism may sound somewhat complex, it is in practice very simple and is a substantial oil servo-motor type of equipment which can be considered as a sound engineering job. For a marine unit the regulating equipment required is simpler than for a stationary plant, as in the latter the load fluctuations must all be met automatically, whereas for marine service the engineer on watch can control the load. For manœuvring in marine service it is, of course, necessary to provide for a byepass direct to the condenser so as to avoid blowing off steam through the safety valve each time the machinery is stopped.

The satisfactory results obtained on the test boiler led to the installation in 1932 of a coal-fired boiler in a factory in Winterthur. This boiler has a capacity of 17,000lb. of steam per hour, a normal working pressure 1,500lb./sq. in and a normal steam temperature of 750° F. The boiler under construction is illustrated in Fig. 1, whilst Fig. 2 is a side view of the boiler showing the thermostat.

The arrangement of the tube bundles for a somewhat similar boiler is shown in Fig. 3, which illustrates the flexibility of the boiler from an arrangement point of view, as it is evident that the tube bundles "c", "d" and "e" in this illustration can be disposed as found convenient according to the requirements of space. The shape of the tubes comprising the radiant heat surface "f" is, of course, fixed by the fuel and method of firing, as these tubes comprise the combustion chamber of the boiler.

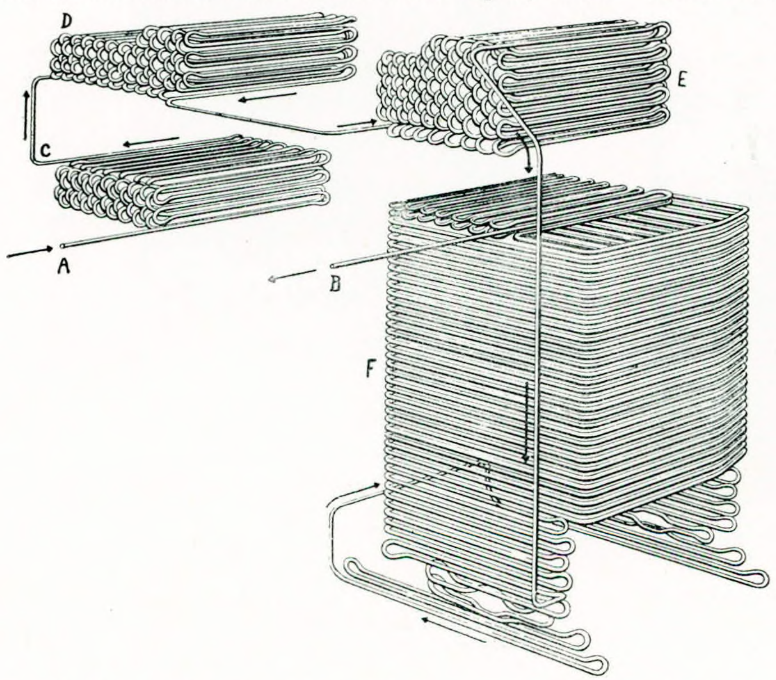


FIG. 3.—Tube system of "Monotube" steam generator. (A) feed water inlet; (B) superheated steam outlet; (C, D, E) tube bundles which can be arranged to suit space available; (F) tube lining of combustion chamber.

The boiler illustrated above and another of more than double the capacity which was installed at Zurich and which is also coal fired, have given completely satisfactory service, the former over a period of about three years, the latter during the last two years. It was only after the satisfactory results obtained with these boilers that it was decided to proceed with the design for marine work, and a further experimental boiler was built with control gear suitable for marine service. Again, for the experimental work, oil firing was decided on, but this had a secondary object as it was intended on the experimental boiler to work with combustion under moderate pressures, so as to gain some experience with very high-rated boilers suitable for naval purposes or for other services where weight and space are extremely limited.

It will have been evident from the previous illustrations that the boiler dimensions are mainly settled by the size of the combustion space and of the convection heated tube bundles and both can be very much reduced by using a very high rate of forced draught and a moderate pressure in the combustion chamber. It must be realised that, with the adaptability as regards arrangement of the tubes, a boiler efficiency can be obtained, even at the highest rate of forced draught, equal to that which is obtained on a normal rate of forced draught.

Fig. 4 shows the tube arrangement for the combustion space of the experimental boiler designed for pressure firing, whilst Fig. 5 shows the outside view of the boiler. It will be noted that in the combustion space the tubes are touching and it may be mentioned that they are surrounded by lagging material outside of which is the light outer casing.

Most satisfactory results have been obtained with the experimental marine boiler and work on the first installation for a ship is now proceeding. This is the s.s. "Kertosono" of the Rotterdam Lloyd Line. In this vessel one Scotch boiler has been taken out and replaced by a Sulzer montube boiler which will generate the same power as was previously done by five Scotch boilers of similar size to that replaced by the high-pressure boiler.

To summarise the advantages of the monotube type of boiler :—

(1) The boiler is extremely safe against explosion as the amount of stored energy is very low, the total weight of water in the boiler being only that contained in the tubes. Further it will be seen from the next paragraph that the danger of tube failure is practically eliminated.

(2) The circulation is absolutely positive and the rate of circulation such that any slight impurities are carried along with the mixture of steam and water instead of depositing out as would be the case with a low rate of circulation.

(3) The boiler and its control gear are simple

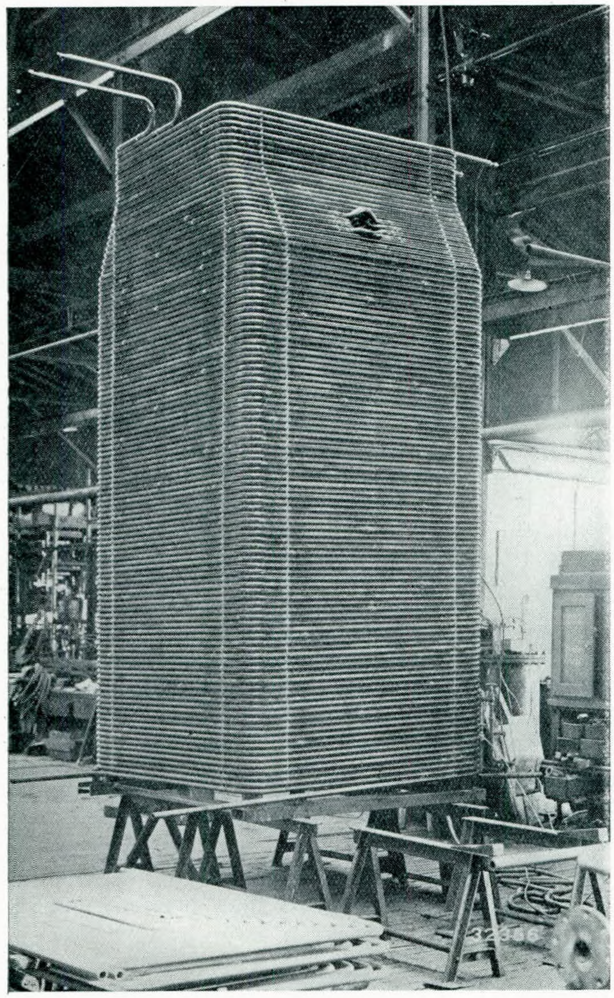


FIG. 4.—Combustion chamber for marine boiler; 23,000lb./hr. steaming rate.

and robust and there is no special equipment involved which is liable to raise difficulties in service or with which the seagoing engineer would not quickly become familiar.

(4) Due to the method of regulation the boiler is equally suitable for coal or oil firing, which is a most important consideration for many services.

(5) The boiler is adaptable as regards space. It can be designed either to suit a very short boiler room where head room is not important, or alternatively can be arranged as a horizontal boiler where head room is of vital importance.

(6) As compared with any type of boiler involving drums or headers it must be lighter as the total tube surface required is actually less and in addition the weight of the drums or headers is saved.

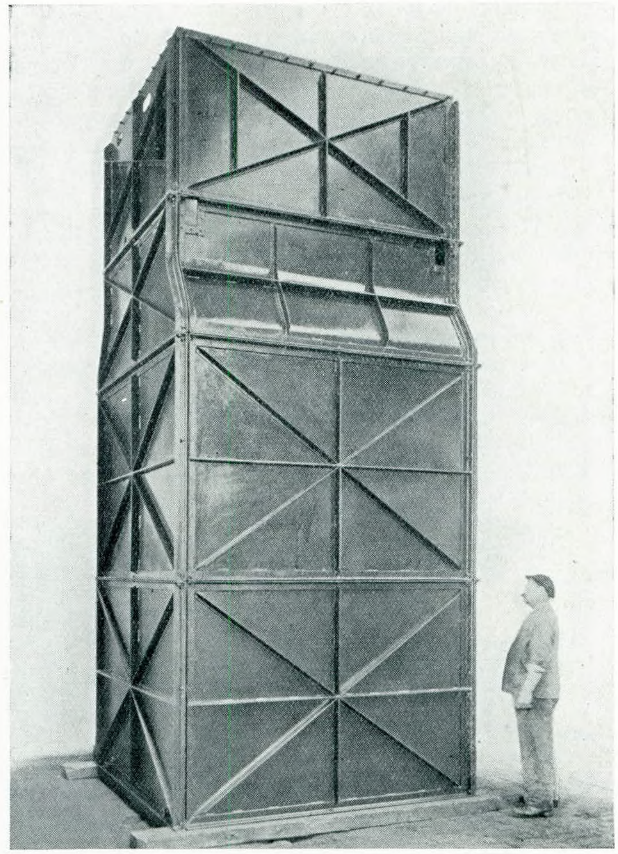


FIG. 5.—Marine type boiler designed for 23,000lb./hr. steaming rate with oil firing.

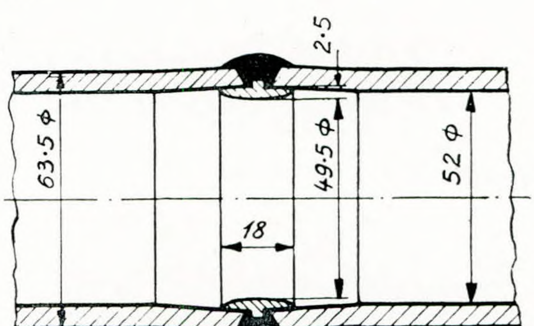


FIG. 6.—Welded tube joint used in construction of "Monotube" boiler.

The Velox Steam Generator.

By M. G. S. SWALLOW.

During 1933 and 1934 we have seen the advent of the Velox steam generator as a commercial boiler. It is now being used in a number of industrial steam plants on land and certain naval powers have marine type units under test or on order.

In the case of a new boiler such as the Velox, not confined to any particular pressure range, it is only natural that the first units should have been

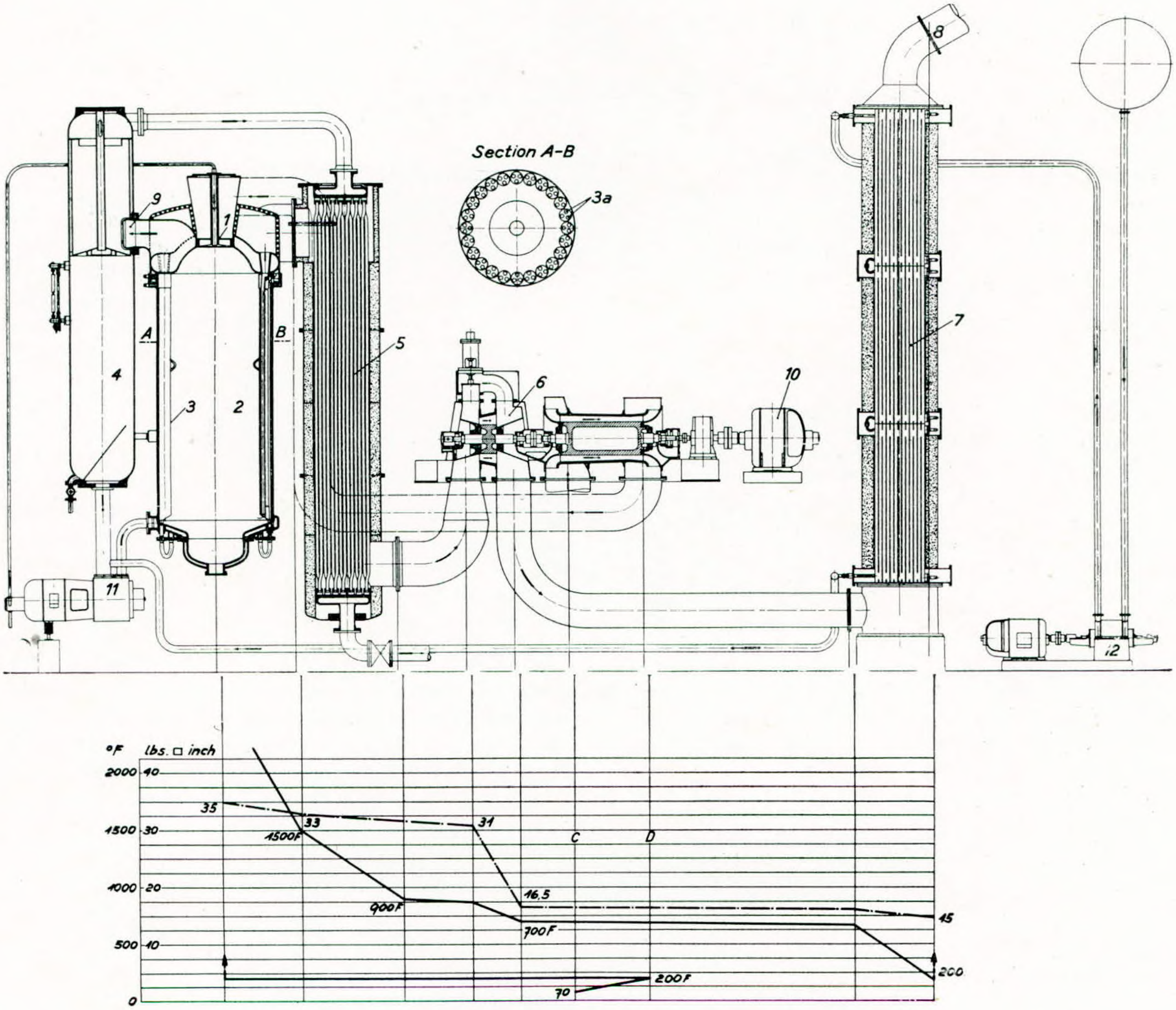


FIG. 1.—Sectional arrangement of the Velox steam generator.

built for moderate steam pressures. The maximum pressure for which this type of boiler has been built up to the present is 640lb./sq. in., but designs have been worked out for a unit operating up to 800lb./sq. in. pressure, which is, however, by no means the limit to which the designs can be extended.

This logical development of a new invention must not obscure the fact that the tubular construction and small dimensions make the Velox boiler particularly well adapted for high-pressure work and there is no constructive reason why the Velox boiler should not ultimately be built for steam raising at extreme high pressures. The structure of the boiler is particularly well adapted for such pressures, as there is, for instance, no drum in contact with the flame and, as generally understood, no steam or water drums are in use. The separator, which is of drum design, is relatively to the whole plant of such small dimensions that there is no structural difficulty in building a drum which is only subject to the boiler pressure and the temperature of the water corresponding to the temperature of saturated steam. All the heating surfaces where steam is generated are tubular and the heating elements are built up of simple components, and what is even more important, there is uniform and symmetrical distribution of material.

For marine installations it is, however, not so much a question of the maximum pressure at which a boiler can be built, but rather the most economical pressure and steam cycle for any particular installation. Conditions on board ship impose certain limitations which do not exist, or only in a less acute form, on land installations, and it can be stated generally that the optimum steam pressure is likely to differ very considerably in the two cases. For a stationary plant, live steam temperatures up to 900/1,000° F. are now being used, but it may be doubted whether temperatures exceeding

S.s. "Conte di Savoia" with existing boilers.

S.s. "Conte di Savoia" arranged for "Velox".

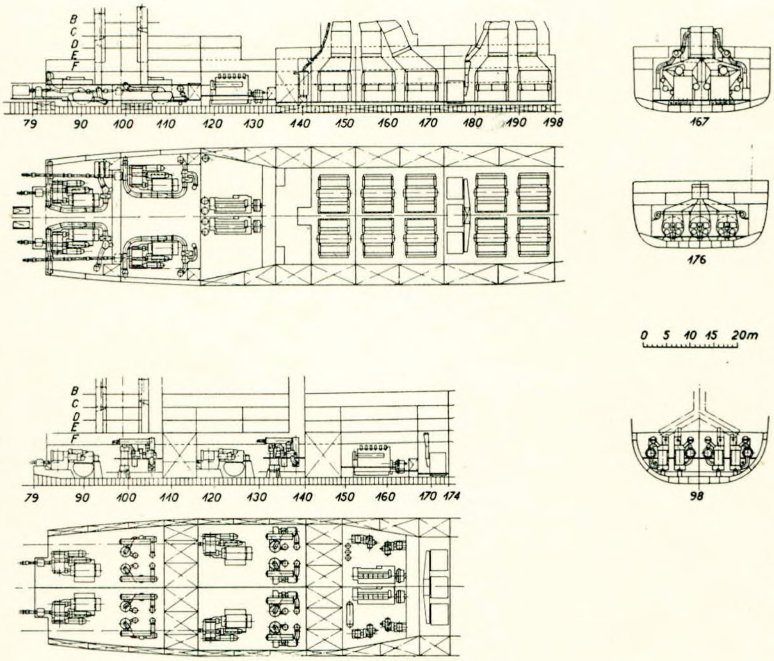
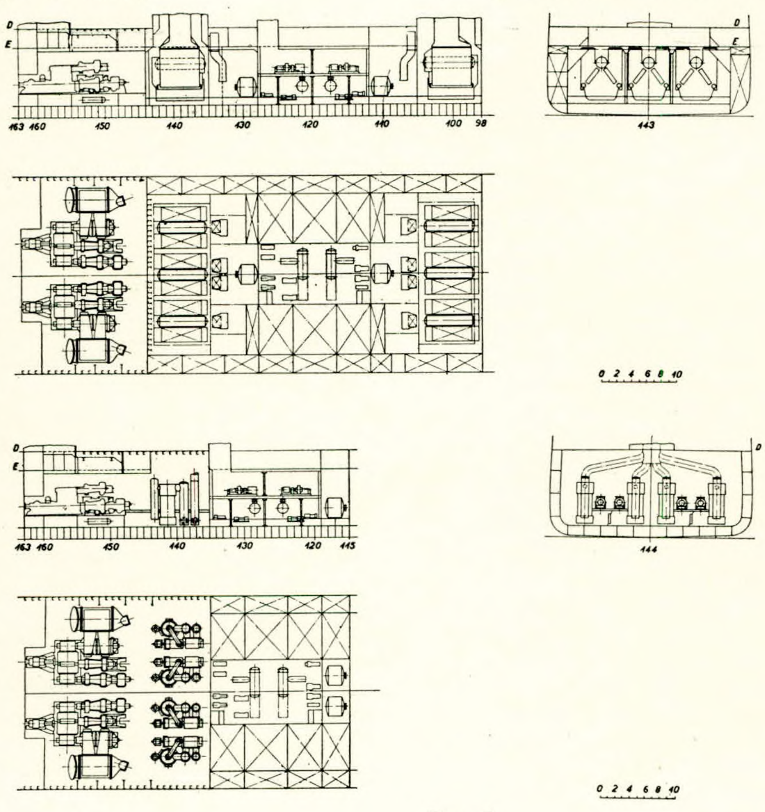


Fig. 2.

800° F. are likely to be used for some years on board ship, this being due to the fact that the marine engine designer must work with a more conservative margin of safety.

As the condition of the steam at the exhaust end affects both the running of the plant and its life, the fixing of the maximum steam temperature also implies a limit to the steam pressure. In addition to this, the size of the unit has to be considered. There is no technical reason why reheating and extensive regenerative feed heating should not be employed on board ship (both with thermodynamic advantage), but it must be kept in mind that on board ship particularly, space limitations generally are of much more importance than on a land installation, and the space required to accommodate reheat boilers and piping and large numbers of feed heaters may make the improvement in thermodynamic economy illusionary, as far as the economic performance of the vessel as a whole is concerned.

It can be generally assumed that the most economical steam pressure for a marine installation must inevitably be lower than for a stationary plant, and it is questionable if a pressure in excess of 600 to 700lb./sq. in.



S.s. "Manhattan" with existing boilers.

S.s. "Manhattan" arranged for "Velox".

Fig. 3.

would be justified for propulsion units of 20,000 s.h.p. or over; whilst for smaller vessels the most economical pressure would probably lie between 400 and 600lb./sq. in.

With these pressures and adequate drainage of the low pressure turbine blading, it should not be necessary to employ reheating even with temperatures of 750 or 800° F.; nor particularly in the Velox boiler is excessive regenerative feed heating of any particular advantage, a feed temperature up to 180° F. being sufficient to obtain an overall efficiency of the Velox steam generator, inclusive of all boiler auxiliaries and feed pump, of the order of 90 per cent. under full load conditions, whilst the efficiency remains practically constant at this figure down to half load.

An installation on these lines, whilst giving a high overall efficiency, would, at the same time, occupy a minimum amount of space and have the additional advantage of considerably reducing the high pressure steam pipe lengths and joints, the maintenance of which, with high pressure and temperature, is of greater importance in marine than in land installations.

The Wagner-Bauer Boiler.

By O. Jebens.

The construction of the Wagner-Bauer boiler is the result of endeavours to produce for marine engine plants of high economy a high-pressure boiler which combines highest efficiency with low weight, and offers reliable and most simple service as required on board ships. The experience and the results gained with the marine boilers known up till now have been carefully considered in every respect, and all complications which might form a source of trouble have been avoided.

From this point of view only watertube boilers with drums could come into consideration, because only this type of boiler offers full safety as regards the mutual relations between the supply of fuel and feed water on one side and the consumption of steam at considerable variations of output, especially when manœuvring, on the other.

In order to obtain a short starting period for the boilers the water capacity has been reduced, but only to such a degree that all normal requirements can still be fulfilled with regard to variations of the water level when manœuvring, and to the necessary pureness of steam at full output.

Exhaustive trials with a small boiler as to the water circulation and the maximum evaporation have shown that the reduction of the water capacity by diminishing the drum diameters is justified, the smaller volume of steam at higher pressure—in the boilers so far built 50 - 80 atm.—having a special influence.

Of course, the demand of simplicity in service as well as safety precluded an artificial circulation during service. Therefore an intensive natural circulation was aimed at by arranging the steam raising tubes and the downcomers in the most suitable manner. Thus, it was arranged to lead the steam raising tubes into the upper boiler drum as near as possible to the mean water level and partly above it, while a nest of downcomers has been arranged at the underside of the upper drum. Also the tubes in the lower drum have been so arranged that the smallest possible alteration of flow from the downcomers to the steam raising tubes is obtained.

In order to be sure that no steam bubbles are produced in the nest of downcomers, the superheater is arranged between the steam raising tubes and the downcomers, the latter being dimensioned small enough to ensure that at the highest load of the boiler the production of steam bubbles in the first row of the downcomers is quite impossible. This is chiefly attained by the great drop of temperature of the heating gases between leaving the steam raising tubes and entering the downcomers, this drop being achieved by the insertion of the superheater.

To ensure a sufficient cross section for the descending water in spite of the considerable reduction of the number of downcomers (compared with former designs), the diameters of these have been increased. The diameters of the steam raising tubes are arranged according to the heat stress, and are therefore considerably smaller than those used up till now. A very good heat absorption in the steam raising tubes due to the better distribution of the heating surfaces, and reduced weight by diminishing the thickness of the walls and the water capacity are thus obtained.

Special importance of course was attached to the necessity to enlarge as far as possible the portion of the total heating surface represented by the radiation heating surface. The following table gives the percentages of alteration of the different heating surfaces as compared with a boiler of one of the former types.

	Generating heating surface.	Radiation heating surface.	% of gen. heating surface.
S.s. "Cobra"	$375m^2$	$16{\cdot}5m^2$	4·4
S.s. "Hindenburg" ...	$41m^2$	$3{\cdot}7m^2$	9·0
S.s. "Bremen"... ...	$1{,}100m^2$	$40m^2$	3·65

Due to the higher stresses, special steels of low percentage alloy with high tensile strength and high yield point at working temperatures are used for the drums and the water tubes. The superheaters are generally so dimensioned that at normal service the temperature of the steam leaving the superheater does not exceed 470 - 480° C. With regard

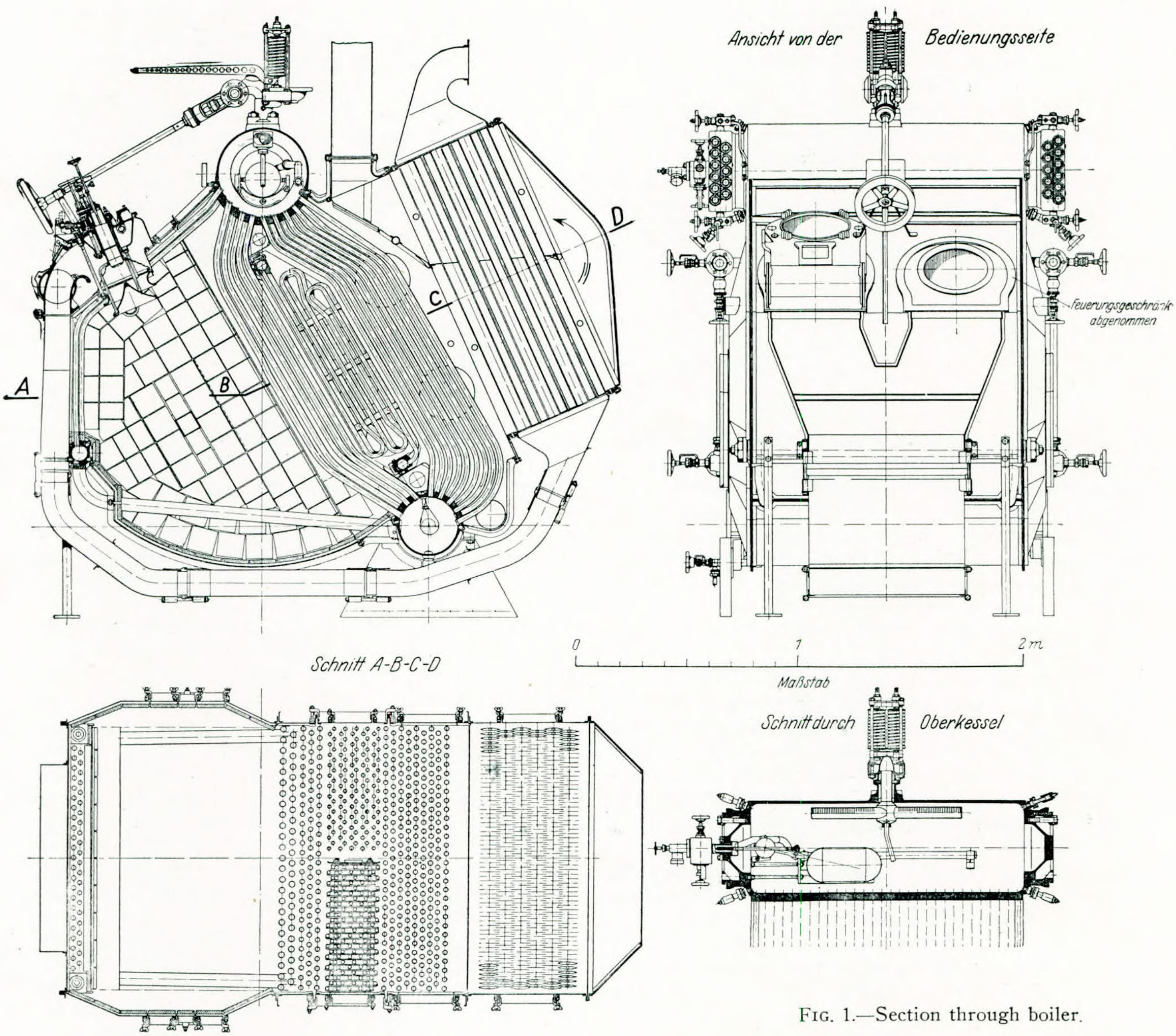
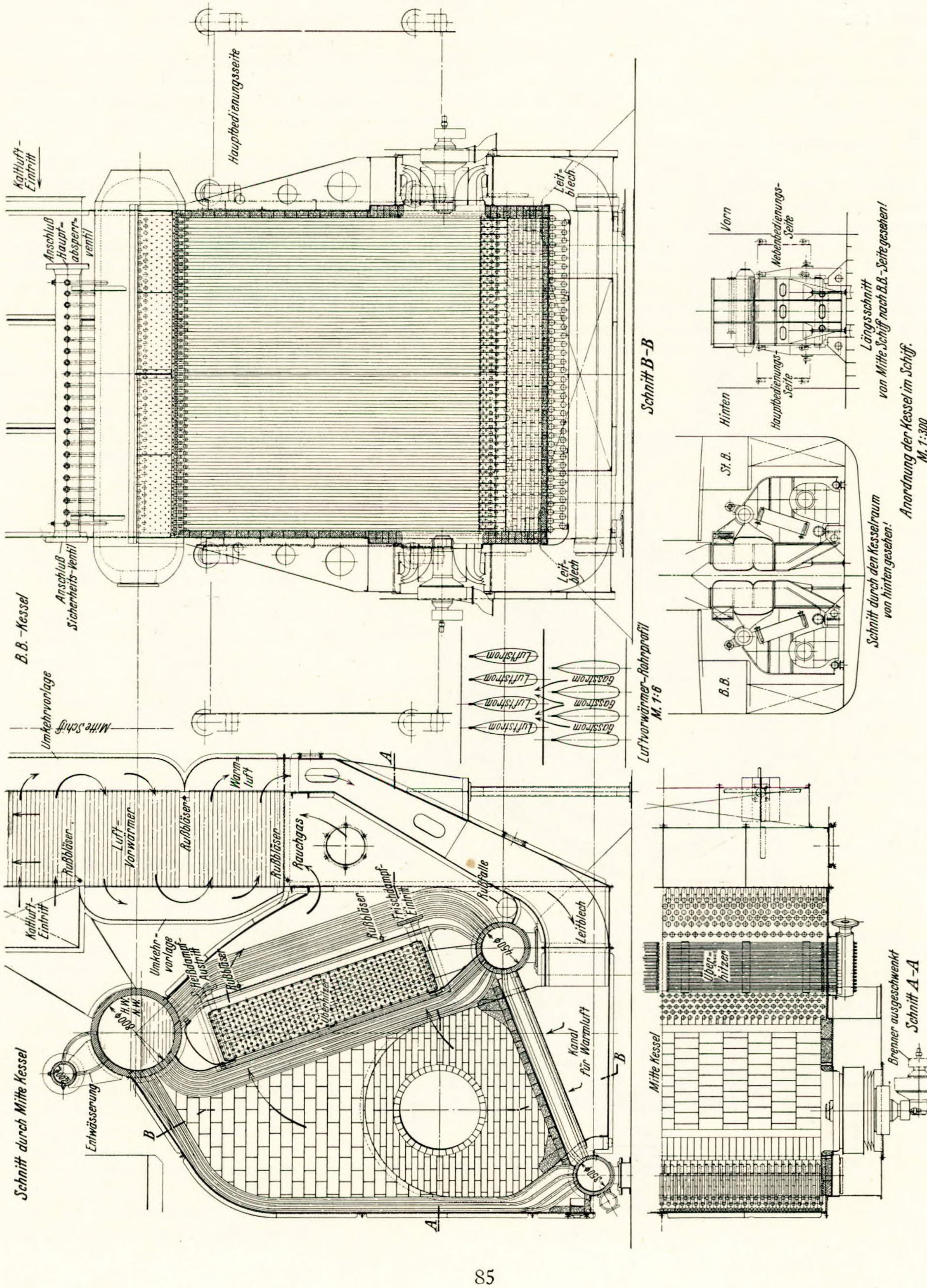


Fig. 1.—Section through boiler.

to the chromium-molybdenum tubes of low percentage alloy available, these tubes, having at 500° C. a very good yield point and durability, are forge-scale proof up to about 700°.

For normal marine engine plants no regulating devices for the superheater are provided, because it is designed for the highest load within its temperature range. When working with small loads the resulting drop of temperature of the superheated steam is low and must be taken into account. On the other hand, a guarantee is given that the highest temperature at full output will in no circumstances be exceeded and that no inadmissible heating of material can take place. Special value has been attached to the possibility of drawing out without trouble the whole superheater, or as far as possible the different elements. It has proved advantageous to arrange the lines of the superheater coils horizontally to avoid water pockets as far as possible.

As regards the arrangement of the water tubes around the furnace, one is not so unrestricted as with boilers having artificial circulation or forced circulation. The possibility of accommodating the Wagner-Bauer boiler without difficulty to meet all requirements arising from the different cross sections of the boiler rooms being considered in any particular case, is clearly shown by the following illustrations. Fig. 1 represents a section through one of the watertube boilers installed in two fast Customs cruisers. The heat transmission surfaces are to be seen from the following table :—


Schnitt durch Mitte Kessel
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Anschluß Sicherheits-Ventil
Hauptbedienungsseite
Leitblech
Umkehrvorlage
Mitte Schiff
Luft-Vorwärmer
Rußbläser
Warmluft
Rauchgas
Frischdampf-Eintritt
Heißdampf-Austritt
Rußfalle
Kanal für Warmluft
Entwässerung
Überhitzer
Brenner ausgeschwenkt
Luftstrom
Gasstrom
Luftvorwärmer-Rohrprofil M. 1:6
Schnitt durch den Kesselraum von hinten gesehen!
Längsschnitt von Mitte Schiff nach B.B.-Seite gesehen!
Anordnung der Kessel im Schiff. M. 1:300
Vorn
Hinten
Nebenbedienungs-Seite
Hauptbedienungs-Seite
St. B.
B.B.

FIG. 2.

entrainment of these impurities into the main steam piping is avoided. Fig. 4 shows one of the boilers at present under construction for a big fast passenger vessel. The heating surface of each of these boilers is 650 m². The same principles of construction as mentioned before are to be recognised.

Finally, it may also be pointed out that the most suitable design of the fittings contributes to the good working of the boiler. In this connection the newly-developed feed regulator is worth mentioning. It actuates the regulating valve through a diaphragm before the level is lowered, if the steam consumption is more or less considerable. The floater serves only to correct the working of the diaphragm.

All other details, for instance manhole covers, etc., are also constructed in accordance with modern points of view, as necessary for the increased working pressures.

To sum up, it can be said that, systematically using all experience gained up till now, the Wagner-Bauer boiler represents a new type which answers to the fullest extent all requirements of marine service as regards safety of working and simplicity of attendance.

DISCUSSION.

The Chairman (Mr. J. Hamilton Gibson, O.B.E., M.Eng.) said that it appeared that definite advantages resulted from the use of forced circulation, forced combustion and generation of steam at highest superheat pressures. The possibilities of this form of steam generation seemed to be well established, and there was no doubt that they would be carefully examined and, as might be approved, exploited and adopted in marine work.

He would ask Admiral Whayman to open the discussion.

Eng. Rear-Admiral W. M. Whayman, C.B., C.B.E. (Vice-President), opening the discussion, said that in all cases the authors were dealing with the watertube boiler and he was fully in agreement that progress in steam generation was going to be with the watertube boiler. The general adoption of the watertube boiler took place first in the vessels of the navies of the world, and the change was believed to be slowly but gradually being adopted in vessels of the Mercantile Marine. This might be considered to be a natural sequence or order of events in view of the fact that economy in weight and space were of greater importance in fighting vessels as compared with vessels built to carry passengers and cargo. Might they not expect, therefore, to find the first use and experience with higher steam pressures and temperatures to be well tried out by home and foreign Admiralties in view of the fact that further economies in space and weight appeared to be the principal advantages to be gained?

As regards the ocean-going passenger steamers, they would all recall the fact that the "Mauretania" had held the record of the Atlantic for this country practically up to the present date, and this had been with the Scotch boiler. All of them now had their eyes turned towards the new Cunard steamship "Queen Mary", which was to regain for this country the blue riband of the Atlantic, and they could not but note the fact that the vessel was being equipped with watertube boilers and that higher pressures and temperatures than obtained in the "Mauretania" would be used. Should they not, therefore, assume that in the march of time the next "greyhound" of the Atlantic would still use steam propelling machinery but still higher pressure and temperature?

He had been associated during most of his marine experience with the watertube boiler and had at all times found it far from easy to convert marine engineers from a preference for the Scotch boiler.

He did not want for a moment to discourage progress in steam generation by the use of high pressures and temperatures, as it was obvious that this was the direction in which advance would be made, and the information which was given to them that evening by the several authors of these papers represented the steps contemplated by many firms in the march of progress. All these proposals required very close study in points of detail and would doubtless receive full consideration and attention.

There was no mention by any of the authors of the subject of first cost of manufacture of the various boilers, and it was therefore not possible to enlarge on this aspect of the situation, but there again experience had strongly emphasized that the use of the watertube boiler depended very largely on its ability to compete in cost per unit of steam generated.

One or two of the authors had dwelt on the question of efficiency, but having in view the very high order of efficiencies which were now obtaining with modern steam generating installations there was little further advance that could be claimed by any form of steam generator for the overall efficiency of boiler, superheater, economiser and preheater. In considering this question of efficiency, however, it had seemed to him that for the higher pressures, above say 500lb. per sq. in., the advantage there might be in efficiency might be more than outbalanced by the extra cost (both initial and running cost) of the consequent plant for feed and air supply purposes. Simplicity in design was to his mind a matter of the greatest importance, and if a small increase in efficiency was obtained at the expense of cost and complication in feeding arrangements it might very well not be worth while.

This question of efficiency, of course, did not rest entirely with the steam generation plant alone, as the prime mover must also be taken into account. It became, therefore, a question of choice as to whether the increase in efficiency was economically advantageous after full consideration had been given to the initial cost of the respective propelling machinery equipments.

Most of the examples put forward by the authors indicated a tubular construction and without the use of the steam and water drum, and they had had assurances of freedom from trouble which might be caused by impurities in the feed water. They all knew that one main reason advanced against the use of the watertube boiler had been the question of the degree of purity of the feed water required. Was it not reasonable, therefore, to assume that this point would require even greater care and attention with an increase in pressure and temperature? He himself still leaned favourably towards a boiler which retained the steam and water drum.

Another important point was the question of water content of the steam generating plant. They were constantly reminded of the advantage the Scotch boiler had in the large reserve of hot water in the system. The ratio of the water content to output per hour became very small indeed with the tubular boiler without drums, and possible damage from derangement of feed water supply was bound, therefore, to occur much more rapidly with the tubular boiler than with the more generally accepted type of watertube boiler as it was known to-day.

Generally speaking, from the examples which had been placed before them that evening, the reliability of the high-pressure tubular boiler depended entirely upon the operation of the feed control system. The adoption of a forced system of circulation seemed to have many points in its favour, but they must make sure that the additional plant required to effect this did not reduce the overall advantages. Doubtless the desirability of forced circulation had appealed at all times to watertube boilermakers, and other things being equal the boiler with the best circulating system should show to the best advantage.

Finally, might he say just a word or two about construction, and again he would like to assert that simplicity in construction should be the real aim of every watertube boilermaker.

They could not help but notice that in nearly all the examples put before them that evening welding played a most important part in the construction of the boiler plant, and advance in the subject of welding would undoubtedly render progress in steam generation very considerable help.

Consideration of the various types indicated that makers had attempted to overcome the difficulty of drum manufacture for higher pressures by abolishing its use, and had thus given up a useful and well-tried form of container for entry of feed water and separation of steam and water. Might it not be possible that improvement in materials and methods of manufacture would enable them still to accept the advantages of the drum in boiler and superheater construction?

Mr. A. G. Bugden (Visitor) said that some years ago he was concerned with the production of the first Benson boiler.

Members would probably imagine that most of these boilers originated on the Continent. In the case of the Benson boiler, however, he was pleased to be able to state that the first one was produced in this country. Benson came to England from the United States late in the year 1921, and early in 1922 he collected a small staff, which included Mr. Pendennis Wallis and himself, in whose names the British patent for the Benson boiler was obtained. There was no doubt that they were a little before their time. In the succeeding twelve or thirteen years only about seven or eight Benson boilers had been made, so that it would be realized that the progress which had been made in the production of high pressure and temperature boilers had been very slow.

There was, however, no question more urgent than the reconsideration of the design of boilers for modern steam conditions. Steam conditions must ever go higher. Higher temperatures at the moment seemed to be held up by the metallurgists, but the speaker would say to boilermakers that for high pressures and temperatures their designs would have to be reconsidered. Admiral Whayman had put in a plea for the drum. In the case of a boiler having a steam drum 40ft. long and 4½in. thick the cost of which was £4,000, one urgently desired to get away from that drum. As Admiral Whayman had also pointed out, however, the designs shown that evening depended upon forced circulation, and forced circulation postulated that reliance must be placed in some form of pump. They had forced circulation on the Benson boiler, and at that time a little more brickwork than the speaker liked, because when the pump stopped the fans had to be kept going and one did not know what was happening to the tubes. Designs on these lines involved the necessity for a small amount of brickwork and, so far, some form of fluid fuel, either gas or oil.

Of course they would realize that boilermakers of the future would be combustion engineers and would not see their boilers until they arrived from the coil makers' works. Another point was that, judging from the illustrations shown that evening, soot blowing must be quite a problem. These designs also necessitated small tubes and hence very careful attention to the water. For the early Benson boiler they put down a small plant to produce distilled water, so that it did not suffer from the deposit of salts which had been mentioned that evening in connection with the Benson boiler paper.

They were unable, of course, to refer to previous designs when the first Benson boiler was made, and in calculating the surface of the superheater he had worked it out on all the known formulæ and then multiplied by two, which gave the desired result. The boiler was still at the works of The English Electric Co.; the heating surface was about 1,000 sq. ft. and the surface of the superheater about 160 sq. ft. The boiler was designed to produce sufficient steam to generate 1,000 kW. Actually it was connected to a turbine of 1,000 h.p., which consisted of one wheel 8in. diameter running at 25,000 r.p.m.

Although he had been present at the birth of the Benson boiler he had now transferred his personal preference to the Loeffler boiler. He was rather mystified, however, as to why Mr. McEwen referred to the complicated device for changing the pitch of the propeller for reversing. Surely they were sufficiently skilled in the design of marine turbines to carry out the manœuvring required. Many years ago in the Navy they had a device for changing the pitch of the propeller. He thought the name of the vessel was the "Reindeer" and the device was not so elaborate as that shown by Mr. McEwen. Why add complication to a good design of boiler by including a propeller with a servo-motor in the boss?

Mr. S. N. Kent (Member) said that in connection with the Benson boiler it had been stated that "with properly arranged high-class oil burners 340,000 B.Th.U.'s per cubic ft. of combustion space can be generated and 260,000 B.Th.U.'s per sq. ft. of radiation surface have actually been transmitted". These seemed rather large figures and he would be glad to have confirmation that they were correct.

He assumed that the seven boilers which had been the subject of papers that evening were intended for high-speed and naval vessels. They certainly did not seem suitable for the ordinary tramp steamer.

They had heard a lot about feed water, but Mr. Kent would be glad if the respective authors would state whether the water was carried or distilled on board the vessel.

How were these modern watertube boilers going to meet the condition of banked fires, manœuvring and winch working? And he would also like to hear about the joints and mountings when the survey was carried out.

Were these high pressures really necessary? Any amount of superheat could be obtained, and they had all heard of one case where the boilers were taken out and boilers of lower pressure installed in their place.

With regard to the Velox steam generator, what happened to the smoke (if there was any), and how could those boiler tubes be kept clean? He had heard that they required pure oil or gas.

He would be glad if all the authors would state their views on the use of these boilers for tramp steamers.

Mr. R. Pendennis Wallis, M.Sc., Wh.Ex. (Visitor) said that he had been associated with The Benson Engineering Co. in 1922 and 1923 when the first generator was designed.

While an excellent paper had been read by Dr. Queisser on behalf of Dr. Goos, it was rather disappointing that the fundamental principle of the Benson boiler had not been more clearly stated. In the normal generation of steam, sensible heat was added to raise the temperature of the water from the feed temperature up to the boiling point. Latent heat was then added through the boiler tubes and then superheat in the superheater. There were three distinct processes. In the original conception of the Benson boiler the idea was to maintain the critical pressure of 3,200lb. per sq. in. and generate steam under conditions where there was no latent heat. The whole of the total heat of the steam was sensible heat.

When endeavours were first made to obtain a patent, the application was for a boiler in which the steam was generated at the critical pressure. The Examiner at the Patent Office objected on the grounds that this process was not novel and referred to experiments that had been carried out by Andrews on carbon di-oxide many years before.

With the aid of a temperature-entropy diagram Mr. Pendennis Wallis demonstrated that if dry saturated steam at the critical temperature and pressure were adiabatically expanded, it immediately became half water.

The patent was eventually obtained by applying for a combination of boiler and superheater in which the steam was generated at the critical pressure of 3,200lb. per sq. in. and heated to such a temperature in the superheater that it remained reasonably dry on its passage through the prime mover.

Most of the papers which had been read during the evening, and the discussion on the various types of high-pressure boilers, had made clear the distinct advantage of forced over natural circulation. With forced circulation the water or steam could be passed through the tubes at a definite known rate and it was then possible to calculate the stresses in the metal of the tubes.

Capt. W. E. Dommett, R.A.F. (Member) said that his practical experience with boilers ended when he left Portsmouth Dockyard. At that time the Belleville boiler was the centre of all the trouble.

He remembered one vessel which came into Portsmouth Dockyard after manœuvres when the Engineer Officer had been showing how good the Belleville boilers were, and half his personnel had to go into sick bay. With the boilers shown that evening, however, and with automatic controls (which, as was to be expected, were being improved) the control was very much simpler for the personnel, and running costs in this respect would be lower accordingly.

Admiral Whayman had mentioned the question of cost. This was a factor which must be borne in mind.

The reference in the Loeffler boiler paper to the variable pitch propeller was one of much interest to him. His experience with variable pitch propellers was that whilst it was possible to get mechanism which would change the pitch, it was necessary to be very careful that the pitch remained where it was wanted. With high-speed shafting "flutter" occurred, which resulted in a considerable amount of vibration with the possibility of parts coming adrift on account of wear in the course of time.

Mr. W. Hamilton Martin (Member) said that it was most interesting to notice the tendency to revive what used to be known some twenty-five to forty years ago as the flash-type boiler, such as the Serpollet, Turner-Miesse, Stanley, White, and the more recent Doble and Bolsover-Express boilers. Whereas these former boilers were used for small applications like steam cars, lorries and special work, the present development was their application to large power production. (He had occasion to refer more fully to the White type of boiler in discussing Mr. G. R. Hutchinson's *paper "Recent Developments in Propelling Equipment Practice of Reciprocating Engined Steamers", and to the Doble boiler in the discussion on Eng. Capt. S. R. Dight's †paper "Experiences with High-Pressure Steam Installations in the Royal Navy").

A slight historical digression, he thought, would be opportune. All the present coil-generator type boilers were based on the Serpollet and White forms or combinations of these. In 1890 Serpollet had in his car a generator consisting of three elements of flattened tubing. These had a water space of $\frac{1}{16}$in. between the flat sides, which were enclosed in cast-iron casings to prevent them opening out when at maximum temperature and pressure, which were 500/550° F. and 225lb. respectively. The interesting part of this boiler was that it was coke-fired by gravity and shaking of the vehicle, and had an average consumption of 3lb. of coke and 15lb. of water per mile. It attained a speed of 23·4 m.p.h. on the level and climbed hills of 1 in 9. Serpollet's works, by the way, had a similar type of plant. He improved the boiler later so that it worked on kerosene and in 1901 he won the Henri de Rothschild Cup at 63 m.p.h.. in the Nice Flying Kilometre Race with one of his 12 h.p. cars. In 1902 he again won this Cup at 73 m.p.h., and in 1903 with a 20 h.p. car he won it outright at 92 m.p.h., competing against petrol cars of 60 h.p. His self-starter consisted of a brass cylinder containing two quarts of water and a piston on which he could put 600lb. air pressure from a steel bottle on the dashboard. The water was forced into the boiler and flashed into steam, thus saving the driver having to use the hand-starting pump. The engine was of the four-cylinder horizontal poppet valve type, and the car's destination could be reached with two of the four cylinders out of order, a performance which would take some achieving with the petrol engines against which it was competing. In 1906 a Stanley steam car did the "Flying Mile" at 127·16 m.p.h., a wonderful record which stood until 1922, when a petrol-driven car just beat it at 129 m.p.h.

The "White" pre-war 40 h.p. cars weighing two tons and capable of 70 m.p.h. consumed paraffin at the rate of one gallon per 11 miles. The 2-ton petrol car of to-day, twenty-five years later, cannot (if at all) do much better. The steam pressure was 650lb. and the superheat very high (higher even than was used to-day), being around 500° C.

The later Doble type would start from cold in 45 seconds and accelerate from a snail-pace to 80 m.p.h. silently and more quickly than any supercharged petrol-driven road racer. It would stop on a 1 in 7 rise and restart with a steady gentle sweep, accelerating to 30 m.p.h. without requiring any gears. It would do 14 miles per gallon on fuel oil at 4d. per gallon, and required 10 gallons of water for approximately every 300 miles running. This type was now being used on the German railways for rail cars and comparative tests with Diesel-driven rail cars were being taken. It ran on ordinary fuel oil while the Diesels required gas oil. From these facts he thought it might be assumed that steam engineers were putting up a very determined fight to come back in the field so long held by petrol and oil engines. He had always felt that there was a good chance for success in due time.

The troubles encountered, such as erratic furnace or burner temperatures, uncontrollable superheats, irregular feed and oscillating steam supply, unsuitable fuels (and, by the way, badly carbonising lubricants at the high superheats of the engines these early generators supplied), and last but not least unsuitable materials for the boiler and superheater tubes, were becoming matters of the past. As a result they now saw this galaxy of large-scale flash boilers making their appearance not for lorries and cars but for ships and power stations.

He thought that at this stage due acknowledgment should be made that probably one of the chief contributory factors which had enabled these makers to develop this type of generator more effectively in larger sizes was that the untiring efforts of certain Continental steelmakers had led to the

*See Vol. XL, 1928, page 171 of The Institute's TRANSACTIONS.

†See Vol. XLIV, 1932, page 582 of The Institute's TRANSACTIONS.

development of workable, weldable, low alloy steels of hot-tough or hot-strong type, which showed good lasting qualities and were of reasonable cost and non-scaling, heat-resistant, workable chrome-aluminium alloy steels. Naturally, the desire had been to develop generators with increased operating efficiency, reduced fuel consumption, less weight and space, at reduced first cost. Improvements in materials permitting higher temperatures and pressures, and in fuel and feed control, were assisting towards this end.

Some of the authors gave certain indications regarding the materials they used. Would all the authors be good enough to give some more particulars as to the suitability, life, and conditions to be met by the materials used in their generators, i.e. in the boiler and superheater tubing and for the supports of these, the economisers, feed and air preheaters, soot blowers, Velox superheater tubes, etc., as the case might be.

It appeared that the time had now come for some authoritative body such as the Coal Utilisation Council or the Institute of Fuel, or preferably an organisation of international standing, to start making standard endurance tests for all kinds of generators. Any new type of boiler or generator could then be subjected to this, and the prospective user would thus be given a fair basis of comparison which would greatly assist in strengthening his confidence in what to him might seem a somewhat radical departure from ordinary boiler practice.

Boilermaking was obviously in a highly transitional period at present, and one wondered whether the trusty old Scotch boiler and even the watertube drum-type boiler would have to prepare for a keen fight to retain their well-earned places.

Was there any danger of erosion of the evaporator tubes in the Velox boiler? If pulverised fuel were considered, the effects of the flue dust and fine ash, which were particularly aggressive at high temperatures when the fuel was of high sulphur content, might conceivably prove a source of trouble at the high gas speeds used.

The Loeffler boiler seemed to hold out promise, but one wondered why the drum was not of more conventional spherically-ended design, preferably seamless rolled of high-yield high-tensile steel to save weight. The ultimate overcoming of the limitations to higher pressures and temperatures imposed by marine operating conditions seemed to be the lesser of two evils and the more likely to be successful, as one felt that any feathering propeller could hardly lay claim to seaworthiness in the sizes and powers proposed.

Dr. S. F. Dorey (Vice-President) said that he welcomed this series of papers and looked forward to the time when those concerned with the manufacture of the various types of boilers described in the Symposium would submit their plans for the consideration of Lloyd's Register when the details of the arrangements could be properly scrutinized.

There was obviously a tendency towards much higher pressures in land installations and certain features presented in some of the designs were worthy of careful consideration, particularly those dealing with controlled forced circulation.

There was also a tendency to associate high pressures with greater risk of explosion, but this did not necessarily follow, being a matter of design, and with some of the boilers, particularly those having a small water content, and incidentally low locked-up energy, the higher pressure might be associated with less damage in the event of explosion.

Boilers having a small water content might have useful features for marine work. There was the point of being able to raise steam very quickly, which would appeal to those people concerned with naval work, etc., where steam raising might assume vital importance. As the boilers would be paid for by the poor taxpayer the question of price would not unduly worry this type of purchaser.

With regard to inspection, he thought that in the tubular type of boiler consideration should be given to the division of the boiler into an appreciable number of elements. There was always the possibility of a breakdown at sea and means should be available for the withdrawal of an element of the boiler, and for the periodic inspection facilities should be provided for the removal of an element to see what was going on inside. With pure steam going through the tube, and with the absence of water, a good clean tube should be maintained. Nevertheless, there were other factors which made it necessary to pay careful attention to the behaviour of the material. Water which was too pure might give a corrosion or erosion effect just as much as impure water or steam.

The arrangements of the boilers should be such as to enable an inspecting authority to assess them for a reasonable life. Lloyd's Register Rules stipulated that watertube boilers must be inspected every twelve months. Scotch boilers were inspected after four years and there was no annual survey until they were six years old, but such conditions could not be considered suitable for the types of boilers described in this Symposium.

A further point in regard to the element sections was the need of being able to shut off these elements so that certain parts could be isolated and circulation maintained in the rest of the boilers to save closing down a boiler in the event of failure of a portion of the tubing. The criterion in marine work was whether a boiler could be considered sufficiently reliable that only one need be fitted in a ship.

It was noticeable that welding played an important part in the construction of some of the boilers described and, so far as the welding of the tubes and their connections to headers was concerned, he thought that, provided the welding was carried out with care, there was no reason why it should not give satisfactory service.

On the proposal of **Mr. A. C. Hardy, B.Sc.** (Associate Member), seconded by **Mr. W. McLaren** (Member), a very warm vote of thanks was accorded to the authors.

By Correspondence.

Mr. J. Hamilton Gibson, O.B.E., M.Eng. (Chairman of Council) wrote that when, a hundred years ago, Jacob Perkins produced steam at critical pressure (about 3,200lb/sq. in.) it was recorded that no attempt was made to utilize this super-pressure steam directly; it was throttled down and superheated, when it then became "manageable". Something of the same nature appeared to be necessary nowadays, for the Benson boiler (as stated on page 66) apparently generated steam round about 3,000lb./sq. in., but a few lines further on the pressure was given as 1,500lb/sq. in and 900° F. final temperature. Saturated steam at 3,000lb./sq. in. did not exceed 700° F., so that the superheat was about 200° F.

Mr. Pendennis Wallis gave some clue in his entropy diagram as to the necessity of superheat at such high pressures. Perhaps Dr. Queisser would enlarge on this aspect, and give some indication of the state of the steam when it was finally passed out as fit for use—i.e. when it was "manageable", or in the best condition for use in a steam turbine. The writer took it that it was desired to delay condensation to as late a stage in the expansion as possible.

It was noteworthy that in the other types of high-pressure boilers described, the steam was *generated* at lower pressures, *e.g.* Atmos. 1,425, Loeffler 1,900, Sulzer 1,500, Velox 640/800, and the La Mont and Wagner boilers 750lb./sq. in., and in all cases superheated to high limits.

It would be of interest to Members to have it explained what advantage, if any, was claimed for generating at or near the critical pressure and then throttling down; also, at which pressure was it best to add superheat—and why.

Mr. S. B. Jackson (Member) wrote that these papers directly raised the question of the use of high pressures versus the low pressures now common in marine service. Marine engineers need have no hesitation in following shore practice by the adoption of higher pressures, as in shore electricity generating stations in America, on the Continent and in Great Britain during the eight years 1924/1932 no fewer than 400 high-pressure boilers had been installed. There was thus an accumulated manufacturing and operating experience extending from two to ten years of boilers with outputs from 80,000 to 500,000lb. per hour, the pressures ranging from 650lb. per sq. in. to 1,900lb. per sq. in. and the temperatures from 700° to 875° F., the special 1,200lb./1,000° F. plant at Detroit which had been operating for three years being excluded. The experience was such that they might be considered satisfactory and reliable in every respect. As evidence of this, boiler reliability factors of 90/95 per cent. were being reached, which compared favourably with the best existing marine practice.

With the increase of pressures and temperatures such as those under discussion, the possibility of satisfactorily employing the regenerative cycle became practical, but owing to complications and other difficulties in installing feed heating on a large scale in straight turbine installations, due to the number of turbines employed such as h.p., i.p., l.p. and astern, etc., probably electric propulsion would be the solution to the problem. The clean design of turbo-electric propulsive equipment lent itself for a variety of reasons to the adoption of feed heating. The adoption of ordinary standard designs of high-pressure water-tube boilers resulted in an increased capital outlay, but the savings due to improved cycle efficiency and the thermodynamic gains of feed heating and other operating economies offset the increased capital charges and a credit balance might be secured. The elimination of drums and the employment of tubular designs were important factors in reducing first cost and improving maintenance, hence the financial gains would be increased. The use of constant-speed machines ensured high turbine efficiency, but in addition 3,000-r.p.m. machines, which were now becoming standard, permitted not only of higher efficiency as compared with the slower machines, but were particularly suitable for high temperatures owing to their smaller dimensions. Tendencies in boiler and turbine design were resulting in the evolution of suitable materials and the localisation of the high temperature region within a comparatively small part of the whole installation. Much research was being conducted on the various chemical and physical problems met in high-pressure and high-temperature work, and it would be safe to state that manufacturers were willing to put forward in the fullest confidence materials for 1,200lb. per sq. in., 875° F. for marine service. On the basis of electric propulsion for a vessel of, say, 55,000 s.h.p. for these steam conditions, 360° F. feed temperature, four-stage feed heating and 29·0in. vacuum, a heat rate of 8,750 B.Th.U.'s per s.h.p. could be produced. With oil fuel of 18,500 B.Th.U.'s per lb., this corresponded to ·472lb. per s.h.p.

While on the subject of performance, the writer regretted that the heat rate was not more widely adopted, as "lb. of fuel per s.h.p." was meaningless in the absence of the fuel calorific value.

In most of the boilers dealt with in the Symposium it was noticed that drums had been dispensed with. This was a welcome development, except of course to the steelmakers, and conduced to economy considering that solid-forged drums were expensive items. Considerable difficulty still existed in satisfactorily forging them and the examination technique was far from perfect or reliable. After all, there was no real reason for the retention of the drum except to permit of natural circulation. Something more positive than this was desirable for a number of reasons, and the advent of forced circulation was a sound development. The result of such a trend was materially to reduce the weight and space occupied, which was quite an advantage for marine work.

The control of superheat at high temperatures became extremely important and the large variations to which engineers had become accustomed were not now permissible. Various devices had been used with more or less success to ensure control, but in this respect the Loeffler system was almost ideal. All that was necessary was to control the steam pump speed, a matter which could be achieved automatically and instantaneously at almost negligible cost. Thus, the Loeffler boiler fulfilled two conditions which were most important (without considering its generally satisfactory operating characteristics), namely, the elimination of drums and the easy superheat control. The pump was a most reliable piece of apparatus, and the gland and impeller arrangements were a tribute to mechanical skill. The boiler had considerable potentialities and was a serious rival to the standard drum and water-tube boiler. For marine service it would prove a very reliable unit. Further, output depended upon the rate of heat which in turn depended upon the steam velocity. It was therefore seen that the overload capacity of this boiler was limited only by the pump size and the pressure drop across the unit.

The Velox boiler seemed to possess advantages where low weight was particularly important as in naval vessels. Rapidity of starting associated with compactness were highly desirable characteristics for such a service. Suggestions were already abroad for a combination Velox-Loeffler system, and to such an experiment he looked forward with interest.

THE AUTHORS' REPLIES TO THE DISCUSSION.

Mr. J. Viktor Blomquist replied that the radical departure in design probably explained the lack of comment on the Atmos boiler. He claimed, however, that this new way of generating steam by employing the revolving principle gave a number of advantages which more than off-set the complication of the stuffing box.

At the end of last century he had had opportunity to assist in the experiments by Dr. de Laval on his super high-pressure boiler based on the same principle as the Benson boiler. Although the boiler was fed with condensate, unavoidable impurities in the water deposited in the tubes at the evaporating zone, causing ruptures. After some years the experiments were discontinued.

In the revolving squirrel-cage rotor such calamities could not happen. The feed water was heated in the economiser to the neighbourhood of the boiling point before it entered the rotor. The tubes of the rotor were provided inside with loose soft iron bars, which constantly scraped off the scale incrustations. These scraped-off scale incrustations were constantly blown off with the water necessary for the regulation of the feed, as proved in an Atmos boiler at Mulhouse, France, which was fed with *non-degassed* water having a hardness of 2-3°. The steam pressure was 100 atmospheres. The tubes were absolutely bright and polished. Such a water could not be used for coil boilers except the Loeffler boiler, but in that case it was necessary to have a steam pump with a capacity of about five times the generated quantity of steam. The power absorbed by this pump was at least 3 per cent. of the power output of the main turbine. The power necessary for driving the squirrel cage rotor was only about 0·1 per cent.

The power consumption of the rotor using coal fuel internally fired was not more than 0·5 per cent. of the power output of the main turbine.

Mr. S. B. Jackson said in the discussion that the Loeffler system was almost ideal in regard to the possibility of controlling the superheat by controlling the steam pump speed. In the Atmos boiler the steam temperature was practically constant without any regulation. Since the drawing reproduced in the paper was made, the construction had been considerably simplified. The coal supply was improved so that no secondary air was used. Another simplification consisted of an improved grate bar construction, by which a metallic seal might be used instead of the air seal between the air supply chamber and the superheater chamber. The new coal supply rendered the torus unnecessary. Each tube of the rotor was fed individually by 10×20mm. tubes, directly connected with the central tube. By making the rotor tubes of different lengths the aperture for the withdrawal of the clinker was increased to 490mm. The grate bars were efficiently cooled by the rotor tubes and were of a simple and cheap construction.

Finally, the Atmos boiler with internal combustion might be used for any pressure up to 1,750lb. per sq. inch and for any purpose.

Dr. E. Goos, in reply to the discussion, stated that although the majority of the new boiler types described by the several authors had retained the drum in some form or other, it was interesting to note that several speakers in the discussion had gained the impression that "most of the examples put forward" dealt with tubular constructions without drums, which seemed to indicate that the drumless type had made the deepest impression and that it was generally felt that the trend of development was in this direction.

Dr. Goos was glad that some of the speakers in the discussion raised the question of first cost, because the Benson boiler, due to absence of the expensive drums, compared most favourably in the matter of low price. It was also emphasized that simplicity was of utmost importance, and there again the Benson boiler could not be surpassed by any other type. It was merely a set of tubes welded together, and there was no additional equipment such as some of the other new types required.

Some speakers asked whether high pressures would be justified at all, or whether the work of the feed pump would not outbalance the thermal gain. The question of the Chairman as to why the Benson boiler generated steam at the critical pressure of 3,200lb. and how this steam was made "manageable" was closely connected with this point. The problem was simply this: The idea of Mr. Benson that steam should be generated at the critical pressure (which included reheating after the steam had been throttled to the pressure at which it was wanted) was no longer considered necessary, and it was now possible to generate steam in the Benson boiler at any desired pressure in the whole commercial range from, say, 300 to 3,500lb. What the Chairman said about Perkins having generated steam at the critical pressure seemed to be a misunderstanding, the first man to go to that extreme pressure having been Mr. Mark Benson. But since at present the Benson boiler was not bound any more to the critical pressure, it had rather perfected the very old development started by Perkins.

Dr. Goos had already stated in his paper that the pressure to which one could economically go depended on the output of the turbine. Whereas for large outputs it was an advantage to use high inlet pressures, the pressures having regard to turbine efficiency, must be lower at smaller outputs. Whereas critical pressure steam would be useful only for a relatively small number of very large installations, it would readily be seen that the Benson boiler, once it could be built for any desired lower pressure, found for itself also the field of medium sized plants down to 6,000 h.p.

Some speakers raised the question of boiler explosion. In the Benson boiler no explosion was possible because the water storage capacity was so small that in the case of a tube failure no damage could be done. Repair of tubes could be carried out very quickly since the heating surface was composed of a number of elements that could be taken out separately and were easily accessible.

The question of material which several speakers raised had been already answered as far as the Benson boiler was concerned in his paper, and he could only emphasize that the very best experience had been gained with the material mentioned there.

One of the speakers in the discussion doubted the figures of the specific heat release and radiation in the combustion chamber as given in the Benson boiler paper. The figures were indeed extremely high, but he was glad to give the confirmation that they were correct.

The preparation of the make-up water was usually carried out in evaporators, unless condensate from some auxiliary boiler was available.

In conclusion, he wished to state that he could understand that after the early and somewhat discouraging experiment which was mentioned by one of the speakers, British marine engineers were somewhat reserved towards higher steam pressures. but he was certain that the good experience gained in the meantime in other countries would also soon bring about a more general trend in the direction of higher pressures in England, a development to which this Symposium would doubtless contribute its share.

Mr. S. McEwen, in his reply to the discussion, expressed his appreciation of the progressive spirit which prompted The Institute of Marine Engineers to give those engaged in the sphere of high-pressure steam practice an opportunity to submit to the Members of The Institute an outline of their achievements, and also of the excellent organisation which enabled so ambitious a project to be conducted so pleasantly (and so informatively) to the authors of the papers.

In opening the discussion Admiral Whayman stated that "in all cases the authors were dealing with watertube boilers and he was fully in agreement that progress in steam generation was going to be with the watertube boiler". The Loeffler boiler, however, was not a watertube boiler since all water was excluded from the tubes, but it might be assumed that Admiral Whayman really intended to differentiate between boilers of the internally-fired shell type and those externally fired with tubular heating surface. On this assumption the Loeffler boiler might claim to be included in the class of steam generator for which Admiral Whayman forecasted more general application for the future.

The definite expression of his opinion in favour of the retention of a water drum emphasized the importance of a characteristic of the Loeffler boiler, namely, the evaporator drum which was an essential feature.

The development of the Loeffler system had been conducted with full recognition of the view expressed by Admiral Whayman with regard to the high boiler efficiencies which were already attainable in normal practice; there was, however, ample scope for improved thermal efficiency of the power plant as a whole, and it was this latter objective which had been attained by the Loeffler system by virtue of its ability to generate and supply to the prime movers steam at a high pressure and temperature, in a simple and practicable manner.

The reference to the Loeffler boiler made by Mr. Bugden was very gratifying, the more so because of the great experience he had had as a pioneer in the field of high-pressure steam generation. The humorous prophesy as to the future association of coil and tube makers with combustion engineers to the exclusion of boiler manufacturers, pointed to a very definite trend in the manufacture of the modern steam generator. Mr. Bugden, however, would probably not complain if it be suggested that his statement in this respect was a slight exaggeration.

Concerning the reversible propeller, it could not be contested that turbines could be designed to permit of all manœuvring operations which might be necessary, but this was achieved at the cost of some complication. Actually, Messrs. Escher Wyss, who without question ranked as most experienced designers of marine turbines, had also designed and developed the reversible propeller, and they affirmed that its adoption led to simplification when all factors were considered.

Mr. Kent pleaded the cause of the tramp steamer and suggested that the new systems included in the Symposium were somewhat "snobbish", seeking only aristocratic associations with majestic war vessels or luxury liners. Actually, the first marine installation of a Loeffler boiler, which was now in hand, was not for the Navy or for a huge liner, but was for a vessel of the Mercantile Marine, viz., the "Conte Rosso" of the Italian Lloyd Shipping Co. This vessel was now equipped with several Scotch marine boilers operating at a pressure of 200lb. per sq. in. One existing boiler, having an evaporative capacity of 16,000lb. of steam per hour, was being removed and in its place a Loeffler boiler would be erected and would have a capacity of 40,000lb. of steam per hour at a pressure of 1,900lb. per sq. in. and a temperature of 930° F. The remaining Scotch marine boilers would remain in service as would the existing turbines, but the additional high-pressure steam would operate new back pressure turbines which would exhaust to the steam main for the existing turbines. Extra power, increased speed, and economy of operation would thus be secured.

Capt. Dommett's comments with regard to the variable pitch propeller, suggesting the possible occurrence of "flutter" at high speeds, drew attention to a matter which had received most careful attention by the designers. An extended practical experience with numerous installations of Kaplan turbines having similar variable pitch propellers had made it possible to eliminate all risk of trouble from such a source. Large bearing surfaces, perfectly lubricated, served to secure complete rigidity in any desired position.

The question of the design of the Loeffler steam drum, which was raised by Mr. Hamilton Martin with the suggestion that weight might be reduced if flat ends were abandoned in favour of spherically-ended drums, applied more particularly to Loeffler boilers for land work than to marine boilers. For the former the drum ends were made flat, partly for the convenience they afforded for the making of various necessary connections. The drum for the marine boiler had, as would be seen by reference to Fig. 2 in the Loeffler boiler paper, one semi-spherical end while the form of the other end was shaped to accommodate the steam circulating pump.

Mr. S. B. Jackson's appreciation of the value of the control of steam temperature which, as he pointed out, was so effectively secured in the Loeffler system, confirmed the importance, now generally realized, of limiting the permissible variation in steam temperature when high temperatures were desired for continuous operation. The reference to the absence of drums in the Loeffler system was probably an oversight since an evaporator drum formed an essential part of the equipment. Mr. Jackson probably had in mind the fact that the drum, unlike those of a watertube boiler, was remote from the furnace and was not heated externally.

The interesting suggestion made by Mr. Jackson to the effect that a combined Velox-Loeffler system was a possibility, had indeed been the subject of some consideration. At the present time, however, the objectives of the two systems were in one respect in direct opposition. The fifth paragraph of the paper on the Loeffler boiler explained the significant relationship between high rates of heat transference and high internal temperatures. Therefore, unless and until metals became available at a reasonable price capable of withstanding even higher temperature than was the case at present, a combination of the two systems was likely to be impracticable.

The Chairman concluded his analysis of the pressure and temperature conditions of the various systems described in the Symposium with a request for information. In the main the questions asked did not apply to the Loeffler system since steam was not generated at a high pressure to be subsequently throttled down and superheated. On the contrary, steam was generated at the pressure necessary to maintain the corresponding working pressure at the turbine stop valve, and superheat was imparted progressively under conditions which avoided excessive tube temperatures at any part of the circuit. It might, however, interest the Chairman to know what governed the selection of pressure and temperature adopted for the Loeffler system, and this might best be stated by quoting from a lecture given by the late Professor Dr. Stephan Loeffler :—

"When the steam temperature is raised to the limits set by the endurance of the metals at present available, or in other words to about 930° F., the heat losses greatly decrease until a pressure of 1,900lb. is reached. Beyond 2,100lb., and particularly with condensing engines, the benefits gained no longer balance the difficulties and expense occasioned in securing the added rise in pressure".

Mr. J. Calderwood, M.Sc., replied that Admiral Whayman had mentioned the question of first cost of manufacture. It would be evident that in the Sulzer Mono-tube boiler the greater freedom for the most advantageous arrangement of heating surface allowed a higher average rate of heat transfer and consequently a smalled quantity of tube was required than in the drum-type boiler of similar output; there was the further saving in the cost of the drums. Against these must be set the cost of control gear, but it was only for a very small boiler that the cost of this outweighed the saving in tubes and drums and it was safe to say that, in general, the first cost of the Sulzer boiler would be lower than for drum-type boilers.

Efficiency had also been mentioned by Admiral Whayman and there Mr. Calderwood must agree that for a moderately-rated boiler little better could be hoped for than was obtained in a well-designed drum-type boiler. For high ratings, however, it was not possible to distribute the heating surface to the best advantage in a drum-type boiler and the dimensions and shape of the combustion chamber were also limited; on this point the Sulzer and other boilers scored as the heating surface could be distributed in a way that would ensure a low uptake temperature at any rating, while much more latitude in the design of the combustion space was allowed.

One must agree with Admiral Whayman that purity of feed was important in any high-pressure boiler, but in this respect a boiler with forced circulation was safer than any with natural circulation, as in the former the quantity of water circulated through the tube remained proportionate to the heat supplied from the furnace, whereas in the latter the circulation rate dropped as scale was formed.

Both Admiral Whayman and Mr. Bugden raised the question of the dependence of the forced circulation boiler on a pump and the danger of tube failure if the pump stopped. In practice this had not proved a difficulty on the Sulzer boiler, as the tubes were in fact well protected by the automatic control gear, and even with coal firing only the stored energy in the fire and brickwork had to be dissipated as the draught could be shut down at once. The best reply to this bogey so far as the Sulzer boiler was concerned was the fact that coal-fired boilers had now been in successful operation for a considerable period.

Mr. Kent's remarks were very interesting and the reasons for care in changing from the Scotch boiler for many services could be quite understood, but it was by no means correct to assume that the Sulzer boiler was suitable only for high-speed and naval vessels, though there was no doubt that the advantages of higher pressures were realised to a greater extent in high-powered installations. In the design of the Sulzer boiler the object had been to produce something which overcame certain of the disadvantages of the drum-type boiler while retaining and improving on its advantages of compactness and light weight. Both boiler and control gear were of robust construction and so should be suitable for any service where coal was the most economical fuel. That banked fires were no serious problem was shown by one coal-fired boiler in service which was shut down for about two hours daily when no steam was required.

For manœuvring of the machinery the control gear was relatively simple to arrange, though there was certainly a small loss of steam as when the boiler was shut down suddenly steam must be bye-passed direct to the condenser for a short period. For winch working the high-pressure boiler must work through the medium of a steam transformer the primary side of which was heated by high-pressure steam, while the secondary produced low-pressure steam for the winches. In this way the boiler circuit water could be kept free from impurities.

Generally, it might be said that the development of the modern boiler must have as its object not only the production of higher steam pressures, but must also offer advantages in space, weight, price and be no less reliable than any of the established boiler types. It must also be equally adaptable to all kinds of fuel and systems of firing. These were the factors that had been considered throughout the development of the Sulzer Mono-tube boiler.

Mr. M. G. S. Swallow, in reply, stated that Admiral Whayman had referred to the question of trouble which might be caused by the impurities in feed water, and this matter had also been touched on by other speakers. The running experience up to date was of course somewhat limited, as the first commercial "Velox" steam generator had only been in use for about two-and-a-half years. The results obtained with treated feed water and long period experiments carried out with untreated feed water with a permanent hardness of 16 degs., had shown that with the ordinary boiler treatment there was no trouble from impurities in the water, due to the high velocity of the water and the proper streamlining of the water passages. Any solid matter accumulated in the bottom of the drum where the sludge could be blown down. With entirely untreated water it was found that no deposit whatever occurred in the evaporator tubes, but that the deposit accumulated at the bottom of the drum and between the drum and the circulating pump. Obviously no boiler of this type would be run permanently with untreated water if the raw water had this degree of hardness.

Admiral Whayman, as well as other speakers, had also referred to the question of the water contents and boiler drums. In the "Velox", a water drum of relatively small dimensions was fitted, this forming an extension to the separator in order to obtain a point in the system for a definite water level and to act as a drum for collecting sludge. The capacity of this drum was not large, but the water storage was sufficiently large that in the event of a breakdown of the feed system there was sufficient water to prevent damage to any part before the whole unit shut down automatically. It must also be kept in mind that the water was circulated by the circulator pump at a rate equal to ten times the normal steam output of the unit.

Mr. Bugden referred to the advantage of getting away from the drum on account of expense. In the "Velox" design the drum was not large and the cost, therefore, was quite moderate compared with the total cost of the boiler.

Mr. Kent, in his remarks, referred to the heat units generated in the combustion space of the Benson boiler. It might, perhaps, be of interest to state that in the "Velox" with combustion under pressure it was possible to generate up to 1,000,000 B.Th.U./cu. ft. of combustion space per hour with a single burner. The application of the "Velox" generator was not necessarily to high speed or Naval vessels only, as where oil fuel was available it was suitable for the ordinary tramp steamer. It was now built in sizes from four tons up to seventy-five tons and the ten ton units and upward compared favourably in cost with any other type of boiler if the higher efficiency, reduction in space and weight, and the absence of manœuvring and stand-by losses were taken into account. The quick starting characteristic of four to five minutes from cold to full pressure enabled the generator to be shut down when not required and at the same time gave the engineer the advantage of having a full head of steam available in a shorter period than was possible with banked boilers, whether of the Scotch or watertube type. Up to the present, there were ten "Velox" steam generators in operation and a further eleven under construction, and there had been no trouble with joints or mountings or with the all-welded construction, and the various boiler insurance companies who had had these under observation were perfectly satisfied with the facilities for survey. Any oil which could be burnt in an ordinary watertube or Scotch boiler was also suitable for the "Velox", and experience had shown that there was no accumulation of dust or soot in any part of the plant, due, no doubt, to the very high velocities employed throughout. The fuel and air supply could be so adjusted that the exhaust gases were quite clear and even rapid variations in the load hardly showed any change of colour of the exhaust gas.

This latter effect was mainly due to the automatic control, to which Capt. W. E. Dommett referred. Once started, the control was entirely automatic by regulating the feed and the fuel and air supply. Once the proportion of the latter was correctly adjusted for smokeless operation, the control was effected automatically over the whole range. The control could, of course, be so arranged that if necessary the steam turbine governor could be the control force operating the steam generator, but normally the "Velox" generator was fitted with separate and complete control gear.

Mr. Hamilton Martin in his very interesting historical survey, going back to the excellent work done many years ago by Serpollet and White, raised the question of material. The only special material used in the "Velox" was the heat resisting castings for the evaporator tube ends, superheater boxes, or special alloy steel for superheater tubes for temperatures exceeding 700° and the gas turbine. All the other material was mild steel. As regards the effect of the flue gas and fine ash which might result with pulverized fuel, it was yet too early to express an opinion, as research work in connection with the burning of pulverized fuel in the "Velox" was not completed. The indications up to the present, however, were that even with this fuel the streamline passages and high velocities would minimize, and probably entirely prevent, erosion. Up to the present with the oil or gas fuel used, it was quite impossible to detect any trace of erosion.

Dr. S. F. Dorey referred to the inspection and replacement of the evaporator elements. In the event of a defective element it was possible either to remove an evaporator element and replace it with a spare one, or to remove it and blank off the passages in a shorter time than required for replacing a boiler tube, one of the main reasons being, of course, that on shutting down a "Velox" generator the cooling down period was very much reduced as there was no heat-retaining material, such as refractory material, in the whole plant. A design of this type was only possible due to the advantages of welding and the use of this for the whole design had fully justified itself by the absence of any failures up to the present.

Mr. S. B. Jackson touched on a rather interesting point in connection with overload capacity. As far as the "Velox" generator was concerned, the limited of steam generation in the evaporator section or the quantity of fuel burnt in the combustion chamber had not yet been reached, the maximum capacity being dependent on the size and speed of the turbo-compressor unit. As regards overload capacity, therefore, the "Velox" was a machine very similar to the modern steam turbine which was designed for a maximum continuous rating, this being the limit without any overload capacity in the accepted meaning of the term, and the capacity of the steam generator should, therefore, be chosen to suit the maximum continuous rating of the propelling machinery.

Mr. O. Jebens, in reply, said that from the point of view of practical working of ships he fully agreed with Admiral Whayman. The special requirements which a marine boiler had to fulfil were that it should afford the maximum of simplicity and of safety, particularly with regard to fluctuations of load, which did not occur nearly so frequently with land boilers as with marine boilers during manœuvring. For this, the retention of a certain amount of water was of decisive importance in respect of safety and convenient working.

The doubts expressed as regards the safety of high-pressure drums seemed no longer to be justified. For one thing it was no longer necessary, even in the case of large boilers, to provide drums of the usual dimensions for high-pressure marine boilers. This was due to the greater density of high-pressure steam, resulting in a substantially smaller load on the upper surface in the upper drum.

Further, if in the case of drum boilers special regulators for regulating the temperature of the superheated steam could be dispensed with at the expense of a certain percentage of the economy of the installation when only partially loaded, this would be well worth while, more particularly so if the avoidance of unusually high superheating temperatures was imperative in the type of boiler under consideration.

Exhaustive tests made with the boilers of this system had revealed further that an artificial circulation was not required, as it had been possible to maintain high loads for considerable periods without any difficulty.

The question of cost had been raised by various speakers. It had been found that in almost all cases the price of a Wagner-Bauer high-pressure turbine installation with the starting installation now customary was competitive, quite apart from the saving in fuel which could be effected through the utilization of a high pressure. Moreover, as there was practically no difference between the construction and service of this system of boiler and that of the usual types of boilers, it could be asserted that high upkeep costs need not be feared, the more so as the question of feed water no longer presented any difficulty if condensation water with small alkalinity and small phosphate surplus was used as make-up feed.

The confidence placed in this system by the circles interested was evidenced by the plant actually under construction for merchant vessels, representing a total capacity of approximately 65,000 h.p.

Some Notes on Heat Transmission.

A further contribution to the discussion on Mr. E. F. Spanner's paper published under the above heading in the February, 1935 Transactions (Vol. XLVII, No. 1, pp. 1-31) is published below together with the author's reply thereto.

Mr. W. J. Niven (Associate Member) wrote that it was generally recognised to-day that the thimbletube boiler had established itself as an efficient steam generator, but he considered it very doubtful whether the modification advocated in the author's paper, as to the size and shape of the tubes, would give any material improvement so far as output was concerned.

Any engineer conversant with the design and peculiarities of this type of boiler could arrange the size and disposition of the thimble tubes to ensure a reasonable heat transmission, so that, as far as the pressure parts of the boiler were concerned, there did not appear to be much room for improvement.

In case of thimbletube boilers, however, a centre space formed by the closed ends of the thimble tubes was obtained, and in the writer's opinion it was there that they should concentrate for any improvement likely to lead to better heat transmission, for until recently this had constituted a "dead" space in the form of a hollow cylindrical plug.

Having an intimate knowledge of the thimbletube boiler, and having examined numbers of boilers after long service, he quite agreed with the author on points (2) and (3) on page 10 of the paper (Vol. XLVII, page 10, of the Transactions) as being worthy of persistent attention. The maintaining of a constant velocity throughout the gas pass, also ensuring that the tube ends were thoroughly scrubbed with hot gas, was vital in obtaining maximum heat transmission. Further, he would say that the changing of a "dead" space into something alive with hot gas for the definite purpose that the additional benefit of radiant heat as well as convection could be obtained, was something worthy of the designer's attention. These desirable features, and the utilization of the centre space in order to effect them, had received the writer's attention for some time now, with the result that a very simple device had been designed and was incorporated in the "Nelvin" thimbletube boiler, Patent No. 422612. Although of simple construction, this device ensured :—

(*a*) constant velocity,
(*b*) thorough scrubbing of the tube ends,
(*c*) effective distribution of the hot gases allowed to enter the centre space, and their complete elimination from that centre space before being allowed to leave the heating surfaces,
(*d*) effective silencing of the gas throughout the boiler, and
(*e*) the benefit of radiant heat from the centre space, whilst the minimum-sized boiler for output could be designed.

The writer had studiously avoided the utilizing of this centre space for heating surface for obvious practical reasons concerning inspection and cleaning, and also because of certain other practical reasons peculiar only to thimbletube boilers.

Efficiency with simplicity and a reasonable marketing cost were the keynotes to success for any boiler, and the thimbletube boiler lent itself most favourably to the attaining of these ideals.

The Author, in reply, wrote that Mr. Niven's remarks were of great interest, his practical experience of the construction and fitting up of thimbletube boilers being very considerable. Mr. Niven's avowed belief in the future of the thimbletube boiler, therefore, was extremely encouraging and entirely in accord with the author's views, and with those of experienced marine engineers. Mr. Niven was also at one with the author, and with Mr. Gill, in deploring the fact that in earlier designs of waste-heat boiler a considerable "dead space" existed in the centre which was simply choked with a large cylindrical baffle, while the fact that Mr. Niven "studiously avoided the utilizing of this centre space for obvious practical reasons concerning inspection and cleaning, and certain other practical reasons peculiar only to thimbletube boilers" (probably the entire absence of need for any circulating devices) was another point on which he was in agreement with the author, although differing this time from both Mr. Fountain and Mr. Gill.

However, on the theoretical side, Mr. Niven would not appear to be on anything like such sound ground, there being several points in his arguments which were obviously open to criticism.

In the first place Mr. Niven suggested that it was doubtful if the changes which the author had made in the size and shape of the tubes would give any material improvement so far as output was concerned. As to that Mr. Fountain, whose experience was unrivalled, had frankly recognised the value of a high heating-surface/water-content ratio, while simple commercial and design considerations fully established the great importance of "tube family" design. The author's effort had succeeded in producing (1) a very high heating-surface/water-content ratio, (2) a better distribution of this ratio along the length of the tube, and (3) all the important facilities attaching to "tube family" design.

In the second place Mr. Niven suggested that advantage attached to the maintenance of a hot gas flow through the centre of the boiler *clear of the tubes* "for the definite purpose" of gaining "additional benefit from the radiant heat" as well as from "convection". This appeared to be an extremely unsound argument for the following reasons :—

(1) Such relatively small amount of *radiant* heat as was available in waste gases would be given up to the tubes much more readily if the gas was moving intimately amongst them than if it was moving along a path which was entirely clear of them.

(2) Only for so long as the gas was actually moving *amongst* the tubes was it possible for *convection* to play its part in transferring heat from the hot gases to the tube surfaces.

(3) With the Clarkson designs, and with the author's designs, opportunity was given the gas to part with its heat to the tubes by radiation and convection *at one and the same time.* In the "Nelvin" boiler there was a separation of these factors, and a simple heat gradient calculation indicated that the average efficiency of the tubes in a "Nelvin" design must inevitably be appreciably below that in either a Clarkson or Spanner design in which the gas was forced into contact with the tubes throughout the whole length of its passage. Mr. Niven would appear to have entirely overlooked the fundamental importance of the fact that the two heat transfer phenomena of convection and radiation could both operate at the same time, and that such operation was greatly assisted by ensuring close proximity between the gas streams and the tube surfaces. Dr. Fishenden's comments might be commended to Mr. Niven's attention, as also certain chapters in "The Calculation of Heat Transmission".

In view of the keen interest now showing itself in thimbletube boiler designs, reference might well be made to Figs. 29 and 30, which were taken from Mr. Niven's Patent Specification No. 422612 and to claims (1) and (2) which read as follows :—

"1. A thimbletube boiler fitted with a gas distributor which is arranged to bye-pass a portion of the entering hot gas and prevent it from giving up its heat to the boiler tubes near the gas inlet, and subsequently to deliver the said portion without substantial loss of its initial heat amongst the rows of boiler tubes nearer the gas exit.

2. A thimbletube boiler according to Claim 1, in which the central space between the tube ends is occupied by a series of spaced discs, constituting the distributor, which extend transversely to the direction of flow of the gases and offer a progressively increasing obstruction to the direct passage of the gases through the central space aforesaid".

It would be clearly noted from these figures and claims that Mr. Niven's principal purpose was to ensure that there should be *delay* in forcing the whole of the hot gas out among the tubes, which delay, however, must simply result in loss of opportunity for the gas to give up its heat to the thimble tubes, without contributing in the least to the effective utilization of the heat transferred to the water in the boiler.

The designs for which the author was responsible differed fundamentally from Mr. Niven's, the object sought by the author being to throw the gas stream out amongst the tubes as quickly as possible, at high speed and with a swirling motion imposed upon it by a spiralled member at the entry, this motion being maintained by the spiralled arrange-

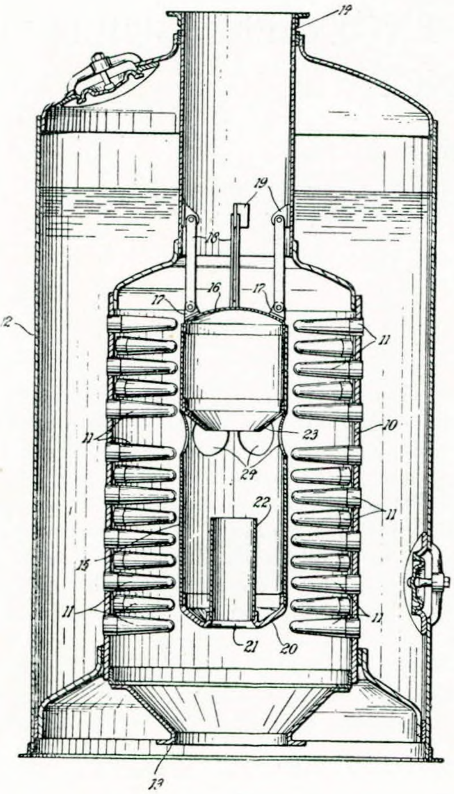


FIG. 29.

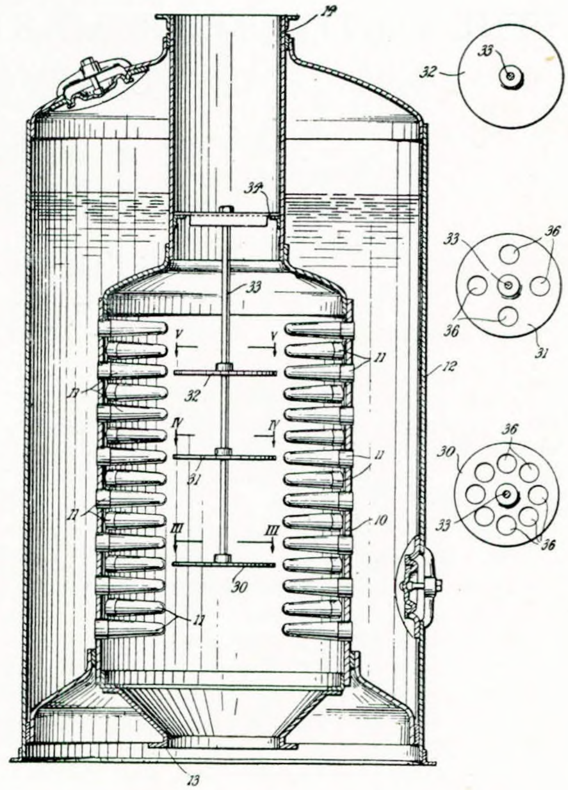
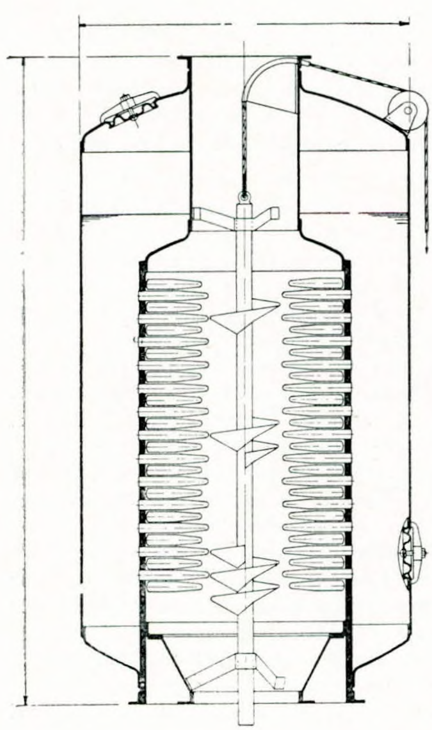
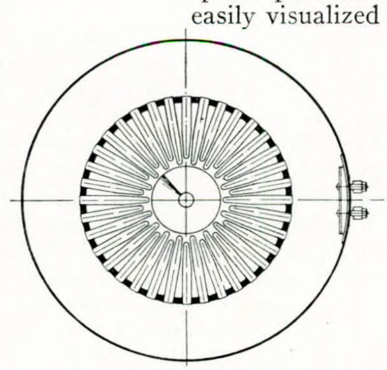


FIG. 30.



ment of the path through the tube nest and by other central spiral members. Everything possible was done to avoid checking the gas speed any more than was inevitable.

Fig. 31 showed a method of ensuring this high speed spiral movement which might be rather more easily visualized than were the arrangements shown in Fig. 13 of the original paper, although these had a precisely similar effect.



Finally, it might be remarked that while turbulence *in* the tube nest was of great importance in facilitating heat transfer to the water in the tubes, turbulence created by the passage of gas through the perforated cylinders and plates in Figs. 29 and 30 could have no such beneficial effect. The cylinder and plates would simply absorb kinetic energy from the gas stream without giving any useful return in the shape of accelerated heat transfer. Further with a gas stream moving at 100ft./second or more it seemed highly probable that the cylinder would become an organ pipe and that the perforated plates would tend to convert a silencer boiler into something akin to a low-pitched syren.

FIG. 31.

THE INSTITUTE OF MARINE ENGINEERS GUILD OF BENEVOLENCE.

Minutes of Proceedings at the ANNUAL GENERAL MEETING.

MARCH 27th, 1935.

CHAIRMAN: Mr. GEORGE ADAMS.

The first Annual General Meeting of The Institute of Marine Engineers Guild of Benevolence was held in the Lecture Hall of The Institute, The Minories, E.C.3, at 6 p.m. on Wednesday, March 27th, 1935.

The Secretary having read the Notices convening the Meeting, the CHAIRMAN said that although there had been no discontinuity during the year in The Institute's benevolent activity, this work had assumed much greater importance when, in August last, the old Benevolent Fund had been merged into the Guild of Benevolence, of which organisation this was the first Annual General Meeting. At the meeting on August 2nd last, the Minutes of which were published in that month's TRANSACTIONS of The Institute, the Guild of Benevolence was inaugurated, Rules were adopted and Committees appointed, and the whole scheme launched. It was now necessary for the Members to confirm those Minutes.

On the proposal of the Honorary Treasurer (MR. A. ROBERTSON), seconded by MR. W. McLAREN, the Minutes were unanimously confirmed.

Before proceeding to the next item on the agenda, the Chairman said that it would have been noted with great pleasure how the Guild of Benevolence had appealed to Mr. John Silley, and it was largely due to his efforts that the scheme had received such a splendid send-off financially.

It was a long spell since The Institute was established in Romford Road and in those early days there did not appear to be much chance of inaugurating such a desirable organisation of benevolence. Indeed, the endeavours of the early members of The Institute were primarily directed to improving technically the professional standing of the Marine Engineer and ensuring that a Member of The Institute would be recognised as a man who had a professional diploma. Great progress had been made in that direction and a big advance had now been made on the benevolent side. Other institutions had similar schemes. The Guild of Benevolence had been associated with The Institute, and they looked forward to the time when all Members of The Institute, as well as Marine Engineers generally, would be recruited as Members of the Guild. He had no doubt that as the benefits and privileges of that association became more widely known, a great increase in their activities would result. The invested funds of the Guild would yield at the most only 4 per cent., so that all the financial assistance they could possibly obtain would be welcomed, as the extent of the benefits was regulated by the amount of money available.

The Chairman then called upon the Secretary to read the Annual Report (copies of which had been circulated with the March TRANSACTIONS).

The HONORARY TREASURER next presented his Financial Statement as follows:—

To be perfectly in order I can only be expected to make reference to the Accounts as presented to you up to the end of last year, and as this covers a period of five months only (and further it being the inaugural period of the Guild) there is not a very great amount that I can say or deal with. The few matters to which I will make reference are of importance and should be dealt with at this meeting.

You will notice on the Balance Sheet two amounts covering cash in the sum of £141 12s. 7d. and Income Tax recoverable for £2 5s., totalling £143 17s. 7d. This comprises money which was the balance of the Revenue Account in the old Benevolent Fund and it was the full intention of the Committee, when framing the Rules of the Guild, that this amount should be placed to the Revenue Account of the Guild of Benevolence. Our Chartered Accountants, Messrs. West & Drake, have interpreted the wording of the Rules in a strictly legal sense and have placed this sum to the Capital Account. They have left it to this meeting to pass a resolution authorising this money to be transferred to Revenue Account. I must therefore ask you to bear this in mind in adopting the accounts and perhaps the Chairman will allow me to move a resolution to this effect.

There is also an item of £11 0s. 6d. which Messrs. West & Drake, again in the strict interpretation of the Rules, have debited to Capital Account. If this had been a credit balance I think the General Committee would have preferred that such amount should remain to the credit of Revenue Account, unless of course the balance was considerable, in which case the General Committee would exercise their discretionary powers. It is of course essential that the Revenue Account should be kept as well in funds at the present time as is possible. Owing to our only having just commenced operations, the demands on the Guild have been small. These, however, are bound to increase and it is well to have a good balance on the Revenue Account to meet all possible claims in the immediate future.

In their Report, Messrs. West & Drake state that the Investments of the old Benevolent Fund have been transferred to the Guild of Benevolence. This is, of course, perfectly correct, but it should be borne in mind that the Council of The Institute of Marine Engineers are the Trustees for the Guild of Benevolence and these investments have been transferred into the name of The Institute of Marine Engineers, acting as Trustees for the Guild.

At a later stage in the proceedings, a special resolution is to be submitted by the General Committee altering Rule 6c. This is with a view to preserving our status legally as what is known as a "Mixed Charity" and by so doing we are enabled to invest our monies, or such proportion as the General Committee think fit, in such investments as Freehold Ground Rents, or Property. The General Committee have so far decided to invest our capital equally in British Government Securities and Freehold Ground Rents.

I may be allowed to refer to the position of the Fund as it stands at the present moment, particularly as considerable amounts have come in since the 1st January of this year.

You will note from the list of donors that the amounts promised total £15,070 10s. This is apart from amounts which have been received as Life Members' subscriptions. Of this total, up to the moment approximately £14,000 has been actually received.

The Council of The Institute have also handed over £75 16s. 4d., being the proceeds from the Publications Account in connection with the Handbook on the Running and Maintenance of Marine Machinery; we shall also receive the benefit of any further proceeds from the sale of this publication next year. It is also anticipated that the Council will make a grant from The Institute's Social Events Account, which in all probability will be placed to the credit of our Revenue Account. You will thus gather that our Revenue Account is already in an exceedingly satisfactory condition.

I trust, however, that I may be excused for again referring to the fact that the number of Members who have so far become Subscribing Members is far below the number which it was hoped to announce. The General Committee would like to see every Member of The Institute placed upon the list of Subscribing Members. If this were so, the income thus derived would enable the Guild to be of far-reaching assistance and importance in providing for those who from time to time require help from a fund of this description.

Mr. W. D. Heck, B.Sc., said that he regarded it as a very great compliment to have the privilege of moving the adoption of the Report and Accounts at this, the first, Annual General Meeting of the Guild.

In considering this report he thought they should turn first to the question of the membership. Mr. Robertson had dealt with this and very little more need be said, but he would like to suggest that possibly the General Committee might arrange a Sub-Committee to deal with this question. The duties of this Committee would be different from those of the Membership Committee of The Institute in that they would not be so much concerned with the qualifications of applicants but rather engaged in pointing out the advantages of membership of the Guild to those who were eligible, and inducing them to join.

Turning to the Accounts he would say that he had studied these as critically as his training as an engineer permitted, and a very comforting feature of the balance sheet was that the value of the investments from the date of their purchase to December 31st last had increased quite considerably. Mr. Adams had suggested that about 4 per cent. on their investments might be anticipated. With their present capital this meant that something like £500 annually, apart from subscriptions, would be available for this excellent cause.

In connection with the Revenue Account he thought that reference should be made to the high ratio of expense to the amount actually disbursed. Calculation showed that in disbursing 9s. expenses amounting to 11s. were incurred. This was a temporary disproportion and was due to two causes. Special efforts had been made during these early months to obtain new Members, and that had necessitated a large expenditure on printing, etc. Again, they had only had the bulk of the funds a very short time and the revenue for the period covered by the Accounts was very small. He thought that next year it would be found that the proportion of expenses to grants would be very considerably reduced.

He noted that the scale of grants was to be 15s. per week for thirteen weeks. Every care, of course, must be taken in distributing this money, but he was happy to note that there was a proviso "except in special cases" attached to the abovementioned period. This was a very wise provision, because it was quite certain that most of the applicants for relief from this fund would not submit any claim until their credit was exhausted, and it would be well in those cases to be able, where necessary, to assist the person concerned to clear his debts and enable him to regain his standing.

Finally, might he say a word about the General

Committee. They had as Chairman Mr. George Adams, who had taken a keen and active interest in the benevolent activities of The Institute throughout its life; they had as Honorary Treasurer Mr. Robertson, who had a flair for finance; and they had the other gentlemen on the Committee, all of whom were of wide experience and great reputation. With these people governing the scheme, they could go forward with confidence.

It was with great pleasure that he moved the adoption of the Report and Accounts.

Mr. A. E. Laslett, I.S.O., seconding the adoption of the Report and Accounts, said that the Chairman had given a very good account of the origin and birth-throes of this very excellent scheme, and he felt that they should all be very proud of the work done during the short existence of the Guild.

There were two items in the Report to which special reference should be made. In the second paragraph of the first clause mention was made of the part played by Messrs. A. Robertson, A. E. Crighton and J. B. Wilkie. He thought that the Members of the Guild had not shown the appreciation which they should to these gentlemen for the way in which they had forced the scheme through. The idea was so big that at first the response to their efforts was not very encouraging, but they had not despaired and eventually the Council of The Institute had been converted.

So far the proportion of members of the Guild to the whole membership of The Institute was very small—something like 5 per cent. That position should be bettered very quickly.

The second point in the Report to which he would like to refer was the splendid effort made by Mr. John Silley. When reading the Report he could not help thinking how the financing of the Guild seemed to have been a one-man job. They were not all in a position to obtain donations of £500 or £1,000, however, though much good work had been done in other directions, but they must all realize that the revenue for the future was dependent upon subscriptions. The subscriptions for the period covered by the Accounts totalled only £46 11s. 6d., and he suggested that those who could do so might raise their subscriptions and thus increase the revenue. Nothing very great could be done with such a small revenue, even with the interest on investments.

He now formally seconded the adoption of the Report and Accounts.

The Honorary Treasurer at this point explained that the total of the Capital Account at the present moment was about £19,000. They had definitely been promised £15,000, of which £14,000 had already been received and the remainder was absolutely certain. In addition they had over £800 in Life Membership subscriptions, and the investments of the old Benevolent Fund of £2,700.

Mr. Heck had referred to the printing and stationery charges as being high in comparison with the grants of relief. It should be remembered that the period covered was very short and that they had hardly got going, and though the cost of the printing and stationery might seem high it included the non-recurring cost of account books and quantities of stationery estimated to be sufficient for the coming year. It was an initial expense which should be replaced by much lower figures in future accounts.

With regard to subscriptions, the Accounts only covered to the 31st December, 1934, and since then a considerable amount had been received. The amount shown in the Accounts for subscriptions would be far exceeded in the present year, and they were hoping for a great influx of new Members.

The Chairman then explained, in connection with the scale of grants, that they had had to be as economical as possible, but in order to give the Members some idea of what had been paid they had mentioned in the Report the basis which had been temporarily formulated.

He thought that mention should be made of the excellent services rendered by Capt. B. Warwick. Capt. Warwick was connected with another similar organisation, and was able to render very valuable help and advice.

They had made provision for special cases. There was still that wonderful spirit abroad that would not allow many people to disclose their distress. There were Members of The Institute who were most reticent regarding their difficulties, but where information reached the Committee they were doing everything possible to help, and they hoped to do more in the future.

The Chairman then put to the Meeting the motion that the Report and Accounts be adopted and it was carried unanimously.

Mr. J. Hamilton Gibson, O.B.E., M.Eng., referring to the next item on the programme—the election of the Chairman for the ensuing year—said that Members of The Institute could not have failed to notice that for some years past the affairs of the old Benevolent Fund and the former Titanic Memorial Fund, as well as more recently the Guild of Benevolence, had been watched over and guided by one in particular who had always had these matters and the relief of needy Marine Engineers and their dependents very much at heart, namely, Mr. George Adams.

It was very necessary that the administration of the Guild of Benevolence should always be in the capable hands of someone who was intimately acquainted with its activities and the problems that arose from time to time, as well as the work of schemes of a similar nature run by other organisations.

They would notice in the Annual Report read by the Secretary that at the Inaugural Meeting last year Mr. George Adams was unanimously elected Chairman of the General Committee. Mr. Adams was Chairman of the old Benevolent Fund and of the Special Committee set up to consider the formation of this new Guild. His excellent work had greatly helped to carry the Guild through this important first period, and he had great pleasure in proposing that Mr. Adams be re-elected as Chairman for the ensuing year.

MR. A. H. LEDGER said that it gave him great pleasure to second this proposal. He had had occasion to meet Mr. Adams in connection with a claim, and he had been charmed by the sympathy, consideration and attention which Mr. Adams had devoted to the matter. With Mr. Adams as Chairman they could be assured that the funds would be wisely and scrupulously administered, and that applicants for grants would receive the utmost sympathy and consideration.

MR. A. JOBLING, supporting the proposal, said that in view of the wonderful work of the Chairman and Committee it would be a great mistake to make any changes for the ensuing year.

The proposal was then put to the Meeting and carried unanimously.

The CHAIRMAN next reported that Messrs. J. Carnaghan, R. Rainie and F. W. Youldon were retiring in accordance with Rule 12(*c*) but were eligible for re-election respectively as representatives of the Vice-Presidents, the Members of the Guild, and the Members of Council.

On the proposal of MR. W. MCLAREN, seconded by MR. J. B. HARVEY, the retiring Members of the Committee were unanimously re-elected en bloc.

The CHAIRMAN expressed his satisfaction at this decision as it enabled him, if he might so use the term, to keep his team together.

The HONORARY TREASURER, proposing that Messrs. J. B. Harvey and H. J. Vose be re-elected Honorary Auditors for the ensuing year, said that as Treasurer of The Institute he could assure the meeting that Mr. Harvey and Mr. Vose very carefully scrutinized the accounts of The Institute, and as Treasurer of the Guild he would like their assistance in a similar capacity in connection with the accounts of the Guild.

MR. HAMPSHIRE seconded this proposal and on being put to the Meeting it was carried unanimously.

The CHAIRMAN then proposed that Mr. W. E. Archer be re-elected Honorary Solicitor to the Guild for the ensuing year. They all knew the good services Mr. Archer had rendered to The Institute in the past, and his assistance had already been very valuable in connection with the work of the Guild.

MR. T. A. CROMPTON seconded this proposal, which was carried unanimously.

The CHAIRMAN next pointed out that an Honorary Medical Officer was very essential if the work of the Guild was to be carried out thoroughly. Dr. W. J. Galt had kindly consented to serve in this capacity, and he (the Chairman) had pleasure in proposing that he be re-elected for the ensuing year.

MR. F. W. YOULDON seconded the motion, which was carried unanimously.

The CHAIRMAN then referred to the following Special Resolution, a copy of which had been sent to each Member:—

> "That Rule 6 (*c*) be amended by the substitution of the words 'if so' for the words 'unless otherwise', so that the amended passage read as follows:—
>
> '(*c*) Monies received from Companies, Corporations, or other sources if so stipulated by the donors'."

The Chairman said that their Honorary Solicitor had pointed out that as the Rule stood the Guild was not a mixed charity, which meant that they could not legally invest their funds in ground rents or freehold property. The passing of this Special Resolution would right the matter.

On the proposal of the HONORARY TREASURER, seconded by MR. T. A. CROMPTON, the Special Resolution was unanimously approved and passed.

The HONORARY TREASURER said that the Meeting having now passed the Accounts, would be in order in resolving that the sum of £143 17s. 7d. to which he had referred in his Financial Statement be placed to the credit of the Revenue Account. He then made the proposal, which was seconded by MR. J. CARNAGHAN and carried unanimously.

The Meeting was then thrown open for suggestions.

MR. F. W. YOULDON suggested that all Members of the Guild should appoint themselves unofficial canvassers with the object of obtaining as many new Members as possible. Literature regarding the Guild had been distributed with the January and a previous issue of the TRANSACTIONS, and he thought that great results might be obtained by personal canvassing for new Members.

MR. W. MCLAREN suggested that in view of the need for economy the alteration to Rule 6(*c*) be printed on a slip and pasted in the existing copies of the Rules.

The CHAIRMAN promised that this suggestion would be adopted and the SECRETARY added that the present stock of Rules was almost exhausted and they would be reprinted in the near future.

MR. H. S. HUMPHREYS, proposing a vote of thanks to the General and Executive Committees and Officers, said that it was difficult to express adequately the gratitude which was due to the Members of the Committees and Officers for the time they had given and the valuable work they had carried out.

At the time of the "Titanic" disaster he was a junior engineer in a vessel employed in the same trade as the "Titanic", and he remembered how impressed he had been by the response to the appeal for money in aid of the dependents of the engineers who lost their lives in that ill-fated ship. That there were well-disposed people ready to help the marine engineer had inspired him.

In 1931 the scope of the "Titanic" Fund was widened to include the widows and children of marine engineers, and their thanks were due to Messrs. Wilkie, Crighton and Robertson for that happy inspiration at the Golf Meeting in 1933 which had resulted in the Guild of Benevolence as it was to-day. The names of John Silley and George Adams would always be respected and revered by Marine Engineers.

In these days of huge corporations, institutions and organisations the personal touch between master and man was lacking, but it augured well for the future that these great organisations came forward and helped so generously their cause which was designed to assist those who fell on hard times.

If he might make one suggestion to the Committees and Officers, it would be that every Member of The Institute should be invited to join regardless of the amount which he could pay. While those who could should pay more than half-a-guinea, there were many others who could not afford this amount, and he thought they would agree that a large number paying small sums was better than a small number paying large amounts. There should be no minimum subscription in connection with benevolence.

The Committees would no doubt give this matter their consideration, and he would now ask the meeting to accord most heartily a warm vote of thanks to these gentlemen for the time and service which they devoted to this good cause.

Mr. Wm. McLaren said that he had much pleasure in seconding the vote of thanks which had just been proposed. The General and Executive Committees and the Officers had carried out their difficult work with great distinction. The Members must give them every encouragement as their troubles were only commencing. When the number of applicants for grants increased they would be faced with even more work.

The Committee had been very wise in fixing the grants in accordance with their income, and under such careful management there was no doubt that the Guild would grow.

The vote of thanks was enthusiastically accorded.

The Chairman, in response, said that on behalf of the Committees and Officers he thanked the meeting for their confidence and helpful encouragement. He felt that he had colleagues of great ability, and he had no doubt that when they met next year satisfactory progress would again be recorded.

This terminated the proceedings and the Chairman declared the meeting closed.

INSTITUTE NOTES.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, March 18th, 1935.

Members.

John George Fothergill Carrol, 39, Roslin Street, Aberdeen.

John Edward Church, m.v. "Durham", c/o New Zealand Shipping Co., Ltd., 138, Leadenhall Street, E.C.3.

George Edward Harwood, 85, Arncliffe Gardens, W. Hartlepool.

William Hoy, 2, Brislee Avenue, Tynemouth.

Robert Hunter, 39, Matthews Road, Yeovil, Somerset.

John Liversage, Buena Vista, Whinmoor Road, Liverpool, 12.

Stuart Murray Lindsay, 11, Harvey Road, Wallasey, Cheshire.

Harold Marshall Pearson, c/o Mrs. Holdsworth, 6, Ashley Park, Bangor, N. Ireland.

Frederick Henry Pugh, Eng. Com'r., R.N. (ret.), Acasta, The Fairway, Greenhill Park, New Barnet, Herts.

John McFarlane Taylor, 21, Grainger Road, Riccarton, Kilmarnock.

Ethelbald William Triolo, 82, Thorold Road, Ilford, Essex.

C. Richard Waller, 922, Bellevue Avenue, Trenton, New Jersey, U.S.A.

Walter Ward, m.v. "Vancolite", c/o Marine Dept., Imperial Oil, Ltd., 56, Church Street, Toronto, Ontario, Canada.

John Francis Winzar, 38, Bedford Street, East Fremantle, W. Australia.

Associate Members.

Alfred James Bescoby, 2, Barnhill Terrace, Macduff, Banffshire.

Robert Samuel Hogg, 8, Wickham Chase, West Wickham, Kent.

James Holker, 28, Farrer Road, Longsight, Manchester, 13.

William Laws, 10a, Charlton Road, Blackheath, S.E.3.

Percy Arnold Manville, 6/2, Commissariat Road, Hastings, Calcutta, India.

Christopher Plews, 111, Seaton Road, Yeovil, Somerset.

Albert Ridings, 34, Broadway, Walkden, near Manchester.

Associates.

John Richardson Hannam, Bramall Lane, Sheffield.

Horace Percy Shrubsall, 73, Beaconsfield Road, Blackheath, S.E.3.

Student.

John Henderson Simpson, B.Sc., 31, Brighton Street, Barrow-in-Furness, Lancs.

Transfer from Associate Member to Member.

Ernest Frederick Ryder Townshend, The Rectory, Llanvapley, Abergavenny, Mon.

Transfer from Associate to Associate Member.

Henry Richard Tyrrell, B.Sc., 48, Windermere Road, Muswell Hill, N.10.

Transfer from Student to Associate Member.

William Sephton, Junior Engineer, B.I.S.N. Co., c/o Mackinnon, Mackenzie & Co., Ballard Estate, Bombay, India.

Transfer from Student to Associate.

Edward John Samuel Lang, 72, Admiralty Street, Keyham, Plymouth.

Elected April 8th, 1935.

Members.

Albert Charles Bishop, 67, Mayesbrook Road, Dagenham, Essex.

William Alfred Brooks, c/o Butterfield & Swire, Hong Kong.

Charles Crandell Crosby, 81, Holland Road, East Ham, E.6.

John Cumming, 1012, Cumbernauld Road, Riddrie, Glasgow, E.1.

David Elias Davies, 19, Blake Road, New Southgate, N.11.

Gilbert Robert Gane, 46, Gloucester Gardens, Paddington, W.2.

Harry Charles Gearing, Messrs. Gearings, Ltd., Atlas Works, Capetown, S. Africa.

James Henderson Grieve, 104, Appin Crescent, Dunfermline.

John Henderson, c/o Mackinnon, Mackenzie & Co., Calcutta, India.

Samuel Spencer Lock, Lago Shipping Co., Ltd., Aruba, D.W.I.

Robert Lockhart, Lloyd's Register of Shipping, Shanghai, China.

William McLaughlin, Custom House, Amoy, China.

John Patrick, Jnr., 4, Carlibar Avenue, Glasgow, W.3.

John C. Russell, Sushila, Bhavann, Mahramapet Waltair, Vizagapatam, India.

Lewis Maughan Scaife, 19, Bideford Gardens, Lowfell, Gateshead.

Associate Members.

Wilfred Ernest Grant, 29, Roy Gardens, Aldborough Hatch, Ilford, Essex.

Keki Framroz Lilauwala, 40, Pitha Street, Fort, Bombay, India.

Thomas Rae, 21, Bank Street, Greenock.

Associates.

Akhtar Ahmad, 786, Darul Fazl, Qadian (Punjab), India.

John Robert Carter, 33, Ridgdale Street, Bow, E.3.

John Stuart Elliott, 9, Byron Road, Ealing, W.5.

Tom Salter, 28, Crofton Avenue, Yeovil, Somerset.

Transfer from Associate Member to Member.

Thomas Raymond Murphy, 18, Alexandra Mount, Litherland, Liverpool 21.

Reinstatement and Transfer from Student to Member.

Thomas William Erskine Dommett, Lieut. (E.), R.N., 14, Cranes Park, Surbiton, Surrey.

Transfer from Student to Associate.

Frank Alfred Larter, 11, Ravenscourt Square, W.6.

Visit to the National Physical Laboratory, Teddington.

On Saturday, 30th March, 1935, by kind permission of the Director, a party of thirteen members participated in a visit to the National Physical Laboratory at Teddington. As a short visit would not permit of the whole of the Laboratory being inspected, the tour was confined to the aerodynamical and physical laboratories and the Alfred Yarrow and William Froude Tanks. The wind tunnels and the ingenious apparatus for testing materials examined in the first two sections greatly interested the visitors, and a considerable time was spent at the two tanks where the methods adopted for constructing and testing ship models were demonstrated and were, of course, of special interest to The Institute party.

This highly-instructive visit concluded with tea, which was very kindly provided in the canteen of the Laboratory.

ADDITIONS TO THE LIBRARY.

Purchased.

Kempe's Engineer's Year-Book, 1935. 41st Edn. Morgan Brothers (Publishers) Ltd., 31s. 6d. net.

British Shipping (Assistance) Act, 1935. H.M. Stationery Office, 2d. net.

"Boiler Feed Water", by P. G. Jackson. 3rd Edn. C. Griffin & Co., Ltd., 166pp., illus., 6s. net.

Universities Year Book, 1935. G. Bell & Sons, 15s. net.

Presented by the Publishers.

"Aluminium Facts and Figures". The British Aluminium Co., Ltd.

The Work of the William Froude Laboratory, with a Bibliography. By R. Johnson. Published the The Institution of Mechanical Engineers.

Board of Trade Notice No. M.142. Fees and Expense in connection with Board of Trade Surveys and other Mercantile Marine Services. Reduction of Fees.

The Mond Nickel Co., Ltd.: "Case-Hardening and the Use of Nickel Steels". "Nickel Cast Iron for Sewage Disposal Plants".

Rensselaer Polytechnic Institute Bulletin No. 50. "Theory and Use of the Metallurgical Polarization Microscope".

Ohio State University Studies: "The Effective Use of Cast-Iron Scrap in the Cupola Charge". "Effect of Quality and Intensity of Light on Visual Performance". "Some Effects of Soil, Water, and Climate upon the Construction, Life and Maintenance of Highways".

"Taurus" Bronze Castings, published by Messrs. D. Brown & Sons (Hudd.), Ltd., from whom Members may obtain copies of this publication post free on request.

The Transactions of The Society of Engineers, 1934, containing the following papers:—

"Review of the Present Methods of Sewage Disposal", by Shenton.

"The Development of the Proposed Manapouri-Deep Cove Hydro-Electric Power Project", by Donnelley.

"The Development of a Two-Stroke Cycle Gas Engine", by Brewer.

"Some Problems of To-day", by Watson.

The following British Standard Specifications:

No. 590—1935. Electrically Welded Mild Steel Chain. Short Link and Pitched or Calibrated.

No. 591—1935. Wrought Iron and Mild Steel Hooks of the "C" or Liverpool Type.

No. 592—1935. Steel Castings for General Engineering Purposes.

No. 599—1935. Pump Tests.

No. 412—1935. *Engine Testing Equipment (revised March, 1935).

*Marine engineers are usually anxious to measure the actual performance of their engines at frequent intervals, more especially after an overhaul. For this reason sea-going engineers will be interested in the above new Specification for Engine Testing Equipment (revised edition) which has recently been published.

This specification contains all that appeared in the 1931 edition, but the new issue has two important additions. The first is the inclusion of a fixed standard for the size and form of thread to be adopted for the connections of all engine testing fittings, such as for pipe bosses, thermo-couples, etc., with the object of securing interchangeability of testing equipment, thus making for simplicity as well as efficiency. The second important addition deals with indicator gear, which is broadly grouped into two classes according to the method of operation, i.e. (i) without levers and (ii) with levers. For the lever type, standard proportions are set out, with limits of accuracy of the gear. The lever lengths, connecting rod lengths, position of pivots, etc., on the indicator side of the main fulcrum are proportionally identical with those on the engine side, except of course that they should be to a reduced scale. A diagram giving a suitable form of arrangement is given in the specification.

This British Standard should prove of interest and value not only to the certificated marine engineer but to the junior engineer also. Copies may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 2s. (2s. 2d. post free).

"The Drawing Office Handbook". Compiled by A. B. Cartwright. The Drawing Office Material Manufacturers' and Dealers' Association, Windsor House, Victoria Street, S.W.1. 237pp., illus., 5s. net.

This handbook might well be described as a wealth of information in condensed form. As indicated in the introduction, the formulæ, rules, tables, and data given are all in accordance with the best and most up-to-date practices. The book is divided into four parts with two alphabetical indexes at the end, one of the contents of the book and the other, a very useful one, of British Standard Specifications.

Part I is a digest of British Standard and other Specifications. The extracts are arranged in tables and, being well grouped together, present a convenient, accurate, and time-saving source of information.

The design formulæ in Part II, embracing practically every one the designer needs in his everyday work, are given in a clear and concise manner, together with the name of the responsible authorities for reference. The reviewer, however, is of opinion that Formula No. 46, page 137, has been superseded by the following:—

(1) For Saturated Steam.

$$A = \frac{1{\cdot}25 \times H}{P} \times \frac{E}{6} = \frac{HE}{4{\cdot}8P}$$

where A = Aggregate area of safety valves.
H = Total heating surface to which factor E applies.
P = Absolute pressure of steam.
E = Evap. of lb. per sq. ft. of heating surface (H) per hour with a minimum of 6.

(2) For Superheated Steam.

$$As = A\left(1 + \frac{Ts}{1{,}000}\right)$$

As = Aggregate area of safety valves.
A = Aggregate area of safety valves required without superheat.
Ts = Degree of superheat in degree Fah.

For authority, see "Annual Report, 6th March, 1933, Consultative Committee of Shipbuilders and Engineers appointed to confer with the Mercantile Marine Department of the Board of Trade".

The third part of the book devoted to springs is fully and academically dealt with by T. H. Sanders, and should prove a valuable aid to those whose work embraces problems of this nature.

The last part of the book on strength of materials, testing, heat treatment and the various tables connected therewith makes a fitting finish to a well compiled volume. It is possible that to the student or younger draughtsman the application of some of the formulæ may present a certain amount of difficulty but that objection vanishes with practice. To designers, calculators, and engineers the book can be thoroughly recommended. It will make a most valuable addition to any drawing office reference library.

JUNIOR SECTION.

The Manufacture and Testing of Steel Forgings.

A lecture on the above subject, illustrated by an excellent film and series of slides, was delivered at The Institute on Thursday, March 28th, 1935, by Dr. W. H. Hatfield, Director of Research, The Brown-Firth Research Laboratories. The chair was occupied by Dr. S. F. Dorey (Vice-President), and a large audience of junior and senior members was intensely interested by the lecturer's fluent and comprehensive survey of present-day practice in the manufacture and testing of steel forgings. The lecturer's reply to the keen discussion which ensued added considerably to the already valuable instruction imparted by the lecture and film demonstration. A very cordial vote of thanks to Dr. Hatfield was proposed by Mr. H. S. Humphreys (Vice-Chairman of Council), seconded by Mr. H. R. Tyrrell (Associate Member) and carried with enthusiasm.

It is hoped to publish this lecture and discussion in a later issue of the TRANSACTIONS.

ABSTRACTS.

The Council are indebted to the respective Journals for permission to reprint the following abstracts and for the loan of the various blocks.

BOARD OF TRADE EXAMINATIONS.

List of Candidates who are reported as having passed examinations for certificates of competency as Sea-Going Engineers under the provisions of the Merchant Shipping Acts.

Name.	Grade.	Port of Examination.
For week ended 7th March, 1935 :—		
Church, John E.	1.C.	London
Cumming, Herbert E.	1.C.	,,
Stratton, Arthur	1.C.	,,
Tighe, Jack	1.C.	,,
Carrol, John G. F.	1.C.	Glasgow
Cunningham, James B.	1.C.	,,
Goodall, Robert W.	1.C.	,,
Scott, Alexander H. G.	1.C.	,,
Smith, William N.	1.C.	,,
Firman, Alfred C.	1.C.	Newcastle
Morgan, Cuthbert S.	1.C.	,,
Ogle, George T.	1.C.	,,
O'Neil, William	1.C.	,,
Orr, John E.	1.C.	,,
Walker, Richard	1.C.	,,
Carmichael, Robert	1.C.M.	,,
Wilkinson, George A.	1.C.M.	,,
Wise, Albert A. E.	1.C.M.	,,
Birkett, Henry	1.C.	Liverpool
Gardner, Sydney H.	1.C.	,,
Hall, Percy	1.C.	,,
Henderson, George	1.C.	,,
Irvine, John	1.C.	,,
Smith, Stanley T.	1.C.	,,
Speed, John P.	1.C.	,,
Swain, James R.	1.C.M.	,,
Jones, Griffith F.	1.C.M.E.	London
Syme, Andrew	1.C.M.E.	Glasgow
East, Arthur S.	1.C.M.E.	London
Mathews, Sylvester	1.C.M.E.	Liverpool
Lyons, John W.	1.CM.E.	Newcastle
Jones, Albert L.	1.C.M.E.	Liverpool
Speller, Arthur L.	1.C.M.E.	,,
Cuthbertson, George	1.C.M.E.	Newcastle
Gillies, Roberts	2.C.M.E.	Glasgow
For week ended 14th March, 1935 :—		
Mitchell, William O.	2.C.	Glasgow
McGuffie, David D.	2.C.M.	,,
Grierson, Donald	2.C.	Liverpool
Hesketh, Herbert F.	2.C.	,,
Hoole, George	2.C.	,,
Rostron, John	2.C.	,,
Bale, Owen T.	2.C.	Cardiff
Jenkins, Charles A.	2.C.	,,
Thomas, Arthur H.	2.C.	,,
Mason, John D. T.	2.C.	London
Charlton, Alfred H.	2.C.	Newcastle
Cowey, Robert P.	2.C.	,,
Riddle, Ellison H.	2.C.	,,
Wood, William H.	2.C.	,,
Gandy, Arthur N.	2.C.M.E.	,,
Appleton, Ronald	Ex.1.C.	Liverpool
Dixon, John G.	Ex.1.C.	Newcastle
Millar, John G. M.	Ex.1.C.	Glasgow
Barrow, John A. R. K.	Ex.1.C.	London
Payne, John E. M.	Ex.1.C.	,,
Vose, William A.	Ex.1.C.	,,
Webb, Frederick W. J.	Ex.1.C.	,,
For week ended 20th March, 1935 :—		
Brooks, William Alfred	1.C.	London
Adams, Frank	1.C.	,,
Olsen, Lewis Mickael	1.C.M.	,,

Name.	Grade.	Port of Examination.
Brown, Robert Arthur	1.C.	Newcastle
Dimond, James William	1.C.	,,
Elsdon, Jonathan Sharp	1.C.	,,
Jordan, Edwin Cyril	1.C.	,,
Meadley, John Bradford	1.C.	,,
Woodrow, Reginald James	1.C.M.	,,
Manning, Henry Eric	1.C.	Liverpool
Dufton, Stanley John	1.C.	,,
Hepburn, William George	1.C.	,,
Wynne, Roy Leslie	1.C.	,,
Young, Joseph Harold	1.C.	,,
James, Evan Trevor	1.C.	Cardiff
Price, Rees Whitney	1.C.	,,
Taylor, Harold	1.C.	,,
Campbell, Donald	1.C.	Glasgow
Inverarity, Patrick Robertson	1.C.	,,
Johnston, David Smith	1.C.	,,
Leitch, John	1.C.	,,
Mackie, Charles	1.C.	,,
McCrorie, Alexander Hood	1.C.	,,
McNeillie, David Andrew	1.C.	,,
Nicholson, John	1.C.	,,
Adamson, James	1.C.M.E.	,,
Ritchie, John	1.C.M.E.	,,
Davies, Ernest Archibald	1.C.M.E.	Cardiff
Coates, Thomas	1.C.M.E.	Liverpool
Brown, John Wilfred	1.C.M.E.	Newcastle
Crowther, Alfred Edward	2.C.S.E.	,,
Quack, Bryan Murray Aitken	1.C.S.E.	London
Tuck, Ernest St. John	1.C.M.E.	,,
Crone, Adam Smith Thomson	1.C.M.E.	,,
Church, John Edward	1.C.M.E.	,,
For week ended 28th March, 1935 :—		
Allan, John S.	2.C.	Glasgow
David, Alexander B.	2.C.	,,
Faulds, Joseph S.	2.C.	,,
Edwards, George L.	2.C.	London
Ellison, Arthur	2.C.	,,
Flesselles, Cedric G.	2.C.M.	,,
Bell, Thomas	2.C.	Liverpool
Cain, William L.	2.C.	,,
Foster, Jack E.	2.C.	,,
Kean, Walter	2.C.	,,
Lewis, Thomas W.	2.C.	,,
Peddar, Herbert P.	2.C.	,,
Whyte, Patrick F.	2.C.	,,
Williams, Henry T.	2.C.M.	,,
Andrews, David G.	2.C.	Newcastle
Doran, Francis J.	2.C.	,,
Grey, William	2.C.	,,
Hetherington, Victor J.	2.C.	,,
Sinclair, Donald A.	2.C.	,,
Tallack, Arthur	2.C.	,,
Jackson, William G.	2.C.M.	,,
Pace, William	2.C.M.	,,
For week ended 4th April, 1935 :—		
Brown, Angus P.	1.C.	Glasgow
Hutton, James C.	1.C.	,,
Bickford, John H. P.	1.C.	London
Hannan, James A.	1.C.	,,
Potts, Frederick J.	1.C.	,,
Smith, William J.	1.C.	,,
Bishop, Albert C.	1.C.M.	,,
Gunthorp, Percy J.	1 C.M.	,,
Lunt, Alfred N.	1.C.	Dublin
Carswell, John	1.C.	Liverpool
Jones, William J. L.	1.C.	,,
Law, Stanley	1.C.	,,
McKinnon, Robert	1.C.	,,

Name.		Grade.	Port of Examination.
Murphy, Thomas R.	...	1.C.	Liverpool
MacSween, Murdo A.	...	1.C.M.	„
Barker, Charles H. ...	...	1.C.	Newcastle
Gent, William ...	...	1.C.	„
Hall, Richard E. ...	...	1.C.	„
Harrison, Alfred ...	...	1.C.	„
Terry, Robert ...	...	1.C.	„
Rowell, Frank ...	...	1.C.M.E.	„
Lusher, Ernest ...	...	2.C.M E.	„
Moore, Frederick E.	...	1.C.M.E.	Liverpool
Peters, Harold B. ...	...	1.C.M.E.	Glasgow
Bellis, John L. ...	...	1.C.M.E.	Liverpool
Chapman, Frederick G.	...	1.C.M.E.	London
Hobling, John C.	...	1.C M	„

Boiler Explosion Inquiries.

"Engineering", 22nd March, 1935.

In accordance with the Boiler Explosions Acts, 1882 and 1890, inquiries have been conducted by Board of Trade officials into a number of explosions. Reports of the investigations have been published recently, and of some of these we give brief summaries below.

Explosion in S.S. "Ardglass".—One source of accidents with boilers is badly fitting man-hole doors. Doors which are corroded away to any extent sometimes allow the jointing material to be blown out, and though there is generally some previous warning, when the joint does blow out the results may well prove serious. An instance of this is given in Report No. 3244, which deals with the failure of a man-hole joint in the small steamer "Ardglass", of 845 tons gross. The vessel had one ordinary return-tube boiler working at 180lb. per sq. in. The ship and machinery were built in 1919. Proper surveys were carried out and the last survey, strangely enough, was made on October 12th, 1933, a week before the accident, which occurred on October 19th. New man-hole jointing rings were fitted on the previous day just prior to lighting up. After the boiler commenced to generate steam, some leakage took place from the lower man-hole doors and they were accordingly tightened up. In spite of this, at 7 a.m. on October 19th a portion 8in. in length of the jointing ring for the starboard manhole was forced out, the contents of the boiler escaped into the stokehold and a fireman was so badly scalded that he died in hospital. The inspecting officers say that on trying the door in position it was found that, with the spigot resting on the bottom of the manhole there was a clearance, due to wastage, of $\frac{3}{8}$in. between the spigot and the flanged opening. It is probable, they add, that the joint ring was inadvertently pushed out of position when the door was being manipulated into place. The manholes and manhole doors were subsequently made good by electric welding.

Explosion in Steam Wherry "Claude".—The report, No. 3240, of a formal investigation which was held owing to an explosion of a vertical boiler in the steam wherry "Claude", is of interest only as it emphasises the need for boilers being in charge of competent persons. The accident occurred on August 21st, 1933, when the vessel was under way in the River Tyne. The vessel herself, a small craft of 27 tons, was 66 years old, and the boiler 26 years old. For many years the boiler had not been properly surveyed or repaired, and was in a totally unfit condition for use at all, as examination after the accident showed that some of the shell plating was wasted away to little more than the thickness of paper. The Commissioners, in their report, remark that "this case affords another example of a matter referred to in a previous case, namely the desirability of having all boilers to which the Boiler Explosions Acts refer periodically inspected by a competent person. The risks run by the users of steam boilers are obviously enhanced in cases where those in charge of their management have little or no experience". An unfortunate result was that one of the persons on board at the time fell overboard through being struck by the escape of steam and was drowned. So serious a view did the Commissioners take of the neglect of the owner to take proper precautions that they ordered him to pay £50 towards the cost of the investigation.

Failure of a Welded Boiler Tube.—No one will deny that solid-drawn boiler tubes are better than welded tubes and that they should invariably be used in the rows nearest the fires in water-tube boilers. This view is emphasised by the remarks contained in Report No. 3255, dealing with an unfortunate accident with an old Babcock & Wilcox land-type boiler at the Ladysmith Works, Whitehaven, of Messrs. The Priestman Whitehaven Collieries, Limited, on August 22nd, 1934. The boiler itself was 34 years old and had been sold to the Whitehaven Colliery Company in 1927 by the Glasgow Corporation. It had 180 generating tubes, 4in. external diameter and 18ft. long in 10 rows, and it was worked at 210lb. per sq. in. pressure. There had been several renewals of tubes, and most of the tubes, but not all, in the lower rows were solid-drawn. On the day of the accident a welded tube in the second row burst along the welded seam and opened up for 18in. of its length. Tests of the materials were carried out with satisfactory results, but examination of sections taken close to the fracture revealed the presence of slag inclusions in sufficient quantities to justify the conclusion that there had been a latent defect in the weld. The boiler was insured, regularly inspected, and under proper supervision. Unfortunately, just at the time of the accident one of the attendants was removing ashes and clinker from the boiler, and was unable to escape quickly enough to avoid being burnt and scalded so badly that he died in hospital on the day following the accident. In the observations of the Deputy Engineer Surveyor-in-Chief, attached to the report, it is stated that, "having regard to the nature of the conditions immediately above the fire, it is considered essential that tubes in the rows near the fire should be solid-drawn in all cases".

"Engineering", 5th April, 1935.

Explosion of a Feed-Water Heater.—Report No. 3256 deals with an unusual accident which occurred at the Sculcoates Lane Power Station, Hull, on July 30th, 1934, when a low-pressure feed-water heater burst with disastrous results. At the Sculcoates Lane station, the generating plant includes two 14,000 kW. Brush-Ljungström turbo-generators supplied with steam at 375lb. per sq. in. pressure. The auxiliary plant for each unit comprises a main condenser, a turbo-driven circulating pump, a turbo-driven extractor pump, an air ejector, and two feed-water heaters of the surface type, known as the high- and low-pressure heaters, respectively. One of the units, No. 5, was set to work in December, 1927, and the other, No. 6, in February, 1930. As originally fitted the high-pressure feed heaters were supplied with bled steam from the turbines, while the low-pressure feed heaters were heated by the exhaust steam from the circulating and extractor pumps. Though the low-pressure heaters had no relief valves fitted directly to them, the arrangement of pipes and valves was such that when the steam pressure rose above 3lb. per square inch, an atmospheric relief valve on the pipe system came into action. Experience with No. 5 unit showed that the use of bled steam was not economical, and alterations were carried out so that the high-pressure feed heater should be heated by the exhaust from the ejector and steam from the turbine drains. This alteration being successful, similar changes were made in the connections of No. 6 unit, but at a trial on May 8th, 1934, after No. 6 unit had been rebladed, it was decided to place the drain connections lower down on the body of the high-pressure heater. In carrying out the work, the foreman fitter, instead of reconnecting the drains to the high-pressure heater, connected them to the low-pressure heater, thus making it possible for the low-pressure heater to be subjected to much higher pressures than was ever intended. No. 6 unit was started up about 1.15 p.m. on May 9th and run until about 11.45 a.m. on May 10th when, owing to a fault in the alternator, it was closed down and was out of commission until July 30th.

Repairs being completed, orders were given to restart the turbine, and it was while the turbine was being warmed up on the afternoon of July 30th that the accident happened, the cast-iron casing of the low-pressure heater being blown to pieces. Five men were injured, and one of them was so badly scalded that he died. In commenting on the accident, the Deputy-Engineer Surveyor-in-Chief says, "Those with experience of large plant will appreciate that in spite of care and organisation, mistakes and unforeseen circumstances will sometimes occur, and it is fortunate for the peace of mind of those responsible that they are not always followed by the serious consequences which obtained in this case". No explanation is given in the report why the foreman fitter, on his own initiative, connected the drains to the low-pressure heater. The heater which burst was about 2ft. in diameter and a little over 7ft. long between the tube plates. It has since been replaced by a heater with a steel, instead of a cast-iron, casing, and with a relief valve fitted directly to the shell. The City Electrical Engineer has also issued an instruction that: "No alteration to plant at the power station must be made without my written consent, and when this has been given, the maintenance engineer will notify the operating staff in writing of the proposed alterations, and such alterations must be noted in the official log book".

All-welded Ship—Reduction of Weight.

"The Engineer", 22nd March, 1935.

In a paper before the Institution of Engineers and Shipbuilders in Scotland, Mr. M. E. Denny described the two Diesel-electric paddle ferry ships put into service a year ago on the Queensferry passage across the Forth, one of which was the first all-electric-welded ship to be built in Scotland. He said that the finished steel weight of the welded ship was 12 per cent. lower than that of her sister ship. The vessels are scheduled to make some 23,296 crossings a year, and they have maintained a standard of regularity of 98·5 per cent.

On Supercharging.

"The Motor Ship", April, 1935.

At the spring meeting of the Institution of Mechanical Engineers (Internal Combustion Engine Section) there was a small series of papers on supercharging, one of which dealt with marine oil engines. It was read by Mr. Sterry B. Freeman, superintendent engineer of Messrs. Alfred Holt & Co. In these days, pressure charging with four-stroke engines is usual, and the majority of Diesel motors of this class will, no doubt, in the future, be fitted with superchargers. Nevertheless, it is well to place on record the conclusions of Mr. Freeman, whose experience of supercharging with marine engines is very extensive, that the fears of increase in piston and cylinder liner wear and other disadvantages "are unfounded".

Superintendent engineers have, at times, been somewhat anxious as to the results of the high mean pressures employed when pressure charging is utilized, and Mr. Freeman's experience of this matter is, therefore, of considerable interest. Whilst for normal unsupercharged four-stroke engines he would set the limit at 93lb. to 95lb. per sq. in. (referred to indicated power), for supercharged units he would allow up to 130lb. per sq. in. for a Büchi pressure-charged engine of 630mm. diameter and 122lb. per sq. in. with the Rateau pressure-charging system in an engine with cylinders 740mm. in diameter. If these pressures are exceeded it is found that trouble may be expected with the cylinder heads, although it is possible that, with more experience, higher pressures will become permissible.

From an economic analysis, the necessity for the adoption of pressure charging appears to be proved. The extra cost of the engine is probably in the neighbourhood of 7 per cent., and additional power from 25 per cent. up to 40 per cent. can be obtained with an increase of only about 4 per cent. in the weight of the engine. Mr. Freeman gave some particulars of the results attained with supercharged engines in vessels of large size; the fuel consumptions over long periods in service varied between 0·37 and 0·386lb. per b.h.p.-hr. for exhaust-gas pressure charging or with chain-driven blowers.

Heat Generation from Exhaust Gas.

The Determination of the Quantity of Hot Water or Steam Obtainable from the Exhaust Gases of Two-stroke Diesel Engines.

By Dip. Ing. Ehmsen, Kiel.

"The Motor Ship", April, 1935.

In "The Motor Ship" of February, 1934, a page of curves was given by means of which the amount of hot water or steam which could be raised from the exhaust gases of four-stroke Diesel engines could readily be determined. Corresponding curves are given on the opposite page dealing with two-stroke machinery.

In the ordinary way, the four-stroke single-acting engine comes into question mainly for units of small and moderate power, hence in the curves which were previously given engines up to about 1,600 h.p. were dealt with. The two-stroke engine is more widely adopted when larger outputs are needed, and the present curves relate to units up to 8,000 b.h.p. For bigger sizes, the figures derived for powers up to 1,600 b.h.p. or 8,000 b.h.p. respectively can be proportionately increased, according to the power developed.

The available quantity of heat in exhaust gases can be calculated from the exhaust gas weight and temperature, and the exhaust gas weight with two-stroke engines is dependent on the stroke volume of the scavenging pump. On account of the large quantity of air supplied by the scavenging pump, the exhaust gas temperature with two-cycle engines is substantially lower than that with four-stroke motors, and it is normally between 300° C. and 320° C. for engines over 1,000 b.h.p. In the accompanying graph, in Fig. 1 for full load, a temperature of 310° C. is chosen. Naturally, any particular temperature may be introduced in its place, and the following calculations correspondingly modified.

All that is necessary to appreciate the theory of the conversion of exhaust gases, so far as the understanding of the graphs given is concerned, is stated in the article to which reference has previously been made. It may merely be added that the exhaust gas weight (G_A) is the sum of the weight of air supplied to a scavenge pump (G_L) and the fuel weight (G_B), or

$$G_A = G_L + G_B$$

G_L is ascertained from the following equation:—

$$G_L = \frac{n \times V_h \times x \times y}{60}$$

In which n = the revolutions of the engine.

V_h = the total stroke volume of the engine.

x = the excess of scavenging air.

y = the specific weight of the air.

x is usually in the neighbourhood of 1·35.

In order to illustrate the use of the curves the following examples may be given.

Example I.

How many kilogs. of steam at a pressure of 4·8 atmospheres and a feed water temperature of 16° C. can be raised from the exhaust gases of a two-stroke Diesel engine of 5,500 b.h.p. at full load?

According to Fig. 1, the exhaust gas weight for an output of 5,500 b.h.p. at full load is 51,500 kilogs. per hour. Through the point of junction of the lines representing 5,500 b.h.p. and 100 per cent. load a line is drawn parallel to the line of equal exhaust gas weight and transferred parallel to the corresponding line in Fig. 2.

Further, in Fig. 3, through the point where the lines representing 4·8 atmospheres and 15° C. feed water temperature meet, a parallel is drawn to the line of equal heat content, and continued parallel to the corresponding lines in Fig. 4. In the foregoing case, according to Fig. 1, the exhaust gas temperature (T_A) equals 310° C., and, according to Fig. 3, the steam temperature (T_B) is about 150° C. The temperature drop is therefore—

$$T = T_A - T_D = 310 - 150 = 160° \text{ C.}$$

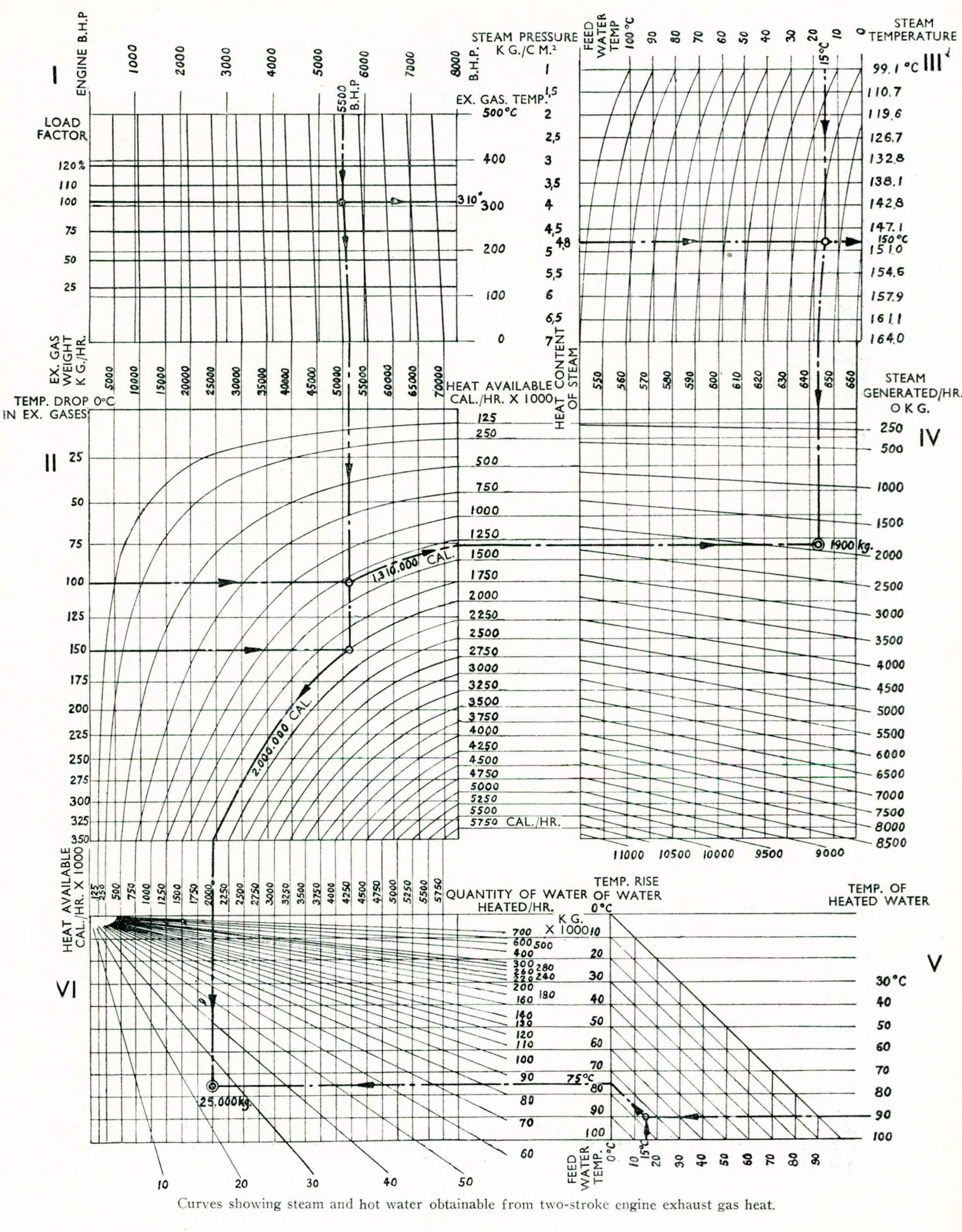
It has been found that in order to obtain the most efficient operation of exhaust gas plant the temperature of the exhaust gases when leaving the boiler should be some 60° C. above the maximum temperature of the hot water or the steam. Hence, the actual available temperature drop is 160° − 60° = 100° C.

Through the meeting point of the lines representing 100° C. and 51,500 kilogs. exhaust gas weight in Fig. 2 a parallel line is drawn to the line of the heat content. The line is transferred and continued in Fig. 4 until it crosses the line representing heat content in Fig. 3. The point where the two lines meet gives the hourly amount of steam raised, which, in this case, amounts to 1,900 kilogs.

Example II.

How many kilogs. of hot water at 90° C. and with a feed water temperature of 15° C. can be raised from the exhaust gases of a two-stroke Diesel engine developing 5,500 b.h.p. at full load?

In Fig. 5 through the junction of the lines representing 15° C. feed water temperature and 90° C. hot water temperature, a parallel line is drawn to the line for equal temperature increase and con-



Curves showing steam and hot water obtainable from two-stroke engine exhaust gas heat.

tinued as a parallel to the corresponding line, Fig. 6. The temperature fall of the exhaust gases in this case is as under :—

$$T = T_A - T_W - 60 = 310 - 90 - 60 = 160° \text{ C.}$$

That is, the exhaust gases will be cooled from $T_A - T = 310° \text{ C.} - 160° \text{ C.} = 150° \text{ C.}$

On account of the question of condensation, the exhaust gases should not be cooled below 160° C., so that the maximum temperature fall which is actually possible is 310° C.−160° C.=150° C.

Through the point where the line for 150° C. and 51,000 kilogs. per hour cross in Fig. 2 a parallel to the line of equal heat content is drawn, and again continued as a parallel to the corresponding line in Fig. 6 until it cuts the line in Fig. 5, representing the temperature fall of the water. This point gives the hourly quantity of hot water produced, which, in this case, is 25,000 kilogs.

The British Corporation Register of Shipping.

"Engineering", 29th March, 1935.

The 45th annual report of the British Corporation Register of Shipping and Aircraft, while mainly concerned with matters affecting the subscribers to the Register and owners of vessels holding its classification, such as the recent revision of the ship and machinery Rules, contains also a number of items of wider interest. At the figure of 31,000 tons the total of classed tonnage built during the year ended December 31st, 1934, although still only one-seventh of the normal amount, is some 40 per cent. greater than in the previous twelve months, and the variety of the vessels included in this total indicates that the shipping improvement is becoming more generally distributed. The largest vessel in the list is the cargo motorship "Houston City" (4,935 tons) with Doxford engines, built by the Furness Shipbuilding Company for the Cardiff firm of Sir William Reardon Smith & Sons.

The extended use of welding in ship and engine construction is the subject of several references. The engine framing and bedplate of the "Houston City" were fabricated and electrically welded, as also were those of the enclosed three-cylinder compound steam engines built by Messrs. A. Stephen & Sons for the Henderson cargo steamer "Martaban". Comparative service records of particular value in the study of ship welding are expected from the Firth of Forth ferries "Queen Margaret" and "Robert the Bruce", the latter of which is welded throughout, the sister vessel being riveted in the usual manner. Both are driven by Davey Paxman engines coupled to Metropolitan-Vickers generators, the motors being connected to the paddle shafts by chain gearing.

The revision of the Rules of the Corporation which included recasting the tables of longitudinal scantlings, a considerable expansion of the machinery rules, and what is described as a "reconstruction" of the special survey rules, included, also, a list of new requirements for ice strengthening. These are divided into five grades ranging from protection against occasional ice, to the highest standard required by the Government of Finland. The new Rules took effect as from November 1st, 1934. The survey of aircraft, in which the British Corporation was early associated, showed a further increase during the year. In this work the Corporation has acted jointly with the corresponding Committee of Lloyd's Register, the two authorities combining to become the Joint Aviation Advisory Committee in 1932, at the instance of the Air Ministry. The future development of aircraft survey work is at present subject to some uncertainty, however, in view of the recommendations of the Gorell Committee on the control of civil aviation.

The address by Mr. G. J. Innes, vice-chairman of the Corporation, with which he presented the report on February 27th, expressed some doubt regarding the possible effect of the Government scheme for the rehabilitation of British shipping, and commented on the absence of any safeguard against the defects which had been found in the operation of the Trades Facilities Act. In particular, he instanced the risk that the Government plan might provide funds for owners who could not or would not obtain them through the normal channels, for the construction of ships which could not operate successfully without embarrassing existing British services.

Mr. Maurice E. Denny, C.B.E., chairman of the Technical and Aviation Committee, followed Mr. Innes's address with a review of the technical work of the year, and outlined the changes in the Rules. These now embody tables covering all normal requirements for vessels from 100ft. to 750ft. long. He remarked upon the great variety of "economy" engines, boilers and axiliaries, which "engineers have been and are busy producing without stint". There is something new and different, he said, in the propelling power of almost every new ship, and a shipbuilder might be pardoned for wishing that engineers would settle down to a lesser number of well-marked "best types" for different services. He drew particular attention to the extended development of electricity on board ship, alike in "hotel" equipment, auxiliary machinery, and main propelling plant, observing that the evidence of expansion in every direction is now strong enough to justify the suggestion that marine engineering is reaching the closing stages of a great steam era, and entering upon an electric era in which steam is a subsidiary.

Turning to the aviation branch of the Corporation's work, Mr. Denny summarised the evolution of aircraft survey practice during the last 10 years and the organisation of the Aircraft International register, in which the inspection authorities of France, Germany, the United States, Norway, Italy, and Japan, with the British Corporation representing Britain, agreed on the application of common rules as far as practicable. The association of the British Corporation with the International Register terminated on the formation of the Joint Aviation Advisory Committee in conjunction with Lloyd's Register.

THE INSTITUTE OF MARINE ENGINEERS

Founded 1889. Incorporated by Royal Charter, 1933.

PATRON: HIS MAJESTY THE KING.

Photo.] [*Vandyk.*

We tender loyal greetings and congratulations to our gracious Patron, His Majesty King George V, on the attainment of his Silver Jubilee.

Long may he reign.

God save the King.