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*Boiler Control.

By E. G. BAILEY[1] and P. S. DICKEY[2].

The purpose of this paper is to discuss the control of marine boilers, and particularly the use of various devices for improving the responsiveness and efficiency of steam generating units.

The unprecedented need for shipping facilities and competent personnel for their efficient operation has greatly accentuated interest in this subject. The intelligent use of meters and automatic controls greatly augments the results of the designers and operators of modern marine power plants.

In recent years practically every industrial process for the transformation of energy or materials has been provided with meters and automatic controls to assure economy and reliability of operation. The most modern form of transportation, the airplane, has demonstrated without question that the proper use of instruments and automatic controls is of material assistance in insuring the reliability of machinery performance.

Benefits Derived from Meters and Control.

The following benefits can be expected through the intelligent use of meters and automatic controls in marine power plants:—

(1) Simplified operation and more efficient use of personnel.
(2) Fuel economy.
(3) Increased life of furnaces and auxiliaries.
(4) Improved engine efficiency through closer regulation of steam pressure and steam temperature conditions.
(5) Less smoke.

(1) *Simplified Operation.*—There are a number of functions in the operation of the boiler plant which require experience and dependability without needing great skill. Such functions as regulation of steam pressure, regulation of feedwater to maintain drum level, regulation of fuel-air ratio, regulation of steam temperature where means are provided and regulation of various other water and oil temperatures require continual vigilance on the part of the operators. While no claim is made that these functions can be done better with automatic devices than by a man who is constantly on the job and provided with centralized controls and sufficient instruments for his guidance, the use of automatic devices to perform such duties releases such men for general supervision. Thus the operators have time to become completely familiar with and maintain a perspective of all the apparatus in the plant, and through greater familiarity and greater watchfulness are able to detect faulty performance of major and auxiliary apparatus before shutdowns occur.

With automatic control fewer men are actually required in the fire room, and less personnel are required at stations in hazardous waters.

Suitable metering and control equipment permits balancing of loads between multiple units so that the most economical operation and longest life of all units are assured.

(2) *Fuel Economy.*—One of the most common losses in the operation of boiler plants is that due to improper maintenance of the fuel-air relation. For each furnace and fuel there is one best relation between the fuel burned and the air supplied for combustion. When air in excess of the proper requirement is supplied, fuel is wasted as a result of the heat carried away in this excess air, and this loss will average 1 per cent. of the total fuel burned for each 10 per cent. of air supplied in excess of requirements. There is still a greater loss when less than the required amount of air is supplied for combustion, and this may be as high as 10 to 15 per cent. of the fuel wasted for each 10 per cent. deficiency of the air supply.

Table 1.—Summary of Test Data Showing Savings Possible with Automatic Combustion Control.

	6 Nozzles Open		7 Nozzles Open		9 Nozzles Open	
	Automatic	Hand	Automatic	Hand	Automatic	Hand
Duration, hours	1	1	24	24	4	4
r.p.m.	82·3	81·9	83·1	82·5	86·2	86·3
s.h.p.† from standardization curves	2,650	2,600	2,690	2,640	3,595	3,610
s.h.p. corrected for wind	2,630	2,580	2,667	2,658	3,616	3,587
Fuel oil supplied, gallons, by meter	378·9	379·7	8828·3	7888·2	1568·2	1447·2
Fuel oil returned, gallons, by meter	145·8	147·2	3251·8	2144·4	392·3	277·4
Fuel oil supplied, temperature through meter, F.	114	115	111	114	112	105
Fuel oil supplied, weight lb. per gal. at above temperature	7·9651	7·9618	7·9734	7·9651	7·9709	7·9917
Fuel oil supplied, lb. per hr. at 18,360 B.T.U.'s per lb.	3018·0	3023·1	2933·0	2617·9	3125·0	2891·4
Fuel oil returned, temperature through meter, F.	153	155	145	141	138	135
Fuel oil returned, weight lb. per gal. at above temperature	7·8502	7·8443	7·8743	7·8860	7·8951	7·9035
Fuel oil returned, lb. per hr. at 18,360 B.T.U.'s per lb.	1144·6	1154·7	1066·9	704·6	774·3	548·1
Fuel oil consumed, lb. per hr. at 18,360 B.T.U.'s per lb.	1873·4	1868·4	1866·1	1913·3	2350·7	2343·3
Fuel oil consumed, lb. per s.h.p. per hr.	0·7123	0·7242	0·6997	0·7198	0·6501	0·6533
Saving using automatic control (at actual test conditions), per cent.	1·6	—	2·8	—	0·5	—
Saving using automatic control, corrected for difference in r.p.m. and vacuum during hand and automatic operation, per cent.	1·5	—	3·1	—	0·7	—
Barrels per day consumed (oil at 90 F.)	133·2	132·9	132·7	136·1	167·2	166·6

†Bleeder steam from high-pressure turbine was used for heating feedwater in third stage heater with 7 and 9 nozzles open while auxiliary steam was used with 6 nozzles open.

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[2] Director of Research, Bailey Meter Company, Cleveland, O.

MAIN TURBINES.

Total number of nozzles	12	12	12	12	12	12
Number of nozzles open	6	6	7	7	9	9
Throttle setting	Wide open	Wide open	Wide open	Wide open	Wide open	Wide open
Steam pressure at throttle, psi G.	443	443	443	445	440	437
Steam pressure at h.p. chest, psi G.	440	441	440	444	432	428
Steam pressure at h.p. first stage, psi G. ...	—	—	—	—	172	173
Steam pressure at h.p. exhaust, psi G. ...	12·4	12·4	11·4	11·6	20·0	20·0
Steam temperature at throttle, F.	—	—	747	763	755	759
Steam temperature at l.p. exhaust, F. ...	88·0	86·0	95·9	94·1	100	98·9

Without suitable metering or automatic control devices it is practically impossible for the boiler operators to maintain continuously the correct fuel-air relation. A conservative estimate of fuel saving through the use of meters and automatic combustion control on average modern steam boilers is from 2 to 4 per cent., and in many cases even greater savings are possible in plants where the operating personnel is inexperienced or lacking in vigilance. Careful tests were made on a recently built ship to determine the savings possible with automatic combustion control. Table 1 shows the summary of data taken and the net savings using automatic combustion control. The saving using automatic control as compared to hand combustion control was 1·5 per cent. during the first test, 3·1 per cent. during the second test and 0·7 per cent. during the last test.

Under hand operation it was noted that the steam pressure would be slightly lower and the excess air would be slightly more than with automatic control. These conditions prevailed during the first two tests, but during the last test an extra effort was made to keep the pressure up and the excess air down to the minimum for the best combustion efficiency. This explains the difference in saving during the tests.

The 7-nozzle test, which was the longest and was conducted under normal operating conditions, is considered the most representative comparison between automatic and hand operation. It showed a saving of 3·1 per cent. on the fuel rate. Operating with seven nozzles open, using 132·7 barrels of fuel oil a day, and assuming operation 200 days a year and oil costing $1 per barrel, a 3·1 per cent. saving would mean a yearly saving of $822·74.

An effort was made to conduct these tests under normal operating conditions. However, the operating personnel were aware the tests were being conducted and possibly watched conditions somewhat closer than normally. A 3·1 per cent. saving was shown over a 24-hr. period and possibly more of a saving would be shown over a longer period of time, such as a complete voyage.

A second example of the economies possible through the use of meters and combustion control is the experience of the Pittsburgh Steamship Company operating ore carriers on the Great Lakes.

In 1936 this company began a modernization programme which involved the change from hand-fired Scotch boilers to watertube boilers with stokers, and the application of meters and combustion control.

TABLE 2.—AVERAGE FUEL RATE (THOUSAND B.T.U. PER MILE), PITTSBURGH STEAMSHIP COMPANY.

	1941			1940			1939		
	No. of ships.	Light.	Loaded.	No. of ships.	Light.	Loaded.	No. of ships.	Light.	Loaded.
Modernized ships	10	3,180	3,530	7	3,060	3,420	5	3,140	3,430
Ships not modernized	30	3,750	4,170	33	3,620	4,110	35	3,715	4,075

Table 2 shows the gain in fuel economy effected by this modernization programme. Obviously much of the improvement is due to changes in design in major equipment, but the consistency of the operating records of those ships equipped with meters and combustion control shows that where this equipment is installed the higher efficiencies possible with the modern equipment are being achieved in day to day operation.

The five new ore carriers being added to the fleet this year are the largest ships of this type on the Great Lakes. They are all being equipped with boiler meters and automatic combustion control.

A third example of the fuel economies available through the use of meters and automatic control is shown by the results from the series of tankers engineered by and built for the Atlantic Refining Company. This series of tankers, of which there are nine built or building, are equipped with turbo-electric drive and oil-fired watertube boilers. The following paragraphs taken from the paper [1][3] by Mr. L. M. Goldsmith, Chief Engineer of Atlantic Refining Company, gives operating data for the s.s. "J. W. Van Dyke", the first of these ships:—

"It was of course impractical to arrange for the measurement of every quantity and temperature throughout the entire steam and water cycles, as indicated on the heat balance diagram, but boiler meters were provided, as was a recording and integrating flow meter for the steam to the main turbine. Thermometers and pressure gauges were installed at all important points so that it has been possible to determine fairly closely and without any unwarranted assumptions how close the actual results came to theoretical expectations.

"It was possible to determine the output and efficiency of the boilers quite closely. The boilers were designed to give an efficiency of 85·5 per cent. at the rated load of 22,500 pounds per hour actual output, at a pressure of 625 pounds per sq. inch, and a temperature of 835° F.; this corresponds to an equivalent evaporation of 26-260 pounds per hour. During the trial two fuel-test runs were made, one of four-hour and one of three-hour duration. During the first of these runs the boilers were operated at a pressure of 620 pounds per sq. inch and a temperature of 855° F., producing 21,810 pounds per hour each, or an equivalent evaporation of 25,100 pounds per hour. The feed temperature was 351° F. The stack temperature was 324° F. CO_2 was 14·7 per cent., CO was 0, and oxygen 0·18 per cent. These results gave an efficiency of 86·6 per cent. a stack loss of 11·3 per cent. and an unaccounted for loss of 2·1 per cent.

"The second run was at almost exactly the same rate and conditions and showed an efficiency of 86·9 per cent. with stack losses of 11·3 per cent. and unaccounted for losses of 1·8 per cent.

"Since these tests were made the results under normal operating conditions have shown that these efficiencies are easily maintainable. Data taken from the log of the homeward (loaded) leg of voyage No. 12 showed that an efficiency of 87·3 per cent. was maintained for the four consecutive full days of this run. We believe that such efficiencies can only be obtained and maintained by the almost perfect combustion conditions made possible by automatic combustion control".

3. *Increased Furnace Life.*—A saving perhaps equal to that of fuel conservation is possible through the use of meters and automatic combustion control due to increased life of refractory boiler furnaces. Proper regulation of the fuel-air ratio is a very important factor in getting the most life out of such furnaces.

Regular cleaning and inspection of the oil burners likewise has much to do with furnace life, and regular inspection of the boiler auxiliaries is very helpful in getting the maximum possible service from these units. If the operators are relieved from the routine duties of maintaining steam pressure, fuel-air ratio, drum level, etc., many other all-important functions should be performed with greater regularity and care.

(4) *Improved Engine Efficiency.*—Considerable gain in overall economy is available in the average marine power plant through more accurate regulation of the steam pressure and temperature. Since design limitations prevent operation at pressures and temperatures in excess of design conditions, the usual tendency is to operate at a safe point well below these values. With automatic regulation of steam pressure and of steam temperature where facilities for controlling temperature are available, the constant vigilance and greater speed of operation of the automatic control permit the pressure and temperature conditions to be maintained at standard values without danger of exceeding these conditions appreciably even while manœuvring the ship.

Since the overall heat rate of a turbine plant operating at 450 pounds and 750° F. will be reduced approximately ½ per cent. for each 25-pound reduction in steam pressure and 1 per cent. for each 25° reduction in steam temperature, the advantage of maintaining steam conditions near the design value is obvious. Furthermore, maximum capacity of the plant may be reduced in direct proportion to the reduction in steam pressure if a low standard is maintained.

[3] Numbers in brackets designate the references in the bibliography at the end of the paper.

As steam pressures and temperatures increases, the need for careful regulation becomes more important, as the hazard of exceeding design conditions is greater and the losses in efficiency due to operating below design conditions are more pronounced.

(5) *Less Smoke.*—Close fuel and air proportioning will eliminate the smoke, particularly while the ship is being manœuvred. In times of war this is of greatest importance. In times of peace absence of smoke is also important in keeping the ship clean and in reducing the amount of fouling in the convection heating surfaces of the boilers.

Metering and Control Devices Available for Marine Work.

Combustion Control.—The method used in governing a steam boiler is not radically different from that of governing a steam engine or turbine. Steam pressure is used as the index of the relation between incoming and outgoing energy, instead of speed as in the case of the engine. There are two important differences however. Instead of having only one factor to be controlled, there are at least three factors; namely, fuel, air and water supply; and these must not only be controlled to satisfy the demand, but the relation between fuel and air must be accurately maintained at all times, and the correct amount of water must be kept in the boiler. Second, the various regulating devices for the fuel, air and water supplies are not concentrated at one point, so that means for remote operation of these devices are necessary in order that the control can be centralized.

Compressed air is used as the actuating medium for most marine combustion controls, principally because of the simplicity of the control equipment required for the necessary accuracy and speed and because there is no fire hazard involved in running compressed-air lines to the various devices situated in different parts of the fire room. Several combustion control systems use electric power as the operating medium and actuate the various valves, dampers, etc., with reversing pilot motors.

All combustion control systems consist of the following parts which are combined in various ways to satisfy each particular plant layout:—

(1) Master steam pressure controller.
(2) Selector stations for remote hand or automatic control.
(3) Fuel-air ratio controller.
(4) Power devices such as piston operators or diaphragm motors for actuating valves, dampers, etc.

There is no fixed rule for connecting up these various devices, as the type of boiler and furnace, type of fuel burning equipment, and arrangement of the fuel and combustion air supply systems determine which arrangement best suits the particular plant. Four arrangements often used are as follows:—

(1) Series control.—Steam pressure adjusts fuel rate. Measured indication of fuel rate establishes a metered air flow.
(2) Series control.—Steam pressure adjusts combustion air flow. Measured indication of air flow establishes metered fuel flow.
(3) Parallel-series control—Steam pressure adjusts fuel rate and combustion air flow simultaueously. Metering type fuel flow -air flow ratio controller readjusts the fuel flow.
(4) Parallel-series control.—Steam pressure adjusts fuel rate and combustion air flow simultaneously. Metering type fuel flow-air flow ratio controller readjusts the fuel flow.

Systems 2 and 4 have the advantage that the fuel supply is always limited to the available supply of combustion air. However, if a reasonably low value of excess air is to be maintained during the port condition, air regulating dampers must be well designed and leakage through the dampers and at other points must be held at minimum values. Obviously, if there is no regulation of air flow at port loads, there can be no regulation of fuel with the second arrangement and thus no steam pressure control at these low rates.

With systems 1 and 3 it is possible to provide a stop or by-pass on the damper which will permit a safe minimum air flow, and below this point the master pressure controller regulates only the fuel supply.

For installations requiring extremely rapid manœuvring over a wide load range the parallel-series system gives best results as fuel and air are changed simultaneously in accordance with the load change.

The arrangement of the combustion control for more than 250 ships for the U.S. Maritime Commission is shown in Fig. 1. This is a very simple system involving only the minimum amount of equipment necessary to operate the boilers at the required rating and to maintain the proper fuel-air relationship. This system has been designed with the underlying thought that most of these ships will be operated by relatively new and inexperienced personnel, and therefore a standardized arrangement has been used and the equipment made just as simple as possible [2], [3].

Fig. 2 shows the arrangement of meters and control for the Atlantic Refining Company turbo-electric tankers. Recording meters are provided which give a continuous record of steam pressure, combustion efficiency and flue gas temperature, so that a complete picture of the performance of the boilers and of the automatic control is available to the operators as well as the

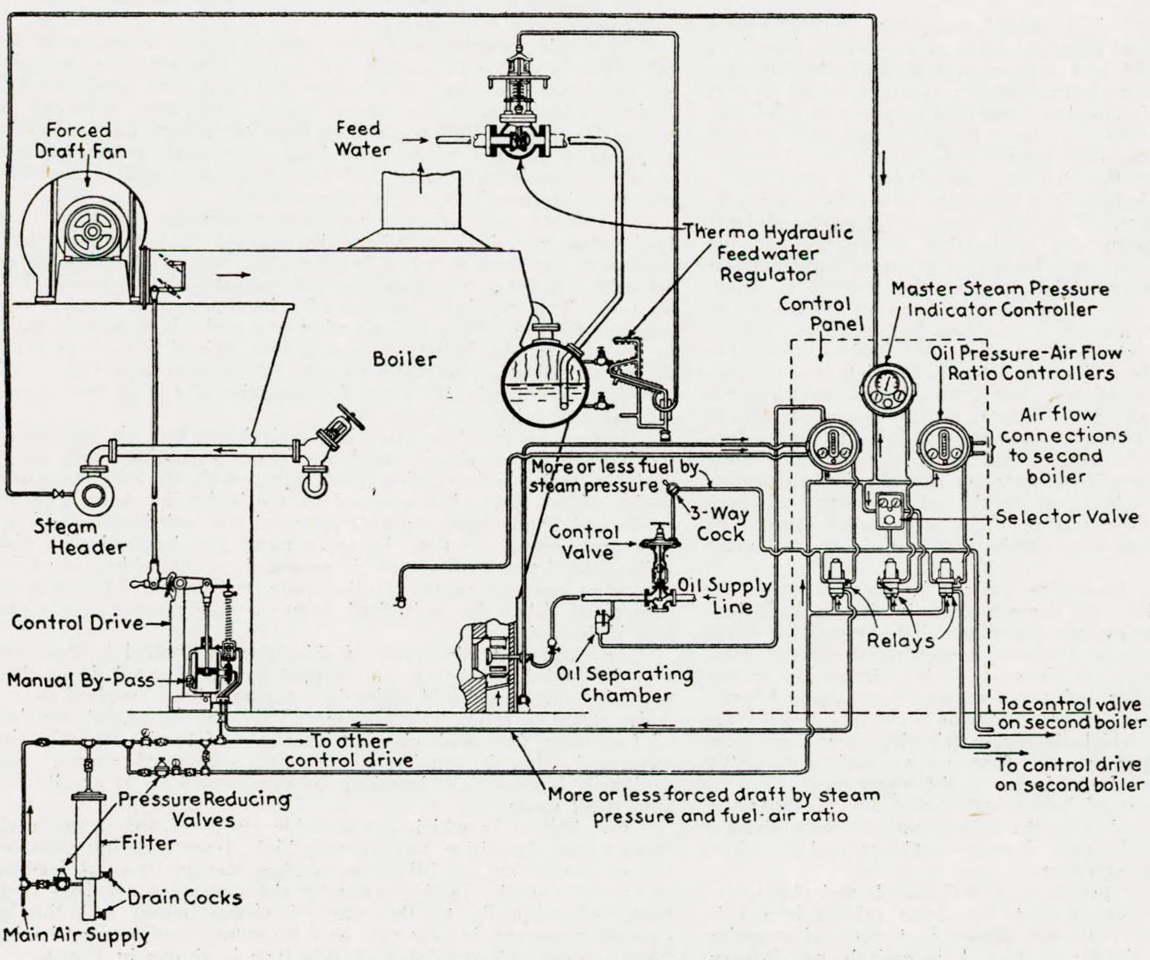

Fig. 1.—*Combustion and feedwater controls, U.S. Maritime Commission.*

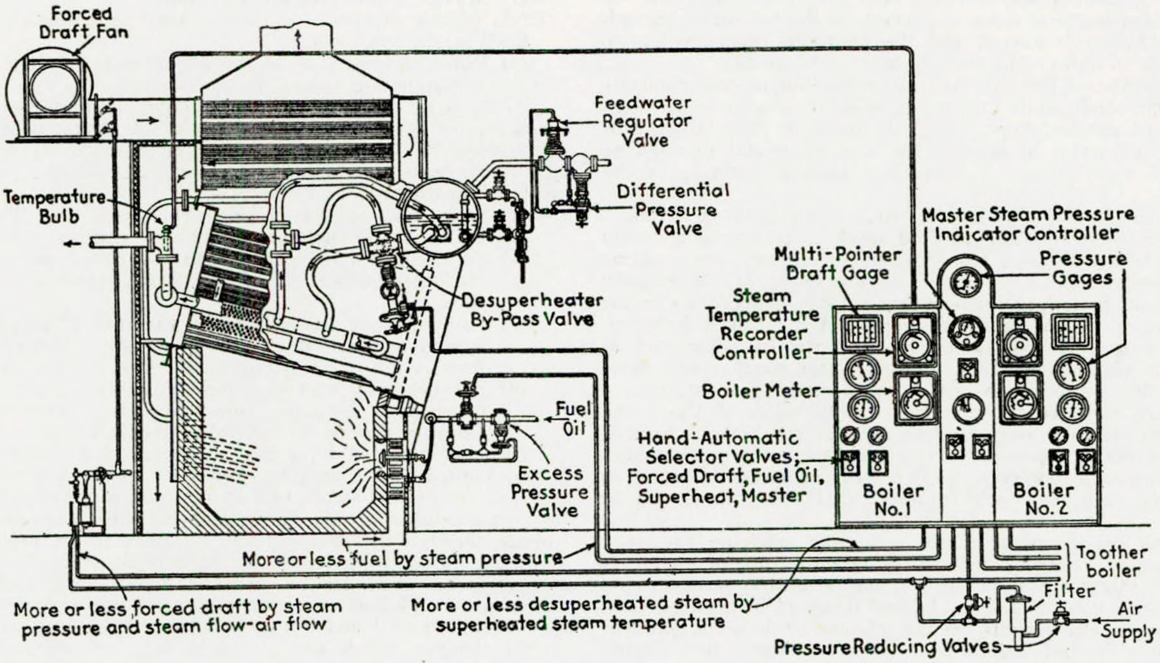

FIG. 2.—*Meters and boiler control, Atlantic Refining Company.*

supervising engineers at all times.

Fig. 3 shows the arrangement of the control for the ore carriers of Pittsburgh Steamship Company. In addition to 13 ships already equipped, five more ships provided with complete boiler control are being added during 1942.

The combustion control is arranged similar to system 4 previously described, except that since these are stoker-fired boilers it is not possible to measure the fuel rate accurately, and therefore the well-known relation between steam flow and combustion air flow is used for readjusting the air supply to maintain combustion efficiency. This steam flow-air flow controller is of the recording type, so that continuous records of combustion efficiency are available. Flue gas temperature is recorded on the chart with the boiler steam flow.

On these stoker-fired boilers it is necessary to use both induced-draft and forced-draft fans. The inlet vanes of the forced-draft fans are used for regulating the combustion air supply and the dampers at the inlet to the induced-draft fans are used for maintaining a constant furnace draft. The draft in the furnace is maintained slightly below atmospheric pressure to keep air infiltration at a minimum and still prevent outflow of flame or hot gases.

Boiler Feedwater Control.—Regulation of feedwater to the boilers is not a particularly difficult job, but one which is so important to continued operation of the plant that only the most reliable men can be assigned to the job. Likewise only the most reliable type of automatic regulators can be used for this job. In the modern steam plant using watertube boilers and using one or more feedwater heaters or economizers it is important that the feedwater flow be steady and approximately equal to the steam output. Severe cycling of the feedwater flow may result in cycling of a number of other auxiliaries, and cause appreciable reduction in overall plant efficiency.

Cyclic action of the feedwater control is usually caused by surges in the water level in the drum ordinarily due to variations in the volume of steam below the waterline. The amount of surge is influenced by the operating pressure, concentration of the feedwater, the arrangement and effectiveness of the circulating system in the boiler, and the amount and arrangement of the steam liberating surface in the boiler drum [4]. Marine watertube boilers are being built with drums in which the steam relieving rates vary from 500 pounds per hour per square foot to approximately 5,000 pounds per hour per square foot of area at the water level.

For these various types of boilers different kinds of feedwater regulators are available, including the self-actuating single element regulator, the pilot-operated single element regulator, and the pilot-operated multiple element regulator.

For boilers operating at pressures of 400 pounds and above, and having steam liberating area so that the steam release is not in excess of 1,200 pounds per hour per square foot, the self-actuating single element regulator, similar to Fig. 4, is entirely satisfactory. This regulator requires no outside source of power for operation, as the generator assembly connected to the boiler drum develops sufficient pressure for actuating the feed valve. A second regulator of this type which is commonly used provides a level sensitive device of the thermal expansion type which develops sufficient power for actuation of the feed valve.

This self-actuating regulator operating only from drum level can often be used with entirely satisfactory results on boilers operating at higher pressures, and boilers equipped with level stabilizing devices within the boiler drum when the steam relieving rate materially exceeds 1,200 pounds per hour per square foot. However, applications of this nature should be made with greater care and should be made only when full knowledge is available concerning the operating conditions to be encountered.

For those installations where remote manual operation of the feed valve is desired, or where the type of feed regulating equipment does not readily adapt itself to the use of the simpler self-actuating regulator, the pilot-operated regulator similar to Fig. 5 may be used. This regulator consists of a level responsive device which may be of the recording or indicating type and which may, if desired, be located on the boiler control panel, with the level responsive device actuating a pilot valve usually of the pneumatic type, so that sufficient pressure is developed for actuating the main feed regulating valve or other supply means.

The application illustrated is a typical one for this type of control. Each boiler of this two-boiler plant is provided with its own variable-stroke reciprocating feed pump with the stroke-adjusting device of the pump [5] adjusted by the indicating drum level controller. A single spare pump is provided for both boilers, with suitable arrangement so that the spare pump can be used with either boiler and the control system is arranged so that either drum level controller can be connected to the spare feed pump. Remote manual control of either the main feed pumps or the spare pump is available if desired.

An important advantage of this type of control is that relays may be added to permit the control to be adjusted for a broad operating range, and still maintain a constant level standard over the entire range of rating of the boiler. This permits smooth regulation of feedwater flow with close maintenance of level. Its only disadvantage is that it requires an outside source of power, which ordinarily is no serious handicap, as compressed air is usually available at all times.

For boilers in which considerable surge of the drum level is encountered, due either to extremely high steam relieving rates or to extreme operating conditions, a multiple element type of feedwater regulator is used. In this regulator the rate of water feed is proportioned primarily to the rate of steam output and the level measuring element is used only as a secondary readjustment having a limited range. A regulator of this type is shown in Fig. 6.

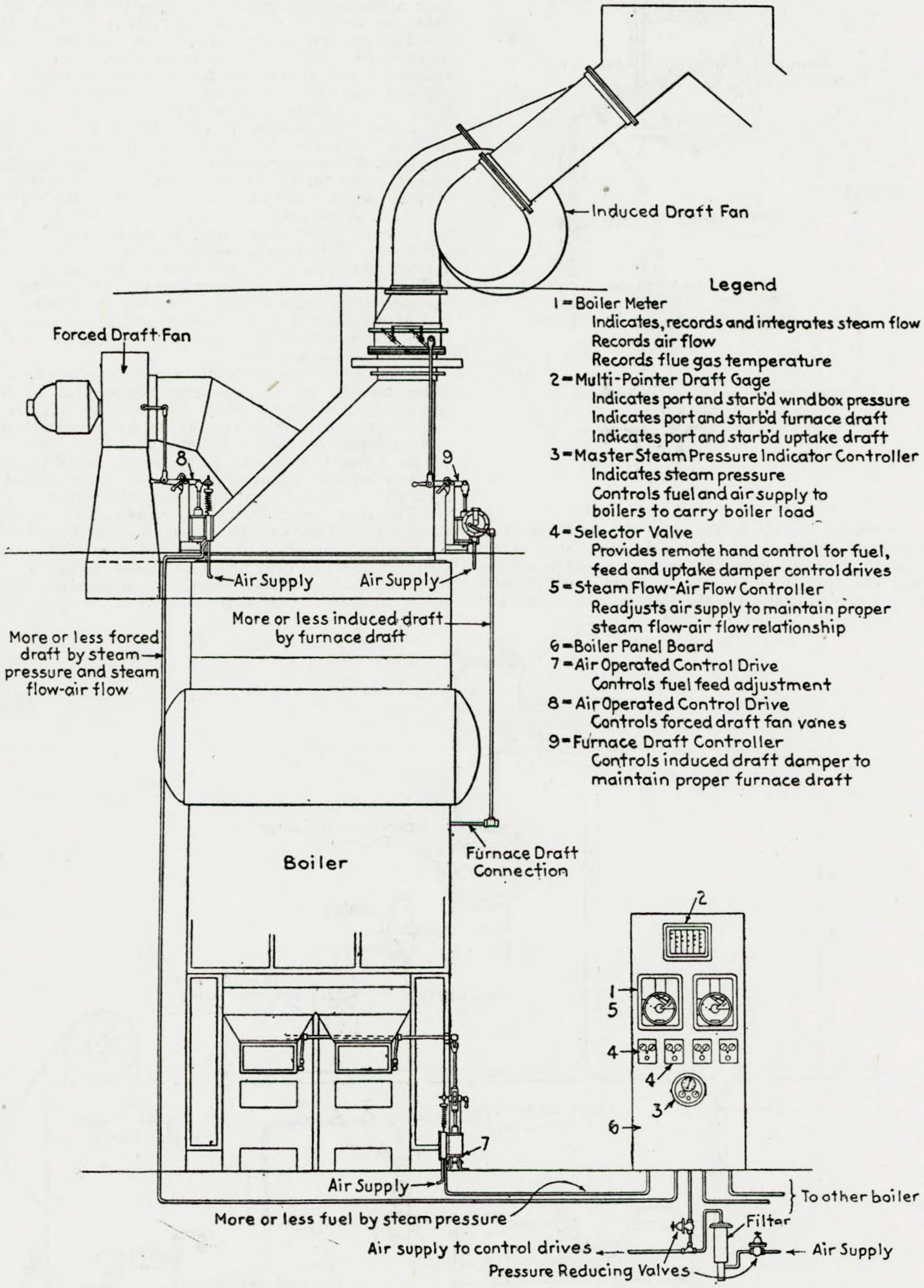

FIG. 3.—*Meters and boiler control, Pittsburgh Steamship Company.*

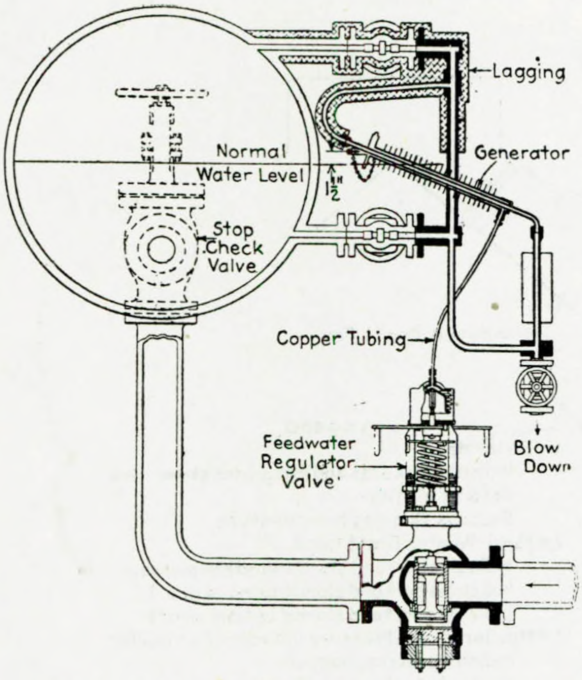

FIG. 4.—*Thermo-hydraulic feedwater control.*

By actually metering the steam flow and the feedwater flow these two values can be very closely proportioned so that only a very limited amount of correction from drum level is necessary, and at the same time the drum level will be maintained within close limits. This type of regulator also has the advantage that it may be adjusted to carry a higher level with high ratings, so that the boiler is better protected against sharp reductions in load and the resultant shrinkage in the drum level. Likewise there is less chance of carry-over upon sharp increases in load, as the level is lower at the low rates, and therefore the drum has capacity to absorb the swell.

This regulator is also pilot-operated and uses compressed air for its operation. Many of the parts are identical with those in the combustion control system, so that a minimum number of spares are required where the same make of equipment for the control of feedwater and combustion are installed.

Steam Temperature Control.—In the past few years increasing use has been made of boiler designs which permit regulation of the superheated steam temperature [4], [6]. This regulation is accomplished either (*a*) by desuperheating all or a portion of the steam between primary and secondary sections of the superheater, or (*b*) by means of dampers which divert all or part of the flue gas passing over the superheater, or (*c*) by means of a divided furnace construction with individual control of the burners on the side of the furnace where the gases pass through the superheater section of the boiler. In view of the importance of close control of steam temperature, particularly as steam temperatures increase, automatic control of temperature should be used to insure against exceeding safe limits and to obtain most economical operation of the turbines or other propulsion machinery.

Control of steam temperature by desuperheating a portion of the steam between primary and secondary sections of the superheater is illustrated in Fig. 2. Note that a 3-way valve is actuated by a diaphragm motor which receives its air pressure loading from the steam temperature indicator-controller. This valve either forces all of the steam through the desuperheater located within the boiler drum or bypasses a portion or all of the steam around it to maintain a constant temperature at the superheater outlet.

The arrangement of the automatic control for the divided furnace boilers of the s.s. "Examiner" [7], which is the U.S. Maritime Commission ship designed for operation at 1,200 pounds per square inch and 750° F. with reheat is shown in Fig. 7. While in this particular case the temperature control regulates the fuel and air supply to maintain reheat steam temperature, a similar arrangement

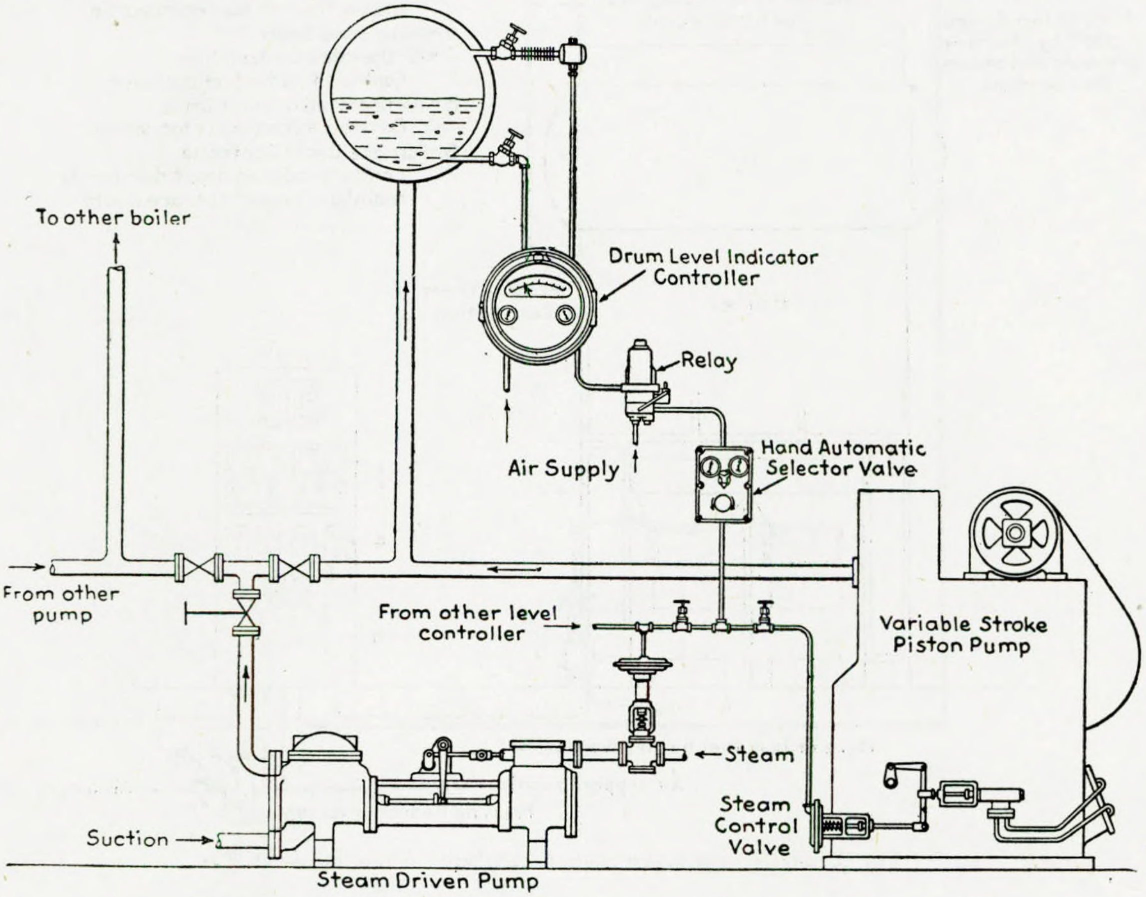

FIG. 5.—*Pilot-operated single-element feedwater control.*

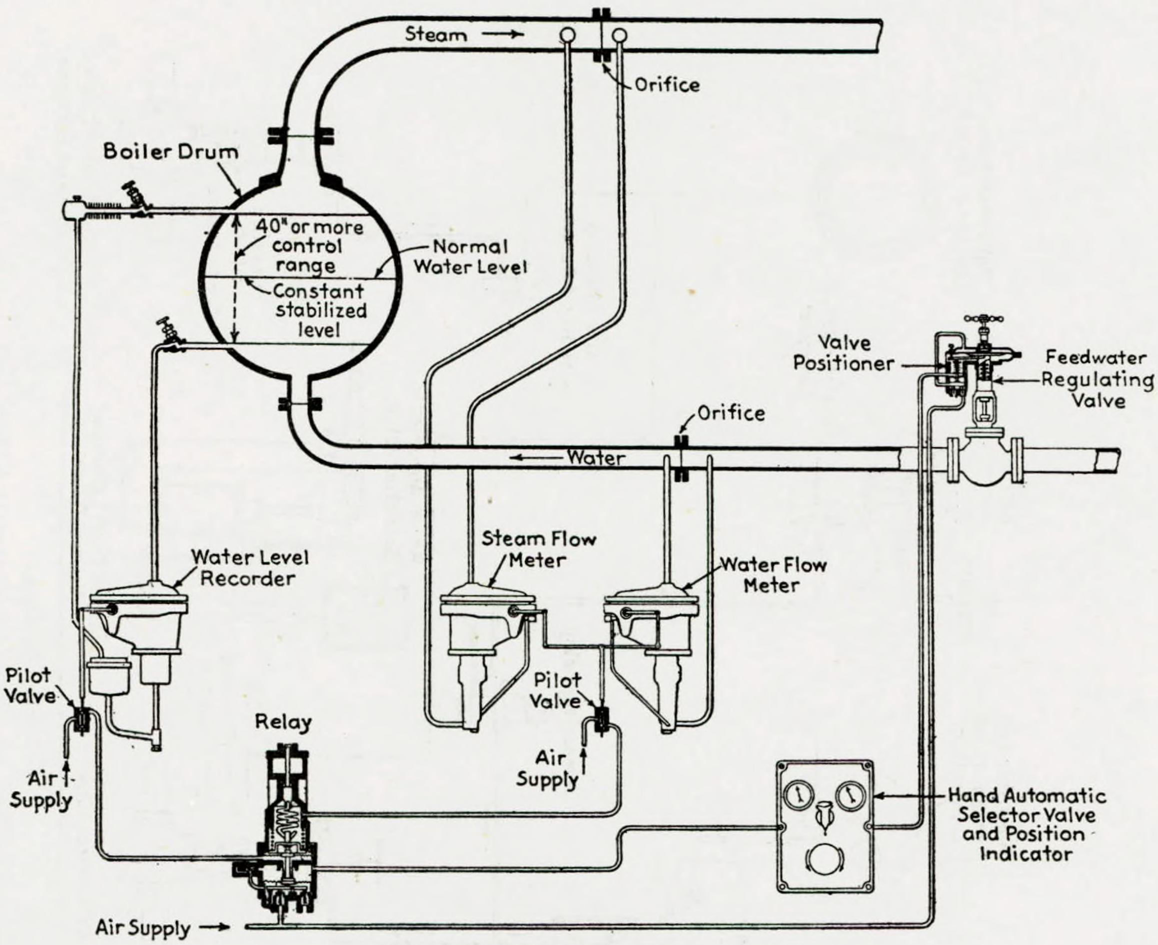

FIG. 6.—*Three-element feedwater control.*

is used on more recent installations operating at higher steam temperature without reheat to control the superheater outlet temperature.

In some cases it is desirable to use a parallel series connection between the controls on the two furnaces, so that the firing rate on both furnaces is changed simultaneously from the steam pressure controller with readjustment of the firing rate on the superheater furnace from the steam temperature controller. The most desirable arrangement is determined by the balance which exists between the two furnaces at various loads, the amount and extent of manœuvring required and the range of operation available with the fuel burning equipment.

Miscellaneous Controls.—There are many places in a ship's power plant where automatic controls can be used to advantage for maintaining oil, water or steam temperatures or pressures, and tank or heater levels. Use of controls will in many cases result in smoother and safer operation, and conserve the operator's time for more important duties.

By selecting controls for these various auxiliary services which are similar in design to the boiler controls, it is possible to train one or two men in the maintenance of this equipment and considerably less time will be required for maintaining and checking the performance of the control equipment than would be required for manual operation of the functions which it performs.

The value of recording meters for flow, level, pressure and temperature has not been fully appreciated by all marine engineers. Some of the hesitancy to use meters which provide the continuous record is due to the fact that the manufacturers of this equipment have been slow to make it suitable for the pitch and roll and the atmospheric conditions which are likely to be encountered aboard ship. Considerable progress has been made by the manufacturers however, and as soon as the marine designers and operating engineers begin to see the advantage of keeping a continuous log of important operating conditions automatically, this equipment will be used more extensively.

Not only is less time required for maintenance of the necessary metering equipment over that for manually recording the data, but the records are kept in better shape and all of the important conditions are recorded. Since the recorder is on watch every minute of the day, no unusual conditions escape its notice; if any faulty operation develops, a complete story of conditions prior to, during and after the fault is available for reference.

SAFETY PRECAUTIONS.

Equipment which has been discussed up to now provides for reliable and economical operation of the boilers after they are on the line. An equally important phase of boiler operation is that of preventing furnace explosions during the lighting off period.

Furnace explosions cannot occur upon lighting, if :—

(1) The furnace is purged of all fuel.
(2) Ample torch flame is properly applied to each burner before fuel is turned on to each burner in succession.
(3) Air velocity at each burner is kept low enough to prevent blowing out the flame.
(4) Fuel is supplied in a sufficiently rich mixture to ignite immediately from the torch.
(5) After ignition is established, the correct proportion of fuel and air is maintained throughout the entire time the furnace is in operation, and if the furnace is operated at a high enough rate to maintain stable ignition.

Two valuable protective devices have recently been developed which can be of material assistance in guarding against furnace explosions. The first is a photoelectric type flame failure detector, which is installed on the furnace near the burners, and which may either sound an alarm or cut off the fuel supply, or both, in case of flame failure.

The second device is known as a purge interlock which is tied in with the fuel supply system so that the fuel to the burners cannot be started until the furnace has been properly purged by a sufficient air flow.

Automatic torches have been used for lighting the main fires; with proper interlocking between the fuel supply system, the automatic torches and the flame failure detectors, complete remote con-

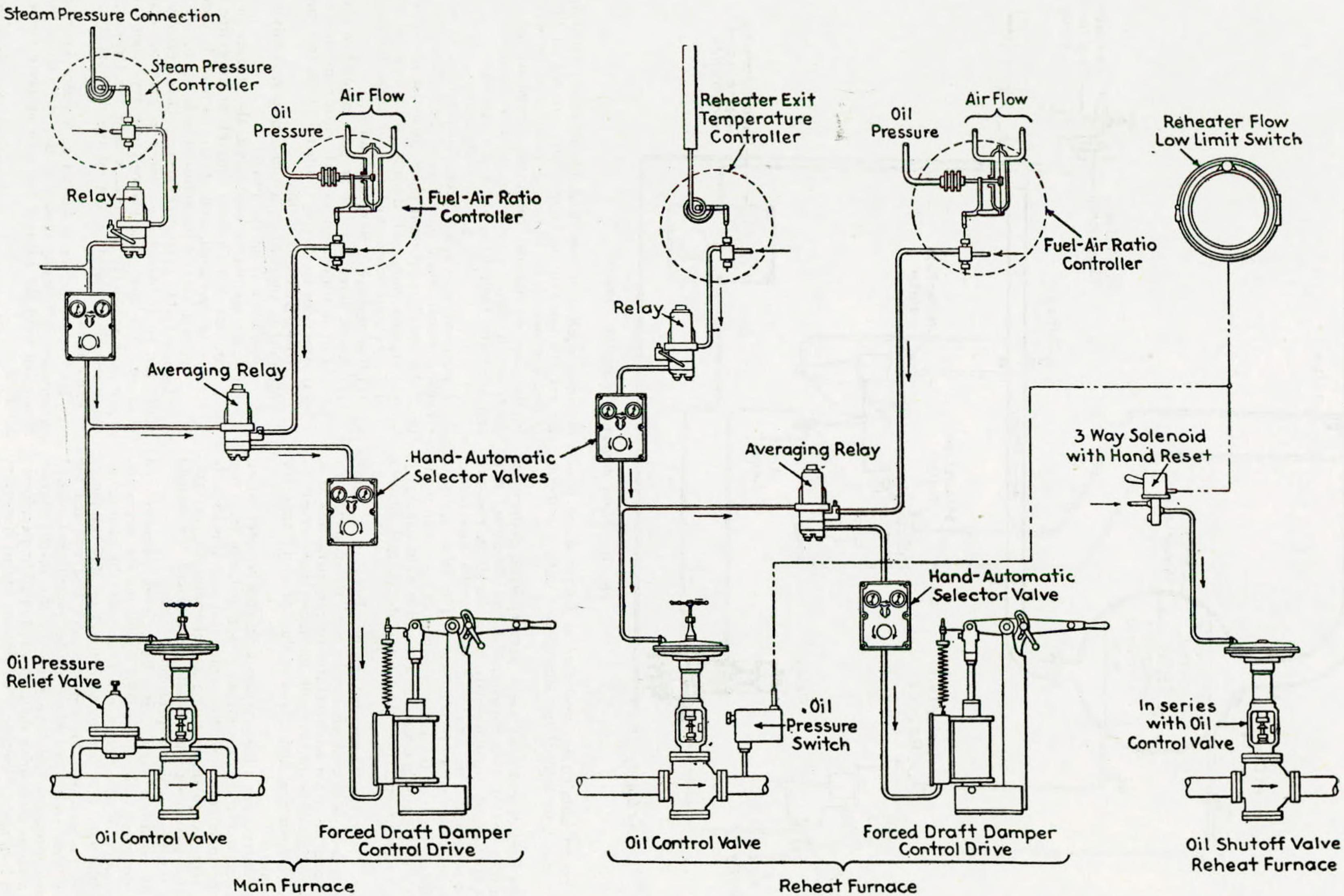

FIG. 7.—*Combustion and steam temperature control for divided-furnace boilers.*

trol of the burner lighting is possible without some of the dangers present when inexperienced personnel must start up the boilers.

Relation of Meters and Control to Other Plant Equipment.

A word of caution to designing engineers is in order with regard to the application of meters and controls to marine power plants. The boiler control system cannot operate the boiler over any greater range than the safe working range of the fuel-burning equipment.

While entirely satisfactory results are obtained with many cargo ships, where automatic control is installed and straight mechanical atomizing burners having less than two to one range are used, this is due to the fact that the manœuvring requirements of this class of ship are not very exacting, and the load range not very broad. One set of atomizers will normally take care of all running requirements, and a second set of atomizers and possibly a reduced number of burners will take care of all port and port manœuvring requirements.

However, on certain classes of work, such as dredges and ships of greater power and speed, a greater range of operation will be required and rapid manœuvring over the entire range of power output may be desirable. For this type of installation it is necessary to use wide-range oil burners in order to achieve the desirable features of automatic control, as with the narrow-range burners so much changing of burners would be required that best performance of the boiler would be unlikely and there would be little saving of time or effort for the operators.

Similarly, if close regulation of combustion efficiency is required over a wide range in load, it is important that adequate means of regulating combustion air supply be provided. Ordinarily it is desirable to vary the speed of combustion air blowers to conserve blower horsepower at the low ratings. However, most variable-speed drives are slow to respond when speed ranges greater than 2 or 3 to 1 are used, and therefore it becomes necessary to use dampers to supplement variable-speed blowers where a wide range is required and where close combustion efficiency control is desired over the entire range. These dampers must be properly proportioned and built to keep leakage at a minimum, if good regulation of air flow at low rates is to be obtained [8]. The accuracy, speed and stability of the control system will depend to a large extent upon the thought given to the damper design.

If flow meters are to be used for the measurement of steam generation and consumption, proper consideration of this fact must be given when the piping is laid out. Orifice type flow meters have been developed to a point where highly accurate measurements are possible if due consideration is given to the design of the orifice and its arrangement in the piping system [9]. Well-established rules have been set up by the meter manufacturers; if these rules are observed when the piping is laid out and when the meters are selected, good results can be expected from the metering equipment.

Conclusion.

It is believed that higher steam pressure and steam temperature can be expected in the future. It is further believed that more extensive use of meters and automatic control will accompany this trend to the higher pressures and temperatures.

The increase in the use of meters and automatic control for marine power plants has been quite phenomenal in the last two years, and through this experience in applying equipment to present-day plants valuable knowledge will be gained for further improvement of installations in all classes of steamships.

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The Engining of Post-War Cargo Vessels of Low Power.

CORRIGENDA.

The following corrections to the Appendices and Discussion published in the August Transactions, pages 135-172, should be noted:—

Appendix 1, page 135, line 1. For "b.h.p." read "s.h.p.".

Appendix 2, facing page 136, item 7. For "S.h.p. read "S.h.p. at propeller shaft".

Appendix 3, facing page 137, item 11. For "S.h.p." read "S.h.p. at propeller shaft".

Appendix 3, facing page 137, item 22, column VII (Diesel-electric machinery), for "2" read "A 14·5 B 15"

Discussion, page 140, Fig. F, and page 141, Fig. H. These two cross sections should be interchanged.

Authors' replies to the Discussion, page 166, col. 1, line 4: "previously for" should read "previous to"; and page 169, col. 1, line 2: "myself" should read "the authors".

Correspondence—Common Boiler Ailments and Their Cures.

Mr. J. M. Thomson (Member), referring to Mr. J. H. Milton's* paper published in the February 1944 Transactions, wrote that the performance of steam generators was viewed from widely different angles by three groups of engineers, namely the manufacturers, the users and the inspectorate. In presenting so exhaustive a description of the ailments inherent in boilers a service had been rendered to the Institute and to engineers because the paper embodied valuable information, the cumulative result of much experience and observation.

Concerning Class 1, external defects of Scotch multitubular boilers, it was stated in the paper (page 4, column 2, line 12) that "The fireside of the furnaces can be more or less ruled out as far as wastage is concerned"; the writer thought that, if oil-fired and pulverized fuel furnaces were excepted, the author's experience of these parts had been fortunate, especially as nothing bearing on the furnace fire-side was enumerated in the paper under Class 3, Mechanical Action. He had occasionally met with wastage of the furnace tubes at the firebar level, caused by chafing by the firebars, but longitudinal "furrowing", often of considerable depth, on the furnace bottom at the front end, circumferential seam, accompanied by wasting of the adjacent rivetheads in this seam, was of frequent incidence and was due to the rubbing of the firing tools. When the "furrows" were not of excessive depth, repair consisted of building these up by welding and by the renewal of any wasted rivets.

In the paper it was rightly pointed out that the grooving at the flanging of the front endplate, as illustrated in Fig. 22 (19 and 30), was the result of mechanical action, but the writer noted that the repair advocated for this ailment, where the grooving exceeded 50 per cent. of the plate thickness in depth, was to cut right through the grooving and to weld from both sides of the plate. He would point out that the grooving actually took place at the position of maximum bending stress and that should this method of repair be adopted the bending stress nevertheless remained an existing, inimical factor and was concentrated at the line of weld, a condition which he could not regard with equanimity. He knew of more than one failure of welds which had been carried out at flanged regions subject to bending action, and he was of opinion that a more reliable repair in similar circumstances was to suitably cut out the affected portion and to fit a riveted patch of the curved "bosom piece" type, additional rivet holes being drilled in the endplate as

* Vol. LVI, No. 1, pp. 1-7.

required. This method of repair provided ample caulking advantages and the necessary degree of flexibility was not impaired.

Mr. J. H. Milton (the author), in reply, agreed that furnaces were sometimes chafed by firebars, and also by firing tools. The term "wastage" as referred to in the paper was that caused by a chemical re-action, which might be oxidation from dampness, the action of the boiler contents on the boiler, acid from damp ashes, or flue gases, but not chafing or erosion of two metal surfaces rubbing together.

Mr. Thomson was quite correct in his statement that when endplates were cut through in way of grooving, and filled in by electrically deposited metal "the bending stress nevertheless remained an existing inimical factor, and was concentrated at the line of weld". The seriousness of this factor surely depended on the degree of ductility of the deposited metal, and provided the welding was correctly executed with a suitable electrode this factor need not be a menace. The author had never seen a curved "bosom piece" type patch fitted to a Scotch boiler front endplate, and he imagined that the fitting would be a matter of extreme importance, that this repair could not be efficiently executed without removing or turning the boiler, and that the additional rivets and extra caulking edges might be a cause of trouble.

MEMBERSHIP ELECTIONS.

Date of Election, 5th September, 1944.

Members.

Andrew Linton Brownlie Alexander, Lt.-Com'r.(E.), R.C.N.R.
Isaac Anderson.
Louis Peter Bek.
Herbert Davey Beverton.
Anthony Close, Lieut.(E.), R.N.R.
Edwin Greenhalgh, Lieut.(E.), R.N.R.
William Gregson, M.Sc.
Andrew Hamilton.
Jacobus Marie Haverman.
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William Mylrea Kissack.
James McCall.
Hugh White Munro-Millar, Lt.-Com'r.(E.), R.N.V.R.
Eric Alford Perks.
Alexander Pladdie.
James Read.
Richard Kirkup Spencer.
John Steel.
Arnold Hunter Stobbs.
Charles Leslie Stokoe.
Glen J. Thomas.
Sydney Thomas.
Frederick Wardle, Lieut.(E.), R.N.R.
John Henry Waters, Com'r.(E.), R.I.N.
Joseph Weldon.
Charles William White.
Charles Fisher Wrigley.
Douglas Eric Guard.
Charles Stewart Hall, Lieut.(E.), R.N.R.
Alexander Hanna.
John Birch Hughes.
Peter Manson.
William Hood Martin.
Matthew Sampson Newton.
William Robertson Pearson.
Ian Christie Robertson.
Alexander Russell Shaw.
Gordon Thomas.
George William Williamson, Group Capt., O.B.E., M.C.

Associates.

Geoffrey Beal.
William Robinson Cromey.
Ronald Pearson Dunwoodie.
John Elliot.
Percy Roland Gill.
Ralph Robert Ginn.

Graduate.

Harry Newton.

Students.

John Bretland Chevallier, Actg. Lieut.(E.), R.N.
William Millar Lawson.

Transfer from Associate Member to Member.

Robert Henry English.
James Andrew Knight.
Frederick Campbell Walsh, Lieut.(E.), R.N.R.

Transfer from Associate to Member.

Jacob Bernard van Wijk.

Transfer from Associate to Associate Member.

Francis David Clark.

Transfer from Student to Associate.

Raymond Yandell Bennee.
James Crawford Milliken.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

Questions and Answers for Marine Engineers. Compiled by Capt. H. C. Dinger, U.S.N.(ret.). Simmons-Boardman Publishing Corporation, New York.

In two books:

"Boilers and Engines", 377 pp., illus., $2.

"Application of Steam and Heat in Producing Power", 83 pp., $1.

These books are a collection of questions and answers which have appeared in "Marine Engineering and Shipping Review", New York.

Written primarily for American marine engineers a large number of the questions are similar to those set in the engineering knowledge papers at the Ministry of War Transport examinations.

A person who writes, edits or publishes a book for students or others of limited experience has a special responsibility; inexperienced readers are liable to take answers from a book at their face value and to quote obvious mistakes or statements which refer to extreme cases and so jeopardize their chances of success at an examination.

The books contain a large amount of useful information with the facts clearly and concisely stated, and the answers are full enough to enable a candidate to compile an answer which should satisfy an examiner. They can be recommended to engineers studying for Ministry of War transport examinations, provided the student has sufficient common sense to realize that, among the hundreds of good answers given in the books, there are some which would bring discredit if given at an examination, e.g.:

Page 29 *"An accumulation of pressure test should last 15 minutes and the steam pressure should not at any time rise more than 60 per cent. above the maximum working pressure".*

Page 91 *"When low-pressure boilers were generally in use it was not unusual to stop tube leaks at joints by putting oatmeal in the feed water".*

To the present junior engineer 180lb./sq. in. means low pressure.

Page 157 *"In the case of the Scotch boiler the limit blow is 2½/32nds. Do not allow the water to go over this limit".*

No reason is given for this low figure which, if quoted at an examination would not satisfy an examiner.

Page 297, referring to slide valves under the heading Lead, *"Slightly more lead is generally given at the bottom on account of the weight of the piston being lifted".*

The correct answer is that the bottom lead is greater than the top lead because the bottom lap is reduced so as to tend to equalise top and bottom cut off and so overcome the effect of the angularity of the connecting rod.

Page 23, Book IV. A table of steam and fuel consumptions for various engines is given. The figures for a turbine with condenser are *"12-40 pounds of steam per indicated horsepower hour and 1·5-5 pounds of coal per indicated horsepower hour".*

These figures are given as 1928 results. Long before 1928 better results than the minimum quoted were being obtained.

The Testing of Internal Combustion Engines. By S. J. Young and R. W. J. Pryer. The English Universities Press Ltd., London, 1943, 200 pp., 87 illus., 8s. 6d.

The authors in the preparation of this small book have drawn upon their experience and material accumulated in the course of their work in the Internal Combustion Engines Laboratory at Loughborough College.

The book covers the general principles of testing procedure and deals with engines of a type likely to be found in well-equipped laboratories.

In the introductory chapter the authors divide engine testing into four categories: routine and acceptance tests; comparative tests; research testing and educational tests; and although it is the last category which the authors have kept in mind as being the type of test with which a heat engines class is principally concerned, the instruction given should enable the student to acquire the knowledge necessary for carrying out the more comprehensive type of commercial test and must form the basis of "research" testing.

Chapters are devoted to general test procedure, engine timing, brake horse-power tests, fuel consumption tests, engine indicating, heat losses, measurement of air consumption, and miscellaneous experiments.

In two Appendices, attention is drawn to the need for consideration of Dynamometer size and characteristics in relation to the speed-r.p.m. characteristics of the engine to be tested, and also the importance of taking dynanometer readings only when the dynamometer arm is in the correct position for which it was calibrated.

The book is clearly printed and well illustrated and fulfils the need for a small book dealing with the testing of internal combustion engines from the point of view of the average technical college, but in addition it should prove valuable to the professional engine tester giving that guidance necessary to enable him to appreciate the significance of the data obtained on engine tests.

Diesel Operation—Fuel and Lubricants. The Texas Company, New York, N.Y., 96 pp., 46 illus.

Although presented in an elementary manner, the material contained in this book is most useful to those who have had Diesel experience. Many practical hints and much valuable data is contained therein and it is suggested that the book should be kept handy for reference in every marine engineer's office.

Industrial Bulletin, No. 4, Oils. Economical Lubrication of Stationary Internal Combustion Engines. H.M. Stationery Office (for the Ministry of Fuel and Power), 17 pp.

This useful booklet contains notes, compiled by the Ministry of Fuel and Power, on the care which should be taken by the operators of stationary internal combustion engines to ensure most economical expenditure of the valuable lubricating oil they use. The description "internal combustion engine" should be accepted as embracing the industrial engines usually encountered irrespective of their sizes, their fuels, gas and oil, and their combustion processes.

The following is the list of articles that appear: Lubricating Oil Running Costs: Pistons and Cylinders: Enclosed Engines: Open Engines: Methods of Reconditioning and Filtration: Routine of Reconditioning and Filtration.

Marine Electric Power. 2nd Edition. By Captain Q. B. Newman, Engineer-in-Chief(ret.), U.S. Coast Guard, 238 pp., 160 illus., $2.50.

As an introduction to the subject of electric propulsion of ships—with particular emphasis on the turbo A.C. system—the book, which is pleasing to read, should have a wide appeal. The diagrams are well drawn and explained, and at no stage in the argument is the reader expected to perform anything but the very simplest of mathematical capers.

Direct current machines are briefly dealt with as are also the fundamentals of D.C. and A.C. theory.

Cargo Coaling Plants. By J. Dalziel. The Railway Gazette, London, 1944, 16 pp., 9 illus., 2s. 6d.

This booklet deals with the various methods in use to-day for the loading of coal from railway wagons into ships' cargo and bunker spaces. The author gives a fair survey of the particular application of conveyor type plant with its ability to cater for awkward spaces, high handling and loading rates, and continuous operation. The merits and demerits of different mechanisms are enumerated, and there is an interesting section on coal breakage percentages.

The booklet should be of considerable interest to those connected with the design, site planning, or operation of ship coaling installations.

With the Merchant Navy. Raphael Tuck & Sons, Ltd., London, 1944, 16 pp., 13 illus., 4s. 6d. (11in.×8½in.).

This is a book that will interest all those who love the sea. It contains thirteen full page pictures painted by that famous marine artist Frank H. Mason, R.I., and around these beautiful paintings Charles Jarman has written a short story of the battles that have been fought by the men of the British Merchant Navy during this war.

He recalls the watchword of a famous Malta convoy: "We must get through"—the contents of this book give the nation a watchword for the peace-time Merchant Navy: "We must remember".

Youth at War. Comprising **Fighter Pilot; Sub-Lieutenant; Infantry Officer.** B. T. Batsford, Ltd., London. 1944. 212 pp., 74 illus, 15s. net.

When war was declared on Germany in September, 1939, the youth of Britain rallied—as their fathers had done before them—to fulfil the needs of the fighting services. Some answered that call because they felt it was their duty to do so; others with a sense of adventure, and some because they loved fighting anyway. Whichever way the appeal was heard, it is certain that not one of those young men who volunteered in 1939 realised the horrors, and the wonders too, that the science of modern warfare would reveal to them.

These three books "Fighter Pilot", by Paul Richey, "Sub-Lieutenant", by Ludovic Kennedy, and "Infantry Officer", by Anthony Irwin, already well known in their original separate publication, are now published in one volume and cover the personal activities of three gallant representatives of the fighting services during the first two years of the war. Looking back from this present year of success, one is obliged to acknowledge how much of this success is due to the pioneer work of these now seasoned fighters, who went forward to endure the battles of 1940, the periods of reverse and deep anxiety. These gallant fellows, displaying wonderful spirit and courage, paved the way and those who survived are still making the path to victory.

"Youth at War" is a thrilling account—a personal, moving story—of the lives of young fighting officers in the battles of the air, sea and land. Each of the three books reveals the necessity for team work, comradeship and self sacrifice as the only combination for success. Surely this is a lesson that should be remembered after the peace bells ring, and should be taught and applied for the future safety of mankind, not left to be made obvious in the rigours and horrors of future wars.

If an evening spent in an easy chair with a seasoned pipe and a good book is an evening well spent, here is the good book.

Half Mast. By Edmund Watts. "The Journal of Commerce and Shipping Telegraph", London, 1944, 86 pp., 5s.

This is the most refreshing and thought-provoking book the reviewer has read for some time and it should be brought to the notice of everyone who is dependent in any way upon the services rendered by the Merchant Navy in peace-time as well as in war. Apart from its value in focussing the interest of the general public on the work of merchant seamen and thus creating a better appreciation of the value of a strong and contented Merchant Service to the nation, it is full of matter of considerable educational value to those who serve in or are connected with the British Merchant Navy.

The Newcomen Society for the Study and History of Engineering and Technology. Transactions, Volume XXI, 1940-1941.

Presented by Eng'r. Com'r. D. Hastie Smith, R.N. (ret.).

Caspian Odyssey. Naval Operations 1918/19. By Nicholas N. Lischin, late Lieutenant, Imperial Russian Navy. Manuscript translation from the Russian.

Purchased.

The Chemical Analysis of Waters, Boiler and Feed-waters, Sewage, and Effluents. By Denis Dickinson. Blackie and Son, Ltd., London, 1944, 140 pp., 4 illus., 6s. net.

In this practical handbook definite instructions, in a convenient form, are given for the qualitative analysis of drinking waters and the other types of liquid mentioned in the title.

Discussion of the principles on which the various methods are based has been reduced to a minimum, but references to original papers have been included for the benefit of those who wish to investigate more thoroughly the mechanism of any individual analysis.

The author has selected the methods which in the course of his wide personal experience he has found to be the best.

The Mediterranean Fleet, Greece to Tripoli. H.M. Stationery Office, London, 1944, 95 pp., illus., 1s. 6d. net.

The history of the fight for Mediterranean supremacy makes fascinating reading and this excellently illustrated book gives the Admiralty account of naval operations from April, 1941, to January, 1943.

Very Ordinary Seamen. By J. P. W. Mallalieu. Victor Gollancz, Ltd., London. 1944. 278 pp., 9s. 6d.

A novel based on the experiences of the author as an ordinary seaman, during five months' naval training, and four and a half months at sea on a destroyer which helped to run safely to Murmansk, through the heaviest bombing attack of the war, the largest convoy ever sent to Russia.

Our Mercantile Marine. By Cuthbert Maughan. Signpost Booklet. The Signpost Press, London. 1944. 30 pp. 6d.

Between the wars the public were careless of the debt they owed to the Mercantile Marine, and in 1939 we had 1,865 fewer ships than in 1914. Here the writer gives an account of the British shipping industry, looking back to the pre-war depression and pointing the moral for the future.

PERSONAL.

Mr. A. H. Hodges (Member) has received official Commendation for outstanding bravery when the vessel of which he was Chief Engineer was attacked by an enemy submarine.

Mr. P. W. McGuire (Member), M.I.Mech.E., Works Director, Chesterfield Tube Company, Ltd., has been appointed Managing Director.

Abstracts of the Technical Press

Neither The Institute of Marine Engineers nor The Institution of Naval Architects is responsible for the statements made or the opinions expressed in the following abstracts.

Reversing Gear for Turbines.

Recent proposals concerning the employment of Diesel engines in connection with geared steam turbines in order to eliminate the need for astern turbines as well as the problem of providing satisfactory astern running arrangements for marine gas turbine installations, are of special interest to the writer because, some 25 years ago, he developed and patented an arrangement for utilising the reduction gearing drive of turbines to obtain reversal of the propeller shaft, thus eliminating the astern elements of the turbine. This arrangement, illustrated in Fig. 1, comprised the addition of an astern pinion to each gear unit which it was desired to reverse. The astern pinion was to be caused to revolve in the opposite direction to the ahead pinion by means of two small "idler" pinions interposed between the turbine driving-shaft and the astern pinion. By causing the turbine driving-shaft to pass through the centre of one of these two idler pinions, and by attaching the other to the shaft of the astern pinion, a neat and compact arrangement was possible. This was helped by fitting the astern clutch close up against the main ahead turbine gearing coupling. In view of the high powers of marine turbines it seemed necessary to have clutches of the positive type, and as the astern gear would, as a rule, only be required when entering or leaving harbour, provision was made for an additional coupling for disconnecting the idler pinions. Alternatively, arrangements could be made for "swinging" the whole astern gear, as a unit, away from the wheel with which it was to engage, although a drawback of this latter scheme is the fact that the astern gear is not immediately available in an emergency. In the application of a reversing gear of this kind, two important problems must be borne in mind. The first concerns the necessity of absorbing the inertia of the rotating parts in order to ensure rapid manœuvring, whilst the other lies in the need for ensuring that the toothed couplings should engage readily. The writer proposed to deal with the first of these problems by providing a hydraulic brake which was an adaptation of the well-known Hele-Shaw pump, in which, however, instead of the pump cylinders discharging completely outside the pump, each pair of two opposite cylinders were interconnected by a small passage. When the brake was in operation, the oil with which the pump was filled could be forced from one cylinder of a pair to the other and back again, in sequence, until the energy of the revolving parts was dissipated. The action of the brake was, in effect, that of a hydraulic "buffer" with a variable and controllable stroke, capable of absorbing rapidly, without shock and with perfect control, very large amounts of energy. The writer's solution of the second of the above problems was the provision of a synchronised coupling, illustrated in Fig. 2, having two or more pivoted pawls, corresponding to two or more teeth of the coupling, which would be used to take up the first slight rotary movement of the turbine and thus bring the driving and driven coupling teeth into line (if they did not happen to be so) following which the full engagement of the coupling teeth could take place as the turbines ran up to speed. —*J. S. Bruce, "The Marine Engineer", Vol. 67, No. 804, July, 1944, pp. 288-289.*

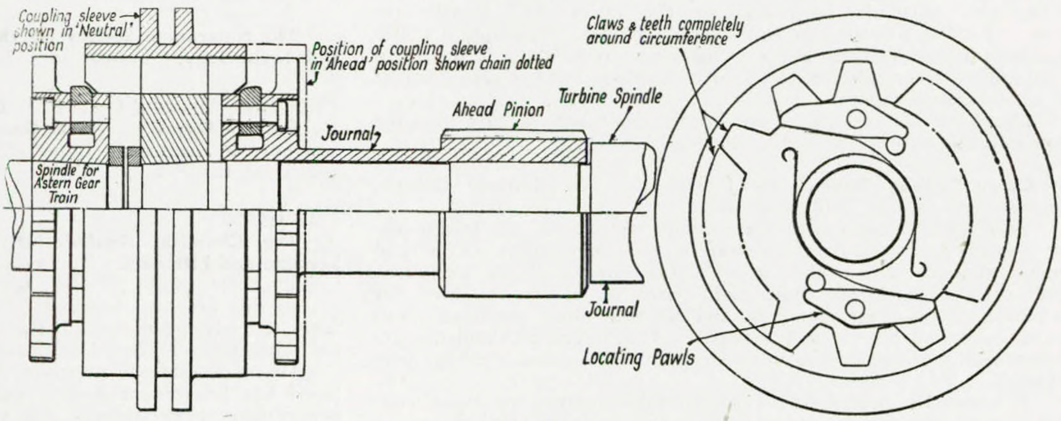


FIG. 2.

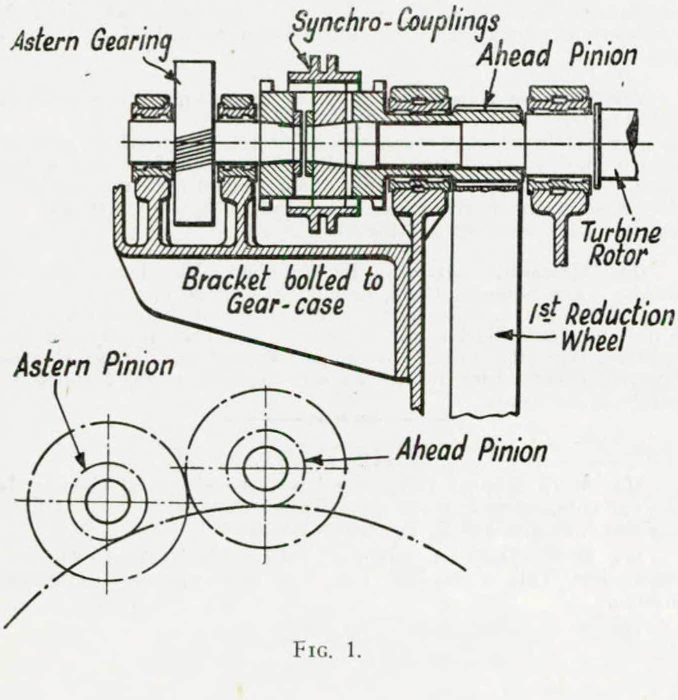


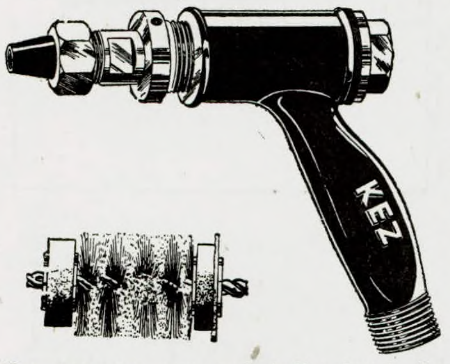
FIG. 1.

Efficiency of Turbine Gearing at Reduced Powers.

The employment of peripheral speeds of up to 800-900ft./sec. for turbines in American naval construction has led to the general adoption of double-reduction gears which, while only very slightly less efficient than single-reduction gearing at full power, are considerably less efficient at cruising speeds. Tests have shown that the efficiency of S.R. and D.R. gears at full power are about 97·0 and 91·5 per cent. respectively, at cruising speeds. Some of the gain due to the adoption of high turbine and low propeller speeds is lost through the low transmission efficiency of D.R. gears at reduced power. Most of the power loss in high-speed mechanical gearing is in the journal bearings, of which the S.R. gear has six or eight, whilst some D.R. gear arrangements have three times as many. The frictional torque in a journal bearing is a function of the absolute viscosity of the lubricant, and the speed of the journal, and attention has recently been directed in America to raising the efficiency of gearing under variable conditions of running. One method proposed for obtaining this result is to regulate the oil inlet temperature to the bearings within fixed limits by external heating, this being facilitated by the fact that the temperature rise in a bearing increases with the loading. The rise at full power may be 30° F., but it will not be more than 5° F. at reduced power. If the oil temperature is limited to 170° F., it would be permissible to arrange for an oil inlet temperature of 140° F. under normal conditions and, at reduced powers, this would be artificially raised to 165° F., in order to secure an improvement in efficiency of up to 8 per cent. This scheme may not have the same significance for merchant vessels as for naval ships, but it provides food for thought on a subject deserving consideration.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 36,329, 20th July, 1944, p. 2.*

Condenser Tube Cleaning.

It is claimed that the removal of sludge or slime from the tubes of condensers and oil coolers, etc., can be greatly facilitated by the use of the so-called Kez pressure gun and bullet system, in which "bullets" in the form of special brushes are projected through the tubes by water pressure or compressed air. The pressure gun and a bullet brush are shown in the accompanying illustrations. In use, the bullets are placed in a series of tubes, the pressure gun applied to each tube end and the trigger pressed. The pressure behind the bullet forces it through the tube, taking accumulated sludge with it. It is desirable to suspend or fix a sheet metal screen at the face end of the tubes to catch the bullets as they emerge. The latter can be used over and over again—only requiring washing. The ends of the bullet brushes are fitted with sealing washers, as shown. The pressure gun has a rubber-covered nozzle, so there is no back splash when using water. Where close access to the tube ends is difficult, an extension tube may be used. This method of cleaning the interior of tubes is, of course, unsuitable for hard scale deposits which obviously call for more drastic treatment. —*"Mechanical World", Vol. 116, No. 3,002, 14th July, 1944, p. 45.*



Kez pressure gun and bullet brush for cleaning condenser tubes.

World's Largest Welded Turbine Rotor.

An article by H. Dahlstrand, of the Allis-Chalmers Manufacturing Co., Milwaukee, Wis., in a recent issue of *Electrical World,* states that the largest all-welded turbine rotor to be constructed to date went into operation on a Middle-Western utility system last December. This rotor, which weighed nearly 45 tons, formed part of the L.P. unit of a 147,000-kW. turbo-generator set which runs at 1,800 r.p.m. and takes steam at a pressure of 1,250lb./in.^{2} and temperature of 925° F. The rotor is made up of six forged steel discs and two forged steel stub ends joined together by welds near the outer peripheries. Each disc is grooved to take blades. It is claimed that this method of fabricating large rotors for steam turbines possesses the following advantages over the conventional one of shrinking the annular discs on a solid shaft or bolting the parts together: *(1)* By making the rotor up from several small forgings it becomes easier to make certain that no dangerous flaws exist in the forgings; *(2)* smaller masses of steel respond more readily to heat treatment, for which reason a better and more uniform material of greater strength may be obtained from the same grade of steel; *(3)* the design may be modified to reduce the stresses, thereby permitting the use of a grade of steel that is more readily available and easier to produce and heat treat, since it has more desirable physical characteristics; *(4)* reduction in the weight to be carried by the bearings without loss of strength or reliability; and *(5)* the elimination, in the discs, of large bores that result in high tangential stresses. This form of welded construction is applicable to practically all turbine rotors, but in the case of small units or of certain special designs, it may be preferable to utilise conventional methods of construction. Small rotors made up of separate components welded together would be too expensive to produce, and there would be no advantage in seeking to get a better material as the relatively small size of the forging already utilised makes it easy enough to obtain the class of material required. As the welding of so large a rotor was unprecedented, special measures had to be taken both before and after welding. Sample welds of the same material as the forgings were made up and put through physical tests and X-ray examination. Sample rings with full-size welds were also made in order to study the behaviour of the weld and to determine the amount of peening required in the weld to prevent excessive distortion. All this was done before the rotor was welded. The material in the welds was, if anything, stronger than that in other parts of the forgings.—*"Mechanical World", Vol. 115, No. 2,999, 23rd June, 1944, p. 693.*

Dual Firing in New Tramps.

Whereas all fast cargo liners and tankers built in this country during the war have been equipped with Diesel engines or with turbines taking steam from oil-fired watertube boilers, slow-speed steamships of the tramp class have been given Scotch boilers arranged for dual firing. The widespread adoption of welding for double-bottom construction has facilitated the provision of the necessary fuel tanks, whilst the oil-burning installation, with its fuel pump, strainer, heater and atomising system, is not complicated. Nevertheless, the provision of dual-firing arrangements increases the building costs of a vessel by an amount considerably greater than that of the Government subsidy payable to the owners under the British Shipping (Assistance) Act of 1939. This Act was intended to encourage owners to build coal-burning and dual-fired ships, for which special differential grants were payable. For tramp ships this payment amounted to 1s. per gross ton, a matter of £1,250 in the case of a 5,000-ton ship, assuming that the grant was paid in each of the five years for which the scheme provided. At the present time it is difficult to say what the position in regard to coal and oil prices is likely to be immediately after the war. Even before the recent wages agreement in the coal-mining industry—under which wages are stabilised for four years and the price of coal will be subject to control—the rising cost of bunker coal was beginning to handicap the coal-burning tramp steamer. For example, just before the outbreak of the war, when the Court Line had taken delivery of two new ships, the m.s. "Hannington Court" and the s.s. "Dorington Court", the chairman of the company, Sir Philip Haldin, made it clear that he considered the motorship to be much the better proposition in the circumstances, in spite of the improvements in economy which had been made in the steam engine. At that time Diesel oil, at about 50s. per ton, had been reduced by about 4s. per ton to the 1937 price, while coal, at 20s. a ton, was about 3s. per ton dearer than in 1937. The "Hannington Court's" Doxford engine of 2,500 b.h.p. gave her a trial speed of 12¾ knots and had an estimated fuel consumption of 0·355lb./b.h.p.-hr. The "Dorington Court" had a triple-expansion engine of the reheater type, developing 1,650 i.h.p. and designed to give her a service speed of 10½ knots with an estimated coal consumption of 19 tons per 24 hours. Since the beginning of the war the price of coal has been increased by about 12s. per ton. The only hope of a reduction in coal costs and prices in the future lies in the possibility of an improvement in outputs, both total and per-man-shift, and there is, unfortunately, little sign of any such improvement so far. It is perhaps significant that two 2,600-ton colliers recently built in this country are motorships.—*"The Shipping World", Vol. CX, No. 2,659, 1st May, 1944, p. 561.*

British Development of the Marine Gas Turbine.

Reports of development work proceeding in Switzerland and in the U.S.A. appear to indicate that the gas turbine may be employed as the prime mover for some marine propulsion work in the future. It is known that investigation and research work on the gas turbine is also being carried out in this country, although the results are, very properly, being kept secret at the present time. Other countries, however, do not feel the same necessity and there is a real risk that we shall be in the same position after this war as we were in regard to the production of oil engines after the last war, when we found that the large oil engine had been developed abroad to an extent that it has not yet been possible to overtake in this country. It is therefore suggested that the leading British firms of marine engine builders should collaborate with the Government and the Admiralty and obtain from the latter particulars of the results of such research work as has been completed up to the present date. These firms would then work together to produce a standard type of gas turbine which could be manufactured by engineering firms disposing of the necessary technical resources, in order that this country should be able to compete with foreign manufacturers of this type of machinery. Such collaboration would also help to prevent cut-throat competition between the British firms who had done the preliminary work. Continuous progress is being made in metallurgical research and in the production of high-efficiency turbine blading, air-compression plant, etc., and it is probable that it may soon be possible to evolve a form of gas turbine which will be as economical as the standard steam turbine using steam from oil-fired watertube boilers at a comparatively low working pressure and moderate degree of superheat. It would be unwise to wait in the hope that some startling advance will be made in either of these two directions such as would effect a radical degree of economy.—*Sterry B. Freeman, "The Motor Ship", Vol. XXV, No. 291, April, 1944, p. 12.*

First Gas-turbine Merchant Ship.

An ocean-going vessel under construction for the U.S. Maritime Commission is being equipped with internal-combustion turbine machinery designed and manufactured by the Elliott Co. It is understood that the installation is of 2,000 b.h.p. and that the gas temperature will not exceed 1,200° F. The performance of this installation will, it is anticipated, be about the same as that obtainable with Diesel engines of similar capacity and, if this is achieved, it will certainly represent a considerable advance on anything which has so far been accomplished with gas turbines. No doubt, in the first instance, Diesel oil will be utilised, and endeavours will be made to obtain experience with the employment of boiler oil.—*"The Motor Ship", Vol. XXV, No. 293, June, 1944, p. 69.*

Chairman of Silver Line's Views on Future of Marine Engineers.

In an article entitled "A Shipping Plan for the Government", by S. M. Thompson, Chairman of the Silver Line, Ltd., the author refers to the present and future E.R. personnel of the Merchant Navy. He declares that the number of M.o.W.T. competency certificates gained by sea-going engineers during this war has been deplorably low and that, according to his own observations, very few ships' engineers seem to have ambitions in this direction, even though they may have sufficient sea time to their credit to submit themselves for examinations. The impossibility of obtaining the statutory number of certificated engineers for service in our merchant ships has led to the introduction of war-time "permits". This may get the ships round in war-time, but, as a long-term policy, it is simply inviting serious trouble. Many uncertificated engineers are now serving in somewhat senior capacities, and they will not take kindly to reversion to more junior positions when the time comes. A large number of these men will undoubtedly wish to return to shore employment as soon as they are free to do so, and there is therefore reason to anticipate a serious shortage of sea-going engineers, certificated and uncertificated, over a number of years and until such time as the results of training an entirely new category of engineers are forthcoming. No doubt many engineers now engaged in war-time shore industries will be released and made available for service in the Merchant Navy, but as most of them will be without any sea experience, it will be some time before the shipping industry is likely to derive any real benefit from their services. Meanwhile, it is interesting to note that certain of our Continental competitors have a system under which only certificated engineers rank as "engineer officers", the remaining engineers on board being all on the same level and graded as "motormen" or, say, "engine-room hands". Under our present system an uncertificated and very junior engineer may rise from the position of sixth, seventh or eighth to that of third engineer, with a considerable increase of pay, but without lifting a finger to possess himself of a B.o.T. certificate of competency. The Continental system commends itself to the author, and he would like to see something on similar lines adopted in the British mercantile marine. The recruitment of ships' engineers from fitters in engineering shops with no sea experience has certain advantages, and it is not suggested that this procedure should be abandoned, but it must be admitted that it does not, on the whole, attract very many of that type of young man who will in the end become a successful executive engineer. The author therefore considers that facilities should be offered to encourage entrants into marine engineering from secondary, grammar and public schools by way of vocational training in marine engineering as part of the school syllabus, and that such training should be made available to any boy, say, from the age of 12 upwards, who might wish to become a sea-going engineer. On leaving school the boy would undergo 12 months' intensive practical workshop training under keen and competent instructors at an establishment maintained by the shipping industry for that purpose. This training should be sufficient to enable the boy to go to sea as an engineering apprentice, in very much the same way as deck apprentices who, in many cases, have undergone some preliminary training at a nautical college. In fact, a similar system might be adopted, under which an apprenticeship of four years at sea in a ship's engine room would entitle a young engineer to present himself for examination for his certificate. Such an arrangement would provide a nucleus of men, not only fully trained in practical and theoretical marine engineering, but also with a background and training to fit them to become successful executives.—*"Fairplay", Vol. CLXIII, No. 3,191, 6th July, 1944, pp. 46 and 48.*

Sulzer Reversing System.

A reversing system for an engine having two camshafts is shown diagrammatically in Fig. 2. One of the camshafts is driven from the crankshaft and is angularly displaced by a servo-motor when reversal takes place. The other camshaft is coupled to the first through transmission mechanism, part of which is moved axially by a piston, thus effecting an additional angular displacement of the second shaft. The spaces at each side of the piston are connected to those of the the servo-motor. One camshaft (*1*) is for operating the fuel pumps (*2*) and the other (*14*) for the control valves (*16*) supplying the starting-air valves (*17*). The servo-motor (*7*) for reversing the camshaft (*1*) in incorporated in the gear-wheel (*5*), which comprises two concentric parts. The inner part is fixed on the shaft and includes a wing piston with pressure spaces (*22, 23*). The helical gear-wheel (*9*), which drives the camshaft (*14*), extends to form a plunger (*10*). The pressure spaces (*18, 19*) are connected to those of the wing piston through passages (*20, 21*). By turning the reversing valve (*24*) into the astern position, pressure is admitted into the spaces (*23, 19*) through a pipe (*25*). Accordingly, the inner part of the servo-motor (*7*) together with the camshaft (*1*) and gear-wheel (*9*), is displaced through a given angle (*33*). The other camshaft (*14*) is similarly rotated. At the same time the plunger (*10*) and gear-wheel (*9*) are moved along the camshaft (*1*) into the astern position, whereby the helical pinion (*11*) and the camshaft (*14*) receives an additional rotation. The result is that the camshaft (*14*) is rotated through a total angle (*34*) larger than the angle (*33*).—*"The Motor Ship", Vol. XXV, No. 294, July, 1944, p. 134.*

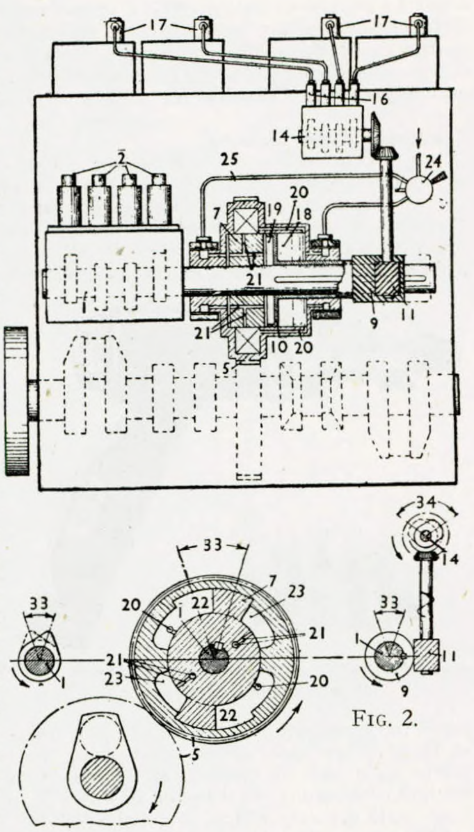


FIG. 2.

Engine Fuel Cut-off Device.

A simple form of apparatus for stopping the supply of fuel to a Diesel engine in the event of a failure of the lubricating-oil system has recently been patented by a Leeds engineer. The device, which is illustrated diagrammatically in Fig. 4, also limits the maximum fuel supply under ordinary running conditions, although able to give an excess fuel delivery when starting-up the engine. Referring to the diagrams, a vertical cylinder (*2*) is bolted to the fuel pump unit (*1*) and a pipe (*3*) is connected to the lubricating system. Inside the plunger (*4*) there is a combined torsion and tension spring (*5*). The cone (*7*) at the top of the plunger bears on a roller (*8*) and therefore moves the fuel-pump control rod (*9*). When the engine is to be started, the plunger (*4*) is turned through 180° to bring a slot (*20*) in the cone into alignment with the roller (*8*), thereby subjecting the spring (*5*) to a torsional stress. The fuel-pump control rod can then be moved by the normal governor spring into a position where excess fuel can be supplied. When the engine starts and the speed increases, the governor moves the control rod and the roller (*8*) moves to the left out of the slot (*20*). The lubricating-oil pressure, building up below the plunger (*4*), forces it against the tension of the spring (*5*) until the roller is entirely clear of the slot. The cylindrical part (*6*) then determines the maximum fuel delivery as long as the lubricating-oil pressure is maintained. The torsion of the spring (*5*) twists the plunger to move the slot out of alignment with the roller. For purposes of remote control a wire (*22*) is secured to the plunger (*4*) for twisting it when required, while the lever (*24*) forces the plunger down against the oil pressure,

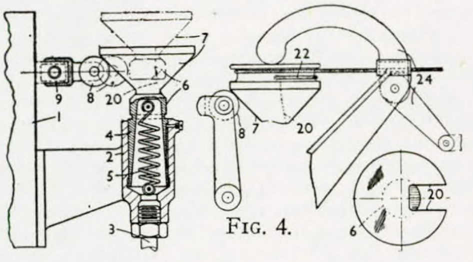


FIG. 4.

thereby stopping the engine.—*"The Oil Engine", Vol. XII, No. 135, July, 1944, p. 82.*

Geared Drive from an Oil Engine with a Compressor and an Exhaust-gas Turbine.

A British patent was recently secured by Sulzer Bros., Winterthur, in respect of an arrangement of power plant shown in Fig. 2. The oil engine has two crankshafts which are attached to gear-wheels (*5*, *6*) driving a central gear-wheel or pinion (*7*) on the transmission shaft (*8*). Air is supplied to the engine, which is of the opposed-piston type, by a reciprocating compressor (*15*) driven by one of the crankshafts (*1*), the discharge from the compressor being led to the cylinders through an air supply pipe (*18*). The exhaust-gas turbine (*13*) at the other end of the engine takes its supply through a pipe (*12*) and is geared to the left-hand crankshaft (*2*) through speed-reduction pinions (*19*). The power absorbed by the compressor (*15*) tends to reduce that transmitted through the right-hand crankshaft (*1*) to the central gear-wheel (*7*), whereas the power output from the exhaust turbine is added to the power transmitted through the left-hand crankshaft (*2*). The cranks of the shaft (*1*) are therefore set in advance of those of the other shaft (*2*), each crank of the latter being exactly on the dead centre when the opposite crank on the shaft (*1*) has already passed the corresponding dead centre by an angle *w*, which may be from 5° to 10°. In consequence of this lead, the power transmitted by the shaft (*1*) is greater than that obtained through the second shaft (*2*). The difference in output may, it is stated, be as much as 20 per cent.—*"The Oil Engine", Vol. XII, No. 135, July, 1944, p. 82.*

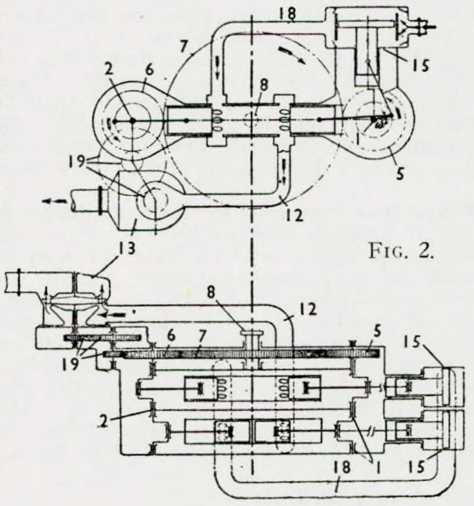


FIG. 2.

Utilisation of Exhaust Gases.

A development of the Diesel engine, which may be regarded as analogous to that of the reciprocating steam engine with exhaust turbine, is the highly supercharged engine in which the energy of the exhaust gases is utilised to drive a gas turbine. To obtain the greatest possible concentration of output in a given engine it is necessary to adopt supercharging, and, as the supercharging pressure increases, so does the work done by the compressor, and there is a consequent increase in fuel consumption, unless the energy of the exhaust gases is utilised. One method of doing this, which has been investigated by Sulzer Bros., consists of coupling the compressor direct to the main engine and using the exhaust-gas turbine to supply power through gearing to the main crankshaft. As the supercharging pressure increases, the total power of the engine falls off; when a supercharging pressure of about 70-80lb./in.^{2} is reached, the power delivered by the Diesel engine equals that absorbed by the compressor, and, therefore, the effective output of the plant will be that delivered at the exhaust turbine. Thus, the set comprising the Diesel engine and compressor can be likened to the boiler in a steam installation, or the combustion chamber in a gas turbine. When this stage is reached a crankshaft becomes unnecessary, the pistons of the Diesel part of the plant being connected directly to those of the compressor. The advantage of this arrangement over the constant-pressure gas turbine is that the thermal efficiency is much greater than that of the type of gas turbine which can be built at the present time, and, furthermore, the combustion and high compression and expansion pressures take place in the cylinder of the engine, which is the most suitable structure for this part of the cycle. Without going to the extreme case in which the high supercharging pressure mentioned above is adopted, it would seem that a supercharging pressure of 30lb./in.^{2} may be advantageous both as regards a reduction in the size and weight of the plant and its thermal efficiency. At the present time metallurgical and other difficulties in the way of constructing gas turbines render it impracticable to produce a simple form of constant-pressure turbine with a thermal efficiency of more than about half that of the combination of Diesel engine and gas turbine described.—*"Fairplay", Vol. CLXIII, No. 3,192, 13th July, 1944, p. 111.*

New Götaverken Diesel Engine.

An improved design of s.a. 2-stroke Diesel engine with under-piston scavenging and a frame of all-welded construction has been developed by the A/B Götaverken, of Gothenburg. The engine is of the crosshead type and has six cylinders of 520 mm. diameter and 900 mm. stroke, the power developed being about 460 i.h.p. per cylinder at 160 r.p.m. The adoption of all-welded construction for the frame results in a saving of about 25 per cent. in weight. In the case of the unit demonstrated, this amounts to some 25 tons. In spite of the reduction in weight due to the substitution of relatively slender welded components for the heavy cast-iron bearing frame, the strength of the new construction is greater than that of a C.I. frame engine. The crosshead design has been chosen, it is stated, because experience has shown that a considerable saving of lubricating oil is made in comparison with a trunk-piston engine. The cylinder liners and jackets of the new engine have been so designed that they can easily be lifted up and exchanged after removal of the cylinder head. It is claimed that a cylinder liner can be replaced in two or three hours instead of up to 30 hours. Another simplification is the elimination of the long stay-bolts running through the whole height of C.I. frame engines for absorbing the shocks when the engine is running. In the new engine, the walls of the welded frame are strong enough to withstand these stresses. The elimination of the scavenging pump by the use of under-piston scavenging—a feature introduced by the Götaverken some time ago—reduces the o.a. length of the engine by 3ft. 3in. Starting up, as well as reversing and turning on the fuel supply, are effected by a single lever, in front of which is a smaller handwheel connected with the reply telegraph. A locking device between the lever and this handwheel operates in such a way that when the reply telegraph is worked in response to a signal from the bridge, the manœuvring lever can only be moved to the position corresponding to that indicated on the E.R. telegraph. The demonstration model of the new engine is being installed in a motorship of 3,300 tons d.w.—*"The Shipping World", Vol. CX, No. 2,658, 25th May, 1944, pp. 539 and 541.*

The Life of Cylinder Liners.

There has been a steady improvement in the life of cylinder liners of Diesel engines during the past few years, mainly because of a reduction in wear. In fact, it is in many cases, no longer the wear which sets a limit to the time during which a liner is able to give satisfactory service. A typical instance of this kind is represented by the case of a twin-screw Doxford-engined ship built about 15 years ago. The first cylinder liner was renewed after eight years' service not because it showed any appreciable wear, but owing to the development of a crack. Had there been no other consideration than wear, it is thought that the liner would have lasted at least 15 years. The cause of this particular crack had nothing to do with the liner as such, but resulted from the stoppage of an auxiliary pump which supplied the cooling water for the fuel valves.—*"The Motor Ship", Vol. XXV, No. 293, June, 1944, p. 89.*

Wear in Heavy Oil Engines.

It is generally recognised that the frequent stopping and starting of Diesel engines causes far more wear than continuous running under heavy load, the reason being that after an engine has been stopped for any length of time the oil films between the shaft and its bearings are destroyed and the surfaces are brought into metallic contact with the result that on starting up again, direct abrasion occurs. This, if repeated often enough, leads to rapid wear at the working surfaces. Even when the forced-lubrication pumps are kept running between stopping and restarting, as when a ship is manœuvring in or out of harbour, it is unlikely that the protecting oil film in the bearings remains unbroken. Again, when the engine is stopped for even a very short time, the heads and walls of the cylinders as well as the piston crowns become cooled, with the result that on restarting, condensation of the moisture in the products of combustion takes places. This, in its turn, leads to corrosion, while if the fuel contains even traces of sulphur, the moisture becomes acid with a corresponding increase in its corrosive effects. It has also been suggested that the dilution of the lubricating oil in the cylinder with fuel is more rapid when the engine is cold than when it is thoroughly warmed up, so that if the engine is frequently stopped and started up, the cylinder walls and piston rings are liable to suffer because the lubricant is not of the required quality. Some evidence confirming the above observations was given in a paper recently read at a meeting of the Diesel Engine Users' Association by Mr. R. P. Kay, who presented a considerable amount of data relating to the operation in Fiji, under particularly onerous war conditions, of a number of Diesel engines. Among the latter was a

5-cylr. airless-injection unit developing 440 b.h.p. at 300 r.p.m. and coupled direct to a 2-cylr. d.a. air compressor. Owing to enemy action an additional air compressor which had been ordered to meet an increasing demand for air had been lost, and it therefore became necessary to run the original set for 24 hours a day for seven days per week. The engine, which was of the s.a. 4-stroke type, was shut down every 1,000 hours for valve changing and at the same time all bolts were inspected for tightness and an internal examination of the cooling pipes, bearing caps, etc., was made. The periods between piston examinations averaged 10,000 hours, while the atomisers were tested and set every 3,000 hours, although they gave very little trouble. The fuel pumps required no attention beyond periodical adjustments and timing. In the last year for which operating records are available, the engine was started only 36 times and ran on an average 233·3 hours per start, *i.e.*, about 20 days, the total running time being 8,399 hours, which was 96·1 per cent. of that possible. Moreover, the engine often ran as much as 1,000 hours—approximately 43 days—between starts, the load factor throughout being about 80 per cent. An examination of the cylinder liners after 37,734 hours of service showed, as might have been expected, that maximum wear had occurred near the top. Transversely, *i.e.*, in the plane of movement of the connecting rod, the wear amounted to 0·012in., while longitudinally it was 0·011in. This excellent performance is substantially less than the figure of 0·001in. per 1,000 hours which is sometimes given as a criterion. As regards bearing wear, the author mentioned the performance of three 7-cylr. engines, each developing 770 b.h.p. at 375 r.p.m. and driving an electrical generator of 525 kW. After about 15,000 hours of service these engines gave bearing trouble which was eventually attributed to crankshaft whip, the journals having worn slightly oval and thus given freedom to the crankshaft in one plane 0·016in. beyond the normal bearing clearance. This trouble was overcome by correcting the journals and refitting the bearings with finer clearances. The only other bearings to give trouble were the small single-row ball races on which the governor fly-weights oscillated, these breaking or wearing out fairly quickly. Larger double-row ball bearings of the self-aligning type proved more satisfactory but the author doubted whether ball races were really suitable for partial radial motion.—*"Shipbuilding and Shipping Record", Vol. LXIII, No. 23, 8th June, 1944, p. 532.*

Watertube Boiler Moved Without Dismantling.

It is estimated that four months and the dollar equivalent of £15,000 were saved by moving a Riley watertube boiler at a U.S. Navy Yard without dismantling and re-assembling it. The movement was necessary to make room for additional steam generators and involved shifting the boiler 78ft. 1in. and lifting it through a height of 10ft. 11in. Some details of the procedure adopted were given by Geo. F. Flay, Jnr., in *Power*. As originally installed, the boiler rested on a 30-in. concrete slab supported by wooden piles. It covered an area of 25ft. 6in. by 33ft. 8in. and rose 52ft. 8in. above the concrete. Ten structural columns, in two rows of five, parallel to the longer dimension, supported about 600 tons, including the four drums, waterwall and boiler tubes, superheater, headers, economisers, casing and steel skeleton, and most of the brickwork. The remaining weight rested on four steel beams supported by concrete and masonry walls and columns bearing directly on the concrete mat. This part of the weight included the mechanical stoker and grates, part of the brickwork and the lower headers. By transferring load from the concrete side walls and the pipe columns to steel beams welded to the boiler skeleton, it became possible to move the boiler as a unit. A rigid carrying frame of beams was assembled under the boiler, which was then moved on rollers along nine double lines of 100-lb. rails specially laid and grouted in place. Finally, the boiler was raised to its new level by slow simultaneous operation of a number of jacks. The lifting operation extended over three days and special care was necessary to secure uniform lifting and freedom from vibration.—*"The Power and Works Engineer", Vol. XXXIX, No. 456, June, 1944, p. 144.*

Pressure Losses in Oil Fuel Systems.

In order to obtain reliable design data where limitations of space and weight impose restrictions on the sizes of the various pipes, valves and bends to be fitted in the O.F. service between the fuel tanks and the boiler furnaces, an investigation into the pressure losses in such systems was carried out in 1939, at the instance of the U.S. Navy Department. Some details of this investigation are now given by Messrs. Cyrus Beck and H. M. Miller in a paper published in a recent issue of the *Journal of the American Society of Naval Engineers* under the title "Pressure Losses in Marine Fuel Oil Systems". The method adopted for the conduct of the investigation was to calculate the equivalent straight pipe length of all the valves, fittings and bends, and to add this length to the actual straight pipe length employed, thereby obtaining the equivalent straight pipe length of the system from which the pressure loss could be calculated by the use of the ordinary formulæ for the flow of fluids through straight pipes. As marine systems incorporate a relatively large number of fittings and bends in comparison with the length of straight pipe, the accurate determination of the value of the equivalent length of the fittings is of the utmost importance. The authors found that apart from the effect of the form of the valve, the radius of the bend, and so on, upon the equivalent length, the numerical value of the equivalent length of any given fitting varies widely according to its position relatively to other fittings and to the length of straight pipe in which it is situated. The complex nature of the whole subject is reflected by the fact that this constitutes only the first of four reports to be presented on the general question of pressure losses in marine fuel oil systems.—*"Shipbuilding and Shipping Record", Vol. LXIII, No. 25, 22nd June, 1944, p. 578.*

Boilers from Destroyers for Synthetic Rubber Factory.

An article in *Power Plant Engineering* describes how ten marine watertube boilers removed from old destroyers of the U.S. Navy were utilised to supply saturated steam at a pressure of 200lb./in.^{2} in a new synthetic rubber factory belonging to the Goodyear Tyre and Rubber Co. The furnace volume of these old boilers was increased and air-cooled furnace walls with natural circulation were provided. Each boiler now generates 50,000lb. of steam per hour from treated water, whereas the original peak capacity used to be 100,000lb./hr., using distilled make-up. The high-pressure steam requirements of the factory are met by new boilers installed for the purpose.—*"The Steam Engineer", Vol. 13, No. 153, June, 1944, p. 286.*

British Invasion Craft.

Some details have now been released for publication of a few of the numerous types of landing craft built in this country for the invasion of Europe. These vessels have been constructed in large numbers by firms with no previous experience of this kind of work, and prefabrication was resorted to on a very wide scale. The main types covered in the appended notes by no means exhaust the list, and there are frequently several varieties of craft in each class, but although far from complete, these notes give some indication of the range of this programme and of the design and performance of a few of the many strange vessels which made possible the landings on the beaches of Normandy.

LBV (landing barge, vehicle).—Converted Thames lighters with steel hull and cut-in ramps, to carry vehicles and stores. Length 75-85ft., beam 18-22ft., Chrysler Royal engine, range 250 miles at 5 knots in good weather. Will carry two 3-ton lorries, two 13-cwt. lorries and one 15-cwt. truck; or two 3-ton lorries and three 15-cwt. trucks.

LBE (landing barge, emergency repair).—Similar to LBV, but equipped with workshop lorry, two vice benches, electric welding set and acetylene cutting gear.

LBO (landing barge, oiler) and LBW (landing barge, water).—Length 80-90ft., capacity 40 tons.

LBK (landing barge, kitchen).—Slightly larger than LBV. Carry own stores and cook for about 800 men. Normal kitchen equipment, including refrigerator and sinks.

LCP (landing craft, personnel).—Mark I and Mark II are the smallest of several different types and sizes of LCP. Built of wood (mostly larch). Mark I (20ft. long, 6ft. beam, weight 1 ton) is towed by Mark II (25ft. 6in. long, 6ft. 3in. beam, weight 2 tons), which has a 65-h.p. Ford V-8 engine. Speed 10 knots, or 5½ knots towing one craft, or 4·8 knots towing two. Each carries 18 men. Range 30 miles.

LCV (landing craft, vehicle).—Length 36ft., beam 10ft., draught 3ft. aft. Single screw driven by 225-h.p. Gray Diesel or 250-h.p. Hudson "Invader" engine. Speed 11 knots and range 80 miles.

Among numerous craft in between the LCP and LCV are LCM (landing craft, medium) and LCS (landing craft, support).

LCP(L) (landing craft, personnel, large).—Length 36ft. 8in., beam 10ft. 10in., loaded draught, forward, 1ft. 6in., aft 3ft. 6in. Light weight 6½ tons. To carry 25 men. Horse-power varies between 140 and 250 h.p. and speed between 9 and 14 knots. Range 120 miles. Armament, one stripped Lewis gun.

LCA (landing craft, assault).—Length 41ft., beam 10ft., loaded draught, forward, 1ft. 6in., aft 2ft. 6in. Weight 9 tons. Carries 35 men. Twin screws driven by 65-h.p. Thornycroft, Parsons, or Scripps V-8 engines. Range 50-80 miles. Bren gun position. Manned by one officer for every three craft and four ratings for each craft. Some are built of wood and are partially armoured against S.A. fire.

LCI(L) (landing craft, infantry, large).—Length 158ft. 4in., beam 23ft. 8in.; draught forward, 5ft. 7in. ocean, 3ft. 1in. beaching;

draught aft, 5ft. 11in., ocean, 5ft. beaching. Weight 216 tons. Carries 200 men below decks and 46-50 on upper deck. Steel hull with two ramps (42in. wide) forward. Sides and bulwarks of B.P. steel. Manned by two officers and 21 ratings. Armament, four 20-mm. Oelikon guns. A newer American-built type can accommodate 186 men in bunks.

LCT (landing craft, tank).—There are five different designs, varying in size. Mark III, length 159ft. 11in., beam 34ft., mean loaded draught forward, 3ft. 6in., aft 7ft. (with two Churchill tanks on board). Light weight 349 tons. Two 500-h.p. Paxman engines driving twin screws give a speed of 10½ knots, loaded. Range 2,700 miles. Armament, two 2-pdrs. or two Oerlikons. Carry five Churchill tanks or 11 Valentine tanks or 300 tons of stores. Larger type 192ft. by 31ft. will carry six Churchill or nine Valentine tanks or 10 lorries or 350 tons of stores.

—"The Shipping World", Vol. CX, No. 2,663, 28th June, 1944, p. 656.

Standardised Oiltight Hatch Covers, E.R. Skylights and F.W. Tanks.

Among the many standard designs of miscellaneous items of deck equipment now being manufactured by British steel construction works for delivery to shipyards, are oiltight hatchways and covers, E.R. skylights and ships' fresh-water tanks. The standard circular oiltight hatch coamings are of ⅜-in. steel plate, 4ft. in inside diameter and 10in. in height above the deck. The cylindrical shell of the coaming is either in one piece with a single vertical weld, or in two semi-circular parts with vertical welds at diametrically opposite positions. The edges of the coamings are slightly chamfered or rolled. The octagonal cover with doublings in way of the securing clips, is made from a single plate 4ft. 4½in. square and 0·040in. thick. The fastening-down arrangements comprise eight hinged clips, each of which consist of a ⅞-in. eyebolt anchored to the coaming between 0·40-in. lugs (also cut from the scrap of the cover), with a wing nut 2in. in width by ⅝in. thick. To secure oiltightness, a packing ring is welded to the lower side of the cover. This ring consists of inner and outer elements, concentric with the coaming and made from flat bars, 1¼in. deep by ½in. thick, grooves being roughly cut in the interior faces to ensure that the packing is held securely in position. The standard engine-room skylights have inside dimensions of 16ft. by 11ft. and are made of ¼-in. plate, welded to 4-in.×¼-in. flat bars, with six hinged flaps, one of which has an escape scuttle cut in it to provide an emergency exit from the engine room. For this purpose, a wire escape ladder is rigged from the E.R. platform or other cenvenient position. A cylindrical coaming, 3ft. in diameter and 2ft. 6in. in height, surmounts the skylight at the centre for the purpose of taking a ventilator which telescopes over the coaming for a distance of 2ft. The cowl rests on rollers mounted on the coaming to facilitate trimming. One section of the skylight is made portable, to facilitate the passage of parts of the machinery. The skylight is attached to the deck by ⅝-in. bolts, spaced 12in. apart, through a foundation angle-bar permanently attached to the hull. The standard fabricated fresh-water tank for ships has a capacity of 3,000 gallons, the internal dimensions being 9ft. 6in. by 7ft. 9in. by 6ft. 6in. The tank is welded throughout of 0·030-in. plate, and its design is such as to allow it to be lowered down a convenient cargo hatchway and moved into position in the appropriate part of the 'tween decks. All the corner joints are continuously welded, while the internal stiffening members are tack welded.*—"The Shipbuilder", Vol. 51, No. 421, May, 1944, pp. 214-215*

The Design and Construction of Diesel-engined Tankers.

The author states that this paper makes no attempt to deal with the intricate calculations and/or controversial points regarding the merits or demerits of the different forms of hull construction and types of Diesel machinery, but he points out that it is necessary to have some idea of the variety of liquids carried by tankers, since there are several inherent characteristics which must be studied in order to provide for their safe carriage. The cargoes include petroleum and its many products, creosote, whale oil, turpentine, vegetable oils, molasses, and in fact any liquid which is suitable for carriage in bulk. The specific gravity of these liquids may be anything from ·65 for the lightest fractions of petroleum, to 1·45 for molasses. The volume of such liquids varies greatly with changes in temperature, more especially in the case of petroleum products. Furthermore, the latter are unstable. The first requirement, therefore, is a design which provides for change of volume and will permit of loading without leaving large masses of liquid to surge and cause damage. As other than liquid cargoes cannot be carried commercially, there must normally be many ballast passages, for which reason the construction must allow for safe ballasting. Other problems include such matters as prevention of leakage and contamination during the operations of loading, carriage and discharge, which entail the study of piping systems, valves, gas lines and cofferdam separation. The dangerous nature of some of the liquids calls for special attention to fire prevention and fire-fighting equipment. Crude oil, owing to its gassy nature and low flash point and which, when mixed with air, will explode at any normal temperature upon contact with a spark, must always be treated as a dangerous cargo. On the other hand, creosote and viscous oils must be warmed to facilitate easy pumping when discharging. With these general points in mind, the author has divided the paper into sections dealing with: (*1*) a general description of oil tankers; (*2*) design of the ship; (*3*) construction of the ship; (*4*) speed and power; and (*5*) the machinery installation. The prototype of the modern ocean-going bulk-oil carrier was the "Glückauf", a 300-ft. vessel carrying about 3,000 tons built on the Tyne in 1886. Prior to that time oil used to be carried in drums or barrels in the holds of ordinary cargo ships. During the First World War much of the bulk oil transport was made by means of large cylindrical tanks let into the structure of ordinary cargo ships. This was not a really safe practice, at any rate for the carriage of benzine, as leakage was liable to occur from the tanks to the holds and cause an accumulation of dangerous gases. The really important development of tankers for bulk oil carrying has taken place since the last great war, and until recent years the centre-line longitudinal bulkhead tanker with summer tanks was the standard type.*—Paper by H. S. Humphreys, "Transactions of the Institute of Marine Engineers", Vol. LVI, No. 3, April, 1944, pp. 21-39.*

Cutting Plates for Welded Ship Construction.

A high degree of accuracy in the cutting of shell plates for ships of all-welded construction is necessary in order to avoid the excessive amount of welding required to join the edges of ill-fitting plates. An article by C. P. Hubert, in the March, 1944 issue of *Civil Engineering*, describes an automatic plate edger, guided by prepared cams, which is being employed in the shipyards of the California Shipbuilding Corporation. This device is claimed to eliminate distortion of the plates due to uneven cooling by flame cutting both sight edges simultaneously. The system consists essentially of three box-type gantry trolleys, two of which traverse and are each provided with a complete flame-cutting assembly that operates on guide rails and cuts transversely. The main or longitudinal trolley has two flame-cutting assemblies which can be adjusted to any desired width for cutting longitudinal parallel edges. The plates are conveyed to the correct cutting position by chain-driven rollers, manipulators for lining up and squaring a plate before cutting being also provided. The guide cams mounted on the trolley enable the operator of the flame cutter to duplicate each plate accurately without the use of templates. In order to make cams for any particular shell plate, certain fundamental measurements must be taken accurately in order that the cams should duplicate exactly the lines on the floor of the moulding loft. A separate pair of cams is made for each shell plate, one for the upper curve and one for the lower. By using reduction gear and a set of chains, the length of the cams is reduced in the ratio of 11 to 1. This reduction is connected to a flat wheel on the side of the longitudinal trolley. Two cam followers are used to actuate the edge-preparation assemblies. These are in constant contact with the cam and when the trolley moves forward the cams make one turn for the full travel of 30ft. of the machine. Because of this great reduction, the resulting curves plotted on the cams are so condensed that the smallest irregularity of fairing of the lines on the loft floor is readily detected, the result is that the shell plates are cut accurately at twice the production rate that can be achieved with hand-cutting equipment.*—"Mechanical World", Vol. 115, No. 2,992, 5th May, 1944, p. 501.*

A Projected "Super-liner".

The opinions recently expressed by Admiral E. S. Land, chairman of the U.S. Maritime Commission, that the development of overseas air lines after the war will rule out the construction of any new express passenger liners of the "Queen Elizabeth" type is not accepted by many authorities on this subject. Sir Patrick Dollan, ex-Lord Provost of Glasgow and a well-known Scottish Labour leader, has declared that he is certain that two giant liners of this class, costing ten million pounds, will be laid down after the war as part of a 10-year's prosperity plan for British shipbuilding. Mr. Vladimir Yourkevitch, designer of the former French liner "Normandie", who has made a special study of the operating records of the biggest pre-war liners, expresses the view that it will be possible to build and operate 36-knot, 100,000-ton vessels with accommodation for about 5,000 passengers. He has pointed out that there are only 29 liners of very large size afloat at the present time, and that further casualties must be expected. At least 66 such vessels will be needed to cope with the expected increase in passenger traffic in the immediate post-war era, whilst the military authorities will simultaneously require a very large amount of troopship tonnage to bring home soldiers. This will necessarily delay the work of reconverting ships to ordinary civilian use for at least two years after the war, during which time new modern luxury liners should be made available for service. "Unless suitable provision is made for replacements", he says, "conditions will be in a turmoil at the end of the war". Mr. Yourkevitch considers that what is needed is a ship nearly 20 per cent. larger than the "Normandie", costing 30 per cent. more to build and 25 to 30 per cent. more to operate, but producing twice as much revenue through (*1*) a very large complement of passengers paying low rates, (*2*) high speeds and quick turnrounds, and (*3*) maximum use of personnel. He declares that the problem of building a ship to carry a large number of passengers at low fares and able to operate at a good profit can be solved by two very important factors—the use of a minimum resistance hull from which the resulting savings in the cost of construction would make the initial per-passenger cost much lower than usual because of the smaller power plant required, and the additional profit-earning space available as compared with vessels of conventional form. The principal dimensions of the proposed ship are an o.a. length of 1,213ft.; length b.p., 1,122ft.; beam, moulded, 138ft.; depth to main deck, 84ft.; depth to upper deck, 130ft.; maximum draught, 34ft.; displacement at this draught, 85,000 tons; and block coefficient, 0·55. Since a ship of this size and speed would also be useful as a naval auxiliary vessel in case of war or emergency, she would be built with that purpose in view, and the drawings show how the upper deck could be adapted for use as a flight deck. Hangar space would be available for about 100 aircraft, apart from which the ship could, of course, also be used as a troop transport. All the auxiliary and deck machinery, including that for handling the lifeboats, would be electric, with current provided by four 6,000-kW. turbo-generators. Airtight hold closures would serve to guard against fire, which when localised and deprived of air would extinguish itself, even if it broke out above the holds or the W.T. compartments below the lower deck. With an airtight and watertight lower deck and with all openings automatically closing if opened for the passage of men and materials, a pressure of air would be maintained higher than the pressure of the water outside, in order to prevent the latter from entering the hull in the event of damage to the shell plating. The ship would, therefore, be virtually unsinkable. No general cargo would be carried because of the need for quick turnrounds, but provision would be made for the carriage of a large number of motor-cars and private aircraft.—*"The Shipping World", Vol. CX, No. 2,655, 3rd May, 1944, p. 469.*

Proposed Design for Diesel-electric Cargo Ship.

The accompanying drawings (Fig. 1) show the proposed outline and E.R. lay-out of a Diesel-electric cargo vessel of 4,500 gross tons, having a length b.p. of 370ft., a moulded breadth of 52ft. and a

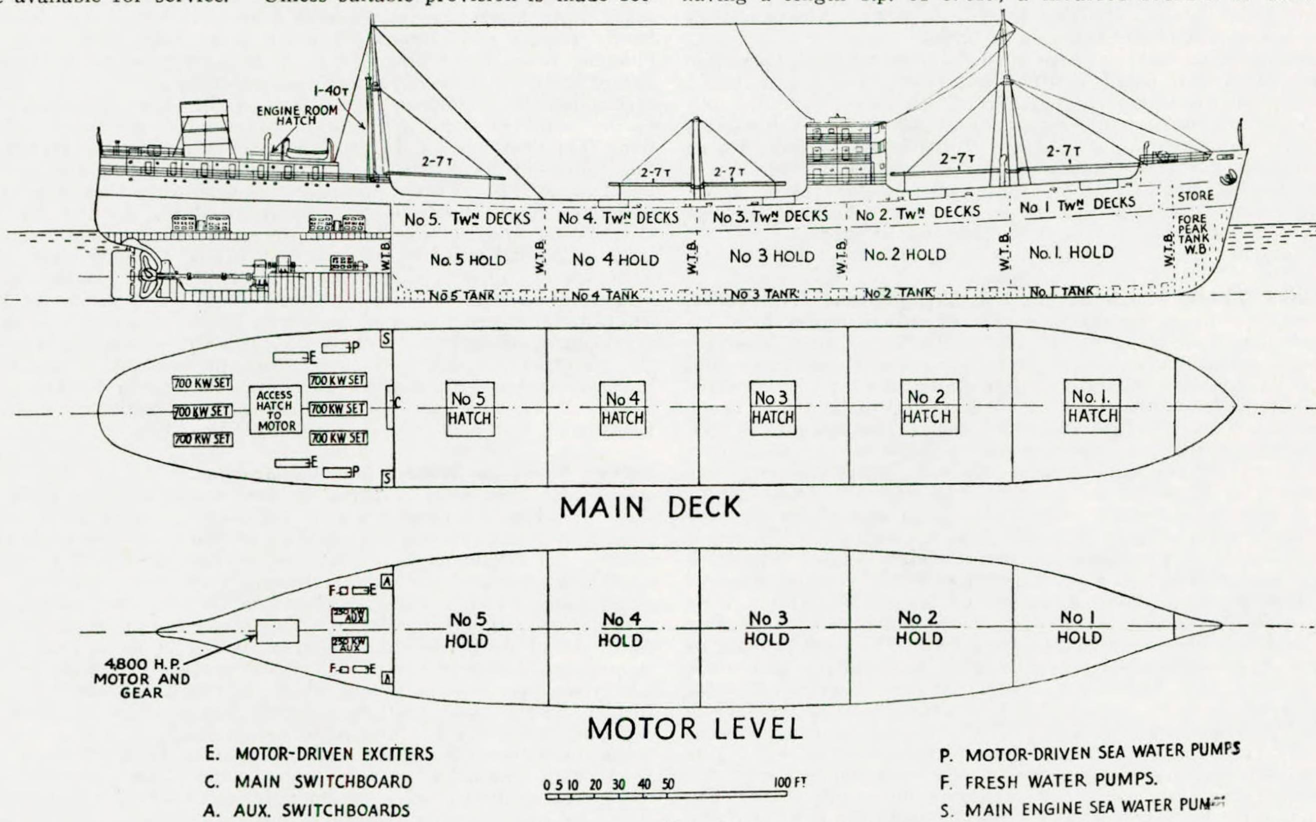


Fig. 1.

depth of 25ft. The main engine room is on two levels, the propulsion motor and reduction gear being located on the lower level, together with two 250-kW. auxiliary generator sets with their switch gear, and various pumps, whilst the six main Diesel-generator sets and certain other auxiliaries, including motor-driven exciter sets, switchboards and control gear, are arranged on the upper level. The

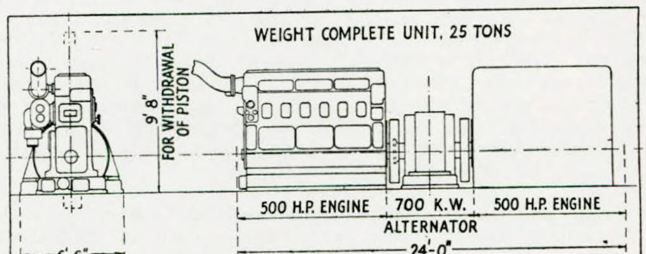


FIG. 2. TWIN-ENGINE GENERATOR UNIT

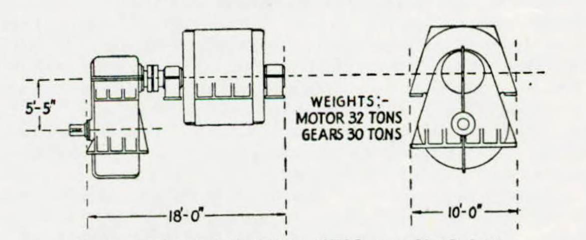
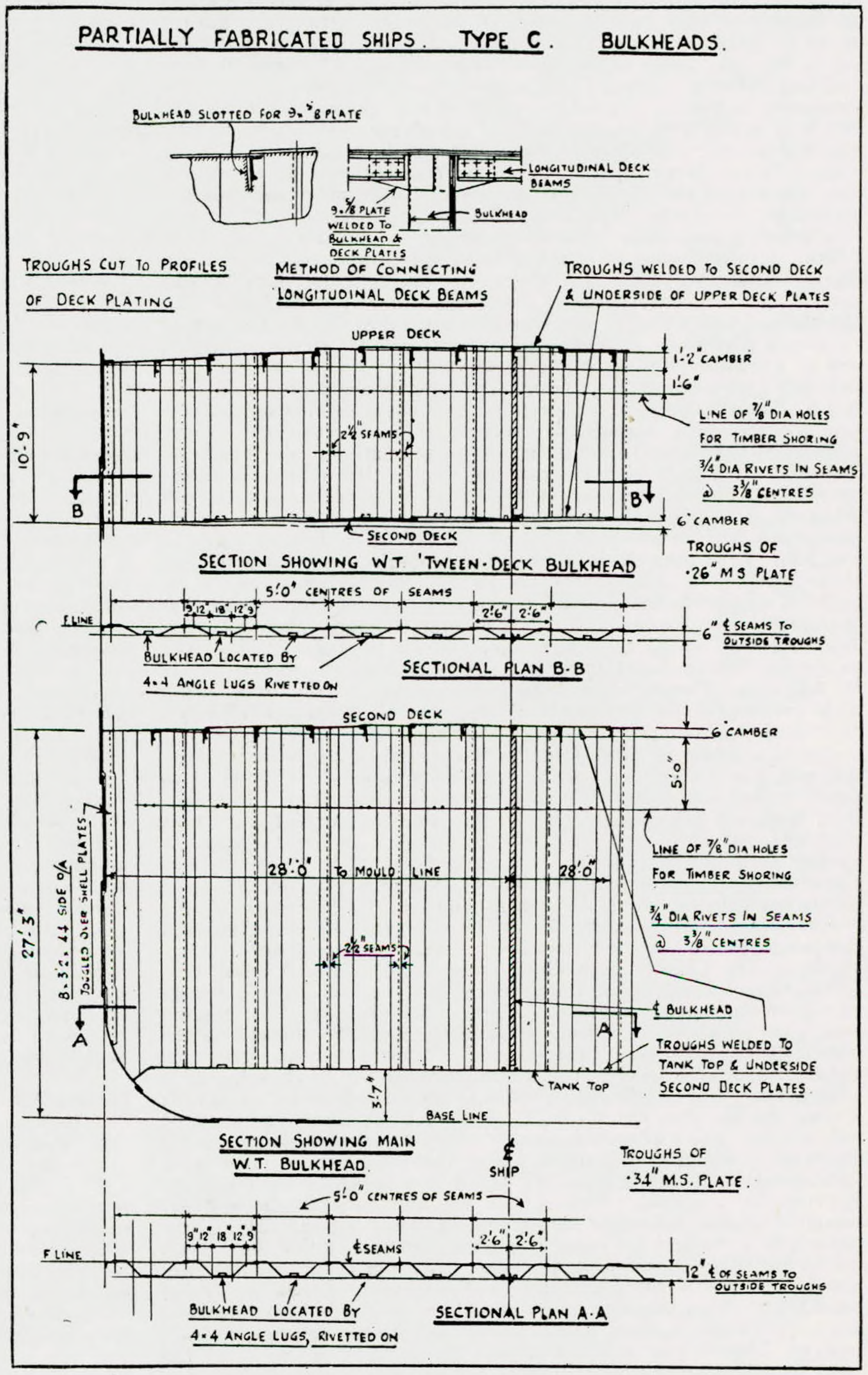


FIG. 3. 4,800.H.P., 600 R.P.M. MOTOR AND GEAR BOX

main generator sets each consist of two 6-cylr. Diesel engines, each developing 500 b.h.p. at a continuous speed of 600 r.p.m., built up as a tandem unit with a flywheel-type alternator between them, as shown in Fig. 2. The arrangement of the 4,800-s.h.p. synchronous propulsion motor and reduction gearing is shown in Fig. 3. The normal running speed of this motor is 600 r.p.m., whilst that of the propeller shaft is 150 r.p.m. A large access hatch is provided for both E.R. levels to facilitate the removal and replacement of any item of machinery. The hatch cover incorporates a large skylight, and a 40-ton derrick at the mainmast is available for handling any large units of the machinery and equipment, if required. It is suggested that the propelling machinery of this vessel should be arranged to operate on a.c., although a d.c. scheme could be employed, if desired. In the latter case, differentially-connected generators with constant-current characteristics would probably give the best results, while with an a.c. system using synchronous motors, contactors would be utilised to select the direction of rotation and the engine units in the power plant would be run at from 25 to 100 per cent. full-load speeds, thus giving speed control over a convenient range. The engines would be designed to develop constant torque over this range. Rapid synchronisation of the alternators and propulsion motor would be obtained by forcing the fields from the separate motor-driven exciter sets, the advantages of such an arrangement being that robust and well-impregnated windings could be used for the alternators and propulsion motor, that rapid reversal of the propeller would be possible, and that racing in a seaway, with all its attendant troubles, would be entirely eliminated. The control gear would be simple in design and of robust construction, and, if required, it could be operated from the bridge, an emergency set of controls being provided in the engine room. An important advantage of a ship of this basic design is the slight effect on the service speed of the vessel caused by a failure of one of the six generating sets; it would, in fact, involve a speed reduction of only about 6 per cent., so that if the service speed of the vessel with all six generating sets was 15 knots, it would only be reduced to 14 knots by the failure of one set. Another advantage would be that the Diesel engines would not have to be reversed for going astern, and since they would always be operating at a constant in one direction, their full-load torque would be available for rapid manœuvring. With the arrangement proposed, reversal of the propeller shaft is positive and very rapid. No brake is required on the shaft, as the braking effect is provided through the magnetic field in the motor. The first cost of a vessel of this kind would be very slightly higher than that of a similar ship with direct-engine drive, but the advantages offered by the electric drive as regards availability of the vessel for profit-earning work, would easily justify the relatively small additional first cost involved.—*A. Wall, B.Sc., "The Shipping World", Vol. CX, No. 2,662, 21st June, 1944, pp. 634-635.*

Corrugated Bulkheads.

During the past six months corrugated bulkheads have been incorporated in all ships of the so-called fabricated type built in this country, and the accompanying drawings show the design of such a bulkhead together with its method of attachment in the case of the "C" type ships. Contrary to usual practice, these vessels have longitudinal deck beams, and it is stated that the utilisation of corrugated bulkheads in conjunction with such an arrangement results in a reduction of just over 30 per cent. in the bulkhead weight. Another advantage in the case of fabricated ships is the saving of work at the shipyards in fitting stiffeners, lugs and brackets. In view of the size of press required to produce the troughed plates, it was decided to concentrate production at one firm, and it is understood that the results of this decision have proved highly satisfactory. It may be noted that the seams of the troughed plates are riveted, the distance from the centres of the seams being 5ft., with one trough between. The troughs, which are perpendicular, are welded to the tank top, second deck and underside of the upper deck plates, and, at the sides, the bulkhead is joggled over the shell plates. The thickness of the troughs throughout is 0·26in., which corresponds to the minimum plate thickness at the top of the normal W.T. bulkhead for ocean-going ships. It is proposed to combine the new type of bulkhead with the special joist recently developed for welded bulkhead construction having a narrow palm for welding by deep penetration from the upper surface only. Corrugated bulkheads have been used extensively in the U.S. in recent years, more especially for tankers, in which, however, the corrugations run horizontally; where longitudinal and transverse bulkheads intersect and at the boundaries, the attachment is made according to the Isherwood system, which involves the use of an I-beam. A very large number of tankers has been constructed in America on this system during the war. Corrugated bulkheads have also been used in Swedish-built tankers, and in the case of one such vessel, the "R. Stenerseh", of 16,800 tons d.w. built by the Götaverken in 1941, it was claimed that the d.w. capacity had been increased by 300 tons by the adoption of corrugated bulkheads.—*"The Shipping World", Vol. CXI, No. 2,665, 12th July, 1944, p. 33.*



Effect of Structural Failures on Commercial Value of Liberty Ships.

Although the number of Liberty ships actually lost as the result of structural failure is only eight—or one out of every 250 ships in service—it is reported that the total number of major hull fractures has been far higher, and that 3·21 per cent. of the vessels in service have suffered from "major cracking accidents". However, in addition to these defective ships—one out of every 33 being affected in this manner—a number of others, one out of every 15 vessels, it is said, have developed "secondary fractures", *i.e.*, cracks in the deck or hull plating which might become dangerous if allowed to spread. These failures, whether major or minor, are all the more disquieting because they cannot be attributed to any particular yards but are stated to be spread over the whole American shipbuilding industry. Certain modifications have now been made to the structural design of these ships which should overcome the trouble, but it is scarcely surprising that the proportion of failures to date has had an adverse effect on the commercial value of the Liberty ships. It has been stated in the New York *Journal of Commerce* that reports to the effect that the Soviet Government had declined to accept 28 Liberty ships under "Lease-Lend" because of inherent structural defects have been flatly denied by officials of the U.S. Maritime Commission, although it is admitted that the Russians are having substantial structural alterations made in the ships of this type which they have received from the U.S. It is explained that the changes asked for by the Russians are called for by the special operating conditions of their service, with special emphasis on ice, one of the alterations being the replacement of bronze by steel propellers. Furthermore, the Commission officials are reported to have denied that the structural alterations now being carried out to certain Liberty ships intended for service as troop transports or for transfer to the Soviet Government, have any relation to the structural failures which have already occurred. While that may well be the case, if the modifications to the design made some time ago are not effective in reducing the casualty rate, then it may be that radical alterations will be necessary. A recent article on Liberty ships in the New York *Journal of Commerce* contained the statement that their design is "a take-off" on the British North-East tramp, a 50-year-old ship in design, even though new in construction, and for that reason 25 years more obsolete by present standards than the Hog Islanders were when they were launched in 1919 and 1920". The prototype British vessel from which was evolved the design of the 60 American "Ocean" class ships built for the British Government, and, eventually, the "Liberty" vessels, was the "Empire Liberty", built by J. L. Thompson & Sons, Ltd., Sunderland, and this ship was a typical example of an up-to-date cargo vessel of a type that, before the war, had shown itself to be economical, and was considered to combine that advantage with that of ease in production. It is true that, fundamentally, the vessel is of the same type as that which was produced 50 years ago, inasmuch as there is no great scope for variations in the hull design of a cargo ship. The machinery, reciprocating engines with Scotch boilers, is also in principle the same as that which was fitted to a ship built at the beginning of the century. In detail, however, there is a very great difference between the two ships, and the new vessel is immeasureably superior in every respect. The Liberty ships differ from those of the "Ocean" type in that they have oil-fired watertube boilers, but here, also, reciprocating engines were employed because facilities for their production were available at a time when there was a bottleneck in the manufacture of turbines and gearing. Apart from the structural defects which have developed in a small number of Liberty ships, these vessels are quite as efficient as most of the British cargo ships built during the last few years. If, as seems certain, the composition of the world's fleets after the war is thrown out of balance by the immense production of Liberty ships, this need not be taken as a condemnation of their design, but rather as a natural sequence of the demand for a vessel which carries the maximum deadweight per annum for the minimum man-hours of construction. There will always be a demand for cargo tramps, and it may be that for certain trades the N.-E. Coast type of vessel, far from being obsolete, will prove to be the most economical for the service. A bad feature of the Liberty ships, when they are considered in the light of post-war trade, is the high ratio of gross tonnage, and also net tonnage, to deadweight. This is due to the fact that the draught (about 27ft.) has been increased beyond that suitable for an open shelter-decker, and, to permit of this increase, it has been necessary to close the tonnage openings. The scantlings have also been increased to take account of the heavier load carried. A more economical ratio of deadweight to tonnage, could be obtained by cutting tonnage openings and reducing the full-load draught by about 18in. The effect on the deadweight would be a reduction from about 10,700 to 9,800 tons. It is reported that certain Greek shipowners who propose to employ American-built Liberty ships as tramps after the war, are actually contemplating substantial alterations of this nature, as well as an increase on the present maximum speed of 11½ knots.—*"Fairplay", Vol. CLXII, No. 3,187, 8th June, 1944, pp. 822 and 824.*

Two Years' War Service Completed by First Liberty Ship.

The Liberty ship "Patrick Henry", the first vessel of her type to be completed under the Maritime Commission's emergency programme, was delivered by her builders, the Bethlehem Fairfield yard at Baltimore, on 30th December, 1941, for operation by Lykes Bros. Steamship Co., Inc., of New Orleans, on behalf of the War Shipping Administration. Since that time she has carried some 76,000 tons of supplies to Allied war fronts and has made voyages to Capetown, Suez, Murmansk and Archangel, in the course of which she was subjected to a succession of bomb and torpedo attacks. Her speed and fuel consumption have, in the words of the War Shipping Administration, proved to be "even better than anticipated", and her machinery has not yet required a general overhaul, although a few minor adjustments of the kind customary with every new ship had to be carried out. One of the "Patrick Henry's" earliest voyages involved the carriage of 11,028 tons of cargo (reduced to 10,898 tons after a call) for 7,633 sea miles at an average speed of 11·6 knots and with an average fuel consumption of 0·0221b. of oil per useful load-ton-mile. This performance compares very favourably with the records set up by two of the emergency Hog Island ships completed in 1920, one of which carried 7,980 tons of cargo for 3,030 sea miles at 9·9 knots and burned 0·0331b. of oil per useful ton-mile, whilst the other steamed 3,201 sea miles at 10·6 knots carrying 7,335 tons of cargo and consuming 0·034lb. of fuel per ton-mile.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 36, 240, 6th April, 1944, p. 11.*

Fabricated Hawse Pipes.

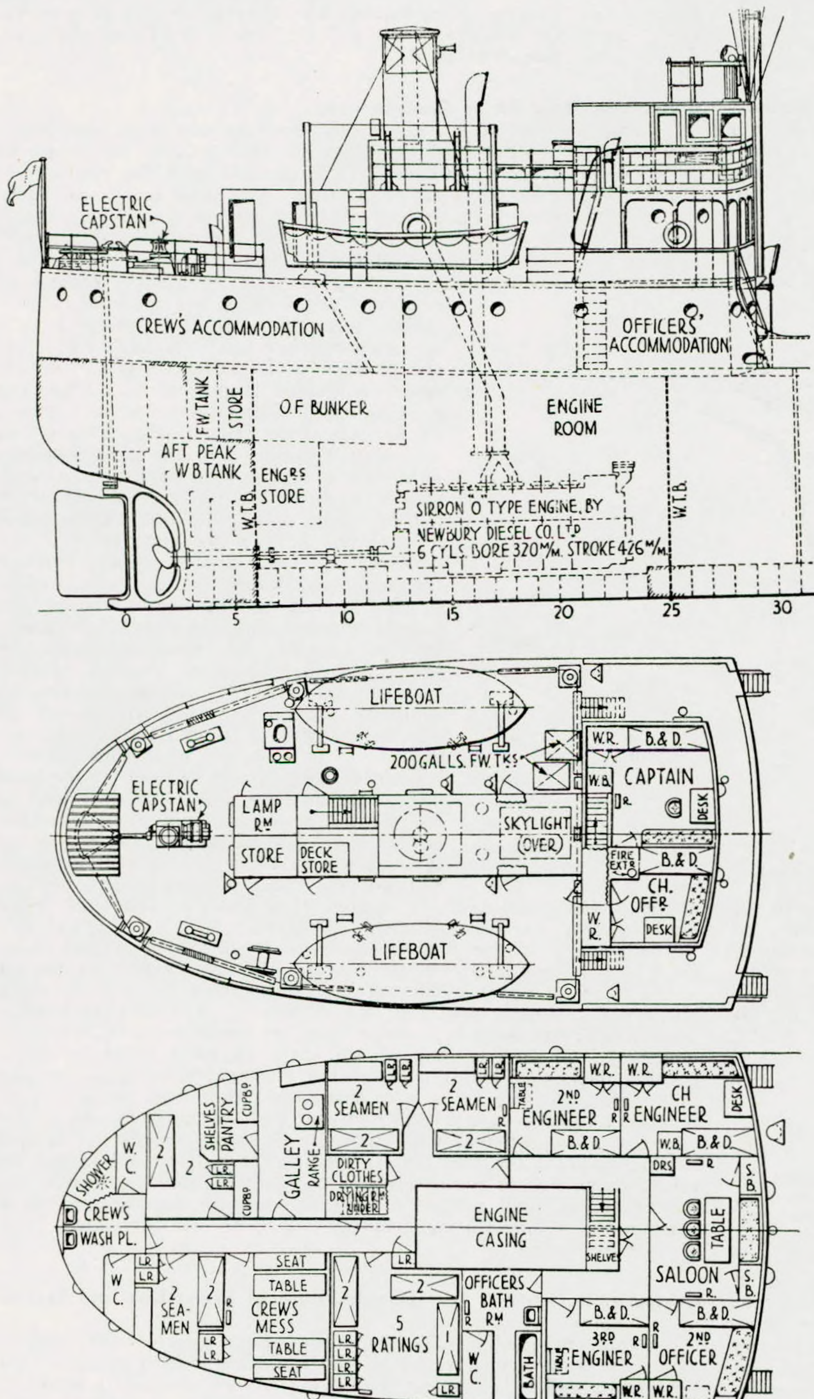
In the course of the discussion which followed the reading of a paper on welded construction at a recent meeting of the N.-E. Coast Institution of Engineers and Shipbuilders, one of the speakers drew attention to the advantages of fabricated hawse pipes, particularly as a means of eliminating much delay. He suggested that the fabricated hawse pipe design might entail reinforced portable parts where most wear takes place to facilitate their renewal. Numerous instances have occurred where moderately light fore-end contact involving minor structural damage has resulted in severe damage to one or both hawse pipes, frequently making immediate renewal necessary. This means a comparatively costly repair job and one which is liable to prove lengthy, whereas with fabricated hawse pipes it is possible to make good the damage very quickly and at a small cost by cropping and welding. When the damage sustained by the vessel calls for the renewal of both hawse pipes and no pattern is available, it becomes necessary to wait until the damaged shell and deck have been replaced before a pattern can be made, and further time is lost while the castings are being made, whereas fabricated hawse pipes could be produced concurrently with the other repairs. The speaker went on to remark that repairs to cast-iron or cast-steel hawse pipes by electric welding are not wholly successful. He also put in a plea for greater attention to the welding of deck fittings, such as hatch cleats, brackets, lashing eyebolts, cargo gear, rails, stanchions, etc. While not affecting the structural safety of the ship, they are often of primary importance to the seaworthiness of the vessel. There have been cases where a sharp tap with a hammer has sufficed to dislodge such fittings.—*"The Shipping World", Vol. CX, No. 2,657, 17th May, 1944, p. 517.*

Engines Aft.

Most ships of any size, with the exception of oil tankers, have their machinery arranged amidships, the long shaft drive to the screw and the disadvantage of having to provide a tunnel for the shaft being tolerated for the sake of convenience of lay-out, and, perhaps even more important, trim. For most types of present-day propelling machinery, the engine compartment shows an excess of buoyancy over weight, and would tend to upset the load trim if removed very far from mid-length. Coupled with this is the question of change of trim due to consumption of fuel, which, in the case of coal-burning steamships, must be stowed near the boilers. Load trim is fairly easy to regulate in service when the cargo is a dense one, not completely filling the hold spaces, though the still-water longitudinal bending moment and the effect of too great a local concentration of weight must be considered, but as most ships have to be able to carry a capacity cargo, the trim argument is a fairly strong one. Experiments carried out with the object of placing the propelling machinery at the quarter-length position aft, have not proved altogether satisfactory. With the improved types of machinery now being developed with reduced weight and smaller space requirements, to say nothing of the reduced fuel consumption, the prospects of a general trend towards placing the engine in its logical place near the propeller seem greatly enhanced, more especially if changes in the tonnage rules should make it possible to take full advantage of reduced machinery space requirements, without penalty.—*"Shipbuilding and Shipping Record", Vol. LXIII, No. 21, 25th May, 1944, p. 483.*

Improved Accommodation in Coasters.

Although the accommodation for the officers and men on board the smaller types of coasting vessels cannot be arranged on the same scale as that on board the standard cargo liners and other ocean-going ships of recent construction, the accompanying elevation and plans of the living quarters of one of the new motor coasters owned by F. T. Everard & Sons, Ltd., show that very considerable improvements have recently been made in the amenities provided on board such vessels. A special feature of the particular ship illustrated is the fact that the whole of the accommodation is arranged aft, and that there is internal access to all the living spaces as well as to the galley without the need for going on deck. Hot and cold running water is provided in the officers' cabins and in the crew's wash place, and the heating arrangements include electric radiators in addition to a steam heating system.—*"Shipbuilding and Shipping Record", Vol. LXIII, No. 21, 25th May, 1944, p. 489.*



Accommodation of Everard coaster.

Performance of American C-2 Class Motor Cargo Liner.

Some details of the performance of one of the Maritime Commission's C-2 type Diesel-engined cargo ships were recently published in *The Log*, of San Francisco. The 6,200-ton vessel in question is of 8,760 tons d.w. capacity and is equipped with two 9-cylr. s.a. two-stroke Nordberg engines, each rated at 3,150 b.h.p. at 225 r.p.m. with a designed b.m.e.p. of 67lb./in.^{2}. The two engines drive a single propeller shaft through hydraulic couplings and reduction gearing at 80 to 85 r.p.m. and are designed to give the ship a service speed of 15½ knots at their normal output. The vessel was completed for service in February, 1940, after undergoing highly satisfactory acceptance trials, during which she did 19·1 knots in light condition with her engines developing 30 per cent. more than their rated power output. Since sailing on her maiden voyage in July, 1940, the ship has covered nearly 200,000 sea miles, latterly as a troop transport. Since 7th December, 1941, no consideration whatever has been given to running the engines under the most efficient conditions possible, and the vessel has been under enemy fire 29 times. When the ship and machinery were new the average daily fuel consumption was 175 barrels (about 24 tons) when averaging 14·8 knots, but this has since decreased to 170 bbl. (21·3 tons) at 15·25 knots. The engines have usually had to be run on a grade of fuel differing from that for which they were designed. On one occasion, when subjected to a succession of air attacks, the vessel ran for about 10 hours at 18½-19 knots in a fully-loaded condition, with the propeller turning at 97 r.p.m. Although no records could be taken at the time, it was estimated that the power output of the main engines on that occasion exceeded 8,000 s.h.p. As a result of this strain, some cylinder heads developed cracks and others began to show signs of cracking, although they remained perfectly safe to use until new ones could have been received under normal conditions; in view of war conditions, however, it was thought best to replace them with new ones before putting to sea again. During the first 2½ years of the ship's service, she covered a total distance of 133,736 sea miles at an average speed of 14·9 knots; the average engine speed was 197·7 r.p.m., whilst that of the propeller was 80·58 r.p.m.; the average propeller slip was 9·5 per cent. and the average coupling slip, 2·62 per cent.; the total running time of the main engines was 10,040 hours; the average daily fuel consumption (main engines) was 143·5 bbl. or about 19·66 tons, the mean draught of the ship being 21ft. 7in.; the cylinder wear per 10,000 miles was 0·0032in.; and the lubricating-oil consumption for the main engines and hydraulic couplings, but exclusive of that for the auxiliary machinery, 34·9 gall. (U.S.) or 29 gall. per day. The ship has not had much engine trouble, and her performance must be regarded as very creditable in view of war-time conditions.—*"The Shipping World", Vol. CX, No. 2,659, 31st May, 1944, pp. 561 and 564.*

Welding Diesel-engine Jacket.

Some interesting details of a welded repair to a cylinder jacket of a large Diesel engine were described by R. C. Wilson in a communication submitted to the Jas. F. Lincoln Arc Welding Foundation in connection with its programme of awards for reports on applications of arc welding. This particular report was reprinted in a recent issue of *Power*. The jacket, which was 42in. in diameter, 78in. high and 4in. thick, had cracked due to overheating of the metal caused by retardation of the water circulation owing to the formation of scale. The crack started at the top and extended straight down for 27in. After withdrawing the cylinder liner and chipping away the scale, the crack was veed to a depth of 3½in. and a surface width of 3in. The sides of the vee were then drilled and tapped to take 3-in. studs at 2-in. centres, the ends of the studs projecting 1in. above the surface of the vee. A layer of soft weld metal was applied first, the casting then being allowed to cool before the main weld was begun. Each welded bead was peened on completion to relieve stress, and the job was finished off by the application of an outside surface weld directly over the crack. The total amount of welding involved was 44 man-hours, costing about £13 for labour and £9 for material. The total cost of the repair, including dismantling and re-assembly, worked out at about £72, compared with £820 for a new jacket, which could not have been obtained without serious delay.—*"The Power and Works Engineer", Vol. XXXIX, No. 456, June, 1944, p. 144.*

Replacement of Castings by Welded Fabrications.

A typical instance of the replacement of an iron casting by a welded steel fabrication is illustrated in Fig. 3, which shows an expansion box for the exhaust-trunk system of the Diesel engine of an oil tanker. Three of these welded steel expansion boxes were fitted as replacements for the cast-iron boxes which had, on several occasions, developed sectional flange cracks while the ship was at sea. A noteworthy feature of the design is the flexibility of the rolled flanges in comparison with the rigid ones of the original castings. A total saving of 20 per cent. was made by the fitting of the welded replacements, which have now been in continuous use for five years without further incident. Fig. 4 shows the construction of a welded steel air vessel of a feed pump in the salinometer condensing system of a steamship. Poor delivery of new castings and lack of a stock pattern made it necessary to utilise welding in this instance. It will be observed that flanging and developing have been used as far as possible in this welded design in order to save labour by reducing the number and length of the welded connections.—*J. K. Johannesen, "Welding", Vol. XII, No. 7, June, 1944, pp. 273-276.*

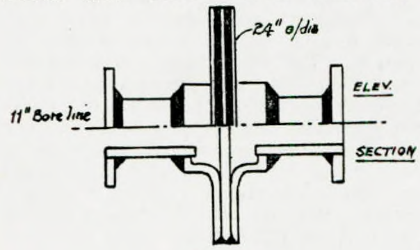


FIG. 3.

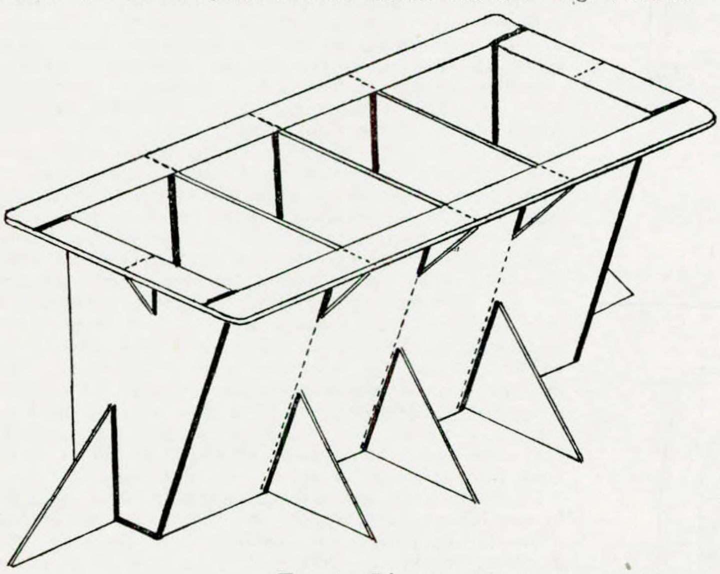


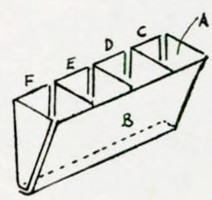
FIG. 4.—*Diagram scheme of assembly.*

How Far Will Oil Replace Coal?

People who urge the use of coal instead of oil at sea and fear that after the war the only export available for this country will be coal, appear to ignore the teachings of this century. Coal is, in fact a wasting asset, rich in precious things, which we sold abroad at, say, 25s. a ton, the pit-head price being 40s. For what purpose? The British output of coal in 1913 was 290 million tons, of which 21 million tons went for bunkers and 73 million tons was sold abroad. In 1938 only 228 million tons were mined, only about 10½ million tons were used on board ship, and only 36 million tons were exported. No amount of skill will make our export more welcome to the peoples of Europe, who have hitherto taken nearly the whole of it. Those countries have found cheaper supplies of water power to create electric energy to serve most of their needs. Coal and coke are in economic demand abroad only for heating and smelting. As regards the relative merits of coal and oil as fuel for ships, more especially for those making long voyages, it must be remembered that a ton of coal takes up 50 per cent. more space, and even for the best grades has a calorific value of 25 per cent. lower than oil fuel. Coal cannot replace oil for Diesel engines, nor can it be pumped to its work either from the shore or on board ship. The writer was entrusted by the Southern Railway Co. with the preparation of the design for the Dover-Dunkirk train ferries, and succeeded in convincing the Co.'s representatives that water-tube boilers fired with coal by mechanical stokers and supplying steam to turbines, would give the best results. In practice, these ships were able to make use in the boilers of over 80 per cent. of the heat of the coal. In this service the Kent collieries mined the coal and loaded it in trucks which were run on to the ship's deck and dumped the fuel direct through hatches into the bunkers which fed the hoppers of the mechanical stokers. The coal was never touched by hand. Every feature of this home service was in favour of coal, whereas the ruling factors for ocean-going ships favour oil every time.—*Sir Westcott Abell, K.B.E., "The Daily Telegraph", No. 27,775, 22nd June, 1944, p. 4.*

Conversion from Oil to Coal Burning.

There are reasons to believe that after the war many steamships will be arranged for burning either oil fuel or coal, according to whichever is more economical. It is possible with the appropriate Wallsend-Howden equipment to change from solid fuel to oil burning or vice versa in under half an hour without losing ship speed. Admittedly this convenience cannot be met with the ideal arrangement of oil burning, but nevertheless a high efficiency is obtainable with this installation when burning oil, and any small sacrifice of efficiency which may be involved is probably more than counterbalanced by the savings which are likely to result when this change-over is expedient. Where really rapid conversion from coal to oil burning is required, firebrick slabs are laid across the firebars at the front of the furnace, but towards the back end of the latter asbestos millboard is laid on top of the bars, with broken firebrick on top. It is important that no air leakage should take place through the bars in the back part of the furnace, as this would reduce furnace efficiency and cause smoky combustion. If time permits, better results can be obtained by removing the bridges, bearers, bars and portable sills from the furnace in order that the maximum possible heating surface and furnace volume should be available for oil burning, irrespective of whether natural or forced draught is employed. If possible and when time permits, a firebrick ring should be fitted at the back end of the furnace and a firebrick wall at the front end. This arrangement gives the best results. Special boiler-room equipment for lighting up when no steam is available for working the O.F. pumps and heaters, has also been developed. It consists of a small paraffin-fired boiler working at a pressure of about 100lb./in.^{2}, with an internal coil through which oil fuel can be circulated by means of a small hand pump. This makes it possible to raise the temperature of the oil to the figure at which it can safely be discharged through the main burners for raising steam in the boilers. A somewhat similar apparatus comprises a brick-lined chamber containing a coil through which the oil fuel is pumped while the chamber is heated by a paraffin burner. This is a somewhat cheaper device than the one first described and it is not absolutely foolproof because it is necessary to take care not to overheat and carbonise the oil in the circulating coil, whereas with the more elaborate apparatus this risk is eliminated by the fact that the temperature of the oil cannot be raised above that of the corresponding saturated steam pressure. In both cases, a small motor-driven pump may be used instead of a hand pump.—*"The Marine Engineer", Vol. 67, No. 802, May, 1944, pp. 185-192.*



Comparisons Between Fuel Consumptions of Motorships and Steamships.

The average daily fuel consumption of the main (Diesel) engines of an American cargo vessel of the C-2 class, which covered over 133,000 sea miles during her first two years of service, is stated to have been 143·5 barrels. This is almost exactly the same as the daily consumption of the average Liberty steamship, but, whereas the 6,000-s.h.p. engines of the motorship give her an average service speed of 14·3 knots, the steamship's engines develop only 2,500 i.h.p. and give her a sea speed of barely 11 knots. It should be noted, however, that Liberty ships use Bunker-C fuel at $1·15 per barrel (in the San Francisco Bay area) while the motorship burns Diesel oil at $1·50 per barrel. Comparative fuel consumptions are nearly always calculated on a basis of lb./s.h.p., using the 2,240-lb. ton, and in this connection, the much greater specific weight of the boiler oil is a matter which cannot be disregarded. It takes 7·4 barrels of Diesel oil to make one ton, but only 6·45 tons of Bunker-C oil, and this means that Diesel oil costs $11·10 per ton, whereas the price of a ton of boiler oil is only $7·42. The cost of Diesel oil, in $ per ton, is therefore almost exactly 50 per cent. greater than that of Bunker-C fuel, a fact which should be borne in mind when computing the relative fuel costs of motorships and steamships of equal d.w. capacity.—*"The Log", Vol. 39, No. 3, March, 1944, pp. 59-63 and 104.*

Automatic Control of Cold-room Temperatures.

The construction of a device for the thermostatic control of a refrigerated compartment cooled by the circulation of brine, is shown in the accompanying sectional diagrams (Figs. 3 and 4). Known as the Sarco temperature controller, the apparatus consists of a thermostat containing a temperature-sensitive liquid which is connected by a capillary tube to a valve-operated element, which, in turn, actuates the valve controlling the brine flow by internal pressure. The device, which is available in sizes ranging from ½in. to 6in. in diameter, gives an increased flow of brine in the event of a rise in the temperature of the cold room, and conversely, reduces the flow if the temperature in it drops. The actual operation of the device is as follows: The "bulb" shown at the right in Fig. 4 contains a quantity of temperature-sensitive mineral oil, and is immersed in the brine flow. Within the stem of this "bulb" is a corrugated flexible tube forming a gland without packing, and a similar element is fitted in the valve-operating unit shown on the left, the two being connected by a length of flexible capillary tubing. The system is filled with oil, and if, *e.g.*, the fluid in the "bulb" should expand due to a rise of temperature, the oil in what may be termed the capillary system, will be displaced towards the valve-operating unit, thereby causing the piston or plunger in the lower end of the latter to move upwards. The stem of this piston passes through the valve-regulating unit to the double pressure-balanced regulating valve, which it opens to permit an increased flow of brine. The movement of the rod and valves is spring controlled; and, when the bulb temperature falls, the spring (which can be seen at the top of the unit) returns the valves as the liquid contracts, so reducing the brine flow. The movements of the valves take place gradually and the extent of their opening and closing is closely related to the requirements. Independent variations in the setting of the instrument can be made by the key shown at the top of the bulb element. The flexible tube between the thermostat and the regulating valve may be up to 50ft. in length, so that the former may be fitted in the most suitable position in the refrigerated compartment. Sarco temperature controllers are being employed for a wide variety of purposes ashore and afloat, among recent applications being the regulation of the temperature of brine-cooled drinking water, as well as the control of air-conditioning plant.—*"The Shipbuilder", Vol. 51, No. 423, July, 1944, pp. 279-280.*

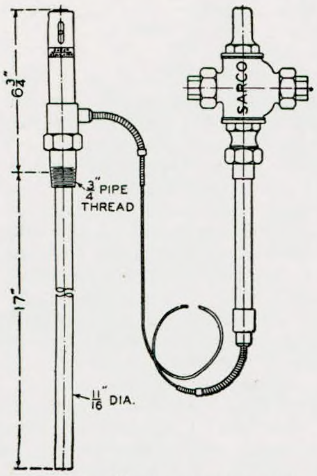


FIG. 3.—*Sarco temperature regulator for brine control.*

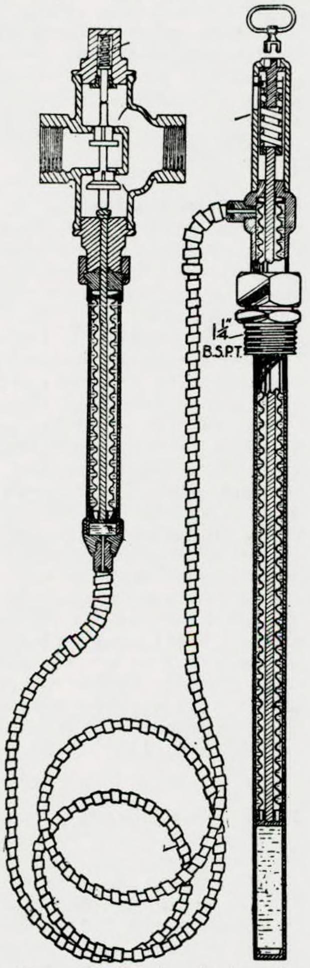


FIG. 4.—*Sectional drawing showing arrangement of Sarco temperature-regulating device.*

Duties of Ships' Greasers.

The question of whether a greaser should also act as a cleaner in a ship's engine room was recently raised in what was described as a test prosecution at Liverpool Police Court, when two greasers belonging to a hospital ship were fined after being found guilty of continuedly and wilfully neglecting their duty. The men, who were represented by counsel, contended that it was not possible for them to carry out cleaning and polishing work in the engine room while the ship was at sea because it was not part of their duty. They had signed on as greasers whose duty it was to oil and attend the engines, and they could not perform this work if they were required to spend their time cleaning and polishing. The defendants' counsel stated that in certain motorships men were signed on as greaser-cleaners and cleaners for the express purpose of carrying out the work which the defendants had declined to perform, and one of the men, giving evidence, stated that he had been a greaser for eight years and had never done any cleaning. The prosecuting counsel pointed out that the hospital ship in which the defendants were serving was a steamship and not a motorship. The senior second engineer of the vessel and the assistant superintendent engineers of two well-known shipping lines gave expert evidence to the effect that cleaning and polishing work in the E.R. department had always been regarded as part of the regular duties of men signed on as greasers, whereupon the Court decided to convict the defendants, as stated.—*"The Journal of Commerce and Shipping Telegraph", No. 36,317, 6th July, 1944, p. 3.*

Fine Cargo Salvage Job.

A very fine cargo salvage job was carried out some time ago at a lonely part of the Namaqualand coast by the staffs of two South African firms, one of which is an engineering concern and the other a local canning factory. The cargo vessel concerned was driven ashore in bad weather on an open rocky coast in a very exposed position at Schulp Point, 45 miles south of Port Nolloth. The crew had to abandon ship in the boats and were located by coastal patrol aircraft which directed them to one of the few safe landing places on this dangerous coast. The ship broke her back soon after stranding and suffered severe damage from the heavy seas breaking over her. It was some weeks before the weather had moderated sufficiently to permit some of the staff of the canning factory, 40 miles distant by sea, to board the wreck from small fishing craft, and it took three more weeks to rig a steel cable ropeway from the vessel to the shore opposite, where a power-driven winch was installed. Rapid progress was then made with the removal of cargo from the after holds, despite frequent stoppages due to the weather. Some three weeks later a second double haulage cable was rigged to the fore part of the wreck, but soon afterwards the vessel began to settle by the stern in heavy weather until she was almost submerged. Some of the E.R. tanks broke loose and smashed through all the shore cables. Considerable difficulty was experienced in securing these tanks to the rocks to prevent them from doing further damage. The after part of the ship was by then completely under water, only the funnel, superstructure and bridge amidships, and the fore part remaining above water. Eleven weeks after the commencement of the cargo salvage operations, the work was stopped by a violent gale which sprang up suddenly one night and broke up the remnants of the shattered hull. The ship's funnel came ashore as flat as if it had been put through plate rolls, the stern and after deck were high and dry on the rocks, crumpled up like newspaper, the midship part of the hull had broken clean away from the fore part, lifted clear of the engines and boilers, and closed in to the shore after swinging completely round. The fore part was intact, but listing 45° and swaying about 3ft. when struck by the waves. The shell plating on the shore side adjoining the forward bulkhead was breaking away from the frames and opening up below the 'tween deck. Thousands of rolls or dress materials, suitings, silks and hosiery were strewn for three or four miles along the rocks. Late that afternoon the 'midship section drove further inshore and settled hard against the stern portion already on the rocks. Cargo was removed from the wreckage after burning away some of the plating. Rocket-firing apparatus was used to shoot a pilot line over the fore part to fishing craft standing by, a heavier cable was then hauled across and the ship was boarded again. The decks were found to be breaking up and the hatch covers had been carried away. Owing to extreme danger to life very little cargo could be salved from the ship at this stage, but cargo coming ashore was collected. Three weeks later the fore part drove inshore and the rest of the cargo was removed when the weather permitted. Except at the start of the salvage operations when fishing craft were used, the salved cargo was transported by lorry from the beach opposite the wreck across 26 miles of sand dunes, as there were no roads. The lorries could only carry half-loads and took three hours to do the trip in bottom gear. The nearest fresh water was 40 miles away. No fresh meat was available, but the salvage men shot plenty of buck. The recovered cargo was taken from the canning factory to Cape Town in a motor coaster carrying about 100 tons at a time, which could not berth at the factory jetty owing to the shallow water and had to be loaded by means of small craft while lying off in the roadstead. Often days passed before the weather allowed this coaster to put to sea. In the end, about 75 per cent. of the entire cargo was salved and delivered to Cape Town. No lives were lost and there were no serious accidents.—*"The Engineer and Foundryman", Vol. VIII, No. XII, March, 1944, pp. 853-854.*

Twin-screw Refrigerated Cargo Liner with Four-stroke Pressure-charged Diesel Engines.

The Houlder Line, Ltd., recently took delivery of a new twin-screw motor-ship of 10,365 gross tons, specially equipped for the carriage of refrigerated cargoes. The vessel is generally similar to the Houlder liner "Beacon Grange", built just before the war, but her design embodies a number of improvements introduced as the result of experience gained with the pre-war ship. Both vessels were built and engined by Hawthorn, Leslie & Co., Ltd., Newcastle-on-Tyne, and are equipped with Werkspoor four-stroke pressure-charged propelling machinery. The new ship, like her predecessor, has accommodation for 12 passengers in single-berth staterooms on the boat deck. The living quarters of the ship's officers are arranged around the E.R. casing on the bridge deck and includes accommodation for eight engineers and four refrigerating engineers, as well as for ten assistant engineers. There are five main cargo holds, six orlop 'tween decks, seven main 'tween decks, seven shelter 'tween decks, five bridge 'tween decks and two boat trunks. The machinery compartment is between Nos. 4 and 5 cargo holds. The double bottom extends for the whole length of the ship and is arranged for the carriage of water ballast and fresh water, and, from the forward E.R. bulkhead right aft, alternatively for fuel oil and water ballast. The forepeak contains water ballast and the after peak fresh water or water ballast. Between the fore peak and No. 2 hold there are also five large deep tanks for fuel oil. The total quantities of fuel oil, fresh water and water ballast that can be carried simultaneously are 1,500 tons, 385 tons and 3,290 tons respectively. The total capacity of the insulated cargo spaces amounts to 556,370 cu. ft. and the d.w. capacity of the ship at maximum draught is 11,544 tons. The cargo-handling equipment comprises sixteen 6-ton derricks, six 10-ton and one 25-ton derricks, served by 24 steam winches. The Werkspoor main engines are 8-cylr. units with a cylinder diameter of 650 mm. and piston stroke of 1,400 mm. They are of the type which has been adopted for the propulsion of many of the Anglo-Saxon Co.'s tankers. In the tankers, however, the auxiliary pumps are usually driven by gearing from the engine crankshaft, whereas in the new Houlder liner they are independently driven by electric motors. For pressure-charging, the under sides of the main-engine pistons are used as air pumps. At the back of each engine is a horizontal air manifold, with inlets at each end and in the centre. Above are boxes, one for each cylinder, containing the suction and discharge valves, which are of the Hoerbiger disc type. The air entering the space below the piston through the suction valve is compressed between the bottom of the piston and the diaphragm at the top of the crank chamber and delivered through the air-delivery valves to the engine. The normal air pressure is about 3lb./in.^{2} and the b.m.e.p. at normal output is slightly over 100lb./in.^{2}, the mechanical efficiency being about 82 per cent. The application of this form of super-charging increases the output by about 30 per cent. above that of a normally aspirated engine of the same capacity. There are two fuel pumps per cylinder, *viz.*, a main pump and a pilot pump. A lever at the manœuvring platform controls the beginning and end of injection of the pilot pumps, and no regulation of the main pumps is required. One pair of cams is used for the ahead and astern operation of each fuel valve, as the fuel is injected at top dead centre under a pressure of about 8,000lb./in.^{2}. The pilot pumps are arranged in two groups of four, and the manœuvring shaft, located above the cylinder heads, carries valve levers pivoted eccentrically, and not mounted exactly at right angles to the axis of the shaft. The levers move sideways on to the astern cam when the manœuvring shaft is turned 180° by the reversing servo-motor. Another feature of the Werkspoor engine is the method of lowering and, if necessary, removing the pistons for replacing the piston rings. The lower part of each cylinder liner is detachable, and below it is an aluminimum distance piece divided vertically. The distance piece is removed, the detachable section of the liner is lowered and removed, and the piston can then be drawn out. Three vertical oil-fired Cochran boilers are mounted on a platform at the after end of the engine room at the level of the cylinders. The two wing boilers are fired by the exhaust gases of the engines when the ship is at sea, but oil firing and exhaust-gas heating cannot be employed simultaneously. Electric current at 220 volts is provided by four 300-kW. generators driven by 6-cylr. Ruston oil engines. The three CO_2 refrigerating compressors are of the horizontal type, each driven by a 185-h.p. electric motor. They are located in a single compartment on the main deck on the port side of the engine casing. The refrigerating condensers are served by two vertical motor-driven circulating-water pumps in the main engine room, each with a capacity of 1,000 g.p.m. The four main brine pumps, each of 500 g.p.m. capacity and of the vertical motor-driven type, are located in a main-deck compartment on the starboard side of the engine casing. There are also three smaller brine pumps in the brine-control rooms, in addition to one for the ship's provision rooms. For circulating fresh-water cooling in port, there is a special 100-ton/hr. pump. Although a large part of the E.R. auxiliary machinery is motor driven, the steam-driven auxiliaries include a 250-ton ballast pump, a 150-ton bilge pump, a 100-ton general-service pump and 100-ton sanitary pump.—*"The Motor Ship", Vol. XXV, No. 292, May, 1944, pp. 56-64.*

Flame Cutting Machines.

The usual type of flame cutting machine which has become almost an essential part of the equipment of a modern shipyard, is generally used for cutting the straight edges of plates either at right angles to the surface or on the slope where a bevelled edge is required for welding. For other than straight-line work such a machine can usually be made to operate against a template, and in this way almost any desired shape of plate can be cut. As an alternative to the use of a template for cutting circular holes such as the ports and scuttles in a ship's plating, a British firm specialising in the production of welding equipment have recently placed on the market a machine which can cut circular holes of any size ranging from 1½ to 21in. in diameter. The gas burner is carried by a small constant-speed electric motor which is mounted on wheels driven through an infinitely-variable gear running in a sealed oil bath and giving the burner a travelling speed of 2 to 18in./min. When cutting circles, an auxiliary centre is used, this being positioned between the driving wheel and the burner for small circles and on the other side of the driving wheel for large circles. For circles above 21in. in diameter as well as for other curved forms of large radius, the machine works against a template or it can be made to run on a track of the correct form. The burner can, of course, be run on a straight track for straight-line cutting in the usual way, and its slope is capable of adjustment to any angle up to 45° with the surface of the plate when a bevelled edgei s required.—*"Shipbuilding and Shipping Record", Vol. LXIII, No. 22, 1st June, 1944, p. 507.*

The 17-knot Ferry Ship "Malmöhus".

The train ferry "Malmöhus", launched last December, is the first motor-ship to be built for the service between Copenhagen and Malmö. She is a twin-screw vessel 309ft. in o.a. length with a mean breadth of 52·5ft., and has a d.w. capacity of 595 tons. The full-load displacement is 3,060 tons on a draught of 13·4ft. Accommodation is provided for 1,800 passengers (1,300 when trains are being transported) and a double length of rail track with a total length of 532ft. on the main deck enables the vessel to carry railway coaches during the 80-minute passage across the Sound. The propelling machinery consists of two sets of 8-cylr. s.a. two-stroke Kockum-M.A.N. engines direct-coupled to propeller shafts running in SKF roller bearings. The propellers are of stainless steel. The designed speed of the ship is 17 knots in deep water with the machinery developing its normal power output of 4,750 b.h.p. As it is necessary in winter to heat up the ship before she leaves port, and no steam is provided, there is an exceptionally large generating installation to supply the current required for electric heating. This installation comprises three 260-kW. 220-volt dynamos, each direct-coupled to a 450-b.h.p. 6-cylr. 4-stroke Kockum-M.A.N. Diesel engine. The electrical equipment of the vessel includes degaussing circuits to eliminate danger from magnetic mines.—*"The Motor Ship", Vol. XXIV, No. 289, February, 1944, pp. 372-373.*