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The Loeffler Boiler Installation in the s.s. "Conte Rosso."

READ

By S. McEWEN (Associate).

On Tuesday, March 9th, 1937, at 6 p.m.

CHAIRMAN: Mr. H. S. HUMPHREYS (Chairman of Council).

Synopsis.

THE s.s. "Conte Rosso", an Italian passenger liner of the luxury class built by Messrs. William Beardmore & Company, after fourteen years of service has been modernised. The principal innovation provided for the installation of a superposed high-pressure plant designed to develop an additional 5,000 s.h.p. and to increase the speed of the vessel by 1½ knots without alteration to the original turbine and condenser equipment.

The performance of the Loeffler boiler generating steam at a pressure of 1850 lb. per sq. inch and a temperature of 890° F., together with the high pressure turbines, is described and particulars are given of the operation of all the accessory equipment including the automatically-controlled high-pressure feed pumps, steam circulating pump and various indicating instruments.

Entropy and Sankey diagrams are given together with the essential data showing the relative performance of the old and the modified power plants.

The information given in the paper is based on the author's own observations during the preliminary trial trips before the vessel resumed its normal service but supplemented and confirmed by reports received from observers who have continued to record the operation of the plant throughout several trips between Genoa and Shanghai.

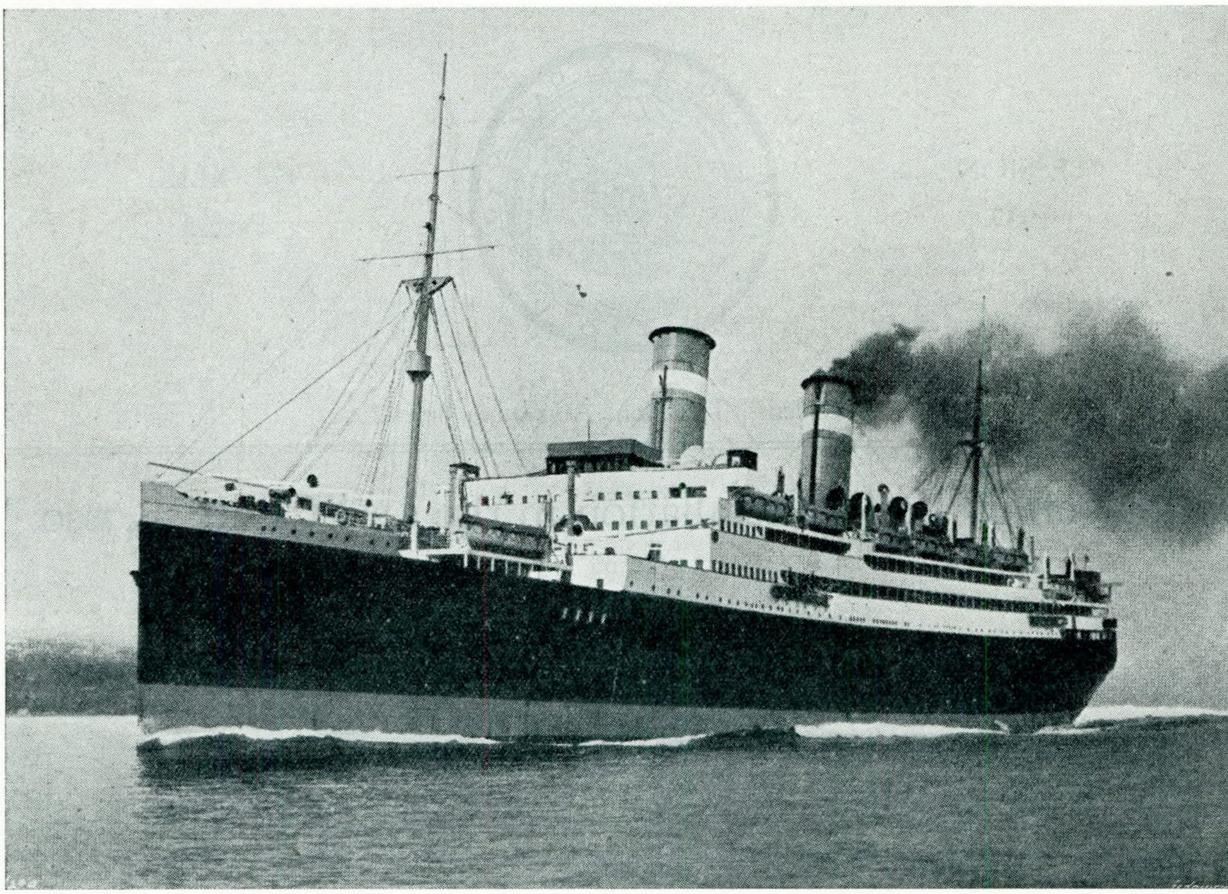
The s.s. "Conte Rosso" is a passenger ship of 18,500 gross tonnage and was built by Messrs. William Beardmore & Company at their Dalmuir Works for the Lloyd Sabaudo Company of Genoa and now operated by the Company under the name of Messrs. Lloyd Triestino of Trieste. The original acceptance trials were completed as long ago as

February, 1922, but the apparent modernity of its luxurious appointments may be understood by referring to "Engineering" of February, 1922, in which a full description of the ship was given. This description was introduced by the statement that "the standard of comfort, convenience and elegance attained in the public rooms and accommodation of passenger steamers, which has now advanced steadily for many years past, has been carried a distinct step forward in the 'Conte Rosso' ".

In March, 1936, the vessel was placed in the hands of Messrs. Cantieri Reuniti dell Adriatico for general overhaul and redecoration. The provision of an open-air bathing pool with sun-bathing terraces, in addition to many other amenities, entitles the ship to be included in the class of luxury liners. Some knowledge of the type of vessel selected for the installation of a Loeffler super-pressure boiler is necessary in order to appraise the degree of confidence with which the owners must have entertained this super-pressure Loeffler system before consenting to its installation.

As part of the reconstruction work it was arranged to increase the power developed by 5,000 s.h.p. from 17,000 s.h.p. to 22,000 s.h.p. and by this means to increase the speed of the ship by $1\frac{1}{2}$ knots.

The original boiler equipment included six double and two single Scotch marine boilers generating steam at a pressure of 200 lb. per square inch. superheated to a temperature of 572° F. One single-ended boiler, which had a maximum capacity of 16,000lb. of steam per hour, was removed and in its place a Loeffler marine boiler was installed capable of generating at normal rate 44,000lb. of steam per hour at a pressure of 1,850lb. per square inch and a temperature of 890° F. The maximum rate provided for was 55,000lb. of steam per hour.



[Reproduced by permission from "Engineering".

View of s.s. "Conte Rosso" on trials.

The Loeffler boiler unit was manufactured by Messrs. Vitkovice Mines, Steel & Ironworks Corporation in their boiler shops at Vitkovice, Moravska-Ostrava, Czechoslovakia. It was installed by them under the direction of Messrs. Cantieri Reuniti dell Adriatico.

The ship has two propeller shafts, and the original turbine equipment which is retained consists of high- and low-pressure turbines with reversing stages coupled through gearing to each propeller shaft. The new turbine installation consists of two super-pressure machines manufactured by Messrs. Escher Wyss of Zurich, one for each propeller shaft and coupled thereto through new gearing forming an extension of the existing gearing. The two super-pressure turbines work in series, that is, all the high-pressure steam from the Loeffler boiler is delivered to one turbine which exhausts at a pressure of 660lb. per square inch to the second turbine. The exhaust steam from the second turbine passes through a steam-to-steam reheater and is delivered to the principal steam main at a pressure of 200lb. per square inch and a temperature of 572° F.

It will be seen that to obtain the additional power required it was decided to superpose a super-pressure steam plant on the existing equipment to an extent which would avoid any modification to the existing turbine, condenser and auxiliary equipment and which could be accommodated within the confines of the existing boiler and engine rooms.

This method of increasing the power and speed of an existing ship at a relatively low capital cost with a relatively low fuel consumption per additional s.h.p. constitutes a development which should prove to be of considerable interest and importance to shipping companies.

The Loeffler system of high-pressure steam generation was described in a paper read at a meeting of this Institute in April, 1935, forming part of "A Symposium on High-Pressure Boilers", and it will therefore be unnecessary to repeat the description in the present paper. A detailed description of the original power plant of the vessel is also omitted since a very full and detailed account is given in "Engineering" of February 17th and 24th, 1922.

The installation of the high-pressure plant together with the general overhaul referred to was completed towards the end of August, 1936, and by the courtesy of Messrs. Lloyd Triestino and of the chief engineer of that company—Dr. Ing. Alfredo Fabri—the author, who desires here to express his gratitude for the privilege, was permitted to be present during the preliminary trials of the new plant, to make the journey with passengers from Trieste to Genoa and subsequently to continue his observations during the run from Genoa to Naples on the outward passage of the ship from Genoa to Shanghai. The invitation extended to the author was in recognition of the interests of Messrs. Mitchell Engineering Limited who own the British rights for the Loeffler system.

The preliminary trials were confined to those which were necessary to comply with the safety regulations required by the classification societies, viz. Registro Italiano and Lloyd's Register of Shipping, before permission could be given for passengers to be carried.

These preliminary trials provided for the operation of the plant while manœuvring in the Adriatic and the subsequent inspection of all parts subjected to heat and pressure, the discharge of the full output of the Loeffler boiler through the safety valves for a period of twenty minutes and the instantaneous cut-off of the supply of steam to the high-pressure turbine when the boiler was operating at full load. These trials being made, the ship was able to leave Genoa for Shanghai on its scheduled date.

During all these initial operations the boiler proved to be very responsive to the demands made on it. When starting up from cold, steam from the low-pressure main would be admitted to the boiler tubes and to the evaporator drum until the whole system was filled with low-pressure steam. The steam circulating pump would then be started and circulation maintained until a supply of high-pressure steam was required. The oil burners would then be lighted and the pressure quickly raised to the full working pressure of 1,850lb. per square inch.

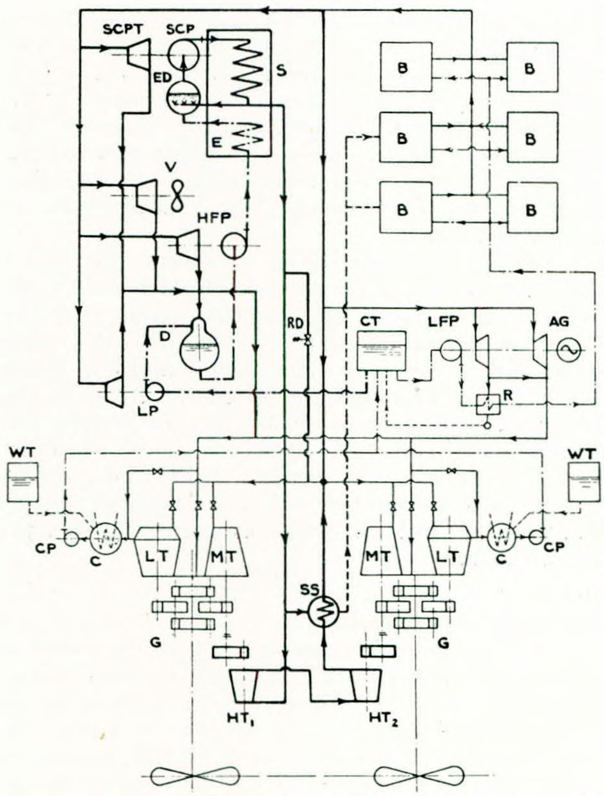
Description of Installation.

A diagrammatic representation of the complete power plant incorporating the super-pressure system is given in the Flow Sheet, Fig. 1. Following the flow of the high-pressure steam, it leaves the Loeffler boiler S. at a pressure of 1,850lb. per square inch and a temperature of 890° F. and passes to the high-pressure turbine H.T.1, thence to the turbine H.T.2 at a pressure of 668lb. per square inch and a temperature of 644° F. The exhaust from the H.T.2 at a pressure of 215lb. per square inch and a temperature of 428° F. passes through the steam-to-steam reheater where it is reheated to 572° F. and thence is delivered to the steam main from the Scotch marine boilers. As will be seen the steam-to-steam reheater S.S. is supplied with steam direct from the Loeffler boiler, which steam condenses and in addition to giving up its superheat and latent heat is undercooled to a temperature of 440° F. The condensate is returned to the Scotch marine boilers, advantage being taken of the difference in pressure so to conserve the sensible heat in the condensate.

The auxiliaries of the Loeffler boiler, namely the turbines driving the steam circulating pump S.C.P. and the high-pressure feed pump H.F.P., are driven by a steam supply of 200lb. pressure from the main supply and they exhaust into a main connected to the low-pressure turbines of the main sets and to the de-aerator.

For emergency purposes a reducing valve R.D. is fitted to a branch of the super-pressure steam main from the Loeffler boiler in order to provide a supply of steam at 200lb. pressure to the main and reversing turbines.

The feed water to the Loeffler boiler is taken from the condensate tank C.T. and pumped to the de-aerator and thence at a temperature of 250° F. to the high-pressure feed pump H.F.P.



S	Superheater.	HT_1	First h.p. turbine.
E	Economiser.	HT_2	Second h.p. turbine.
ED	Evaporator drum.	MT	M.P. turbine.
SCP	Steam circ. pump.	LT	L.P. turbine.
SCPT	Steam circ. pump turbine.	G	Gear.
V	F.D. fan.	SS	Steam to steam re-heater.
HFP	H.P. feed pump.	CP	Condensate pump.
D	De-aerator.	CT	Condensate tank.
LP	Lift pump.	C	Condenser.
B	Scotch marine boiler.	WT	Water tank.
LFP	L.P. feed pump.	AG	Auxiliary generator.
R	Feed re-heater.	RD	Reducing valve.

FIG. 1.

Performance Data.

Output 22,280 shaft h.p.

LOEFFLER BOILER PLANT.

Boiler output	44,000lb./hr.
Superheated steam pressure...	1,850lb./sq./in.
Superheated steam temperature	890° F.
Superheated steam temperature of steam leaving radiant superheater	770° F.

Feed Water.

Temperature of feed water—boiler inlet...	250° F.
Temperature of feed water leaving economiser	464° F.
Stack temperature	300° F.
CO_2	12%
Efficiency of Loeffler boiler	90%

First H.P. Turbine.

Output	1,300 shaft h.p.
R.p.m.	9,200
Steam pressure inlet	1,780lb./sq./in.
Steam temperature inlet	880° F.
Steam pressure exhaust	668lb./sq./in.
Steam temperature exhaust	644° F.

Second H.P. Turbine.

Output	1,300 shaft h.p.
R.p.m.	9,200
Steam pressure inlet	655lb./sq./in.
Steam temperature inlet	644° F.
Steam pressure exhaust	213lb./sq./in.
Steam temperature exhaust	428° F.

Circulating Pump Turbine.

Output	260 - 360 h.p.
R.p.m.—normal load	9,200 - 10,100

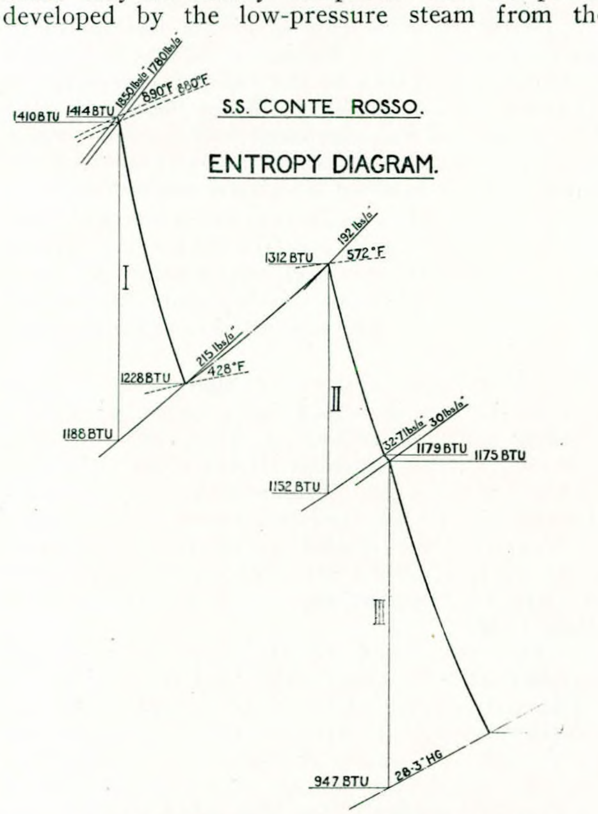
H.P. Feed Pump Driving Turbine.

Output	285 - 356 h.p.
R.p.m.	9,400 - 9,900

Scotch Marine Boiler Plant.

Superheated steam pressure	200lb./sq./in.
Superheated steam temperature	572° F.
Feed water inlet temperature	210° F.

In order that the power developed by the high-pressure high-temperature steam from the Loeffler boiler may be readily compared with the power developed by the low-pressure steam from the Scotch marine boilers, an entropy diagram is given in Fig. 2. The table below the entropy diagram gives the comparative performance of the modified plant with the superposed unit and the performance of the original plant.



LOEFFLER BOILER	
SUPERHEATED STEAM PRESSURE	1850 lbs/"
" " TEMP.	890°F
BOILER EFFICENCY	90%

SCOTCH MARINE BOILER	
SUPERHEATED STEAM PRESSURE	200 lbs/"
" " TEMP.	572°F
BOILER EFFICENCY	78%

NEW PLANT

	LBS. OF STEAM PER HOUR	ADIAB. HEAT DROP BTU/LBS	OUTPUT S.H.P. HR.
I	40500	222	2600
II	153300	160	7230
III	185400	228	12450
	TOTAL OUTPUT		22280

OIL CONSUMPTION $\frac{1}{22280}$ $\left(\frac{44000\text{x}1196}{0\cdot9\text{x}18000}+\frac{190000\text{x}1134}{0\cdot78\text{x}18000}\right)=0\cdot836$ lbs./SHP.

OLD PLANT

	LBS. OF STEAM PER HOUR	ADIAB. HEAT DROP BTU/LBS	OUTPUT SHP. HR.
II	143000	160	6740
III	164500	228	11060
	TOTAL OUTPUT		17800

OIL CONSUMPTION $\frac{206000\text{x}1134}{0\cdot78\text{x}18000\text{x}17800}=0\cdot935$ lbs/SHP

FIG. 2.

Fig. 3 is a Sankey diagram from which the distribution of heat may be followed. The diagram should be self-explanatory, but it may be pointed out that in representing the heat distribution to units of the plant the net consumption is indicated. Thus in the case of the high-pressure feed pump, from the

S.S. CONTE ROSSO.

SANKEY DIAGRAM FOR LOEFFLER BOILER PLANT.

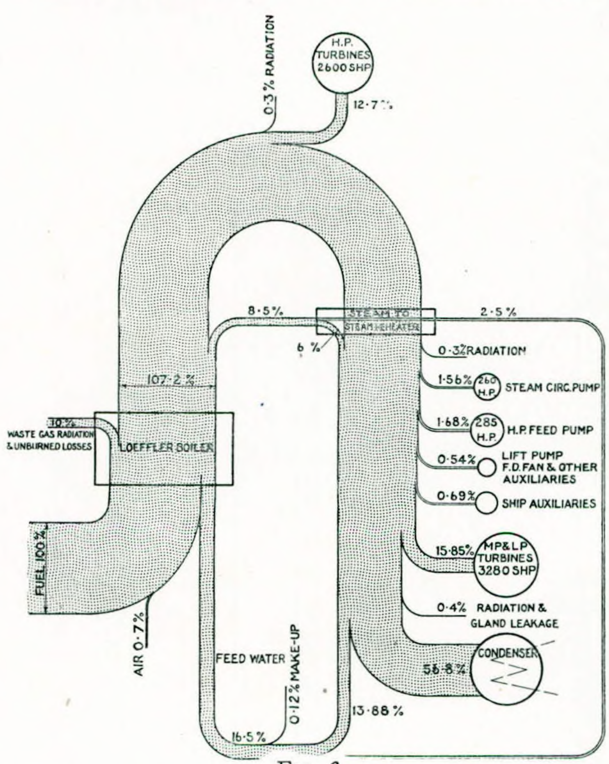


FIG. 3.

total heat in the steam supplied to the turbine driving the pump there is deducted the heat which leaving the turbine is usefully employed elsewhere in the system.

In the case of the steam circulating pump some of the power absorbed is utilised in compressing the steam and this re-appears as superheat. This has not been taken into consideration in determining the figure of 1·56 per cent. shown on the diagram. Allowing for the recovered heat of compression the net consumption is approximately 1·1 per cent.

Description of Plant.

The Loeffler boiler as installed is shown in two sectional views, Fig. 4. The side walls and back walls of the combustion chamber are cooled with closely pitched steam tubes forming the radiant superheater. The steam tubes forming the convection heating surface and the economiser are placed above the combustion chamber providing a horizontal pass for the gases. The final heat recovery from the gases is effected by a Ljungstrom air heater placed above and in front of the boiler. The whole of the boiler proper is surrounded by a plenum chamber formed by the construction of a double casing through which part of the air for combustion circulates. Oil burners of the Wallsend-Howden system are fitted and are supplied with oil at a maximum pressure of 156lb. from a turbine-driven pump. It is thus possible to vary the oil supply and consequently the output of the boilers by varying the revolutions of the turbine.

The single evaporator drum with its direct connected steam circulating pump and turbine is shown in section in Fig. 5. This unit was described in the previous paper included in the symposium, but Fig. 5 shows the steam circulating pump with its driving turbine in greater detail. As with previous Loeffler boiler installations, the steam pump and its turbine was manufactured by Messrs. Escher Wyss of Zurich.

The total weight of the Loeffler boiler as installed is 53 tons and this weight includes the radiant superheater, convection superheater, economiser, air heater, casing and steelwork, firebricks, steam piping, headers, etc., valves, fittings and burners, and the evaporator drum with steam circulating pump and turbine.

The feed water is delivered by one of two centrifugal turbine-driven high-pressure feed pumps manufactured by Messrs. Klein, Schanzlin & Becker. Each pump has two stages; the high pressure stage is directly connected to the turbine and runs at 10,000 r.p.m. At this high speed there would be a possibility of vaporisation on the suction side if supplied direct with water from the de-aerator, and to prevent this a first stage is provided to run by gearing at a lower speed, viz. 3,000 r.p.m. Thus the water from the de-aerator at a gauge pressure of 18 lb. per square inch is raised in the first stage to 71 lb. per square inch.

The super-pressure steam turbines are of the impulse type as designed and manufactured by Messrs. Escher Wyss. Fig. 6 illustrates the first turbine of the series with outer casing removed and showing the new gearing.

Instruments and Automatic Control.

In order that all the operating conditions of the high-pressure plant may be observed at any time, a very complete equipment of indicators has been installed. This equipment includes steam flow meter, feed water flow meter, CO_2 recorder, multi-point temperature indicator, and draught indicators.

Many of the above instruments have been assembled on one panel conveniently placed for ready observation by the operating engineer. Generally, these instruments are of a type such as is adopted for land power plants and consequently are more delicate and fragile in appearance than is customarily to be seen in apparatus favoured by marine engineers. The more extensive use of

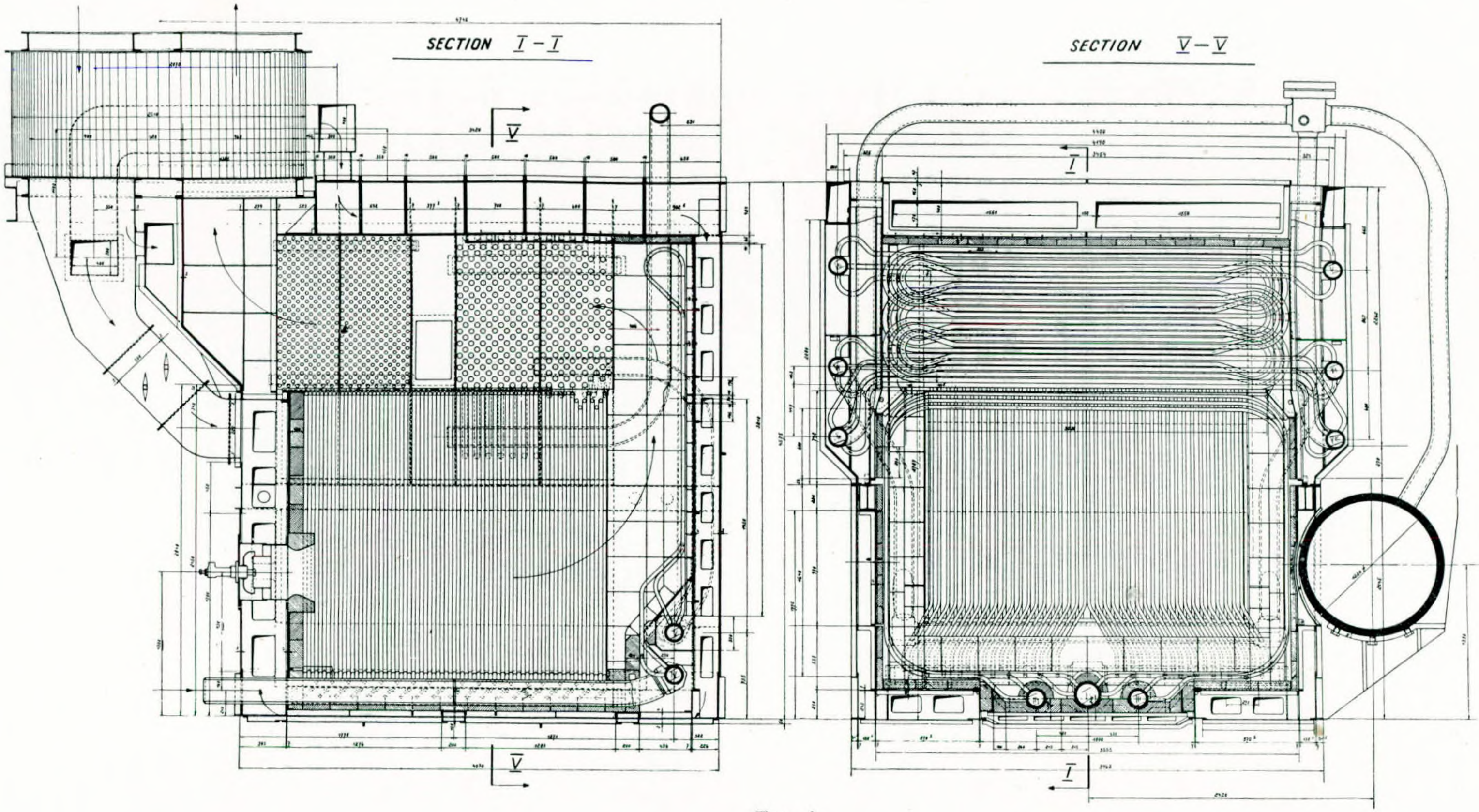


FIG. 4.

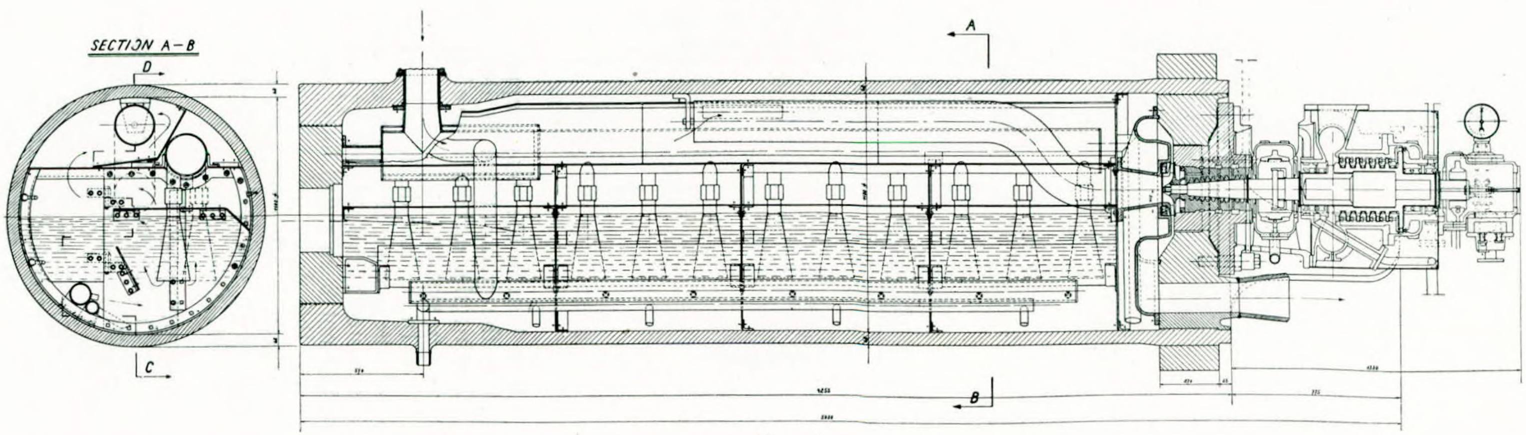


FIG. 5.

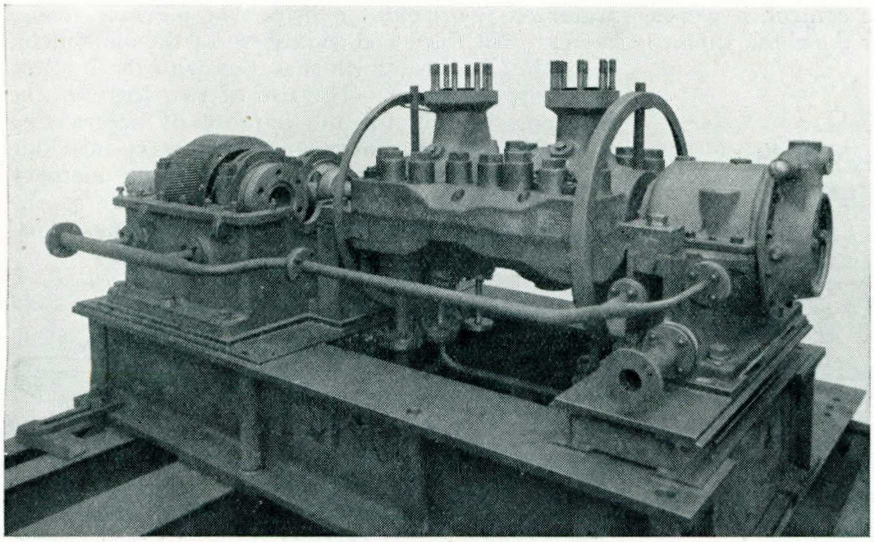


Fig. 6.

Siemens' system is applied to the control of the feed valve to maintain an equal quantity flow of steam and feed water but subject to the preservation of a proper water level.

The operation of this control equipment may be understood by reference to Figs. 7 and 8, and although the diagram would appear to indicate a very complicated and extensive equipment, actually it is relatively small, very neat and unobtrusive.

Referring first to Fig. 7, A.R. represents the Ascania regulator, part of which consists of a diaphragm; one side of this diaphragm is subject to steam pressure and the other to feed water pressure. The diaphragm is loaded by a balance beam on one end of which discs may be placed to adjust the load to give a predetermined pressure difference between steam and water. Any movement of the balance beam due to any change in the pressure difference is mechanically transmitted to an oil jet pivoted as indicated in the diagram. The jet in a central position delivers oil equally to two sides of a piston in a cylinder; any movement of the jet directs the oil to one side or other of the piston causing the latter to move and by mechanical means open or close the valve R.V. admitting steam to the turbine driving the pump H.F.P. In this way a constant pressure difference is maintained by automatically controlling the revolution of the feed pump.

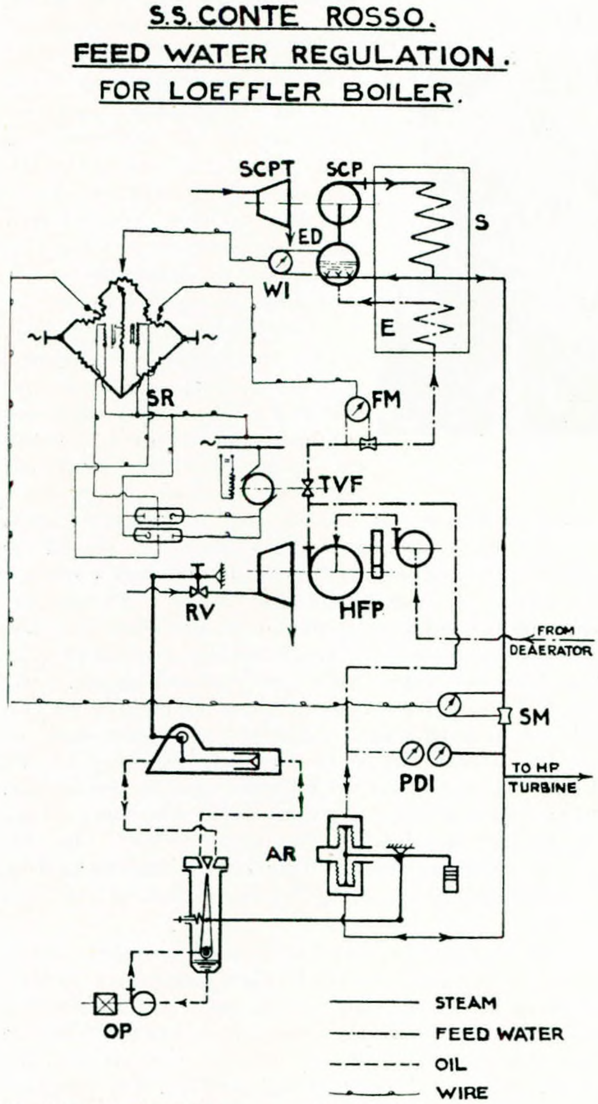
With the advantage of a fixed pressure difference the Siemens' control takes charge of further regulation by operating on the valve through which water is admitted to the evaporator drum. Whereas the Ascania control is mainly mechanical the Siemens' control is electrical and on the diagram the regulator S.R. is a form of Wheatstone Bridge in which three resistances are varied, one by the steam flow meter S.M., the second by the feed water F.M. and the third by the water level indicator W.1. A motor-operated valve T.V.F. is opened or closed according to the impulses received through S.R.

It will be realised that a control which operates to keep both steam and water flow equal and to maintain a constant level in the drum will simplify the duty of the engineer in control, although it may be said that a ship on a long journey will make a very uniform demand from its boilers for very long periods. The Loeffler boiler on the s.s. "Conte Rosso" has in fact been operated on long runs without the control gear in operation, and no difficulty was experienced in maintaining a proper water level

recording, indicating and control equipment has frequently been urged upon marine engineers and this was repeated by Dr. Ing. Friedrich Münzinger in his paper entitled "Modern Forms of Water-tube Boilers for Land and Marine Use" and read by him before The Institution of Mechanical Engineers on the 20th November, 1936. In the author's opinion, in order to secure this desired result there should be mutual co-operation and concessions as between marine engineers and instrument manufacturers. The former should be prepared to tolerate some delicacy in instrument design while the latter should endeavour to make their apparatus more robust. Although the present tendency is in the direction of better lighted engine rooms, it is still difficult to observe the movement of a hair-line and to read small figures. An operating engineer who has to put on glasses and use an electric torch in order to read his instruments will have reasonable cause for accusing the manufacturers of having no understanding of marine requirements.

Automatic control has not been installed with this high-pressure plant except that for feed-water regulation and this latter is of the most modern and interesting character such as will justify a somewhat lengthy description.

The system of automatic feed control installed provides for dual regulation. Both the speed of the turbine driving the feed pump and the movement of the feed regulating valve are automatically controlled. Regulation of the turbine speed serves to maintain a constant difference in pressure between that of the feed pump discharge and that in the steam main, then with the advantage of this constant basis of pressure the control of the feed valve will maintain constant water level in the evaporator drum. The Ascania system has been adopted for the control of the feed pump turbine speed to give a predetermined pressure difference while the by hand control. The automatic control, however, does definitely meet a demand for the elimination of hand control wherever possible.

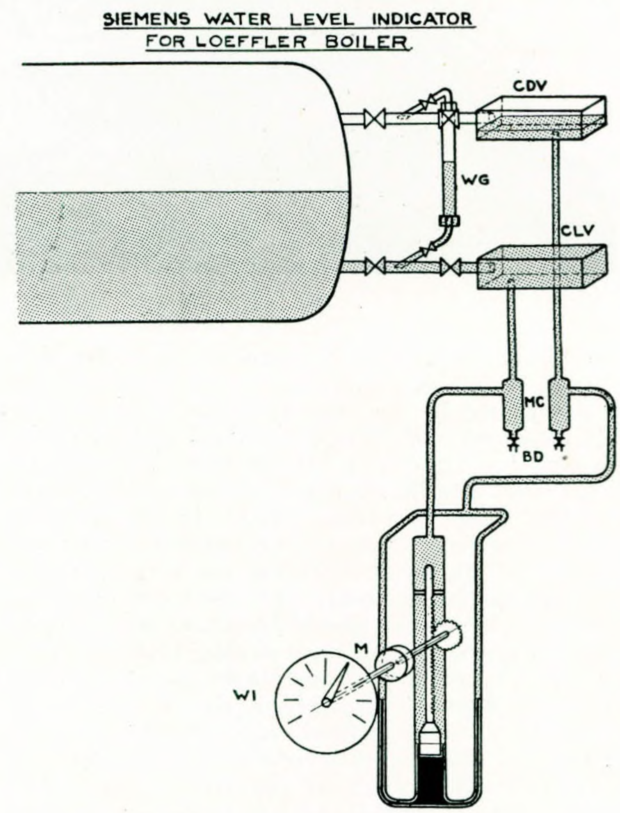


WI Water level indicator.
FM Feed water flow indicator.
SM Steam flow indicator.
TVF Throttle valve in feed water line.
RV Regulating valve.
AR Ascania regulator.
SR Siemens regulator.
OP Oil pump.
PDI Pressure difference indicator.

FIG. 7.

The Siemens water level indicator is shown diagrammatically in Fig. 8.

For very high steam pressures it is not desirable to use glass level gauges for constant use. A protected glass water gauge W.G. is fitted for check observations but is normally isolated by valves. Referring to the diagram the steam and water spaces of the evaporator drum are connected respectively to vessels C.D.V. and C.L.V. In the former a constant level of water is maintained by condensation of steam from, and overflow back to, the evaporator drum; this gives a constant head of water on two legs of a three-tube mercury manometer. The third and central leg of the manometer has a head of water which varies with the level of water in the drum. The use of two legs for the constant head is for the purpose of neutralising the effect of any movement from the vertical due to the roll of the ship. The level of the mercury in the central leg of the manometer governs the position of a float which, by rising or falling, trans-



CDV Condenser vessel.
WG Water gauge.
CLV Cooling vessel.
MC Mud chamber.
BD Blowdown valve.
WI Water level indicator.
M Magnetic coupling.

FIG. 8.

mits its movement through a rack and pinion and a magnetic coupling to an outside indicator as diagrammatically shown. There is thus no direct connection between the interior float and the outside indicator, the movement of the latter being due to magnetic influence, thereby avoiding the obvious disadvantage of glands and stuffing boxes to retain high pressures.

General Observations.

Since the super-pressure plant was put into commission several round trips have been made between Genoa and Shanghai, so that there has been ample time to observe all details of performance, particularly those which are of major importance to the owners. Generally it can be stated that no difficulties whatever have been encountered which could be attributed to the use of high-pressure high-temperature steam; the power developed by the super-pressure sets is greater than that which was guaranteed, with the result that the guaranteed increase of speed of the ship has been exceeded by one half knot. The acceptance tests have proved that all the performance guarantees had been fulfilled.

After continued operation a thorough examination of the combustion chamber disclosed a most satisfactory condition. There were no ash or coke deposits on the heating surfaces nor could any deterioration of the tubes be detected. The condition of the boiler was such as to impress the operating staff most favourably.

Notwithstanding the use of a relatively small evaporating drum and the high degree of salt concentration obtained on occasions, no trouble whatever has been experienced due to carry-over of salts with the steam.

The installation of one Loeffler boiler in the space occupied by one single Scotch marine boiler has increased the steaming capacity of the boiler plant by 13·5 per cent.; it has increased the power developed by about 30 per cent., while the fuel oil consumption per s.h.p. for the whole power plant both old and new together has been reduced by 10 per cent.

The commercial value of an increase in speed of a vessel may be difficult to compute and is a factor the importance of which is best known to the owners. It is safe to say, however, that the commercial gain is vastly greater than the capital charges involved by the installation of a relatively small addition to the existing power plant.

In conclusion the author desires to express his thanks to Messrs. The Vitkovice Mines, Steel & Ironworks Corporation for supplying details of the equipment and operating data; to Messrs. Escher Wyss for information relating to the turbine equipment; to Messrs. Siemens Schuckert (Gt. Britain) Limited for details of their control equipment and to Dipl. Ing. Ludwig for his assistance in preparing the charts and diagrams included in this paper.

Discussion.

Mr. A. C. Hardy, B.Sc. (Associate Member), opening the discussion, drew attention to the increasing importance of what he called fuel valve type boilers, i.e., machines capable of producing steam very quickly from cold and of transmitting this steam at a high pressure and high velocity to the particular turbine with which it was associated. Technical language did not give to this kind of steam-producing machine any rational term, and he thought that the only way really of describing such units was to call them fuel valve boilers. This was an unorthodox term with which some people might find it difficult to agree.

The reason for adopting the expression was that it had many of the characteristics of the fuel valve of a Diesel engine in that it supplied the necessary energy to what in effect was the working cylinder, i.e., the turbine. Furthermore, it could start up and stop almost with the facility of a Diesel engine. It reduced the space required for the machinery and the weight, and this whole method of generating steam was a new conception. There were many similar types of fuel valve boilers among which might be cited the Sulzer, Velox and Benson. The first and last had sea experience and the second would shortly be fitted to a French ship. The Loeffler boiler, which was the subject of this paper, was another successful type and it was to be noted that whilst adding 5,000 h.p. to the total output of the twin screws of the "Conte Rosso", it occupied the space required only by one of the original Scotch boilers.

It would appear that the discussion on this paper should fall under two heads. Members present would undoubtedly argue the merits of one fuel valve type boiler as against another and then again there should be something said about the fuel valve boiler as such against the normal orthodox type of water-tube boiler. Undoubtedly the people responsible for the design of the latter would consider that they still had a very excellent case, and there was no doubt that this kind of boiler would continue to be used for some time to come. For certain types of ships nevertheless, the Loeffler type commanded attention once it had been definitely established that they were as easy to operate and as easy to overhaul as, say, the Diesel engine.

Eng. Rear-Admiral W. R. Parnall (Member) said that he could not help remarking upon the enterprise, energy and courage of all those who had been connected with the installation described by the author. No doubt they must have had very good reasons for putting a high-pressure boiler of this type into such a luxury ship. Some of the reasons could be assessed. They wanted to get a definite increase of speed and power, and with this end in view to install a superimposed turbine. Superimposed turbines were not favoured in land practice in this country, but they were frequently adopted on the Continent and in America. He thought that most steamship owners in this country would follow the national trend and were not likely to adopt the high-pressure boiler with a turbine superimposed on existing plant. However, from the point of view of getting experience with a modern high-pressure boiler, the installation the author had described was most valuable.

Four points in connection with the use of high-pressure boilers occurred to him. First, the adoption of high pressures and temperatures would perhaps lead to trouble and operational difficulties. Secondly, it was probable that the weight of the scantlings would have to be increased; thirdly there would be the loss of power in the feed pump; and finally they would not gain very much anyway.

However, the information the author had given in the paper went far to remove these objections. With regard to operational difficulties, the author had explained that the engineers in the "Conte Rosso" had experienced none on the trials or in service. The controls looked complicated, but it had been explained that the boiler had on occasion been operated without controls. This was an important point on the score of simplicity.

With regard to weight, 53 tons for the boiler and all its appendages with an output of 20 tons of steam per hour represented a figure of 2.6 per ton of steam. This was very good, especially as it was with an efficiency of 90 per cent. The author did not say anything about the weight of the turbines, feed pump, reheaters and piping. What were the weights of these, especially that of the reheaters?

The point he (the speaker) had made about the increased power required for the feed pump and the statement that little would be gained, seemed to be refuted by the Sankey diagram. It showed that the additional power required by the feed pump was very small, and as regards the gain it indicated that 12·7 per cent. of the heat in the fuel in the high-pressure turbines and 15·85 per cent. in the other two turbines, making a total of 28·55 per cent. of the heat released in the furnace, appeared as s.h.p. That worked out at less than 9,000 B.T.U's per s.h.p. or something under 0·5lb. of fuel per s.h.p. The best figure he knew for any modern plant of moderate pressure was that quoted by Mr. John Johnson in his paper on the future of steam propulsion read last year before The Institution of Mechanical Engineers. Mr. Johnson's figure for the "Empress of Britain" of 375lb. pressure, 740° F. temperature, 29¼in. vacuum, was ·55lb. for propulsion. There was thus a difference between the moderate pressure plant and the Loeffler boiler of ·05lb. per s.h.p., which represented a saving of approximately 10 per cent. Was that a worthwhile gain? He thought that they would have little difficulty in deciding that it was, because not only did it reduce the total cost of the fuel, but it reduced the stowage by 10 per cent.

For this gain they might be prepared to carry a little more weight of machinery, but actually there seemed no necessity for this as with these high-pressure boilers, owing to the employment of larger units, greater heat release per cubic foot of the furnace and higher furnace velocities, it appeared possible to reduce weight in company with increased efficiency. So it seemed that with high pressures there should be a saving in weight, both in respect of the quantity of fuel carried about and in the actual installation. He thought, therefore, that the more general use of high pressures might be expected, and the information the author had given that evening was an important step towards its consummation.

Mr. John Reid (Visitor) said that the steam generator described in the paper would no doubt seem satisfactory to those of them who had least prospect of being called upon to operate it.

The results obtained with the original Scotch boilers in the "Conte Rosso" could not be said to have been very brilliant, so that making a comparison between these and the results of the new Loeffler boiler did not give a true indication. There was no denying, however, that to substitute one of these new boilers for one of the old Scotch boilers and thereby get an additional s.h.p. of 5,000 and an increased speed of 1½ knots was a remarkable piece of work.

He would confine his remarks to the question of furnace work and combustion, in which he specialised.

It would be natural in deciding as to the possibilities of the particular boiler illustrated in the paper to figure out the character of the combustion developed in the furnace at full load. There appeared to be three burners in this case, of well-known type, taking air required from a common casing obtaining its supply, no doubt highly heated, from the discharge of the Lungstrom heater shown in the top left-hand corner of the boiler arrangement. The furnace walls constituted a radiant superheater, and it was of the utmost importance, therefore, that the heat transmission through the furnace walls surrounding the flame should be by radiation, which was itself a reflex of perfect combustion under effective combustion control.

But beyond the furnace arrangements for heat transmission there were most elaborate heat exchanging devices which were only too apt to be used for the development of heat by livening up combustion which had not been completed in the furnaces, where it belonged. This, of course, implied that the furnace efficiency was below par, and since the heat transmission through the boiler heating surfaces was subject to some reduction in efficiency due to the fouling up of the heating surfaces in process of time, it seemed somewhat difficult to credit the figure of 90 per cent. boiler efficiency which was given in the data.

It would be remembered how often this figure of 90 per cent. had been held out as a possibility in the past ten years or so for all the brilliant new developments in marine boiler work, and how frequently results in service had fallen short of this ideal figure. It seemed strange in calculating these efficiencies to note with what unanimity boiler designers and builders claimed that 100 per cent. of the heat value of the oil sprayed into the furnace was always developed there, whereas operating data clearly showed that this was never the case, and that in late years the importance attached to superheat temperature had tended still further to reduce furnace efficiency in the interests of superheat.

None the less, all interested in boiler developments must have noted with great interest the very serious effort made with this Loeffler boiler to put in automatic control of maximum efficiency on the steam distribution side of the boiler. Unfortunately, similar care did not seem to have been taken on the combustion side.

Mr. F. O. Beckett (Member) said the Loeffler boiler in the s.s. "Conte Rosso" had certainly given a remarkable performance and output compared with the Scotch boiler which it replaced.

The principle on which the Loeffler boiler worked appeared to be about the most satisfactory for marine use of the various high-pressure types, in that all the steam was generated in an external drum which was not exposed to any external heat.

The tubes which were heated contained only clean steam. There was always the chance of leaky condensers, etc., but in this type any deposit formed should be in the drum, and the tubes would keep clean unless there was any priming.

Part of the superheated steam went to the turbine and part returned to the drum, where it gave up its superheat and a further supply of saturated steam was generated.

This paper gave a fairly lengthy description of the feed pump and control arrangement, but contained very little about the steam circulating pump beyond giving a picture of it. There were two centrifugal turbine-driven high-pressure feed pumps, one of which was evidently a standby, but as far as he could see there was only one steam circulating pump. This appeared to be turbine driven and attached direct to the end of the drum. He understood that it was of the single impeller type, and as it dealt with saturated steam only, it should give little trouble. However, on this point he would like a little further information. Was there only one steam circulating pump? If so, had there been any trouble experienced with the pump? In the event of the steam circulating pump breaking down, what would be the effect on the tubes? Would they be burnt out unless the boiler was shut down fairly quickly? Of course they all realised that on board ship, where engineers were always on watch, no time would be lost in doing so.

Anything was liable to break down sooner or later, especially under the severe conditions often met with at sea during bad weather, and he wondered what the effect would be.

He assumed that the boiler could not be worked if the steam circulating pump broke down, so that the satisfactory running of the plant depended entirely on this one pump.

Mr. C. L. Jaques (Member) said the paper seemed to prove that the Loeffler system was a success and would be of importance in boosting the turbine steamer in the same way as the exhaust turbine gave new life to steam reciprocating-engined vessels.

An analysis of the steam flow showed that approximately 3,500 of the 44,000lb. per hour of high-pressure steam went to the reheater, leaving 40,500lb. for the new turbines. Comparing the steam flows in the two tables at the foot of Fig. 2, it was seen that there were increases with the new installation of 10,300lb. per hour and 20,900lb. per hour through the i.p. and l.p. turbines respectively. The difference between these figures, 10,600lb. per hour, represented exhaust from the new plant auxiliaries—assuming that the original auxiliaries exhausted as before and in similar quantities. In addition, exhaust from the auxiliaries was used in the deaerator, and assuming average condensate temperatures, the consumption here would be about 6,000lb. per hour. Thus there appeared to be an approximate total demand from the new auxiliaries of 16,600lb. per hour for a boiler supplying 44,000lb. per hour. That might seem excessive, but they must remember that some of the heat was recovered in the l.p. turbines.

From the h.p. turbines 40,500lb. per hour was exhausted, of which 16,600lb. was used in auxiliary drives, leaving 23,900lb. per hour available for the i.p. turbines, the remainder of this demand being supplied direct from the Scotch boilers. From the tables at the foot of Fig. 2 the throughput in the i.p. turbines had increased by 10,300lb. per hour, so that there was a net reduction in the 200lb. per square inch boiler load of 13,600lb. in the new arrangement, and, as one boiler with an output of 16,000lb. per hour had been removed, there had been no reduction in the loads of the remaining Scotch boilers.

He noticed that the load on the l.p. turbine gave a 12½ per cent. increase on the condenser load. The author stated that no alteration to the condensing plant was necessary, so the original plant must have been designed on a liberal scale.

They were all doubtful about the steam circulating pump, but that apparently gave no trouble.

What was the oxygen concentration they allowed in the feed water? Was any further conditioning of the boiler water necessary, and what measures were taken to control the salt concentration?

He would also be interested to know how the automatic feed regulator operated at low loads, and what was the minimum load at which automatic feed would be practicable.

Eng. Rear-Admiral W. M. Whayman, C.B., C.B.E. (Vice-President) said that the author had presented a most interesting paper on the results of a new plant at sea.

With regard to the boiler efficiency, he rather gathered that the figure of 90 per cent. given by the author was a net efficiency figure, and if that were so it was not very different from efficiencies realised on most of the boiler installations in modern ships.

His own last experience was with a boiler fitted with an air heater and superheater, and the efficiency was in the region of 86 to 86½ per cent. on the gross value of the fuel, and the users of the plant confirmed that this efficiency had been obtained. The author's overall efficiency was therefore strictly comparable with the overall efficiency one would expect of a modern steam generating plant.

The Loeffler boiler was one of the modern high-pressure boilers which appealed to him particularly as being of simple construction. Leaving out the question of the circulating pump, the boiler was extremely simple and had no complicated construction.

He did not think that the author laid sufficient stress on the control of the amount of superheat, because it had been the experience on new ships that there was some difficulty in the satisfactory control of the temperature of the steam delivered to the turbine. This was an important matter and if the Loeffler boiler could give accurate control of the steam temperature it possessed a decided advantage. The Loeffler boiler did seem to be a boiler of the future.

Mr. H. J. Hetherington (Member) said he would be glad if the author would explain how the Loeffler boiler was started up from cold.

He would take this opportunity of pointing out that, as usual, those abroad were ahead of us in bringing out this new type of boiler, and he hoped the time was not far distant when an attempt would be made in this country to introduce something on similar lines.

On the proposal of **Mr. T. A. Bennett, B.Sc.** (Member of Council) a vote of thanks was warmly accorded to the author.

By Correspondence.

Mr. T. Dodds (Member) wrote that the figures shown on the Sankey diagram were for the maximum turbine output and for minimum feed pump and steam circulating pump consumption. These two auxiliaries accounted for 8·6 per cent. to 10·8 per cent., i.e.

$$\frac{260+285}{2,600+3,280+260+285} \text{ to } \frac{360+356}{2,600+3,280+360+356}$$

of the utilisable heat supplied by the Loeffler boiler. Were they electrically driven it would be so calculated.

A more extensive use of recording, indicating and control equipment was urged. What necessary instruments were lacking in the modern liner? It should be recalled that in up-to-date land plant the instruments were checked, corrected and overhauled by the makers, or an instrument mechanic was employed to attend to them. The former would not always be convenient in marine practice, whilst the writer feared the latter would not be contemplated. An increase in robustness should ensure the more general adoption of such apparatus at sea.

It was stated that the high-pressure plant was run for long periods without the control gear in operation. As a rule conditions on long runs were fairly steady. If the plant was then regulated by hand, did the control gear function satisfactorily when manoeuvring or when steaming in bad weather?

The Author's Reply to the Discussion.

The author, in reply, expressed his pleasure at the manner in which the paper had been received. He had anticipated criticism a good deal more severe than that to which the paper had been subjected.

With regard to Mr. Hardy's suggestion that this steam generator should be known by some other name than boiler, he entirely agreed. But he must talk the language that was current, and if he referred to a fuel valve boiler no-one would know what was intended. It had to be called a boiler in order to be understood. The term "steam generator" was perhaps better, but he generally evaded the issue by calling it the Loeffler steam system, because he thought it was not a boiler or generator. The high-pressure boiler could not be regarded as a boiler alone; coupled with it must be the turbines and the way the steam was used right through the complete heat cycle, and he attempted in the paper to give the whole distribution of heat through the cycle. He assured Mr. Hardy that he would support him in getting away from the old-fashioned terms.

Admiral Parnall expressed a good deal of appreciation for which the author was grateful. As a matter of fact he answered all his own criticisms and left him (the author) with very little to say on the matter. Admiral Parnall asked what was the weight of the feed pump, reheaters, etc. He could not give the information at the moment. It did not occur to him to inquire, because it was obviously negligible. A small feed pump running at 10,000 r.p.m. was not an important item as regards weight. Again the steam reheater was well up in the engine room and its weight was obviously negligible.

Mr. Reid referred to the apparently poor results obtained from the old plant. The ship was 15 years old and the author had the impression that the performance compared very favourably indeed with ships of that period. He thought the results published in "Engineering" in 1922 were regarded as a distinct step forward and a performance that was good at that time. Whatever the results, however, might be, the fact remained that the extra power obtained by superimposing a high-pressure plant was independent of the old plant. Had the old plant been more efficient, then the results would still have been equally as good, because they would have got the same advantage from the steam which passed through the high-pressure turbines to the low-pressure turbines.

Mr. Reid also referred to the condition of the furnace and the burners, the way in which the oil was burned, and whether they got a good distribution throughout the combustion chamber. The author thought that the answer was best given by offering the actual results. After a lengthy run there was no deposit of carbon on the tubes, which indicated good combustion. The temperature of the funnel gases indicated whether the heat was being liberated and absorbed in the way intended. The temperature of the funnel gases was to be 300°. That result was obtained, which was sufficient proof that the combustion followed the course foreseen when the plant was designed. Had it been otherwise, the heat would have passed through the boiler, radiant heat would not have been absorbed as expected, and the result would have been seen in the final temperature of the gases. Of the final temperature of 890° of the steam, as much as 770° was obtained in the radiant superheater itself. That would not be obtained if the combustion was not as good as the designers considered possible.

With regard to the 90 per cent. efficiency, Admiral Whayman had explained that this was not a high figure, and he could assure Mr. Reid that it was not exaggerated. Efficiency was purely a question of heating surface. In this case they wanted 90 per cent. efficiency and they obtained it by the necessary heating surface, and a higher efficiency could be obtained by putting in more heating surface. The figure of 90 per cent. was quite definitely possible.

Mr. Beckett doubted whether clean steam was obtainable. This was a matter he had gone into at length in other papers, and he hesitated to go over the ground again. With a Loeffler boiler clean steam was obtained. The circulating pump was and acted as an ideal steam separator. It gave the steam a whirling motion and any water or impurities which might be carried over into the pump were thrown out by the centrifugal force to the periphery of the pump casing, where outlets were provided, and piped back to the steam drum. Mr. Beckett also asked what would happen if the steam pump failed. There was only one pump and there had been no known failure of a Loeffler plant due to the breakdown of a circulating pump, but if it did fail no damage could take place in the boiler. On the failure of the pump, the fires would be drawn as soon as possible, but before that a relief valve, which was hand operated, would be opened and the steam escaped. The relief valve continued to operate as long as there was any water in the drum, and thus protected the heating surface. It was quite simple, and long before there was any risk of overheating the tubes, the temperature in the furnace could be reduced and the steam pressure dropped, thus ensuring perfect safety. It was a very efficient and positive safeguard should the pump fail.

Mr. Jaques inquired about the oxygen concentration in the feed water and what conditioning was done to the feed water. Nothing was done as far as the Loeffler boiler was concerned, the original equipment in the "Conte Rosso" being used. The condensate for the whole of the old plant went to the deaerator, and there was no further conditioning. The telegram he had read at the conclusion of the paper showed that in spite of the known fact that there was a fairly high concentration of salt in the feed water, there was no trouble.

He thanked Admiral Whayman for his appreciation of the subject matter of the paper, and confirmed again that boiler efficiency was purely a question of heating surface to-day. It was not always so. They used to get secondary combustion, but with the high velocities of to-day they could be sure of these things. It was, he repeated, purely a question of heating surface, and the Loeffler boiler would give an efficiency as high as the purchaser would pay for and as circumstances might justify.

Mr. Hetherington had asked the practical question, which he was glad to answer, of how to start the Loeffler boiler up from cold. He had described this fully elsewhere and a brief account was given on page 67 of the paper. The procedure was roughly that the boiler was filled with feed water up to the working level. In the "Conte Rosso" there was steam from the Scotch boilers. That supply of steam was turned on into the drum and also into the superheater tubes, i.e. two supplies, one into the drum and the other into the tubes, and the steam was allowed to bubble through the water. This was maintained until the boiler was filled with saturated steam at a temperature equal to a pressure of 200lb. Having got so far, the superheater tubes must be drained and the circulating pump could then be started, when it would draw saturated steam from the top of the drum and circulate the steam through the heating surface, maintaining that circulation until the temperatures were uniform throughout the whole of the system. When a signal was received that full steam was required on the boiler, the burners were lit and very quickly superheated steam was available. The pressure could be raised from 200 to 2,000lb. very quickly—in fact as quickly as one liked to burn the fuel.

Mr. Dodds was thanked for his written communication and in reply it could be stated that the reason the plant was operated with hand control was because there was some preliminary difficulties in getting the combined automatic control to function properly, but after the necessary adjustments had been made the automatic control did function perfectly satisfactorily under all conditions.

Deductions from Observations on Diesel Engine Cylinders.

(Sir Archibald Denny Award Essay).

By W. G. MACKAY (Associate Member).

While at sea the engineer is chiefly concerned with seeing that the cylinders and pistons receive an adequate supply of oil and, generally speaking, it is considered satisfactory to over-lubricate rather than to risk any dryness. In what follows, an attempt will be made to show that correct lubrication is of primary importance and a modification of the piston ring arrangement will be suggested which should assist towards that end.

The writer was entrusted with the care of the cylinder lubrication on a twin-screw ship with four-cycle single-acting blast-injection engines. The lower part of the cylinders was accessible for inspection with a spot light so that the effect of all adjustments of the oil supply could be carefully observed. Four of the cylinders had been replaced eight months previously, the others being nine years old and showing wear up to 6·5m.m. on a bore of 650m.m. The pistons were oil cooled and had grooves for nine rings. From the data given, it will be seen that badly worn grooves had been knifed out and oversized rings fitted as wear took place. Triple-seal rings had been introduced in varying positions on the piston and advantage taken of their efficiency to omit some of the others. Lubrication was by means of mechanical lubricators

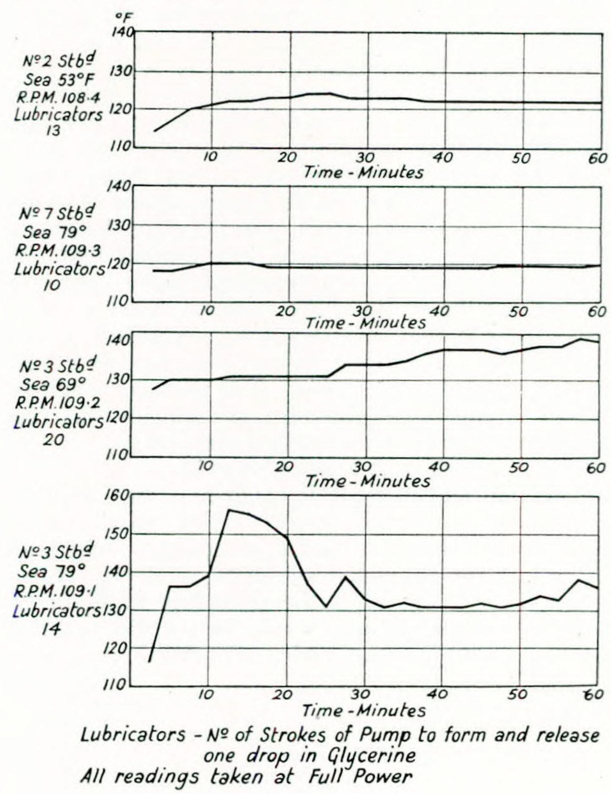


FIG. 1.

supplying oil to nipples at the front and the back of the liner, the oil entering at a point opposite the space between the second and third rings when the crank was on bottom centre. The pumps were timed to deliver between the suction and compression strokes. The oil was distributed by grooves cut semi-circumferentially and sloping downwards, the ends overlapping but not meeting.

In spite of a generous supply of oil, some knocking and blow-past was taking place. The knocking was eliminated by reducing the supply of cooling oil to the piston and manipulating the pet cock on the stand pipe. It was due to hammer, but with an increase of 5 degrees in the outlet temperature of the cooling oil it was also found possible to reduce considerably the oil required for correct lubrication. Since none of the cylinders was under lubricated, it was assumed that the blow-past was due to an excess of oil. They were syringed with a half-and-half mixture of cylinder oil and paraffin which released large quantities of soft black carbon. This was continued until no more carbon appeared and the oil supply was then reduced. The appearance of the cylinder liner was found to be a reliable guide when taken in conjunction with the amount of oil supplied. For this purpose it had to be assumed that each pump delivered an equal amount per stroke and the standard of comparison was the number of strokes required to form and release one drop, the sight glasses being filled with glycerine. Close attention was also paid to the deposits in the diaphragm. The slightest under-lubrication produced a polished glassy surface on the cylinder while the deposit was dry and gritty. Too much oil was shown by the formation of brown patches on the cylinder walls which gradually blackened and dried until blow-past took place. The deposit was plentiful and consisted of soft carbon mixed with unused oil. A cylinder which was considered correctly lubricated showed a clean oily surface, while a little grey green sludge appeared on the diaphragm.

During a voyage, the sea temperature varied between 45° F. and 87° F., while the engine room temperature ranged between 80° F. and 110° F. At the higher sea temperatures, the temperature of the water was raised another 10° before reaching the cylinders by an oil cooler. These temperatures had a very pronounced effect on the lubrication of the cylinders. In the first place the pumps required considerable adjustment to enable them to deliver equal quantities of oil at various atmospheric temperatures due to the varying viscosity of the oil. With the larger range of sea temperature, conditions at the delivery end of the pipe would vary still more. Warm oil delivered to a proportionately warmer cylinder would spread with rapidity, while

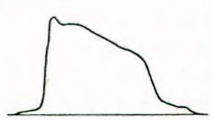
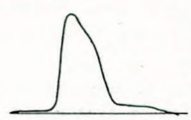
Total Hours Run	Hours Since Overhaul	Max. Cyl. Wear MM.	Lubricators	Max. Press. Lb/In²	Temp. °F	
1750	1750	New	12	Nil.	115°	Cylr. No. 8 Stbd. No pressure rise
5250	5250	-	13	19·5	131°	Cylr. No. 2 Stbd. 
42,000	1750	6·05	12	15·75	126°	Cylr. No. 7 Stbd. 
42,000	7000	5·25	11	44·5	138°	Cylr. No. 4 Stbd. 
1750	1750	-	12	46	140°	Cylr. No. 5 Stbd. 

FIG. 2.

cold viscous oil would reach a cylinder which was comparatively cold. For this reason perhaps, it was possible to maintain an adequate oil film on a lower consumption in hot weather. It was not apparent, however, why a worn cylinder should be more consistent than a new one under the varying conditions.

As a result of close attention it was found that a reduction of some 15 per cent. of the consumption had been obtained, while it was obvious that some cylinders required very much less oil than others for correct lubrication. Newer cylinders were not by any means the most economical, while some of the others which were due for overhaul compared favourably with those in which the rings had been recently re-conditioned. Another point noticed was that old cylinders were hotter to the hand than newer ones and, while some were very hot, others ran at quite moderate temperatures. To obtain more information on this point the back lubricator pipe was disconnected and a thermometer attached so that the gases released as the piston reached the bottom of its stroke would pass over the bulb. As experience was gained it was found that the oil pipe could be left disconnected for upwards of an hour without any sign of distress, providing that the cylinder was correctly lubricated to begin with. The curves in Fig. 1 are records of temperatures taken at 2½-minute intervals over periods of one hour from cylinders of different ages under differing conditions. A clean cylinder with an oily surface showed steady low temperatures and a tenuous oil film. The slight rise and fall to a steady level is not easy to explain. Those with an upward trend need no comment, while a cylinder which was over-lubricated showed the initial rise and fall to an even more marked degree. The reason may be that a certain amount of carbon is formed at all times which a sufficiency of oil is able to keep from hardening until it has worked its way down past the rings. When the oil supply is cut off the downward tendency stops. The gumminess improves the sealing of the rings with the resultant drop in temperature whilst the ultimate hardening causes sticking and a rise in temperature. It is obvious we are depending on the oil not only to lubricate working parts but to act as a sealing agent as well. Excessive oil is probably left on the cylinder walls and burned during the working stroke, the carbon formed being collected by the rings and causing them to stick in their grooves.

Most of the readings were taken on the following voyage when two other new cylinders had been fitted. The next step was to use an indicator. After a little experience it was found that a spring No. 30 was best suited for the work. Draw cards were taken as the piston passed over bottom centre at the end of the working stroke, and it became evident that it would be necessary to know how the rings were spaced on the piston. The first cards were taken from No. 2 starboard cylinder which had been renewed a year previously and had run about 5,000 hours. For comparison, examples were taken from Nos. 4, 7 and 8 starboard, relevant data for each being as shown in Fig. 2. Two things may account for the sudden rise in pressure and more gradual drop on the return stroke. The gas penetrates to a certain ring and is almost entirely retained by it. As the piston comes to rest and reverses some flutter and a change of bearing surface from one side to the other allows gas to leak past to lower spaces. At the same time spaces at higher pressures are communicating with those below by means of the oil grooves cut in the cylinder wall. In these ways the pressure tends to spread to the other rings while it is fairly safe to assume that the downward movement of the gas carries the oil with it. That is to say, the top rings on which most of the load seems to fall have the oil carried away from them. The only oil that they receive is by scraping from the cylinder walls and, unless a very definite surplus is provided, they will have a lean time attempting to pick up what has been left by the less worn lower rings. Cards taken from Nos. 4 and 7 starboard show that the pressure was spread over a large number of rings and, while they require slightly more oil than the newer cylinders, they were easily kept in good condition and more consistent in cold weather. Due to this spreading of the pressure it may be said that the oil was given a better chance to spread itself over the working surfaces. The temperature was higher and the oil less viscous in cold weather. In the case of No. 8 cylinder no gas passed the second ring at all, which meant that two sparsely lubricated rings were doing all the work. While this is a tribute to the immediate efficiency of these rings it does not seem likely that the same high standard will be maintained for long. In fact, a card taken from No. 5 cylinder, which was renewed at the same time as No. 8, shows the result of partial seizure of these rings early in their life. No attempt has been made to show the relation between the spacing of the rings on the piston and the pressure fluctuation, since mechanically operated cards could not be obtained. As many examples as possible were obtained from each cylinder under varying conditions and the results may be summarised as follows.

A new cylinder showed no gas passing the first two rings from the top.

A cylinder with 5,000 hours running showed a little gas passing the second and possibly the third ring, the amount being increased as either too much or too little oil was supplied.

Worn cylinders newly overhauled showed a small amount of gas penetrating several rings. Under and over lubrication led to an increase, but conditions were more stable when external temperatures varied.

Worn cylinders with pistons due for overhaul showed high gas pressures penetrating several rings. Incorrect lubrication led to blow-past, but a very consistent performance could be maintained in all weathers.

A new cylinder in which tight rings had caused partial seizure during the first 50 hours running showed a high gas pressure passing the first two rings.

A study of the measurements of the cylinder bore taken at regular intervals makes it appear that, initially, the maximum wear rate is at the top in way of the first two rings and that, with age, it decreases at this point and increases immediately below. Diagrams from cylinders of various ages appear to bear this out and to show that, during the early part of their life, top rings carry all the load, while as wear takes place part of it is transferred to those below. It is unfortunate then that those rings have to depend for their lubrication on excess oil left on the cylinder wall by the lower rings. Normally the oil on entering is carried upward and spread over the cylinder wall by the third and lower rings. It is not until the piston is moving downward on the working stroke that the top rings come into contact with the fresh oil and they are then carrying the maximum load on their underside, the surface over which the oil must pass to lubricate them properly. Diagrams from worn cylinders show, however, that even with a large amount of penetration, good oil consumption and sealing can be maintained. When the cylinders and rings are new it may be said that the load is carried by one ring. As wear takes place it spreads to the second, then the third and so on until, if the process were carried far enough, it would pass all of them. The upper rings must act as retarders, or much higher temperatures would be shown by cylinders such as No. 4 starboard. If the original intention of fitting nine rings was to form a labyrinth packing it appears that the purpose was defeated by the efficiency of the rings themselves until considerable wear had taken place. New Ramsbottom rings may be given a butt clearance of ·04 inches, while when properly fitted the vertical clearance may be about ·002 inches. Worn rings working in a worn cylinder may show as much as 2″ butt clearance at the top, $1\frac{1}{8}$″ at the bottom, and ·015″ vertical clearance as well as very considerable radial wear. With rings in this condition gas would pass the butts and behind the rings. Normally, this state of affairs is uncontrolled but, from what has gone before, it may be deduced that it is not uncontrollable.

Using Ramsbottom rings it should be possible to make the rings into a true packing by giving a large butt clearance to those at the top of the piston when the cylinder is new. By doing so a certain amount of gas would pass the first ring to the first space, spread round the piston to the gap in the next ring, pass down to the next space and so until it reached the third ring from the bottom which would be left normally fitted. With pressure on both sides of the ring a certain amount of balance would be obtained and a better chance for the maintenance of an oil film between the working surfaces. More equal temperatures over the sides of the piston and consequently the lower part of the cylinder wall would result in better lubrication in cold weather, while a reduction in wear of the rings in their grooves would be expected. To achieve real success on the latter point it would be necessary to obtain positive lubrication of the upper ring. It is assumed that the oil is introduced at present at the second space so that it may not be exposed directly to the

Arrangements of Piston Rings.

Piston.	No. 2 Stbd. Size.	Type.	No. 7. Stbd. Size.	Type.	No. 8 Stbd. Size.	Type.	Suggested. Size.	Type.
Ring 1	15mm.	Lap Joint	15mm.	Ramsbottom	15mm.	Ramsbottom	14mm.	Ramsbottom
„ 2	15mm.	Lap Joint	16mm.	Triple Seal	16mm.	Triple Seal	14mm.	Ramsbottom
„ 3	15mm.	Triple Seal		Blank		Blank	14mm.	Ramsbottom
„ 4		Blank	15mm.	Triple Seal	16mm.	Triple Seal	14mm.	Ramsbottom
„ 5	14mm.	Triple Seal		Blank		Blank	14mm.	Ramsbottom
„ 6		Blank	14mm.	Lap Joint	14mm.	Lap Joint	14mm.	Ramsbottom
„ 7	14mm.	Ramsbottom	14mm.	Lap Joint	14mm.	Lap Joint	14mm.	Triple Seal
„ 8	14mm.	Ramsbottom	14mm.	Lap Joint	14mm.	Lap Joint	14mm.	Triple Seal
„ 9	14mm.	Scraper	14mm.	Scraper	14mm.	Scraper	14mm.	Scraper

exhaust gases. It has been shown, however, that this object defeats itself by leaving the top ring practically unlubricated so that, due to resultant rapid wear, the protection soon ceases to exist. Since the oil is introduced when the temperature and pressure in the cylinder are at a minimum, it should be quite safe to place the oil hole opposite the top space and to lead the oil grooves upwards for a part of the way as well as downwards so that they just come above the top ring when the crank is on bottom centre. In this way some of the oil would be passed to the upper side of the top ring and spread as the piston ascended, the remainder being distributed as usual. Unless the large gap in the ring were placed opposite this part of the groove, this arrangement ought to ensure an oil film about the ring when it was most needed with beneficial results to itself and the parts of the cylinder with which it came in contact.

It is suggested, then, that an attempt should be made to reproduce in a new cylinder conditions which usually exist about the rings when considerable wear of the cylinder has taken place. In conjunction with this, positive lubrication of the top ring and a standard of correct lubrication is advocated. It appeared in practice that correct lubrication could be maintained very economically and without undue trouble if attention were paid to fluctuations in temperature and speed. The diagrams shown are typical examples chosen from a large number taken under all sorts of conditions. Regulation of the oil supply and observation of the condition of the cylinders was part of the routine of watch keeping; the other work being done in spare time it lacks in continuity. The deductions are made from a purely practical point of view and a desire to effect an improvement which must become more necessary every day as piston speeds and loading increase. In an engine of the type mentioned it is easy to observe all that is going on, and knowledge gained thus could be applied with much greater advantage to an enclosed trunk-piston or double-acting type where conditions are not only more severe but the amount and nature of the waste from the cylinders of vital importance to the operation of other parts of the engine.

INSTITUTE NOTES.

ELECTION OF MEMBERS

List of those elected at Council Meeting held on Monday, 5th April, 1937.

Members.

Richard Joseph Blackman, 15, Lennox Road, Gravesend, Kent.

Robert Lindsay Campbell, 67, Ayr Road, Prestwick, Ayrshire.

Marino Corsi, Corso Torino 1-31, Genoa.

Louis Earl Crowther, Amara, Mayfield Road, Whitby, Yorks.

James Diack, Fenham House, 86, Brighton Grove, Newcastle-on-Tyne.

William Farrage, The Laurels, Bottesford, Nottingham.

Nisbet Carlin Fleming, Rosedale, 229, Neilston Road, Paisley.

Charles Thomas Glover, 47, Dewsbury Road, Dollis Hill, N.W.10.

Jonathan Edward Green, 38, The Drive, Tynemouth.

Walter Oswald Hunt, Mines Office, Ipoh, Perak, F.M.S.

John Ernest York McCormick, Cliftonville, 6, Elmar Road, Aigburth, Liverpool.

Edwin Clement Manger, County Oak, Crawley, Sussex.

Cedric John Newman, Dayspring, 14 Victoria Road, Gorleston-on-Sea, Suffolk.

Arthur Dinsdale Smith, 38, Maple Avenue, Monkseaton.

George Henry Titchmarsh, 78, Gordon Avenue, Hamilton, Newcastle, N.S.W.

James Henry Atkin Trowell, Mines Dept., Ipoh, F.M.S.

Companions.

Thomas Ormiston Callender, Director and Manager, Marine Dept., Callender's Cable and Construction Co., Ltd.

Cuthbert Isaac Willan, South Park, Hexham.

Associates.

Robert Ewing Craig Ballantyne, Campana, Doran Drive, Redhill, Surrey.

Robert George Bridges, Dilkhush, Grange Park Avenue, Sunderland.

John McIntyre, Flat 28, Central Fire Station, Manchester.

William James Owen Studd, Capt., Scocles Court, Minster, Isle of Sheppey, Kent.

ADDITIONS TO THE LIBRARY.

Purchased.

"Reports of the Progress of Applied Chemistry", Vol. XXI, issued by the Society of Chemical Industry at 12s. 6d. net, containing the following :—

"General, Plant, and Machinery", by Donald.
"Fuel", by Hodsman, Millett and Clark.
"Gas, Carbonisation, Tar and Tar Products", by Hollings and Voss.
"Mineral Oils", by Goulston.
"Intermediates and Colouring Matters", by Rodd, Davidson and Stocks.
"Textiles, Fibres, and Cellulose", by Speakman and Stott.
"Pulp and Paper", by Grant.
"Bleaching, Dyeing, Printing and Finishing", by Turner.
"Acids, Alkalis, Salts, etc.", by Hirst, Rowell and Weil.
"Glass", by Turner and Preston.
"Refractories, Ceramics and Cements", by Sugden.

"Iron and Steel", by Bannister.
"Non-ferrous Metals", by Powell.
"Electro-Chemical and Electro-Metallurgical Industries", by Cuthberston.
"Oils, Fats and Waxes", by Hilditch.
"Paints, Pigments, Varnishes, Resins and Solvents", by Members of the Oil and Colour Chemists' Association.
"Rubber", by Twiss.
"Leather and Glue", by Burton.
"Soils and Fertilisers", by Crowther.
"Sugars and Starches", by Eynon and Lane.
"The Fermentation Industries", by Hopkins and Norris.
"Food", by Cox.
"Fine Chemicals, Medicinal Substances, and Essential Oils", by Stedman.
"Photographic Materials and Processes", by Horton.
"Explosives", by Weir.
"Sanitation and Water Purification", by Thompson.

Presented by the Publishers.

Board of Trade Circular 1709. Instructions to Surveyors—Deck Sheathings for Cargo and Passenger Ships.

"The Operation and Maintenance of Marine Diesel Engines", by S. B. Freeman. Diesel Engine Users Association.

The following British Standard Specifications:
No. 487-1937. Fusion Welded Steel Air Receivers.
No. 721-1937. Machine Cut Gears. C. Worm Gearing.
No. 726-1937. Measurement of Air Flow and the Free Air Delivered by Compressors.

The Journal of the Institute of Metals, Vol. LIX, containing the following papers:—
"The Scientific Organisation of Works", by Chevenard.
"Fluxes for Use in Soft Soldering", by Willstrop.
"Note on Pickling or Etching Baths for Duralumin", by Sutton and Peake.
"A Note on the Influence of Salt-Bath Heat-Treatment on the Corrosion-Resistance of Duralumin Sheet", by Sidery.
"Shrinkage During the Solidification of Aluminium Alloys", by Stott.
"Study of the Forgeability of Various Light and Ultra-Light Alloys", by Portevin and Bastien.
"Mechanical Properties of Aluminium and its Alloys After Prolonged Heating", by von Zeerleder and Irmann.
"The Conductivity of Super-Purity Aluminium: The Influence of Small Metallic Additions", by Gauthier.
"An Anodic Treatment for the Production of Aluminium Reflectors", by Pullen.
"The Creep of Tin and Tin Alloys, Part I", by Hanson and Sandford.
"Metals of the Platinum Group: Ores, Recovery and Refining, Fabrication and Uses, and Properties", by Atkinson and Raper.
"The Complex Interdependence of the Properties of Alloys and the Industrial Conditions of their Manufacture, Testing and Use", by de Fleury and Portier.
"Veining and Sub-Boundary Structures in Metals", by Northcott.
"Methods for the Examination of Thermal Effects Due to Order-Disorder Transformation", by Sykes and Jones.
"A Further Study of the Constitution of the Cadmium-Tin Alloys", by Hanson and Pell-Walpole.
"The Nature of the Solid Solution of Antimony in Lead", by Ageew and Krotov.
"The Solid Solutions of Indium and Lead", by Ageew and Ageewa.

"Principles of Heating, Ventilating and Air Conditioning", by A. M. Greene. Chapman & Hall, Ltd., 446 pp., illus., 22s. 6d. net.

This book, as the author states, has been written for the use of engineering students, architects and building superintendents, to whom it will prove very informative and interesting. Its appeal, however, to the practical ventilating engineer in this country will be somewhat limited, as much of the subject has already been dealt with in earlier treatises.

For intending purchasers of ventilating or air conditioning equipment it provides a useful reference, as not only are the manufacturers' names given, but detailed data sheets relating to the performance of their various products will be found in the appendix.

The book is well written and profusely illustrated.

"Electricity and Magnetism", by R. G. Mitton, M.Sc., D.Phil. J. M. Dent & Sons, Ltd., 272 pp., illus., 3s. 6d. net.

This book has been primarily written for students preparing for School Certificate Examinations, but in order to develop interest in the practical applications of electricity the scope of the book extends beyond the requirements of the examination syllabus and includes chapters dealing with modern discoveries in electricity, alternating currents, motors, generators, etc.

The needs of the students preparing for the examinations mentioned above have been ably met, and we can cordially recommend the book to all teachers of the subject. The subject matter is quite comprehensive and set out in a simple manner. Numerous worked examples are given throughout the book, and at the end of each chapter a series of exercises and a selection of questions from various named examination papers are given. These are well chosen and will be of great assistance to the teacher.

The portions of the book dealing with practical applications of electricity are carefully written and chosen and will no doubt have the desired effect of stimulating interest in the subject, but unless illustrated and explained by lecture or laboratory demonstrations this will be practically the limit of their utility.

It is a pity that "C" is used throughout the book as the symbol for current, as this leaves something to be unlearned later by those students who continue their study of the subject. The illustrations are good and numerous, the general production of the book is excellent, and the price particularly reasonable.

"Thermodynamics Applied to Heat Engines", by E. H. Lewitt, B.Sc. Sir Isaac Pitman & Sons, Ltd., 2nd edn., 376 pp., illus., 12s. 6d. net.

This book was originally published in 1933, and the early call for a second edition is sufficient proof of its usefulness. Its sixteen chapters cover the usual ground in a degree course—the application of the laws of gases and vapours to the theory of steam and internal combustion engines, air compressors, and refrigerators.

There is a chapter on the combustion of fuels, and the book concludes with an account of the kinetic theory of gases. Numerous illustrative examples are worked out fully in the text, and there are plenty of exercises, with answers, for the student.

Some criticism might be directed against an occasional looseness of language or statement, e.g. on page 241 "a ring of fixed blades between each wheel of moving blades" and on page 250 "This relative velocity may be found by subtracting the vectors of the steam velocity and the blade velocity". The author considers it sufficient to define a reaction turbine as one in which the steam expands as it flows over the blades, but the student will probably still wonder why this expansion gives rise to a "reaction", and some explanation should be given. On page 251 the statement occurs: "As the steam must glide off the blade without shock the blade tip at exit must be made parallel to the relative velocity vector V"; surely it is the exit angle of the blade which itself determines the direction of this velocity vector, and actually the blade exit angle is fixed by other quite different considerations?

These are, however, very minor criticisms of a book which on the whole ably fulfils its purpose and can be recommended to students preparing for a degree or the Associate Membership Examination of The Institute.

JUNIOR SECTION.

Different Types of War Vessels.

A very successful joint meeting of the Junior Section and the students of Battersea Polytechnic was held at the College at 7 p.m. on Thursday, March 18th, 1937, when Eng. Rear-Admiral W. M. Whayman, C.B., C.B.E. (Vice-President), delivered a most interesting lecture on "Different Types of War Vessels". Mr. G. F. O'Riordan, B.Sc. (Member), Principal of the Polytechnic, occupied the Chair.

A carefully selected series of slides enabled Admiral Whayman to illustrate his description of all the principal types of ships employed in the Royal Navy, including battleships, battle cruisers, cruisers, destroyers, aircraft carriers, minesweepers, submarines, sloops and repair ships. Advantage was taken by the large audience of the opportunity to ask a variety of questions, almost half an hour of the proceedings being thus occupied.

On the proposal of Mr. Harris (Secretary of the Polytechnic's Engineering Society), a very hearty vote of thanks was accorded to Admiral Whayman for his lecture, and Mr. O'Riordan's able chairmanship was acknowledged by a vote of thanks proposed by Mr. B. C. Curling (Secretary).

ABSTRACTS OF THE TECHNICAL PRESS.

New German Cruising Liners.

The author gives a brief description of the cruising liner now under construction at the Hamburg yard of the Howaldtswerke for "Strength through Joy", the official German organisation for the promotion of popular recreation, the programme of which includes cruises to Norway, the Mediterranean, and Madeira. The two vessels ordered—a second vessel is being built by Blohm & Voss of Hamburg—represent a novel type of cruising liner inasmuch as a one class lay-out of accommodation had to be arranged for 1,500 tourists in two and four berth outboard cabins, which were to be as nearly as possible equivalent as regards size, position and fittings. In addition, dining saloons of sufficient size to permit meals to be taken at one sitting were to be provided, and the accommodation generally was to be adaptable to the range of climatic conditions to be met with on the different cruises. The principal dimensions of the vessel described are as follows: Length B.P. 653ft.; breadth mld. 78ft. 9in.; depth to bulkhead deck 42ft.; draught 24ft. 7in. The twin-screw propelling installation is of the Diesel-electric type and consists of two pairs of Howaldt-MAN six-cylinder two-stroke trunk piston motors (520mm. dia. × 700mm. stroke) with a normal output of 2,070 e.h.p. at 235 r.p.m., coupled to 1,500 kW. a.c. generators. Each pair of generators provides current of 2,300 volt and 47 cycles per sec. for an a.c. synchronous propelling motor developing normally 4,000 s.h.p. at 117·5 r.p.m. sufficient to give the vessel a speed of 15·5 knots, with a maximum continuous output of 4,400 s.h.p. at 121 r.p.m. to provide for adverse weather conditions. Two further Diesel generators of the same particulars as the propulsion sets provide alternating current for the engine room and ship auxiliaries.—*H. Schmeerenbeck, Kiel. "Schiffbau", Vol. 38 No. 6, pp. 89-91.*

Fireproofing Achieved by Rebuilding.

In the course of reconstructing the "Catherine", a 2,000-ton passenger and cargo vessel on service in the West Indies, extensive use was made of incombustible materials. Metal, asbestos and bakelite are used for furniture, and curtains, etc. are impregnated so as to render them non-inflammable. Cabin bulkheads are of "Marinite", a type of asbestos sheeting ¾in. thick. A somewhat similar material was used for lining bulkheads and decks. For lining the main fireproof bulkheads and for refrigeration insulation, a rock wool material, BX-100 3in. thick was employed. Interior doors are of Marinite and bakelite, and all doors in fireproof bulkheads close automatically. The Author states that fireproofing has not been achieved at the expense of appearance, and that the materials used in addition to being fireproof are vermin-proof, durable and otherwise suitable for use in a hot climate. — *"Marine Engineering & Shipping Review", vol. 42, p. 131-5.*

The Floating Whale-Oil Factory "Strombus".

This vessel was originally built as a tanker and subsequently converted into a whale-oil factory, and has now been reconstructed a second time. The principal dimensions are 410ft. b.p., 51·8ft. breadth moulded and 34ft. depth, and the deadweight 7,720 tons on a draft of 27·4ft. The chief modification consisted in constructing at the stern a slipway up which the whale carcases can be hauled, so that they can be cut up on deck, instead of alongside, as formerly. The factory equipment has also been modernised, and is now capable of handling 12 large whales a day. As the engines are aft, the construction of a slipway on the centreline involved replacing the single funnel by two funnels abreast; similarly the mainmast was replaced by twin derrick posts. The vertical walls at the sides of the slipway are of double construction and serve to provide light and air to the engine and boiler rooms. Parts of the slipway floor are portable to facilitate shipping of machinery parts. The arrangements for hauling the whales on to the deck comprise a 12-ton and a 40-ton winch, the ropes from which pass over spring-mounted pulleys in order to damp out shock loads. Special attention has been payed to artificial ventilation of the factory and living accommodation. The crew carried numbers 180.—*"Engineering", 19/3/37, p. 313-5.*

Engineering Through the Nations.

In the Annual Lecture to the Graduates' Section of The Institution of Mechanical Engineers, Col. S. Kitson Clark reviewed the development of ideas which has taken place from the day when men first took up a hammer till they became the finished product of the present day. He considers that in the first instance men confined themselves to the observation of the phenomena around them and that the application of knowledge formed only a second stage, while the idea to ask and answer the question "why these things were" did not come into their minds till far later times. Thus, after observing such phenomena as Light, Division of the Waters, Dry Land, Herb and Fruit, the Sun and the Moon, men began to watch the times and seasons and the firmament. On this path they were led to the arithmetical operations and to drawing. The lecturer places the discovery of numbers and of "the quality of lines" in the time of the Babylonians, who, reckoning up the sun's movements relative to the earth, divided up the circle of this revolution into 360 days. Having made a circle, they must then have noticed that the length of a radius repeated as a chord round the circumference closes an equilateral six-sided figure, and the lecturer suggests that the combination of this number with the ten of fingers and toes formed the basis of the sexagesimal system of the Babylonians, as illustrated by the recent discovery of a tablet dated 2300/1600 B.C. which presents a remarkable series of numbers. On this tablet seven symbols run thus:—1, 4, 9, 16, 25, 36, 49; then follow double symbols:—1·4, 1·21, etc. From the run of the figures it is clear that squares in rising value are being recorded, and that the eighth symbol, which is a pair, equals our 64; therefore, the 1 in position before a digit is put for the measure of notation 60. Commenting on the sexagesimal system, the lecturer points out the convenience of the divisibility of its measure by 2, 3, 5, 6, 10, 12, 15, and 30 compared with the mere 2 and 5 of the decimal system. He emphasizes the drawback of its multiplicity, however, and points out the advantage of the compromise solution of the problem of notation represented by the British system. Here with 10 toes we have the decimal notation, our feet as measure units have 12 inches, the year has twelve months, the day 12 hours, and minutes and seconds repeat the 360 of the Babylonians. Referring to the Roman system of notation, which had separate units up to four, then V, double for X, making VI with an additive I and IV with a subtractive I, the lecturer draws attention to the difficulty of calculation on the basis of these dispositions, such as multiplying DCCXXIII by CCLXIV which could only be performed by means of an Abacus, horizontally strung, so that beads might be slipped into place and remain there. The missing feature of the Roman system was the principle of value by position involved in making 1·4 mean 64, which had already appeared in the prehistoric tablet, but which was not re-introduced until the fifth or sixth century A.D. Had it been possible to make an Abacus with vertical strings, and by some hidden force cause the beads when counted to remain in place, the Romans might have arrived at the positional value of digits. It was left to an unknown Hindu, however, to present this invention to the world together with the further step of introducing zero, on the use of which all our present calculations are based at some stage or other. On the Babylonian development of the system of notation followed achievements in construction such as the irrigation of Mesopotamia, reservoir construction, and the diversion of the Nile in Egypt, the measurement of the river's rise and fall by gauges, and the survey of land. The inquiries of the Greek philosophers and mathematicians, while contributing to the training of the human mind, did not solve general problems by general principles, nor devote the results to material projects. The work of Archimedes, however, resulted at last in a definite practice in engineering—the discharge of bilge from Hiero's ship by a screw, the use of the knowledge that fluids under pressure have effect in every direction, the property of a lever, and the measurement of specific weight. For a long time to come men, looking out on the universe, did not inquire into the causes of the phenomena which they observed and of the effects of which they made use. But when in the seventeenth century, Newton concerned himself with one great problem and formulated the solution of gravity, then the engineer could put into his calculation a master principle which rationalised all his achievements.—*Col. S. Kitson Clark, "The Engineer", 19th March, 1937.*

Vibrations on Engines.

Discussing in an editorial article the problems of engine vibration with particular reference to ships and aircraft, where the foundations are more or less elastic, the writer reviews the results of the experimental investigations presented by Messrs. L. J. Mesurier and R. Stansfield in their paper, read before the North East Coast Institution of Engineers and Shipbuilders, entitled "Vibrations in Engine Structures". In this paper, the authors calculated and compared the stresses induced by vibratory motion on various parts of engines operating under service conditions, the research being carried out with the aid of a Standard-Sunbury type of electro-magnetic indicator. This instrument includes a cathode-ray oscillograph, and by diagrams thrown on a flourescent screen of this, records were obtained of the relevent stresses, and, consequently, of the oscillatory motion described by the structural member under investigation. Of the series of tests undertaken, one related to the rate of variation of pressure in the cylinders of slow-speed oil engines of the airless injection type. This revealed that only a relatively small fraction of the total rise in pressure was due to the uncontrolled burning of the fuel admitted during the delay period of the cycle, and it was observed that the structures of the engines were subjected to stresses and strains in excess of the intensities derived from the indicator diagrams by amounts increasing with the uncontrolled pressure rise during the process of combustion. The impact stresses ultimately exceeded the stress corresponding to the maximum pressure in the cylinder, even when the stress was produced at pressures less than this maximum. When long-delay fuels were used the impact effect, initiated by the uncontrolled combustion following the period of delay tended to produce stresses equalling those for full-load conditions, whereas with short-delay fuels the maximum stresses fell steadily in value to a point where they attained the limiting value due to impact loading. The research on petrol engines lends support to the view that troublesome detonation probably arises from two sources. One of these is characterised by the observed fact that detonation is followed by oscillatory pressures having frequencies within the range of 3,000 to 8,000 cycles per second, according to the size of the cylinder, and the authors suggest that these vibrations lead to disturbances on the thin layer of gas which clings to the surface of the combustion chamber, thereby resisting the flow of heat during smooth running of the engines. The second type of detonation is characterised by the observation that the rapid rise of pressure produces impact stresses much in excess of those for smooth running conditions. Here the mechanical strength of the material is simultaneously reduced on account of the relatively high temperatures, and this combination of effects may lead to breakdown. Alternatively, failure may be brought about by the overheated metal inducing pre-ignition and thus making for impact loads greatly in excess of those produced under normal conditions of combustion. These periodic forces initiate vibrations on the frames of the engines. Very complicated oscillations are undoubtedly described by certain engine parts and the writer considers that diagrams of the kind obtained in these tests should greatly facilitate the work involved in reducing noise due to engines. This may be effected by increasing the degree of stiffness of given parts, a procedure which leads to an increase in the natural frequency and a decrease in the amplitude for prescribed conditions of motion, whence sound of a higher pitch is emitted. The authors also discovered that in high-speed engines the maximum pressure in cylinders was appreciably greater with long-delay fuels than with short-delay fuels unless the injection was retarded and the efficiency correspondingly reduced. It was also noted that the course of combustion was influenced mainly by the degree of turbulence and distribution of the spray after the instant corresponding with the end of the delay period, and that the combustion may lag considerably behind the supply of fuel to the cylinders.—*"Engineering", 2nd April, 1937.*

The Present Position of the British Mercantile Marine.

Examining editorially on the annual report recently issued by the Chamber of Shipping of the United Kingdom, the writer draws attention to the pronouncement "that it would be wrong to imagine that the recent improvement in tramp freight rates has fully restored tramp shipping to financial stability, for its exhaustion was too grave to be repaired by a few months of prosperity". He considers that the prices at which some shipping shares are changing hands might be difficult to justify if they were regarded solely as dividend earning investments and that the renewal of the shipping subsidy was indicated in view of the remaining arrears of depreciation. In respect of the arrears which had accumulated during the last six years of depression a special inquiry of the Chamber—covering 257 purely tramp companies out of 377 recipients of the subsidy and related to an aggregate ordinary share capital of £25.800,000—revealed a total amount of £18,665.000, of which £10.589.000 was still outstanding. Of the £8,076,000 depreciation provided the greater part was met from other sources than the profits of ship operation, and nearly one-fourth of it during 1930, before the slump reached its most acute phase. The average rate of dividend on the capital stated, during the same period was 1·5 per cent., of which only one-third was actually earned by the vessels trading. For the liner companies, the customary summary published in "Fairplay" indicated that in 1936, 28 liner companies with a total paid-up capital and reserves amounting to £95,500,000, and owning vessels aggregating 5·4 million gross tons with a book value of £74,800,000 were able to set aside only £4,200,000 for depreciation and to pay only 1·69 per cent. on the capital and reserves. A survey of the tonnage statistics shows that at the end of June, 1936, U.K. sea-going steam and motor tonnage amounted to 17·2 million tons gross, equal to 28 per cent. of the world total, as against 18·9 million tons gross and 44 per cent. in June, 1914. Omitting vessels under 4,000 tons gross and those more than 25 years old, the United Kingdom proportion was, however, 36 per cent. in 1936, as compared with 27 per cent. in 1914. Compared in another way, United Kingdom tonnage fell by 15·4 per cent. between 1930 and 1936, whereas tonnage owned in other countries was reduced in the same period by only 1·8 per cent. The disproportionate increase in foreign-owned tonnage has resulted, in a great measure, from the operation of subsidies. Thus, the four principal subsidising countries, namely France, Italy, Japan, and the United States, together increased the number of their vessels over 2,000 tons gross from 1,401 in 1914 to 3,231 in 1936, while the numbers of British vessels of corresponding size have fallen from 3,906 to 2,873. The extent of state aid to Japanese shipping is illustrated by the following figures:—Loans for new construction between 1930 and 1933 amounted to £2,700,000: grants in aid of scrap and build schemes to £900,000, and operating subsidies to slightly less than £6,700,000. In addition, plans have been announced to double the 1935 total of 4,000,000 tons, an important feature of the new programme being the construction of 450,000 tons of high-speed cargo vessels of 4,000 tons deadweight and over and tankers with speeds up to 20 knots. Port statistics further indicate that from Bombay to Japan, Japanese vessels carry 80 per cent. of the traffic and 89 per cent. in the opposite direction; in Far Eastern ports generally, entrances and clearances of Japanese ships have increased by amounts varying from 6 to 26 per cent., while those of British ships have remained stationary. In summarising the present position of British shipping, the writer finally quotes figures of tonnage available in relation to demand, which show a reduction of the excess supply from 38 per cent. in 1933 to 15 per cent. in 1936, while the total of laid-up shipping in U.K. ports on 31st December, 1936, was only 332,041, the lowest figure for 15 years. —*"Engineering", 26th March, 1937.*

EXTRACTS.

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

Four 17-knot Italian Banana Carriers.

Vessels for the Genoa-Somaliland Service with a Maximum Trial Trip Speed of 19·2 Knots.

"The Motor Ship", March, 1937.

Much has been written of the growth of the banana industry, and the ships which have been built for the express purpose of transporting this fruit. During the years of depression there has been a very substantial fall in the trade, and, for instance, whereas in 1930 the total export of bananas from all the producing countries amounted to about 2,460,000 tons, in 1934, the last year for which figures are available, the amount was only 1,866,000 tons. The largest quantity comes from Honduras (about 390,000 tons in 1934), whilst from Jamaica in the same year the weight of bananas was 319,000 tons.

Whilst the general world export of bananas has thus diminished—no doubt it is now on the increase again—there has been a substantial advance in the tonnage shipped from Somaliland to Italy. In 1930 it amounted to no more than 700 tons. In 1934 it was 14,000 tons, and this year will probably be in the neighbourhood of 20,000 tons. The distance to be covered is, however, large—about 4,000 sea miles—which is nearly the same as from Jamaica to Europe.

There is, in Italy, a Banana Monopoly operated by an organization known as the Regia Azienda Monopolio Banane, which presumably controls the sale and transport of bananas for Italian consumption.

It was decided by this organization, at the beginning of 1936, that fast new tonnage of the most modern type should be built to transport bananas from Italian Somaliland to Italy. After obtaining tenders from six of the leading shipyards orders were placed for four similar vessels, two with the Cantieri Riuniti dell' Adriatico, to be equipped with C.R.A.-Sulzer engines, and two with the Cantiere Navale Ansaldo, Genoa; in these Fiat Diesel motors are to be installed.

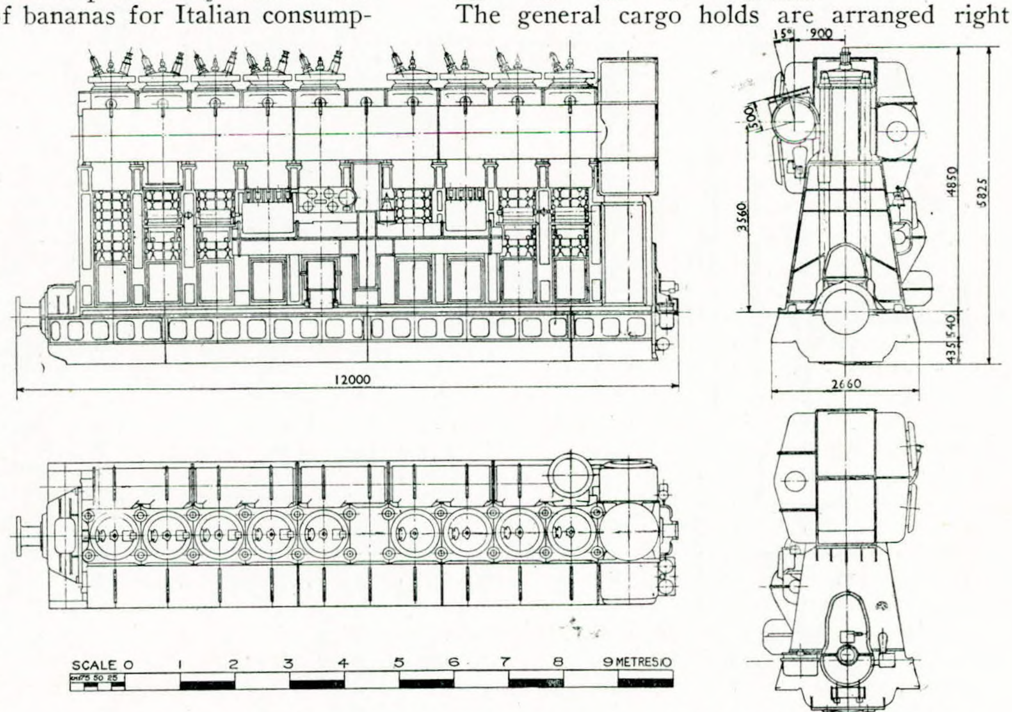
Five models were built for testing in the tank, and it is stated that the results achieved by the model ultimately adopted showed an improvement of 23 per cent. in propulsive efficiency, compared with the first model with which trials were made. Final tests were effected on 26th June, 1936, and the order was placed on 1st July, the condition being that two of the ships should be delivered within 12 months and the other two within 13 months.

Leading Details of the Hull.

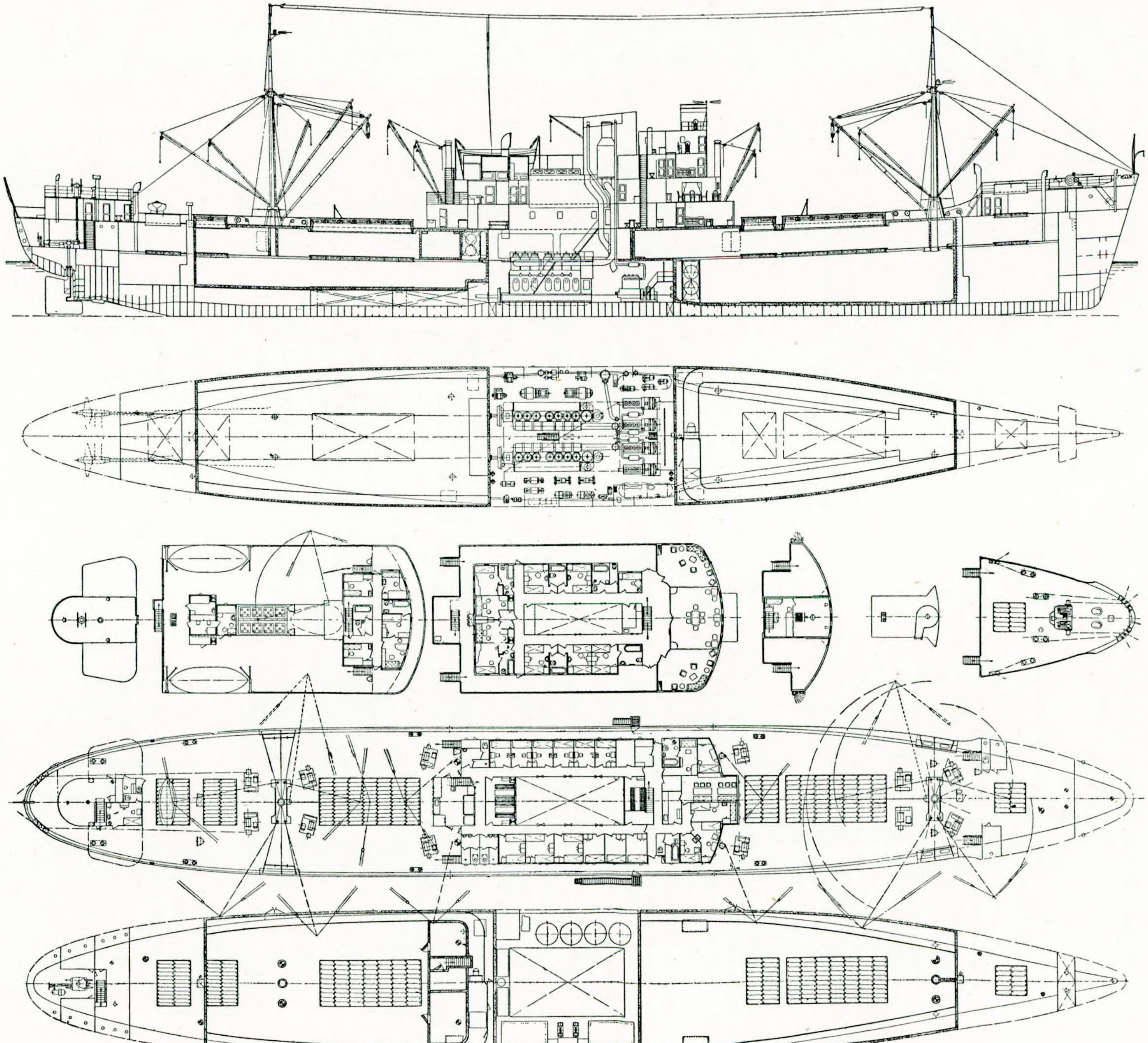
The plans of the ships as finally designed are given, showing a round-nosed sloping bow and low funnel. The general dimensions are as under :—

Length overall	112 metres, or 364ft.
Length b.p.	108 metres, or 352·2ft.
Beam	14·6 metres, or 47·9ft.
Depth to main deck ...	5·81 metres, or 19·1ft.
Mean draught with full cargo	5·56 metres, or 18·25ft.
Deadweight capacity ...	2,300 tons.
Gross register	3,500 tons.
Displacement with full cargo	5,200 tons.
Displacement light	2,900 tons.
Refrigerated cubic capacity	4,000 cubic metres or about 140,000 cubic ft.
General cargo capacity ...	1,000 cubic metres, or about 35,000 cubic ft.
Deadweight of bananas with refrigerated space full	900 tons.

The general cargo holds are arranged right



Outline plan and elevations of the Fiat engines to be installed in Italian banana carriers.



General arrangement plans of the new C.R.A.-Sulzer-Engined banana-carrying ships.

forward and aft, the remainder of the hold capacity of the ship being refrigerated, with the propelling and auxiliary machinery space located approximately amidships.

In view of the relatively high propulsive efficiency which is claimed for these ships, it is interesting to note that the ratio of length to beam is 7·4, compared with a figure of 6·8 to 6·9 with corresponding Scandinavian-built fruit ships of approximate size. The Suez Canal tonnage is 2,250 gross, and as the ships will make the passage through the Canal 24 times each year, paying about 34 lire per ton (or 7s. 3d.), a diminution of only 10 tons in the Suez Canal tonnage represents an annual economy of 8,160 lire, which, when capitalized, is equivalent to 163,000 lire, or about £1,750.

In the specification it was laid down that the ships should be able to maintain a mean speed of 18·5 knots on trial, when loaded, and that a maximum speed of 19·2 knots should be reached. In normal service it is intended that a speed of 17 knots shall be averaged, with a total deadweight of 1,150 tons, which comprises the figure of 900 tons of bananas, also fuel and water.

The hull weights are as follow :—

Hull Weights.

Bare hull	1,481 tons
Equipment	842 tons
Machinery	563 tons
Spares	14 tons
Total	2,900 tons
Deadweight capacity	2,300 tons
Total displacement with full cargo...	5,200 tons

The deadweight is made up as under :—

Deadweight Tonnage.

Crew	10 tons
Fuel	250 tons
Water	120 tons
Consumable stores	10 tons
Cargo	1,900 tons
Total	2,290 tons

When the cargo is bananas, which, as we have mentioned, weigh only 900 tons, there is a reduction of about 680 tons in the net displacement. In case of necessity the ship is able to carry 400 tons of fresh water and 450 tons of fuel.

The metacentric heights under various conditions of loading are given below :—

Metacentric Heights.

Light ship (2,900 tons) ...	0·32 metres, or 1·05ft.
Hull with full cargo (5,200 tons)	0·67 metres, or 2·2ft.
Hull with full cargo of bananas (4,400 tons)...	0·81 metres, or 2·66ft.

A crew of 36 is carried, comprising the master, four deck officers, the chief and three engineers, seven assistants, and 20 seamen, stewards, etc. All the engineers, including the assistants, have single-berth cabins. The whole of the crew has quarters amidships, none of the accommodation being aft.

Contrary to the general arrangement adopted with the passenger accommodation in fruit ships, in the new vessels a complete deck is given over to the cabins and public rooms for the 12 passengers. There are two de luxe suites, each for one passenger, comprising a bedroom, a bathroom and a large sitting-room. In addition, there are five double-berth cabins, whilst forward are arranged the dining saloon and two smoking-rooms. It may be noted that there is accommodation only for 12 passengers in the dining saloon.

The hot and humid climatic conditions encountered during the service of the ships has been considered, and the ventilating system is such that with an atmospheric temperature of 45° C., or 113° F., and a humidity of 90 per cent., a temperature of 29° C. (85° F.) and a degree of humidity of 60 per cent. will be guaranteed in each cabin, in the dining-room and in the smoking verandas.

For the handling of the cargo there are 15 electric winches, 12 of 5 tons, one capable of dealing with 30 tons, one of 15 tons, and another with a lift of 1½ tons for handling the machinery. It is believed that with the 12 5-ton winches in operation it will be possible to load 900 tons of bananas in one day. The reason for fitting cargo-handling gear to deal with a lift of 30 tons is that the transport of locomotives and heavy machinery to Somaliland is likely to be required in the future. The main hatches are exceptionally large, being 10·65 metres long and 4·80 metres wide.

A Marconi 1·5-kW. wireless plant is installed, and there is an Echo sounder used in that part of the Gulf of Aden which is not yet charted. The steering gear is of the Ansaldo electro-hydraulic type, and the anchor has a weight of 3,390 kg.

The electrical installation is surprisingly large, and there are four 150-kW. Diesel-engined dynamos, the Diesel engines in the C.R.A.-built ship being of the Sulzer type, whilst the other two vessels will have Fiat engines. The former are four-cylinder two-stroke single-acting sets, and the Fiat engines are of the four-stroke six-cylinder type, the speed in each case being 400 r.p.m. It is claimed that the electrical installation is larger than that in corresponding banana-carrying ships.

The refrigerating machinery has a rating of 350,000 calories, and is based on a sea temperature of 33° C., or about 92° F. There are two CO_2 two-cylinder compressors, each driven by a motor rated at 140 kW. The surface of the air coolers is 1,300 sq. metres.

Propelling Machinery.

In each ship the normal output required at sea for the speed of 17 knots is 5,000 b.h.p., but on trials each engine is capable of 3,600 b.h.p., or a total of 7,200 b.h.p. The two vessels with C.R.A.-Sulzer engines have two seven-cylinder two-stroke single-acting units, with a cylinder diameter of 560 mm. and a piston stroke of 840 mm. They are of the crosshead type.

For the supply of starting air there are two compressors with an output of 10 cubic metres per hour, charging two reservoirs of 9 cubic metres each. The two salt-water pumps each have a capacity of 270 tons hourly, and in view of the high temperature of the sea, already stated, it is necessary to have a large volume of water in circulation. There are two 60-ton piston-cooling pumps and two 50-ton lubricating-oil pumps driven by 35-kW. electric motors. Other electrically driven auxiliaries in the engine-room include ballast, fuel transfer, sanitary, fire and fresh-water pumps, besides which there are two centrifugal separators dealing with fuel and lubricating oil. As drinking water is scarce in Somaliland, a small distilling plant is installed, capable of supplying 2½ tons of drinking water daily.

In the two ships being built at the Ansaldo yard, the two Fiat engines are of the nine-cylinder type, with a cylinder diameter of 520 mm. and a piston stroke of 820 mm. They are of the crosshead two-stroke single-acting design. Cast-iron columns are employed with steel tie rods, connecting the bottom of the bedplate with the top of the cylinders. The glands of the piston water cooling pipes are external to the crankchamber. The cylinder liners are in two parts, the upper forming a combustion chamber and the lower in which are arranged the scavenging air and exhaust ports.

The scavenging air admission is controlled by automatic valves in the scavenging air trunk. Cast steel is employed for the cylinder covers, which penetrate slightly into the liner, in order to protect the joints between the cover, the liner and the cylinder barrel. The fuel injectors are water cooled. The upper portion of the piston, of forged steel, is water-cooled, and carries the piston rings. The scavenging air pump is driven from a crank at the fore end of the crankshaft and is of the double-acting twin-cylinder type.

The auxiliaries in the engine-rooms of the Fiat-engined ships are similar to those described in connection with the other two vessels, except in regard to the auxiliary Diesel engines.

The first of the engines in each class is to carry out a continuous 48-hour trial on the test bed, and the other engines will run for 18 hours continuously. The sea trials are to be arranged under loaded conditions, and, as recorded, an average speed of 18·5 knots will be attained.

The total fuel consumption, including that necessary for the operation of all auxiliaries, is not to exceed 165 gr. or ·36lb. per b.h.p.-hour. The propelling engines alone are to show a fuel consumption of 150gr., or 0·33lb. per b.h.p.-hour.

The performance of the Scandinavian banana-carrying ships has been borne in mind in designing these new vessels, and it is hoped by the owners and builders that they will prove to be even more successful than the modern type now operated by Scandinavians.

The Prevention of Corrosion in Oil Engines.

By Dr. Ing. K. Krekeler *

"The Motor Ship", April, 1937.

In Diesel engines as built for marine propulsion corrosion is liable to develop from different causes and with various results. Corrosion may be divided into three categories according to their occurrence :

1. Corrosion on water-cooled piston rods.
2. Corrosion in cylinder heads and liners.
3. Corrosion in cylinders and on working parts with the engine stopped.

In the following article the question of this corrosion is investigated and the measures which have been employed for its prevention are discussed.

Corrosion on Water-cooled Piston Rods.

Engine parts which are subject to alternating stress cannot be allowed to run with the intensity of stress based on ordinary tests. It is very difficult for the designer to determine what the permissible stress should be. Often failure occurs after considerable periods of operation at stresses which are far below those which the parts have been designed to withstand. It is now generally agreed that corrosion is the cause of this phenomenon.

A particularly good example of this is to be found with water-cooled pistons in which the cooling water passes through the piston rods. Under the influence of the water flowing through the rod, small cuts appear which develop into cracks as the result of the alternating load. As the corrosion in these cracks penetrates, the cross section of the piston rod becomes so diminished that a break may occur.

The cooling water passing through the cylinder heads and liners carries with it a certain quantity of air, and this is apt to cause corrosion. Specially severe corrosion may develop when sea water is employed for cooling purposes, but this is becoming less common.

Corrosion which occurs when the engine is stopped is mainly due to "sweating". The process is dangerous as it is most severe in inaccessible parts and cannot be easily prevented. It occurs in the interior of cylinders, due to the cooling off of the engine after being on load, and in the running mechanism (pistons, connecting rods, camshafts, etc.), through variations in temperatures and weather conditions. The corrosion may also result in certain cases from the employment of unsatisfactory fuel.

It is sometimes thought that sweating on the running parts cannot occur because of the film of lubricating oil. This is, however, not the case, since the moisture penetrates the film and corrosion may develop.

Special Steels and Protective Sleeves.

In a discussion of the measures to overcome corrosion, that referred to under Nos. 1 and 2 may

*Abstract of an article delivered before the Schiffbau Technische Gesellschaft.

be dealt with together, as the same preventive method may be adopted in the two cases. This is possible when the same medium is employed for cooling the cylinders and the piston rods. Attempts have been made to prevent corrosion by the employment of special steels, but no success has been attained. A second method, involving the adoption of corrosion-resistant metals or non-metallic sleeves, has also proved to be no solution. Either the sleeves are so brittle that cracks occur and no protection is, therefore, afforded, or the heat transmission from the cooling medium is considerably reduced. In some instances a chromium deposition on the rod has been employed to render it corrosion-proof. Laboratory tests and practice, however, demonstrated that although the appearance of corrosion was greatly delayed by this arrangement, complete success was not achieved. The degree of freedom from corrosion was found to depend largely on the quality of the water used.

The Use of Emulsifying Oil.

Of late years a new means of preventing corrosion has been developed. A small quantity (about 1 per cent.) of emulsifying corrosion-prevention oil is placed in the cooling water. This is the subject of a German Patent No. 622911. The effect is that a very thin film of oil forms on the surface and prevents corrosive action. It is so thin that heat transference is not diminished, nor is any influence effected upon the cooling capacity of the water. There is, moreover, no longer any corrosive effect upon the non-metallic parts.

Various characteristics are needed for the production of a satisfactory corrosion-resisting oil. In the first place, the oil must be emulsified completely with the water so that a satisfactory oil film can be deposited on the parts. Moreover, it must possess the quality of emulsifying even when it is only added to the extent of 1 per cent. With the most rapid reversal of flow of the cooling water, it must remain in an emulsified condition and, above all, it must be possible to centrifuge it so as to separate it from the crankcase oil.

Of great importance is the exact maintenance of the proportion of oil to water. This can be readily effected by means of a simple and handy measuring apparatus. The prevention of corrosion in cylinder heads and liners is carried out by the same oil and it has been found equally effective.

Prevention of Corrosion when the Engine is Stopped.

In order to avoid corrosive action on the working parts of an engine through "sweating", when it is stopped, a similar oil may be employed as is utilised with cooling water, except that it is applied unmixed with water. The corrosion oil has self-emulsifying characteristics, so that when any water comes in contact with the oil emulsification takes place automatically and thereby extracts from the cooling water its corrosive properties.

After applying the oil to the parts in question, there is no need to rub it off when the engine is started again on account of the fact that an extremely thin film of the oil is utilised.

Supercharging on the Buchi System.

By Alfred J. Büchi*

"The Motor Ship", April, 1937.

What were certainly the first tests with exhaust gas turbines in combination with internal combustion engines were made in 1911 in the Sulzer Works at Winterthur. The experimental plant worked according to the proposals then made by me. It is worth noting that during these tests supercharging was effected with low pressures and

*Extract from a paper read at a meeting of the American Society of Mechanical Engineers.

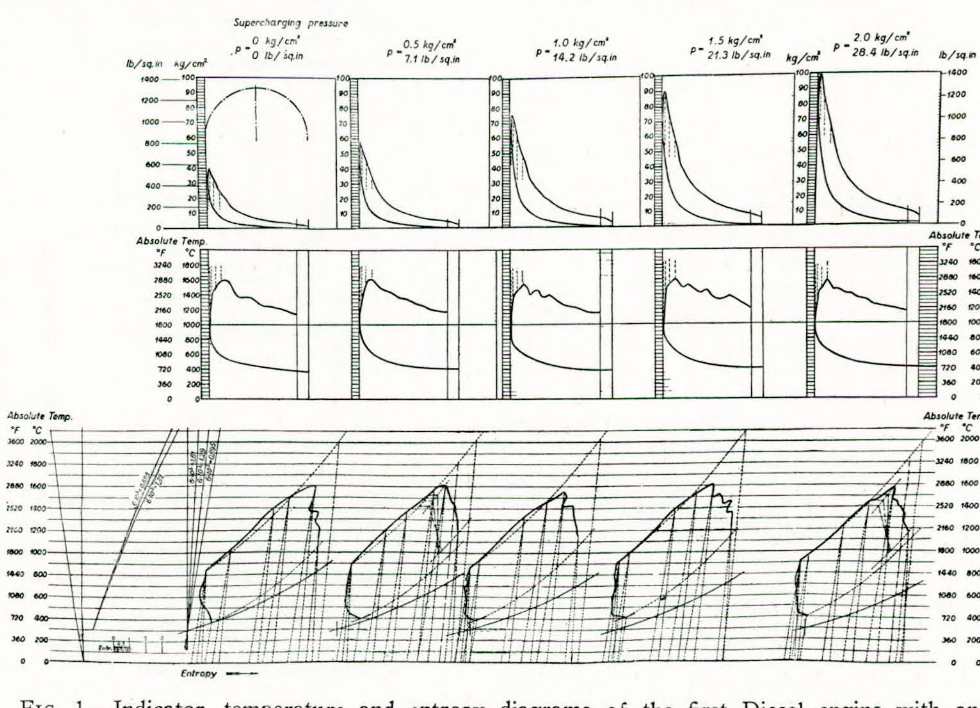


Fig. 1.—Indicator, temperature and entropy diagrams of the first Diesel engine with an exhaust gas turbine.

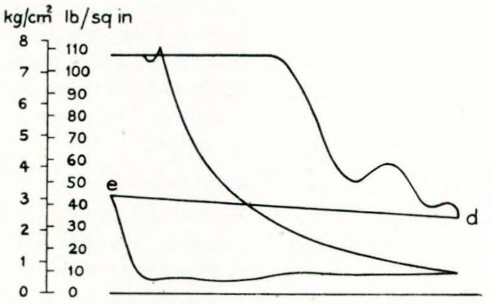


FIG. 2.—Weak-spring diagram.

also with pressures up to about 30lb. per sq. in.

In Fig. 1 are given indicator, temperature and entropy diagrams of the 1911 experimental plant for various supercharging pressures of 0, 7·1, 14·2, 21·3 and 28·4lb. per sq. in. Fig. 2 illustrates a weak-spring diagram and shows that the exhaust pressure was practically constant during the exhausting into the turbine according to line d—e. With the exhaust gas turbine which was used, no difficulties arose in running, and the increased mean effective pressure was taken by the running gear of the engine quite easily and without any excessive wear. For further improvements in the results it was necessary to introduce the greatest possible weight of charging air into the engine cylinder, in order, for a given swept volume, to obtain a high specific output with low gas temperatures, little transmission of heat, and high mechanical efficiency.

The Büchi supercharging system as at present adopted takes full consideration of these requirements. It consists mainly in the cylinder being not only charged with precompressed air, but also scavenged with a great quantity of cold precompressed combustion air.

It was not so easy to find a suitable working process. In consequence of rather low efficiencies of the exhaust gas turbine and the rotary blower driven by it for a certain supercharging pressure, approximately the same exhaust gas pressure as the blower pressure is necessary to drive the turbine with the given temperatures of the exhaust gases from the internal combustion engine. Consequently, a pronounced pressure difference between the charging air and exhaust gases, which is required for an effective scavenging of the combustion cylinders, is not available. For this the Büchi system makes use of an artifice; the pressure drop required between the supercharging pressure and the exhaust gas pressure before the turbine is generated artificially when it is needed and to the desired degree. This is effected by means of strong pressure oscillations, artificially caused in the piping between the engine and the exhaust gas turbine.

If the working cylinders have to be scavenged, the inlet and outlet valves must be open simultaneously during the scavenging period. Also during the scavenging period the scavenging process may under no consideration be disturbed by the exhaust occurring from another cylinder. Otherwise the gases from the exhausting cylinder would find their way through the open exhaust valves into the cylinder that has to be scavenged. This drawback occurs when all the cylinders of one internal combustion engine exhaust into the same exhaust manifold. It is eliminated in the Büchi system by the exhaust gases being led from the engine to the turbine through several pipes, or through pipes with suitable partitions fitted in them.

In Fig. 3 are given the pressure oscillations for various loads in one of the two exhaust pipes of a six-cylinder M.A.N. Diesel engine with exhaust turbo-charging.

The pressure oscillations of the other three cylinders of the same six-cylinder engine, which exhausted into a separate exhaust pipe to the turbine are to be considered as displaced by 120°, as indicated in dotted lines in the middle diagram of Fig. 3.

How the quantity of scavenging air adjusts itself in accordance with the load on the engine can be seen from Fig. 4. Curve *(a) corresponds* to an engine in which the load was altered at

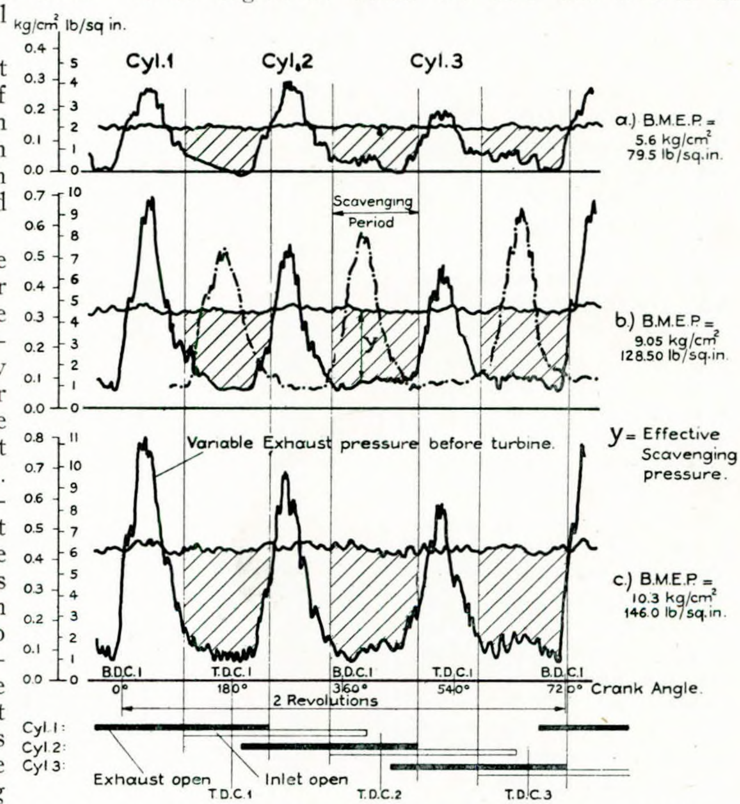


FIG. 3.—Pressure oscillations in two exhaust pipes of a six-cylinder M.A.N. engine.

constant speed (a stationary type engine). Curve (b), on the other hand, corresponds to a marine engine, in which the load was decreased by reducing the speed in accordance with the propeller law. Curve (a) was obtained from an S.L.M.-Diesel engine with eight cylinders, developing 1,000 b.h.p. at 273 r.p.m. with continuous supercharging, whilst curve (b) is from an eight-cylinder Harland and Wolff-Kincaid marine Diesel engine developing continuously 4,500 b.h.p. with supercharging. The speed of the latter engine is 112 r.p.m. The speeds of the corresponding blowers, designated (c) and (d) are also plotted on Fig. 4.

In Fig. 5 the conditions of pressure, volume and temperature of the working process with the Büchi exhaust turbo-charging are shown by an entropy diagram. The values plotted were obtained from tests on a Tosi six-cylinder Diesel engine with exhaust turbo-charging. A-B is the compression, B-C-D the combustion, and D-F the expansion in the working cylinder. At the point F the exhaust valves open, and the exhaust gases flow to the turbine, at the same time expanding as indicated by F-G. G-H corresponds to the cooling of the exhaust gases. The gases have at first, before the exhaust valve begins to open, according to the diagram, a temperature of 967° C. abs. = 694° C. or 1,282° F. Due to the drop to the pressure before the turbine, the temperature falls to 532° C. or 989° F. With 27·4 per cent. excess scavenging air the exhaust gases are cooled to 435° C. = 815° F. The cooling through scavenging is consequently 97° C. or 174° F., including a loss of heat of about 5° C. or 9° F. During the expansion in the turbine the temperature drops farther to 407° C. or 765° F.

The theoretical diagram A, B_1, C_1, D_1, E, F is given in dotted lines; the actual diagram runs as shown by the full line. Transferring the points of the diagram to pressure-volume co-ordinates gives the indicator diagram shown also in Fig. 5 above the entropy diagram. From this the corresponding indicated pressure can be determined. The mechanical efficiency of the engine in question was measured and found to be 85 per cent. The effective output and, knowing the introduced heat with the fuel, the fuel consumption can then be calculated from the indicator diagram. Based on the diagram in Fig. 5, the effective output of a six-cylinder engine, of 450 mm. bore and 700 mm. stroke, is found to be 1,060 b.h.p. at 187 r.p.m. with a b.m.e.p. of 109lb. per sq. in. The fuel consumption works out at 160 grams, or 0·353lb. per b.h.p.-hr.

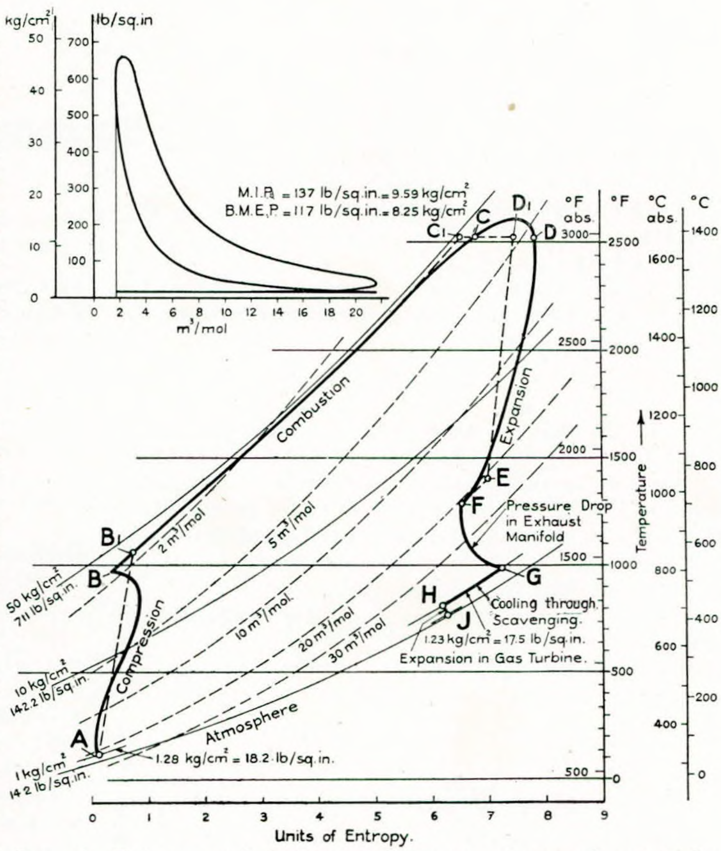


FIG. 5.—Entropy and indicator diagrams of an exhaust turbo-charged engine.

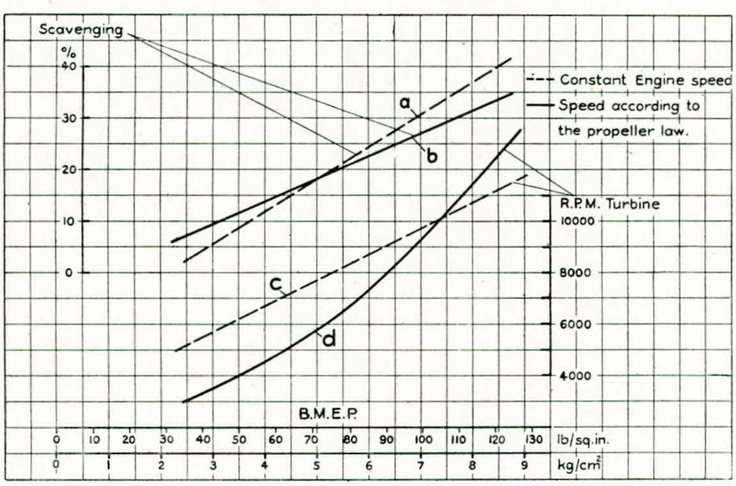


FIG. 4.—Scavenging percentages and speed of turbo-blowers.

In the entropy diagrams, H-I represents the expansion in the exhaust gas turbine. Its effective output must be equal to the power required for driving the air charging blower. The symbols used in calculating this have the following significations :—

G_1 = Weight of air delivered for charging and scavenging; R = Gas constant for air; T_1 = Abs. temperature for the air at blower inlet; p_1 = Abs. initial pressure, p_2 = Abs. final pressure of the air delivered.

In all references to horse-power, metric horse-power is intended.

ηK = Isothermal efficiency of the charging and scavenging air compressor.

$L_e(K)$ = Effective work done in compressing the charging and scavenging air.

$$L_e(K) = \frac{1}{\eta K} \times G_1 \times R \times T_1 \, \text{Log}_e \left(\frac{p_1}{p_2}\right)$$

G_2 = Weight of exhaust gases passing through the turbine; C_p = Specific heat of the exhaust gases at constant pressure; A = Mechanical heat equivalent; t_1' = Abs. temperature of exhaust gases before the turbine; t_2' = Abs. temperature of exhaust gases after adiabatic expansion in the turbine; $G_2 = G_1 +$ quantity of fuel introduced $= kG_1$.

ηT = Adiabatic efficiency of the exhaust gas turbine.

$L_e(T)$ = Effective output of the exhaust gas turbine.

$$L_e(T) = \eta T \times G_2 \times \frac{C_p}{A} (t_1' - t_2')$$

$$L_e(k) = L_e(T)$$

The effective temperature drop required in the exhaust gas turbine is therefore calculated as follows :—

$$t_2' - t_1' = \frac{1}{k \times \eta K \times \eta T} \times \frac{RT_1}{c_p \times 428} \times \log_e \left(\frac{p_1}{p_2}\right)$$

Fig. 6 illustrates quite clearly the effect of the scavenging.

Fig. 7 shows a side elevation and a section through the M.S. "Reina del Pacifico" of the Pacific S.N. Co. This vessel is in service between England and the West Coast of South America via the Panama Canal. It is noteworthy through being propelled by four 12-cylinder Harland and Wolff single-acting four-stroke trunk-piston engines with exhaust turbo-charging. The trunk-piston design gives an engine very low in height, so that many continuous decks could be arranged far down in the ship. There are only two exhaust pipes provided for each engine.

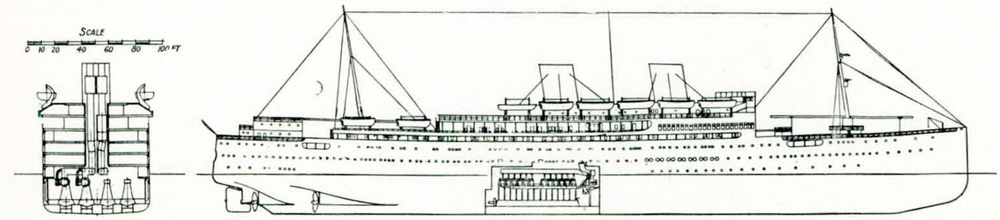


FIG. 7.—The "Reina del Pacifico", fitted with four 5,500 b.h.p. pressure-charged engines.

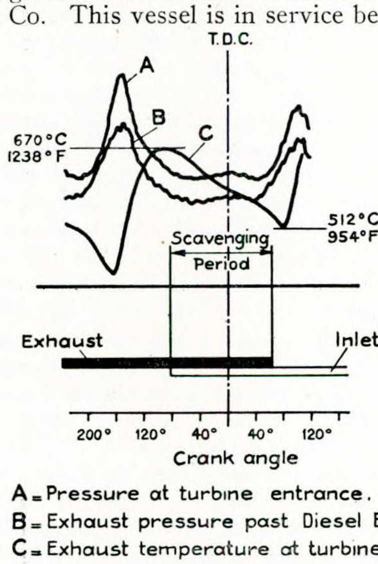


FIG. 6.—Temperature and pressure during exhaust and scavenging period.

Baffles for Marine Water-tube Boilers.

A correspondent discusses some of the latest developments, with particular reference to the marine field.

"The Marine Engineer", February, 1937.

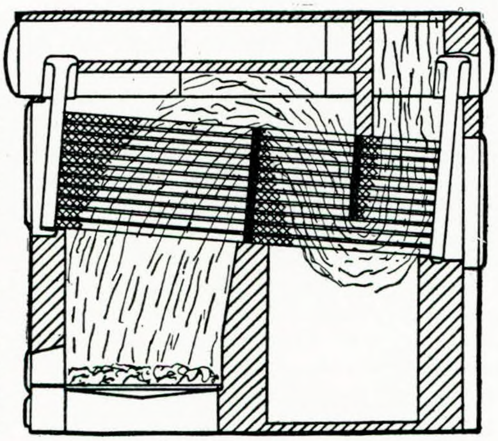
The combustion chambers for water-tube boilers, both marine and land types, have been revolutionised during the past few years by such inventions as the suspended arch, the suspended wall, and the water-cooled steel tube wall. Another valuable development in this field, and one which is particularly applicable to marine conditions, is the Beco expansion joint baffle.

Water-tube boilers of all types, whether of the horizontal, inclined, or vertical-tube types, have baffles between the tubes to direct the travel of the flames and hot gases so as to give a path of maximum length. The general practice adopted, although by no means the most efficient, is to build these baffles of bricks or blocks, forming narrow solid walls. In this arrangement no provision is included for expansion and contraction and severe internal strains are therefore set up because of the great temperature changes in the combustion chamber, causing cracking and other damage. As a result the flames and hot gases are short circuited, and they do not travel through the full length of the passes.

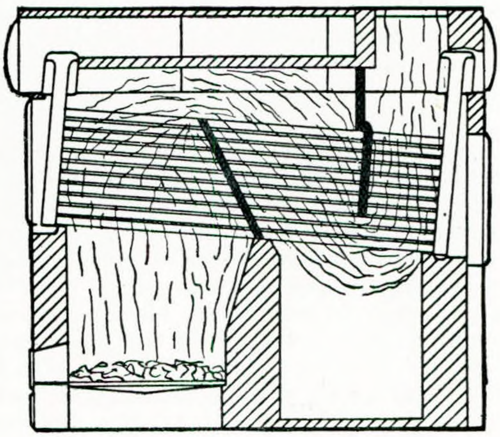
Baffles of this kind are also in constant need of repair, while they are frequently at the wrong points in the setting and at the wrong angle because of constructional difficulties inherent in a solid wall of this type. Because of this the flames and hot gases are not deflected in the correct path, so that only part of the tube lengths come into effective action even if short-circuiting did not take place due to cracking.

In the Beco baffle, as illustrated, the principle of the design is on much more scientific lines. The construction is carried out within the boiler setting, using a semi-liquid mixture of pulverised fire-brick and special cement which is poured into wood temporary moulds, the width of the baffles being 4in.

At intervals of about 7in. in the height corrugated iron strips 3ft. long and 4in. wide are laid between the tubes in the cement for the full length of the baffle. The cement mixture rapidly sets hard without heating and forms a baffle of sections divided by the corrugated iron strips, which take up all the expansion and contraction.

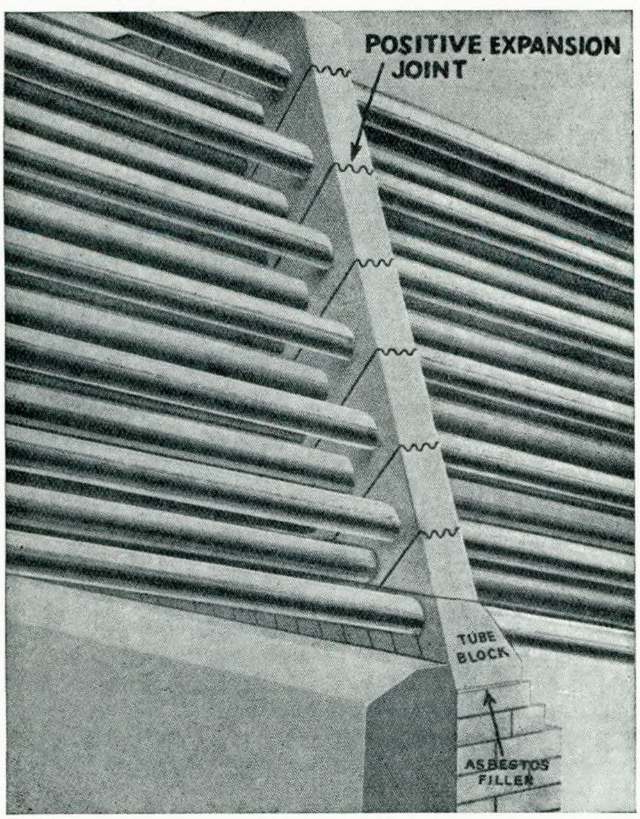


Ordinary verticle baffles applied to a water-tube boiler, showing the sections not reached by hot gases.



Beco baffles applied to the same boiler with all the tubes exposed to the main stream of hot gases.

The principal advantages of this arrangement are freedom from cracking, owing to the absence of internal stresses, baffles of this type remaining gas tight for years. Furthermore, with this construction any type of water-tube boiler can easily be fitted with baffles of any angle, shape, and size, so that the arrangement necessary to give the maximum efficiency can easily be installed in a manner quite different to solid walls built of bricks or blocks.



A Beco boiler baffle showing method of construction.

Thus the flow of the hot gases is easily directed so that the whole length of every boiler tube is used for heat transmission. As a result the efficiency of the average water-tube boiler can be increased from 3 to 5 per cent., with a reduction in the temperature of the waste combustion gases of some 100 to 200° F. and a corresponding increase in the rate of evaporation. Water-tube boilers representing over 30,000,000 sq. ft. of heating surface are now being operated on these lines, the marine field becoming increasingly important.

The First Parsons Memorial Lecture.

If Members will turn to page XVI of their Transactions for April 1936, they will see that one of the three forms of memorial to one of our most distinguished Past Presidents, the late Sir Charles Parsons, F.R.S., is "an annual lecture in any of the subjects in which Sir Charles Parsons was interested, to be delivered by a distinguished man of any nationality". The arrangements are in the hands of the Royal Society who will invite the various technical institutions, including the Institute of Marine Engineers, to nominate the Lecturers when the respective dates come round.

The first lecturer was nominated by the Institution of Electrical Engineers who generously suggested that preference should be given to the North East Coast Institution of Engineers and Shipbuilders, as Parsons' activities had been centred mainly at Newcastle-on-Tyne. Sir Frank Smith, F.R.S., was chosen to prepare and deliver the address in Newcastle on November 6th, and a better choice could not have been made because not only had he been closely associated with Sir Charles Parsons for many years, but he had acted as Secretary of the Memorial Committee during its meetings at the Royal Society.

The lecture was entitled "Sir Charles Parsons and Steam" but it touched also on his work in connection with electrical generators and motors, astronomical telescopes, and the making of artificial diamonds. After describing the scientific and engineering atmosphere in which Charles Parsons was reared, the lecturer proceeded:

When he was eighteen Parsons went to Trinity College, Dublin, and after one year there he entered St. John's College, Cambridge. In those days there was no engineering school in Cambridge, but Sir Alfred Ewing has said that there was at least one room which looked like an engineering laboratory, and that was Parsons' own room, crowded as it was with models intended to put his inventive ideas into practical shape. He passed out of Cambridge in 1877. The world of engineering was before him. It is well known that he took out his first patents for the steam turbine in 1884; it is well known also that at that date the properties and potentialities of steam were better understood by him than most engineers. It is not so well known that many engineers of that period, notwithstanding the recent advances in knowledge of thermo-dynamics, viewed the future of the steam engine with pessimism, a pessimism that must have been far from encouraging to Parsons.

Watt's invention marked the beginning of a new epoch, because the consumption of coal per horsepower hour was reduced to about 5·5lb., approximately one-fifth of that used previously. Indeed, Boulton and Watt guaranteed with 84lb. of Newcastle coal to raise 30,000,000lb. weight 1ft. high. "By burning this quality of coals", says Boulton, "you will produce a power equal to that exerted by ten horses". But, says Stuart in his "Anecdotes", "in forming this estimate his honourable mercantile spirit shone in a new brighter light". The efficiency was, in fact, equivalent to 1 horsepower hour for a consumption of 5·5lb. of coal. So marked was the superiority of the new engine that the patentees said: "All that we ask from those who choose to have our engine is the value of one-third part of coals which are saved by using our improved machine instead of the old". However, the engines which had been improved by Smeaton were excluded from this offer. As an example of the saving and the revenue, it is of interest to note that at the Chacewater mine in Cornwall the saving on coal was upwards of £6,000 per annum, and the patentees drew £2,000 per annum of this.

It is also recorded that the efficiency of the single-cylinder engine used in the Cornish mines rose from about 18 millions of foot-pounds per cwt. of coal in 1813 to 68 millions in 1844, after which less effort seems to have been made to maintain a high efficiency. The efficiency in 1844 was about 3·2lb. of coal per horse-power hour. In 1887, when steam at pressure was in use and triple and quadruple-expansion engines were employed at sea, there was a consumption in good engines of large size of 2lb. per horse-power hour, and by triple-expansion this was reduced in large marine engines to about 1¾lb. On the other hand, in small power engines the consumption was at least 2½lb., and in general 3lb. or more. In the present epoch, that of the steam turbine, it is possible to produce to-day 1,000,000 units of electrical power for a consumption of 407 tons of coal; that is, 1 horse-power hour for a little less than 0·7lb. of coal.

When Parsons took out his first patent, the upper limit of temperature in the internal combustion engine was about 1,900° C. If the lower limit had been 15° C. and the engine had been a perfect one, the efficiency would have been 0·87. In practice, the lower temperature was higher than 400° C., the engine was not perfect, and the actual efficiency was about 0·2. However, as Ewing pointed out, this meant that the gas engine had all the greater margin for future improvement, while the steam engine of 1884 "had been improved so far that little increase in its efficiency can be expected, and more than a little is impossible". When Ewing wrote these words, Parsons had invented the turbine and challenged the pessimists.

It seems probable that Parsons was inspired by three main influences when he invented the compound turbine. The first of these was his love of attempting to do what others thought impossible, which provided the driving force of many of his projects. The second was his knowledge of thermodynamics and the properties of steam; and the third was the advent of the dynamo for power purposes.

Parsons appears to have been but little influenced by the opinions of others; he realised that the ideal engine was one that could be coupled directly to the armature of the dynamo, and that since the motion of the armature was purely rotary, that of the prime mover should be purely rotary, too.

After a vast amount of theoretical and experimental research directed to the elucidation of the principles involved, Parsons decided that the difficulty of excessive speed of rotation could be avoided by causing the steam to fall in pressure in a series of steps, each step being, as it were, an elemental turbine, and each extracting its own portion of energy. By such graduated lowering of the pressure, step by step, both the velocity and the changes in volume of the steam could be kept within reasonable limits, and design could follow on the lines of the water turbine, for which a high efficiency was claimed.

The first claim in Parsons' patent of 1884 is "the use in combination of a hollow cylinder with projecting rings of blades, and within it a solid or rotary cylinder with projecting rings or blades". This, in language not so technical, is the claim for the division of the steam's action into a number of successive steps. The steam passes from stage to stage, first acquiring motion which it then imparts to the moving vanes in each stage, until at last it has expanded down to the lowest available pressure and its work is done.

Reference to Parsons' original patent shows his remarkable foresight of the lines on which turbine machinery was to be developed. The second claim, for example, embodies the principle of double flow, whereby the steam is caused to travel in two streams simultaneously in two directions, thus balancing the pressures set up and at the same time enabling the length of the blades to be reduced by half. Without this principle, the efficient construction of the immense machines of to-day would not have been practicable. The same remark applies to the principle of dividing up the machine into two or more parts dealing with the steam in series, a typical feature of all the largest modern units and one which is very useful in marine work, where speed-reducing gears are used or more than one propeller shaft has to be driven.

As I have already said, there was no novelty in taking advantage of the expansive power of steam; the novelty was in the method of application, and the more one examines the details of the method, the more one must admire the genius of Parsons.

The Marine Turbine.

Striking as the development of turbo-generators has been, that of the turbine for the propulsion of ships is more striking still. It has already been pointed out that the turbo-generator and the electric lighting industry were in a sense born together, and the introduction of the turbine into the new public electric supply systems was by no means difficult. It was not so easy to introduce the turbine into the Royal Navy and the mercantile marine. The piston engine with triplex and compound cylinders was giving good service, and had a high efficiency, and there seemed general contentment with paddle-wheel steamers on regular passenger services, such as that from Dover to Calais. Moreover, in the very early days, the turbine without condenser, though compact and convenient, could not be called efficient. Indeed, some there were who called it a "steam eater" owing to the large consumption of steam. However, from the outset Parsons had in mind the possibility of using the turbine for battleships and Atlantic liners, and once the superiority of the turbine over the piston engine was established in the matter of fuel consumption, he set to work to convince the Navy and the mercantile marine of the turbine's merits.

It was in 1894, when a condensing steam turbine of 200 h.p., with an expansion ratio of 90 volumes, was found to have a steam consumption not greater than a good compound piston engine, that Parsons entered the marine business. With a boldness that amazed even his closest friends—for there was no established theory of marine propulsion to guide him—he planned to build a 100ft. experimental vessel to be named the "Turbinia", and with this the capabilities of the turbine for ship propulsion were to be demonstrated to the Admiralty. Hull, propeller, and engines, were all designed by Parsons, and in doing so he relied entirely on the results of his own researches.

At that time there was no National Physical Laboratory ship tank in which models could be tested, so he made models and tested them in his own inimitable way by towing them with fishing rod and line in a small pond. In doing this he was following the principle laid down by Froude. With the data so obtained he designed the "Turbinia", and calculated the horse-power necessary to drive her at 34 knots. It is of interest to note that three years afterwards a model of the "Turbinia" was tested at the Naval Tank at Portsmouth, and the difference between Parsons' estimate of the horse-power required and that of the Admiralty experts was only from 2 to 3 per cent., a remarkable tribute to the ingenuity of Parsons.

After the completion of the vessel there were many troubles, more especially with the phenomenon known as propeller cavitation, and at one stage almost any man other than Parsons would have abandoned the project. With the energy and determination so characteristic of him, he practically started work anew, new turbines and new propellers being fitted. Ultimately a speed of 34 knots was obtained, and Parsons made his plans to demonstrate the turbine's possibilities. This he did in no uncertain fashion. During the Naval Review at Spithead in 1897, in honour of the Diamond Jubilee of Her Majesty Queen Victoria, the "Turbinia" was present and charged down the line of cruisers and battleships. A picket-boat was put out to stop the supposed intruder, but the "Turbinia" was proceeding at 30 knots, against which the speed of the picket-boat was useless. Having left the picket-boat in the rear, the "Turbinia" very nearly ran down the French official yacht, and only escaped doing so by an even greater demonstration of her speed. At any rate, her performances at the Review focussed the attention of the Admiralty on the possibilities of turbine propulsion for men-of-war, and orders for two destroyers soon followed.

In this short address it is quite impossible to describe the full development of the marine turbine for the Royal Navy and the mercantile marine. Indeed, the story would occupy a large volume. Any story of Parsons and the steam engine would, however, be incomplete without mention of such epoch-making ships as the "Amethyst" and the "Dreadnought" in the Navy, and the "King Edward" and "Mauretania" in the mercantile marine.

The "Amethyst" was one of four small swift cruisers built in 1902, and was fitted with turbine machinery. The other three ships were of exactly the same dimensions and form of hull, and were fitted with well-designed piston engines made by highly experienced firms. The vessels, which were of 3,000 tons displacement, were designed for a speed of 21¾ knots, with 10,000 i.h.p. The trials of the ships with the reciprocating engines resulted in a maximum speed of 22·34 knots, but the "Amethyst", with the same boiler power, easily steamed 23·63 knots, and there was no vibration of the ship. The steam consumption per horse-power hour of the "Amethyst" was compared with that of the "Topaze", one of the other vessels, and at 20 knots the figures were 14lb. and 16·91lb. respectively, the former being regarded then as very exceptional.

These trials had a far-reaching influence, for they established the efficiency of the marine turbine beyond all doubt, and when a committee consisting of representatives of the Services and of science was appointed by the Admiralty in 1905, it recommended the fitting of turbine engines for all new armoured ships. The battleship "Dreadnought" followed. The following were among the reasons given by the First Lord of the Admiralty for the adoption of the Parsons turbine in that ship :—

> "Saving in weight and reduction in number of working parts, and reduced liability to breakdown, its smooth working, ease of manipulation, saving in coal consumption at high powers, and hence boiler space, and saving in engine-room complement".

The Merchant Service.

In the Navy efficiency is the first consideration rather than low first cost and running charges. It was not surprising, therefore, that, notwithstanding Parsons' public statement that in the case of an Atlantic liner "turbine engines would effect a reduction in weight of machinery and an increased economy of fuel", the merchant service were unconvinced. Parsons therefore decided to follow the plan he initiated with the "Turbinia" and make a demonstration with a paddle steamer fitted with turbines. This, however, was abandoned, and instead, on the initiation of Mr. Archibald Denny (later Sir Archibald Denny), a merchant turbine steamer, the "King Edward", was built by Messrs. Denny, of Dumbarton. Messrs. Denny found that the coal bill of the "King Edward" was less by 15-25 per cent. than that of comparable vessels propelled with reciprocating engines; also the cost of oil was negligible.

This success led to other vessels of the merchant service being fitted with turbines, and within seven years the horse-power in a single steamer increased from 3,500 (the "King Edward") to 78,000, the mean power developed on a 1,250-mile trial of the "Mauretania". Among the smaller vessels fitted, one of the most interesting is the "Queen", built for the South-Eastern Railway Company for the Dover-Calais service in 1902. The performance of this steamer attracted interest the world over, because of the exact comparisons made with the performance of paddle steamers in the same service.

Other turbine vessels followed rapidly, but although all the data were favourable, the real turning point in favour of turbine machinery in the merchant service was not reached until 1904, when the decision was made to fit the new Cunarders, the "Lusitania" and the "Mauretania", with turbine engines. The construction of their turbines required remarkable courage, for the construction of engines of 70,000 h.p. was a very considerable step in advance of anything that had been done previously. These vessels were for many years the most remarkable ships on the ocean, and until the Great War both of them crossed the Atlantic, in sunshine and storm, at an average speed of 25½ to 26 knots, and with a steam consumption of about 11¼lb. per S.H.P. hour. Almost each successive trip appeared to establish a new record and, as is well known, the "Mauretania" held the Blue Riband of the Atlantic for twenty-two years. To-day, the "Queen Mary", with her turbine engines of about 200,000 h.p., and a record speed of 30·6 knots, runs in her stead.

The foregoing extracts from Sir Frank Smith's lecture are selected as being of special interest to marine engineers, but Members would be well advisd to secure for themselves complete copies which they will find printed in full in the principal technical journals, e.g. "The Engineer" of November 13th and 20th, 1936.

High Vacuum for Steamships.

"Marine Engineering and Shipping Review", March, 1937.

The maintenance of high vacuum in year-round service provides such important gains that the use of high grade equipment to assure it is amply justified.

An example of the great strides made is in the steam consumption of the jets themselves. Within the last five years it has been possible to perfect jets to the extent that the same results can now be obtained with half of the steam consumption formerly required, according to *Heat Engineering.*

In service the ejectors are used with the main condensers, the auxiliary condensers and the distillers. The design was developed by the Foster Wheeler Corporation, New York, to meet the specific requirements and limitations of naval vessels; the rather unusual position of the steam jet elements with relation to the shell is a direct result of restricted space conditions.

Simplification is another factor of moment. The elimination of valves, reduction in number of parts, welding to supersede gasket joints—are all included in the drive for higher efficiency, great reliability, easier control and lighter weight. For more than 45 years Foster Wheeler apparatus has been serving the U.S. Navy in various types of vessels.

In merchant ships the advantages derived are of even greater importance than in Government vessels since low cost of operation is essential in meeting competition and in deriving profits from the close margin upon which they must be earned.

Drafting Room Lighting.

By E. C. Alger.*

"Marine Engineering and Shipping Review". February, 1937.

Due to the large volume of work that the Bethlehem Shipbuilding Corporation has been carrying on, officials at the Fore River Plant a short time ago considered it advisable to increase the space as well as recondition the drafting rooms. They undertook a general renovation of these facilities, realizing that it was a good investment to do everything possible to increase the efficiency of these departments, in order to get plans out in time to allow for orderly construction of the ships by the construction departments.

In considering additions to the drafting rooms, the importance of providing sufficient artificial lamps to insure eye comfort under all conditions to the staff engaged in the close visual tasks of drafting was kept constantly in mind. This illumination was intended to supplement daylight with its various degrees of intensity and also to be adequate for twilight and night time use.

Our representatives visited many of the largest drafting rooms in the east and studied the methods, fixtures, designs, operation and results. It was found that most offices were illuminated either by the direct method or the semi-indirect method, using diffusing globes. In most cases illumination intensities considerably under 20 foot candles were obtained on the drafting tables. This lighting was supplemented by local lamps.

Some years ago a system of direct lighting in metal reflector diffusing globe units was installed at the Fore River plant. At the time it was considered most efficient for a beam ceiling of low reflection factor. Its inherent weaknesses were the specular reflections over the tracing cloth, shadows and a predominant yellow colour which did not mix well with daylight, especially during the late afternoons of the winter months. The advent of new lighting sources featuring modern reflecting mediums and equipment and incorporating designs of the best architectural appearance interested us in its possible application to our problem.

Tests were made of indirect aluminium troughs, carrying 200-watt daylight lamps on 12in. centres, as it was felt that such construction would perhaps present the best appearance. This proved impractical due to maintenance, operating cost and low efficiency. Indirect light sources of various sorts, carrying incandescent lamps, were also considered but were found to lack the colour quality to mix well with daylight for good visual conditions. The application of the new mercury vapor light sources to industry was of interest and it was decided to make a trial installation of a combination of mercury and mazda units both of the direct low-pressure and the indirect high-pressure type. These were tried out for a sufficiently long period of time to get the reactions of the draughtsmen with the following results :—

The indirect Holophane R-1,000-VM combination of 400-watt, high-pressure mercury and four 200-watt mazda lamps provided the highest intensity without shadows or reflected glare, and a colour value that was truly remarkable with its close blend with daylight. A canopy, especially designed, carries the transformers and the complete assembly, consisting of a prismatic glass refractor which directs the light from the mercury vapor lights, surrounded by the four mazda lamps attached to an aluminium mask, over a wide spread on the ceiling. Mixing the light from the mazdas with that of the mercury lamps was found to present a very attractive appearance as well as to solve the illumination problem efficiently.

With this system the average intensity of 33 to 40 foot candles prevails throughout the drafting rooms with a spacing of about 15ft. by 15ft. on a 12ft. ceiling painted with a primer coat finish only.

Attention is drawn to the fact that on a clear day the average intensity readings taken at a drafting table level, across the room with the side row of lights operating, varies little, also the colour value is within 10 per cent. of daylight value so that there is the equivalent of daylight on all boards. Venetian blinds have been provided in the new drafting rooms better to control daylight and the direct rays of the sun, with the result that uniform illumination can be had at all times.

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Ships' Engines.

"The Engineer", 19th March, 1937.

When reviewing the year's technical work at the annual meeting of the British Corporation Register in Glasgow, Sir Maurice Denny said the steam engine, now aided by such improvements as exhaust turbines, poppet valves, and cam-operated slide valves, was stubbornly resisting displacement by other means of propulsion. In his opinion it was difficult to imagine that the steam turbine would ever be ousted from ships of high power. When internal combustion engines were fitted there was an apparent preference for the two-stroke type, and almost all motor ships now had an exhaust gas boiler which could be fired with oil fuel when in port, Of the outstanding feature of the year, he could say but little, for the Loeffler high-pressure boiler fitted experimentally in the "Conte Rosso" was still under trial. The results of experience with the first application to marine work of a steam generator operating at 1,900lb. per sq. in. were being awaited with interest.

The Normandie's New Records.

"The Engineer", 26th March, 1937.

During the twenty-four hours which ended at noon on Saturday, 20th March, the "Normandie", of the French Line, which left New York on Thursday, attained the highest average speed ever made in a day's run by a mercantile ship. Her day's average was 728 nautical miles, at an average speed of 31·65 knots. The previous record for the east-bound passage was gained by the "Queen Mary", of the Cunard White Star Line, in August last, when she steamed 713 nautical miles in a day at an average speed of 31 knots. A further record was gained by the "Normandie" on Monday when she passed the Bishop Rock at 42 min. 56 sec. past six o'clock, covering the 2,967 miles from the Ambrose Lightship in the record time of 4 days 6 min. 23 sec., at an average speed of 30·99 knots. When in August last the "Queen Mary" gained the record for the east-bound passage on the official course, her time from the Ambrose Lightship to the Bishop Rock was 3 days 23 hr. 57 min., at an average speed of 30·63 knots. It may be recalled that the "Normandie's" previous record was 4 days 3 hr. 28 min., at an average speed of 30·31 knots. During the recent overhaul of the "Normandie" the generating sets and the propelling motors were thoroughly overhauled and adjusted, and new propellers were fitted. The records above referred to are more noteworthy on account of the fact that the voyage was made in winter, and that during the voyage headwinds and snow were encountered. We are given to understand that the machinery was run at the normal revolutions throughout the trip.

A Reheated Marine Steam Installation.

"The Engineer", 2nd April, 1937.

During last week-end successful trials were carried out on the North-East Coast with the "Lancaster Castle", one of two sister cargo steamers built by Sir James Laing and Sons, Ltd., of Sunderland, and engined by the North-Eastern Marine Engineering Company, Ltd., of Wallsend and Sunderland, for the service of James Chambers and Co., of Liverpool. Each of the ships has a length of 454ft., with a breadth of 57ft., and a designed carrying capacity of 9,250 tons. The propelling machinery, which is designed for a service speed of $10\frac{3}{4}$ knots, consists of a triple-expansion, three-cylinder steam engine, taking steam from two Scotch boilers at a working pressure of 220lb. per sq. in., and a superheated steam temperature of 775° F. On leaving the h.p. cylinder the steam is reheated by an amount which ensures its dryness during expansion in the m.p. and the l.p. cylinders. During the trials the engines worked admirably, and an average speed of 12 knots under ballast conditions was recorded with ease. Confirmation of the economical running of the machinery is given, we are informed, by the performance of the "Lowther Castle", which has completed a maiden voyage of 6,000 to 7,000 miles at an average speed of $10\frac{1}{2}$ knots on a coal consumption of 14 tons of North Country coal per day. There was a representative company of shipowners, marine superintendents, and engineers on board.

"Graf Zeppelin".

"The Engineer", 18th December, 1936.

During its eight years' service the "Graf Zeppelin" has covered a distance of 1,022,000 miles on 578 flights. The airship has crossed the Atlantic 139 times, and has carried a total of 13,000 passengers.

Oldest Warship.

"The Engineer", 18th December, 1936.

What is said to be the oldest warship in the world is to be broken up at Dalmuir, on the Clyde. She is the Portuguese cruiser "Vasco da Gama", which was built at Blackwall some sixty years ago. The ship's original displacement was 2,422 tons, but this figure was increased by 500 tons in 1903, when she was reconditioned and lengthened by 33ft.

The Twin-Screw Dredger "Chien She".

"The Shipbuilder and Marine Engine-Builder", April, 1937.

During the latter part of 1936 there was issued by the Whangpoo Conservancy Board a lengthy report dealing with the problem of dredging the mouth of the Yangtse River, and the means whereby the desired results could be achieved and maintained. The programme envisaged involved the construction of a large hopper dredger of the drag-suction type, and the contract for the vessel was secured by the firm of F. Schichau, G.m.b.H., of Danzig, the machinery and dredging equipment having been constructed at this firm's Elbing establishment.

The principal dimensions and other important details of the "Chien She", as the dredger was named, are given in Table I.

TABLE I.—PRINCIPAL DIMENSIONS, ETC., OF THE "CHIEN SHE".

Length overall	373ft. 0in.
Length B.P.	360ft. 0in.
Breadth moulded...	60ft. 0in.
Depth moulded	26ft. 6in.
Gross tonnage	4,699
Net tonnage	1,858
Load draught	18ft. 0in.
Deadweight, tons	4,500
Hopper capacity, cubic yards—	
(*a*) To top of coaming	4,200
(*b*) To deck level	3,700
Maximum dredging depth	45ft. 0in.
Crew	106

The vessel was built under special survey in accordance with the requirements of Lloyd's Register of Shipping for the classification ✠100 A.1, Hopper Dredger, and the regulations of the Board of Trade also have been complied with.

There are six transverse bulkheads, which divide the vessel into the following compartments: After peak, engine-room, boiler-room and bunkers, hopper spaces, dredging-machinery room, hold and store, and fore peak. The hopper spaces are divided longitudinally by a central well, in which the hinged dredging ladder and suction pipe are situated. The spoil hoppers abreast this well have sloping boundaries, which form large buoyancy spaces at the sides and centre of the vessel. The outer spaces have extra deep floors. These are plated over to form feed-water tanks, built with recesses in way of the sea-suction valves to the hoppers. The tank top and its connection to the shell and hopper side plating have been electrically welded.

The port and starboard hopper spaces are each divided into 10 compartments by cross girders at the bottom, and each compartment has hinged double doors at the bottom for releasing the spoil. The doors, which are of oak encased in steel, are raised by two steel wire strops fitted with stretching screws, and connected to equalising gear to ensure proper distribution of the loading. Each pair of door wires is further connected to a second equalising gear (consisting of turnbuckles and shackles), which is connected to the main chains leading to sliding-motion girders disposed longitudinally, one at each side, at the level of the gangways over the hopper spaces. These sliding girders are capable of longitudinal movement, being operated by hydraulic cylinders (600lb. per sq. in. pressure) placed on deck at the after end of the hopper spaces. Arrangements are also provided for the individual operation of the doors.

The forward hold provides storage for wire ropes, spare dredging gear, etc.

The bunker and tank capacities are given in Table II. It will be noted that arrangements have been made for either coal or oil to be utilised as fuel.

TABLE II.—BUNKER AND TANK CAPACITIES.

	Cu. ft.	Tons.
Bunkers:—		
*Transverse bunkers—		
Oil fuel	6,740	
Coal	6,460	145
Starboard bunker—		
Oil fuel	12,050	
Coal	10,300	228
Port bunker—		
Oil fuel	12,350	
Coal	10,510	232
Settling tanks—		
Oil fuel	1,000	
Total coal capacity ...		605
Fresh Water:—		
Feed-water tanks, port ...		127
Feed-water tanks, starboard...		127
Drinking water		18
Total fresh water ...		272
Water Ballast:—		
After peak		154
Fore peak		156
Total water ballast ...		310

*The transverse bunkers comprise two tanks at the middle of the length of the boiler-room, not extending the full width of the vessel.

The deck auxiliaries are steam-driven, and comprise a direct-grip horizontal windlass, two double-cylinder winches (one serving a 5-ton derrick for the hold, and the other an 8-ton derrick for the suction drag-head), steering gear, two warping winches, and two coaling winches. For raising and lowering the outboard suction pipe and ladder, a powerful double-cylinder winch is provided. This winch has double drums of large diameter with machine-cut grooves for the steel-wire cables, the ends of which are connected to buffer springs for taking up shocks which may occur during dredging operations.

Some notes on the dredging equipment may be given. The lower part of the outboard suction is fitted with an interchangeable cast-steel suction drag-head of massive design, fitted at the entrance with manganese-steel cutting blades. Vertical grid plates are incorporated to prevent large objects from reaching the pump. Three different sizes of drag-head have been supplied, measuring respectively 6, 8 and 10ft. on the cutting edge. The inner surfaces are stream-lined, and each head is cast with a water jacket, in which pressure-water jet openings are arranged. These face in the direction of flow of the spoil, and can be used to assist the dredging of stiff materials.

The main dredging pump is of the centrifugal type, built of cast-steel sections, bolted together and lined internally with manganese-steel wearing plates. The semi-shrouded impeller is 8ft. 6in. in diameter over the tips, and has four mild-steel blades 20in. in width, riveted to vanes cast on the impeller disc. The impeller shaft is 13¾in. in diameter at the bearings, and is connected *via* a Michell thrust block to the pumping engine. The installation has a water-pumping capacity of 18,000 tons per hour at 120 r.p.m. when delivering through the distributors at the hopper tops. When dredging thick mud having an *in situ* density of 1·8, the pump can fill the hoppers with a load of 4,000 tons in less than 20 minutes.

The main dredging pump is driven by a directly coupled vertical triple-expansion marine steam engine capable of developing 2,400 i.h.p. at 150 r.p.m., and designed for a moderate degree of superheat. The pump and engine, together with a full range of auxiliaries, are installed in the forward engine-room. Among these auxiliaries, mention may be made of a double-stage centrifugal pump, the chambers of which are disposed in series. This unit is installed to supply water at high pressure to the draghead jets and also to the bottom door frames for cleaning the joints after the spoil has been dumped. The pump has a capacity of 2,500 gallons per minute against a head of 150ft., or 6,000 gallons per minute at 30ft. head, and is driven directly by a set of vertical, compound, enclosed engines developing 290 i.h.p. at 325 r.p.m. Two steam-driven vertical duplex hydraulic pumps are also installed for providing pressure-water to the various hydraulic rams and sluice valves.

The arrangement of suction and delivery piping and valves is very flexible, and permits dredged material to be discharged directly to the hoppers, while the contents of the hoppers may also be pumped out and discharged overboard. The main delivery pipe from the pump is bifurcated at the deck level, to provide separate mains for the port and starboard hoppers. Each main has five outlets or distributors, fitted with hydraulically-operated sluice valves for controlling the loading.

The propelling machinery consists of twin sets of triple-expansion surface-condensing steam engines developing together 3,000 i.h.p. at 130 r.p.m. For the generation of steam, four single-ended cylindrical return-tube boilers, each having four furnaces and fitted with superheating equipment, are installed. The boilers operate under Howden's system of forced draught, and the furnace fronts are arranged for coal or oil-firing. The dimensions of the boilers are 17ft. 1in. mean diameter by 12ft. 11in. mean length. The working pressure is 200lb. per sq. in., and the temperature is 610° F. to compensate for the great distance to the forward engine-room. The total heating surface of the four boilers is 13,760 sq. ft., the grate area 328 sq. ft., and the superheater surface 540 sq. ft.

A summary of the contract conditions and trial results is given in Table III.

TABLE III.—CONTRACT CONDITIONS AND TRIAL RESULTS.

	Guaranteed.	Actual.
Dredging output in cubic yards *in situ* mud, per 10 dredging hours, including transport to dumping area	25,000	26,507
Coal consumption, dredging, lb. per I.H.P. per hour	2·1	1·77
Speed fully loaded, knots ...	10·25	11·188
Speed in light condition, knots ...	—	11·632
Coal consumption, steaming at 10·25 knots, lb. per I.H.P. per hour	—	1·98
Oil-fuel consumption, dredging. lb. per I.H.P. per hour ...	—	1·104
Oil-fuel consumption, steaming, lb. per I.H.P. per hour ...	—	1·293

We are indebted to the Whangpoo Conservancy Board for the data from which this article has been compiled. The report mentioned in the opening paragraph was, for the most part, prepared by Mr. William Smith, M.Inst.N.A., the Board's Dredging Engineer, who supervised the construction of the vessel; the primary responsibility for the whole undertaking devolved upon Mr. Herbert Chatley, M.Inst.C.E., Engineer-in-Chief to the Conservancy Board.

First Harland-Elsinore Installation.

The "Torr Head" is a new cargo vessel for the Ulster Steamship Co., Ltd. Her triple-expansion engine exhausts into an Elsinore-type turbine.

"The Marine Engineer", April, 1937.

Harland & Wolff Ltd. will, in the course of a week or two, hand over from their Queen's Island yard the "Torr Head", a cargo steamship which they are now completing for the Ulster Steamship Co. Ltd. (Head Line, Lord Line, Holland-Ireland Line). It is nearly sixty years since the first Head Line steamship, the "Fairhead", was launched from Queen's Island—actually in 1879, the year "The Marine Engineer" commenced publication. It is a tribute to her builders, Harland & Wolff Ltd., that this wonderful old ship is still at sea. Her original propelling machinery was modernised in 1925 and the vessel remained in the Head Line fleet until 1932, when she was sold to the Saorstat & Continental Steamship Co. Ltd., of Dublin. To-day, under a new name, she is maintaining a regular service between the Continental ports of Hamburg, Antwerp, etc., and the Irish Free State, which must almost constitute a record of ship longevity.

The "Torr Head" is a single-screw shelter decker with a well-raked, rounded stem, cruiser stern, two masts, and a single oval funnel. She has been built under British Corporation survey and has been designed especially for her owners' requirements. Not only has she been specially stiffened for navigation in ice, but there is also an upper navigating bridge for use in the St. Lawrence. The principal dimensions of the new vessel are as follows :—

Length overall, about	424ft.
Length between perpendiculars	400ft.
Breadth moulded	58ft. 6in.
Depth moulded to shelter deck	37ft. 3in.
Gross tonnage, about	5,000

There are two complete steel decks, also a lower deck in No. 1 hold, and poop and forecastle decks. The hull is divided into nine compartments by eight watertight bulkheads extending to the main deck. There is a double bottom fitted fore and aft, divided and arranged for the carriage of water ballast, with feed water tanks below the engine-room. The forward peak tank is arranged for water ballast and the after peak tank for fresh water or water ballast.

Hold arrangement.

There are three cargo holds forward and two aft of the machinery space and, in addition, deep tanks arranged for the carriage of water ballast or cargo are placed immediately aft of the engine-room. The shelter 'tween decks forward and aft are arranged for cargo carrying with permanent coal bunkers abreast the machinery space and a reserve bunker in way of No. 3 hatch; No. 3 cargo hold can also be used as a reserve bunker when so required.

The cargo holds and 'tween decks are served by five large cargo hatches, while the cargo handling equipment consists of eleven tubular steel 5-ton derricks and two 7-ton derricks operated by thirteen steam winches.

A powerful steam windlass is fitted forward and a steam warping winch is located aft, this winch being also suitably arranged for handling the stern anchor cable. The streamlined rudder is operated by a steering gear of steam-hydraulic type controlled by telemotor from the wheelhouse.

Accommodation of a superior type is fitted in deckhouses amidships for captain, deck and engineer officers, also a number of single- and two-berth staterooms for passengers, with suitable dining saloon and smoke room; the accommodation for seamen, firemen, and petty officers is located aft.

Steam fire extinguishing is arranged to the cargo holds and 'tween decks. The life-saving equipment consists of four 24ft. lifeboats fitted under Optimum davits, and a 16ft. dinghy is placed aft.

New-type machinery.

The machinery installation of the new vessel is of particular interest as it is the first of its type to be constructed in the British Isles. It embodies a reciprocating steam engine combined with an exhaust steam turbine on the Harland-Elsinore system, and the installation will operate with considerable economy in fuel. The main engine is of the triple-expansion type, having cylinders 22in., 37in., and 61in. in diameter by 45in. stroke. Steam admission and exhaust valves are of the Andrews & Cameron cam-operated balanced type, separate valves and ports being provided for steam admission and exhaust. The exhaust turbine is mounted on a special seat on top of the main condenser in the manner frequently described in this paper. The power of the turbine is transmitted through a single-reduction gear of the double-helical type, and finally through a roller chain drive to the main thrust shaft. A disconnecting clutch is interposed between reduction gear and chain drive pinion; the chain wheel on the engine thrust shaft is of the special elastic spring type. The spring mounting of the chain wheel smoothes out the uneven turning effect of the engine while the presence of the turbine tends to prevent the engine from racing under fluctuating conditions of propeller immersion. Bilge and hotwell pumps are driven off the main engine, and the air, circulating and feed pumps are independently driven.

Other auxiliaries include ballast pump, general service pump, auxiliary feed pump, two stages of feed heating, feed filter, forced draught fan, dynamo engine, evaporator, auxiliary condenser, and ash hoist. All the independent auxiliaries are steam-driven.

Steam is provided by three single-ended Scotch boilers which are arranged for coal firing with forced draught, the steam conditions being 220lb. per sq. in. working pressure and 200° F. superheat. The superheaters are of the Melesco smoke-tube type.

The electrical installation comprises a 12½ kW. 110-volt generator driven by an enclosed steam engine which gives current to the lighting throughout the decks and machinery spaces. The cabins are supplied with berth lights and fans, while there is an electrically-operated refrigerating machine for ship's supplies.

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 11th February, 1937.		
Phillips, Barry A.	2.C.	Cardiff
Huntingford, Alan	2.C.	Liverpool
McLaren, William R. ...	2.C.	,,
Sergeant, William	2.C.	,,
Williams, Thomas S. ...	2.C.	,,
McGowan, David	2.C.M.	,,
Stephens, Leonard G. ...	2.C.	London
Ireland, Derek F.	2.C.M.	,,
Brown, Joseph	2.C.	Newcastle
Finch, Harry	2.C.	,,
Fletcher, George E.	2.C.	,,
Millar, Donald E.	2.C.	,,
Peel, George B.	2.C.	,,
Thompson, Thomas	2.C.	Newcastle
Connor, William M. ...	2.C.M.	,,
Wilson, Kenneth	2.C.M.	,,
Youngson, William H. ...	2.C.M.	,,
Anderson, James McE. ...	2.C.	Glasgow
Bate, William	2.C.	,,
Campbell, William McI. ...	2.C.	,,
Robertson, Douglas	2.C.	,,
Ronaasen, Harold	2.C.	,,
Anderson, David C.... ...	2.C.M.	,,
Brydon, Thomas	2.C.M.	,,
For week ended 18th February, 1937.		
Hall, Edward R.	1.C.M.E.	London
Downey, Wilfred	1.C.M.E.	Cardiff
Mathers, Lyle M.	1.C.M.E.	Glasgow
Roscoe, William N. ...	1.C.M.E.	Cardiff
Tanner, Charles F. D. ...	1.C.M.E.	Glasgow
Gateley, Joseph P.	1.C.M.E.	,,
Boase, Eric J. J.	1.C.M.E.	London
Carrick, Thomas McF. ...	1.C.M.E.	Glasgow
Aiken, Alexander C. L. ...	1.C.M.E.	,,
Davidson, Harry	1.C.	Liverpool
Gordon, David	1.C.	,,
Webster, Henry	1.C.	,,
Bull, Oswin	1.C.	Newcastle
Moffatt, Robert	1.C.	,,
Thompson, John	1.C.	,,
Kent, Charles	1.C.S.E.	,,
Frost, William B.	1.C.	Cardiff
Langlands, Thomas B. ...	1.C.	,,
Nicholls, Stanley W. ...	1.C.	,,
Fraser, Charles F.	1.C.	Glasgow
McHaffie, Ernest	1.C.	,,
Simmons, Alexander ...	1.C.	,,
Craven, Adam	1.C.M.	,,
McLaren, Duncan M. ...	1.C.M.	,,
Allen, John E. L.	1.C.	London
Miller, John A. C.	1.C.	,,
Timpson, Arthur D. ...	1.C.	,,
Willis, Abram	1.C.M.	,,
Benke, Arthur L.	1.C.S.E.	,,
Aldous, Archie E.	1.C.S.E.	,,
Phillips, Thomas W. ...	1.C.M.E.	Cardiff
Scott, Archibald J.	1.C.M.E.	Glasgow
Forster, Edward W.... ...	1.C.S.E.	Newcastle
Barker, Thomas	1.C.M E.	,,
Newhouse, George A. ...	1.C.M.E.	,,
For week ended 25th February, 1937.		
Innes, George	2.C.	Glasgow
McGregor, Duncan F. ...	2.C.	,,

Name.	Grade.	Port of Examination.
MacLiver, Hector	2.C.	Glasgow
Renfrew, William	2.C.M.	„
Chesters, Harold	2.C.	Liverpool
Frazer, Henry	2.C.	„
Hendry, George	2.C.	„
Potter, Norman	2.C.	„
Roberts, William C.... ...	2.C.	„
Atkinson, Laurence D. ...	2.C.	London
O'Brien, William R. ...	2.C.	„
Whitworth, Newton G. ...	2.C.	„
Loveleace, Graham C. ...	2.C.M.	„
Lacon, William H.	2.C.	Newcastle
Lawson, Walter C.	2.C.	„
Hodgson, Ernest M. ...	2.C.M.	„
Newton, Charles S.	2.C.M.	„
Smith, William H.	2.C.M.	„

For week ended 4th March, 1937 :—

Thomson, George K. ...	1.C.M.	Belfast
Bradford, Anthony J. ...	1.C.	Liverpool
Burnett, Ernest	1.C.	„
Kneale, Robert C.	1.C.	„
Bolton, Stanley	1.C.	Newcastle
Jones, Wilfrid J.	1.C.	„
MacKenzie, Matthew ...	1.C.M.	„
Heyes, Sidney	1.C.	London
Anderson, Ord A.	1.C.	Glasgow
Keith, David T.	1.C.	„
Munro, George A.	1.C.	„
Twaddle, Thomas	1.C.	„
Ferguson, Fergus	1.C.M.	„
MacKay, Thomas McB. ...	1.C.M.	„
Robertson, John	1.C.M.	„
Barr, Hugh G.	1.C.M.E.	Liverpool
Christian, Frederick ...	1.C.M.E.	„
Deakin, Leslie	1.C.M.E.	„
Hall, Stanley S.	1.C.M.E.	„
Carmichael, John	1.C.M.E.	Newcastle
Gidney, Alfred	1.C.M.E.	„
Mead, Gerald S.	1.C.M.E.	„
Arnold, Harry	1.C.M.E.	London
Benson, John E.	1.C.M.E.	„
Brebner, Sampson	1.C.M.E.	„
Nicoll, Alexander	1.C.M.E.	„
Symington, Gilbert S. ...	1.C.M.E.	Glasgow

For week ended 11th March, 1937 :—

Carey, Thomas B.	2.C.	Cardiff
Price, Geoffrey W. ...	2.C.	„
Evans, Eric	2.C.M.	„
Bringloe, William L. ...	2.C.	Liverpool
Mitchell, William D. ...	2.C.	London
Bainbridge, Cuthbert A. ...	2.C.	Newcastle
Kelters, John C.	2.C.	„
Makepeace, William ...	2.C.	„
McKaine, William L. ...	2.C.	„
Johnson, Donald	2.C.M.	„
Shaw, William G.	2.C.M.	„
Parker, George E.	2.C.M.E.	Liverpool
Mead, Gerald S.	Ex.1.C.	London
Harding, Edmund	Ex.1.C.	Liverpool
Sephton, William	Ex.1.C.	„

For week ended 18th March, 1937 :—

Skirrow, John	1.C.	Cardiff
Dobson, Charles V. ...	1.C.	Newcastle
Hornsby, Robert	1.C.	„
Knox, Arthur	1.C.	„
Swanston, Rowland M. ...	1.C.	„
Birkert, Frederick W. ...	1.C.M.	„
Brown, Richard H. ...	1.C.M.	„
Easton, Leslie	1.C.M.	„
Heslop, John	1.C.M.	„
Milne, Alexander O. ...	1.C.M.	„
Green, Leslie N.	1.C.	Liverpool
Sandiford, Lionel T. ...	1.C.	„
Barkley, Clifford W. ...	1.C.	Cardiff
Watkins, Herbert L. ...	1.C.	„
Wilson, Edward	1.C.	„

Name.	Grade.	Port of Examination.
McMurchie, Duncan ...	1.C.	Glasgow
McNeilly, Peter	1.C.	„
Milne, John B. B.	1.C.	„
Noel, Theodore H.	1.C.	„
Foggin, Gilbert	1.C.	London
Groves, Herbert G.	1.C.	„
Jones, Clifford E.	1.C.M.	„
Timpson, Arthur D. ...	1.C.M.E.	„
Mills, Dewar	1.C.M.E.	„
Robertson, James R. B. ...	1.C.M.E.	Glasgow
Craig, James	1.C.M.E.	„
Johnson, Frederick	1.C.M.E.	Newcastle
Porter, John S.	1.C.M.E.	Liverpool
Potts, Thomas D.	1.C.S.E.	Newcastle
Clothier, Arthur G. ...	1.C.S.E.	Liverpool

For week ended 25th March, 1937 :—

White, George D. H. ...	2.C.	London
Crone, George W.	2.C.	Liverpool
Hulse, Thomas P.	2.C.	„
Bywater, Frank	2.C.M.	„
Ellis, William	2.C.M.	„
Cobb, Robert	2.C.	Newcastle
Davison, Henry M.	2.C.	„
Eaton, Philip A. O.	2.C.	„
Finch, James S.	2.C.	„
Thompson, John	2.C.	„
Whiteway, Robert	2.C.	„
Duncan, John A.	2.C.	Glasgow
Kirkaldy, Angus B.... ...	2.C.	„
Nutt, William A.	1.C.M.	„

For week ended 1st April, 1937 :—

Findlay, Thomas N. ...	1.C.	Belfast
McFall, George K. V. ...	1.C.	„
Dickinson, William H. ...	2.C.	„
Chalmers, William J. G. ...	1.C.	Newcastle
Groves, Ronald G.	1.C.	„
Knowles, William E. ...	1.C.	„
Metcalfe, Norman	1.C.	„
Stewart, James	1.C.	„
Taylor, Donald A.	1.C.	„
Young, Arnold L.	1.C.	„
Andrew, John W.	1.C.M.	„
Quenet, Stanley P.	1.C.M.	„
Markwick, John E.	1.C.M.E.	„
Scott, Sidney L.	1.C.M.E.	Belfast
Munro, James	1.C.M.E.	Newcastle
Winyard, Charles	1.C.M.E.	„

For week ended 8th April, 1937 :—

Thomas, John	1.C.	Liverpool
Timmis, George H. ...	1.C.	„
Torry, George H.	1.C.	„
Wilson, Reginald H. ...	1.C.	„
Platt, Fred R.	1.C.M.E.	London
Brooke, Noel C. D. ...	1.C.M.E.	„
Collins, Thomas F.	1.C.M.E.	„
Miller, Andrew B.	1.C.M.E.	Glasgow
Galbraith, Alexander B. ...	1.C.M.E.	„
Carrol, John G. F.	1.C.M.E.	„
Wannop, Edward	1.C.M.E.	Liverpool
McGee, William B.	1.C.M.E.	„
Lace, Wilfred C.	1.C.M.E.	„
Bridge, John H.	1.C.M.E.	„
Collier, Gordon T.	1.C.	London
Dwyer, John J.	1.C.	„
Roughton, William J. ...	1.C.	„
Warren, William W. ...	1.C.	„
Williams, Albert D.... ...	1.C.	„
Willoughby, Leonard A. ...	1.C.M.	„
Fraser, Hector	1.C.	Glasgow
Gray, Kenneth C.	1.C.	„
Leslie, William	1.C.	„
MacGillivray, Alexander ...	1.C.	„
Taylor, Andrew	1.C.	„
Titterington, Thomas ...	1.C.	„
Bailey, Walter F.	1.C.	Liverpool
Clague, George A.	1.C.	„
Entwistle, Leslie	1.C.	„
Morris, John W.	1.C.	„
Nelson, Lockhart M. ...	1.C.	„