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Marine Superheaters.

READ

By J. H. WHEADON (Member) at a Meeting of the Junior Section.

On Thursday, April 23rd, 1936 at 7 p.m.

Chairman: Mr. E. R. Chamberlain (Associate).

THE application of superheating to marine steam propulsion dates from about the year 1850 and it is recorded that in 1864 30 steam vessels were fitted with superheaters. These early superheaters were, however, owing to unsuitable material, crude construction or bad design, a continual source of trouble. Lubricants at that time were principally derived from tallow which, upon contact with superheated steam, developed acidity and rapidly corroded the internal parts of the engines. So seldom were these early superheaters free from trouble that when the principle of compounding was introduced, superheating was practically discontinued and remained so for many years. It was not until compounding had raised the efficiency of the saturated steam engine to its virtual limit that superheating was introduced, but this time with the advantage that a greatly extended knowledge of the properties of high temperature steam and its effect upon materials, etc. existed. Its use, however, did not become really practical and profitable until, after years of classic experiments Dr. Schmidt, who is universally recognized as the pioneer of practical superheating, introduced his well-known smoke-tube superheater in 1902.

The economic value of superheated steam has been known since the early days of the steam engine, but not until the fundamental laws of heat engines had been established was it recognized that the actual fuel saving obtained in practice is much greater than purely thermodynamic reasons would imply. Although this applies to both the reciprocating engine and the turbine, the reason is not the same in both cases.

The temperature of the steam entering the cylinder of a reciprocating engine is much higher than that of the cylinder walls which have been previously cooled during the expansion stroke. Saturated steam can only part with some of its heat to the walls at the expense of a certain amount of condensation. Superheated steam, however, is able to give up heat to the extent of its superheat before condensation takes place and, if the superheat is sufficient, initial condensation will be eliminated altogether.

Fig. 1 shows the percentage of initial condensation to be expected with any given cut-off and the amount of super-heat required to eliminate it. Naturally, the earlier cut-off takes place, the cooler will be the cylinder walls when admission occurs

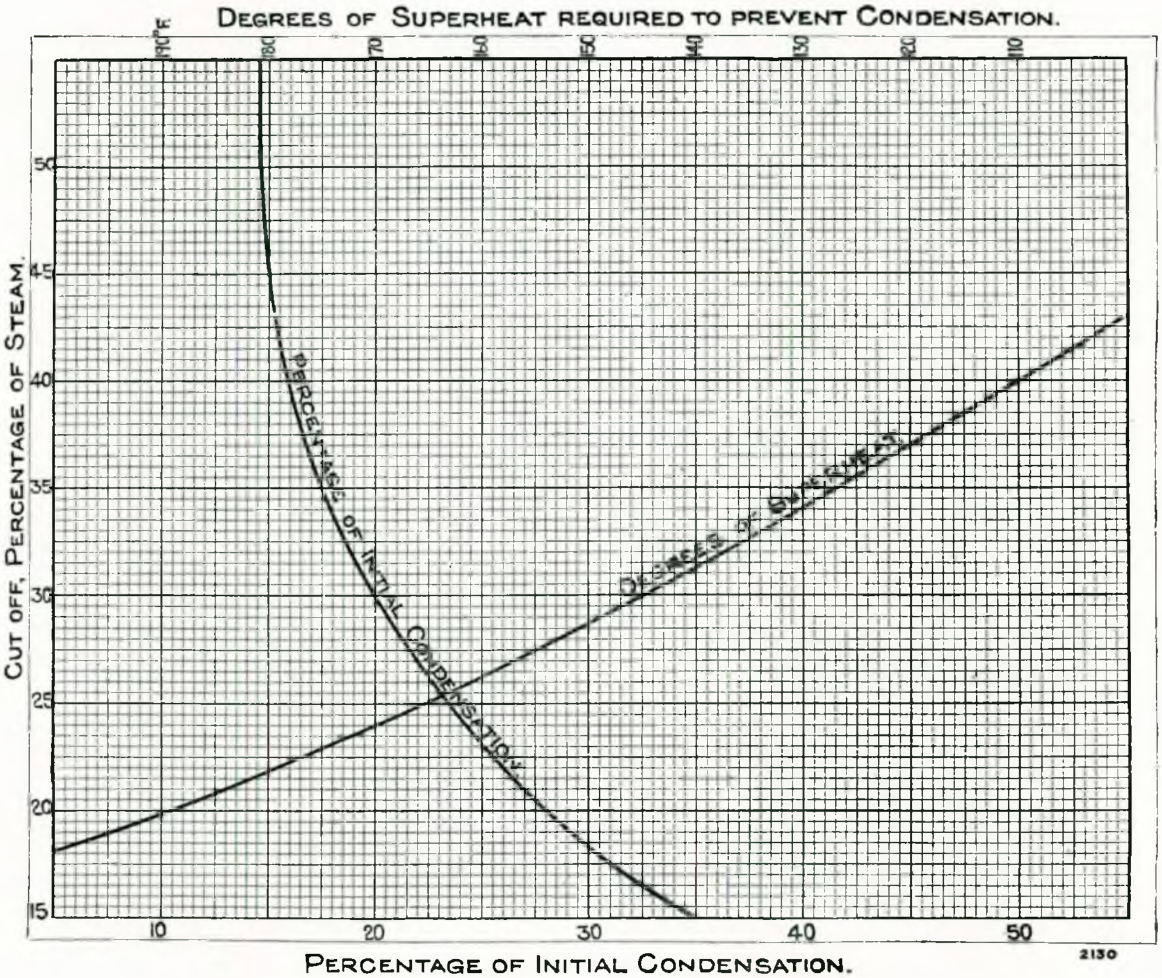
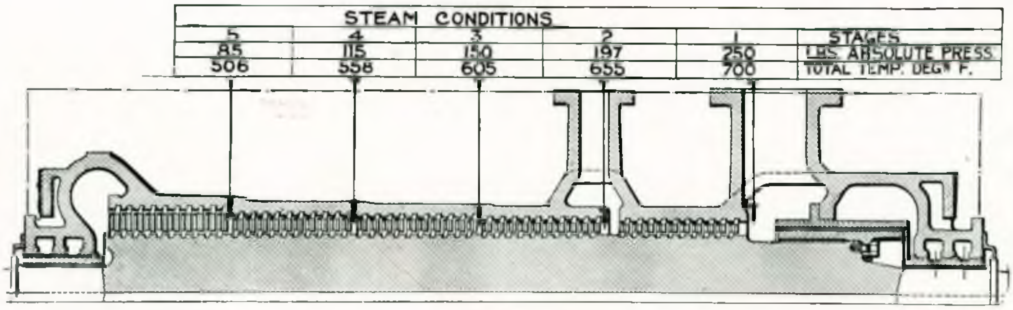


FIG. 1.—Superheat required to eliminate initial condensation.

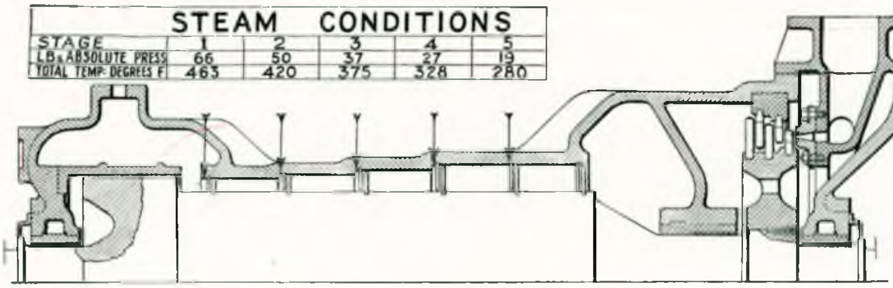
and, therefore, the greater the percentage of initial condensation. From this diagram it will be observed that when cutting-off at 30 per cent. stroke on the particular engine to which these data apply, the initial condensation is 20 per cent.; in other words, 1/5th of the entering steam is immediately condensed by the cooler walls. The amount of superheat required to eliminate this initial condensation is shown to be 145° F. The fact also that superheated steam having the properties of a dry gas is a bad conductor of heat tends further to reduce the condensation loss.

In the case of the steam turbine, the same physical conditions do not exist. The temperature gradient is uniform and constant under steady load from admission to exhaust; initial condensation is therefore negligible. Water, however, is formed in doing work, the amount of moisture gradually increasing to a maximum at exhaust. This suspended moisture not only introduces frictional resistance with consequent loss of effective power, but does damage to the low-pressure blading by erosion. The presence of moisture reduces the efficiency of a turbine stage by a percentage equal approximately to the percentage of moisture present. Thus, if the wetness in a stage is 3 per cent. the efficiency of that stage is reduced by about 3 per cent. The point at which the condensation commences should therefore be retarded as far as possible. Fig. 2 shows a typical set of Parsons triple expansion marine turbines with particulars of steam conditions. It is interesting in that it reveals clearly the value of superheating in retarding the incidence in condensation. In this particular set, having an initial steam pressure of 250lb. per sq. in. absolute and 700° F. total temperature, the 4th stage of the low pressure turbine is reached before condensation commences.

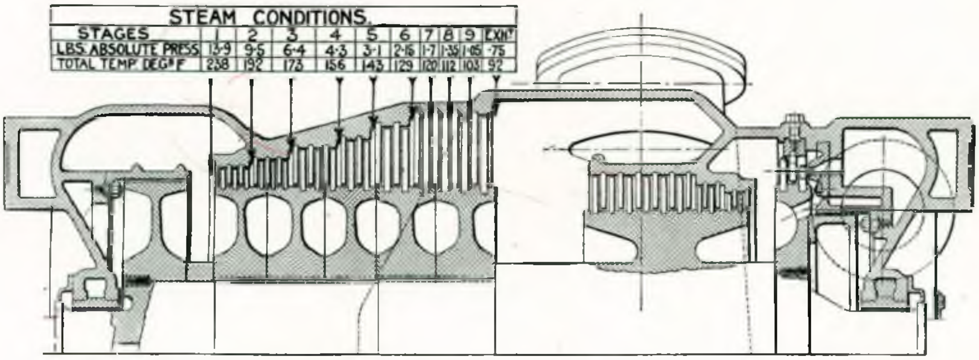
Briefly, then, superheated steam benefits the reciprocating engine largely by reducing the condensation loss and the turbine by reducing the fluid friction, and both types to a lesser degree by increasing the temperature range. Thus, the actual gain from superheating is substantially more than theory would lead one to expect. For example, the theoretical reduction of fuel due to superheating 200° F. is between 3-4 per cent., whereas in actual



H.p. ahead turbine.



I.p. ahead and h.p. astern turbine.



L.p. ahead and l.p. astern turbine.

FIG. 2.—Steam conditions throughout the stages of a triple expansion set of turbines.

practice the gain ranges from 10-15 per cent., depending upon the size and type of the prime mover.

In addition to the fuel saving, there are other advantages associated with marine superheating, namely :—

(1) increase in d.w. capacity due to decreased bunkers carried.
(2) reduction in the quantity of coal purchased abroad at high prices.
(3) The possible omission of a coaling port with consequent saving of time and port dues.

TYPES OF SUPERHEATERS.

Superheater design and arrangement is largely dependent upon the type of boiler with which it is associated. In this respect the water-tube boiler is inherently more flexible than the Scotch boiler, for it allows greater latitude in both the proportions and position of the superheater. As the majority of superheaters employed in the merchant service are still of the Scotch boiler type, these will be dealt with first.

Scotch Boiler Types.

Scotch boiler superheaters can be grouped into three basic types, the principal point of difference being in the location of their elements, as follows :—

(1) Uptake and smokebox, (2) smoke-tube and (3) combustion chamber. Before examining the three types in greater detail, it will be of assistance in appreciating their limitations if the variation in gas temperatures obtaining in an average Scotch boiler from furnace to uptake, as shown in Fig. 3 is studied. The rate of heat transmission is dependent upon the mean temperature difference between the gas and steam. In the case of the uptake superheater supplied with saturated steam at, say, 400° F. and with a gas temperature in the uptake of 500-550° F., the small temperature difference limits the superheat obtainable with this type to about 80° F. By inserting the elements within the smoke-tubes as in the Schmidt type, where the gas temperature varies from 1,000° F. down to about 650° F., the increased temperature difference admits of about 200° F. of superheat being obtained. For the highest superheat the elements are disposed entirely within the combustion chamber.

Until comparatively recent years, the lack of suitable materials, lubricants and packings, etc. made the use of a high degree of superheat rather

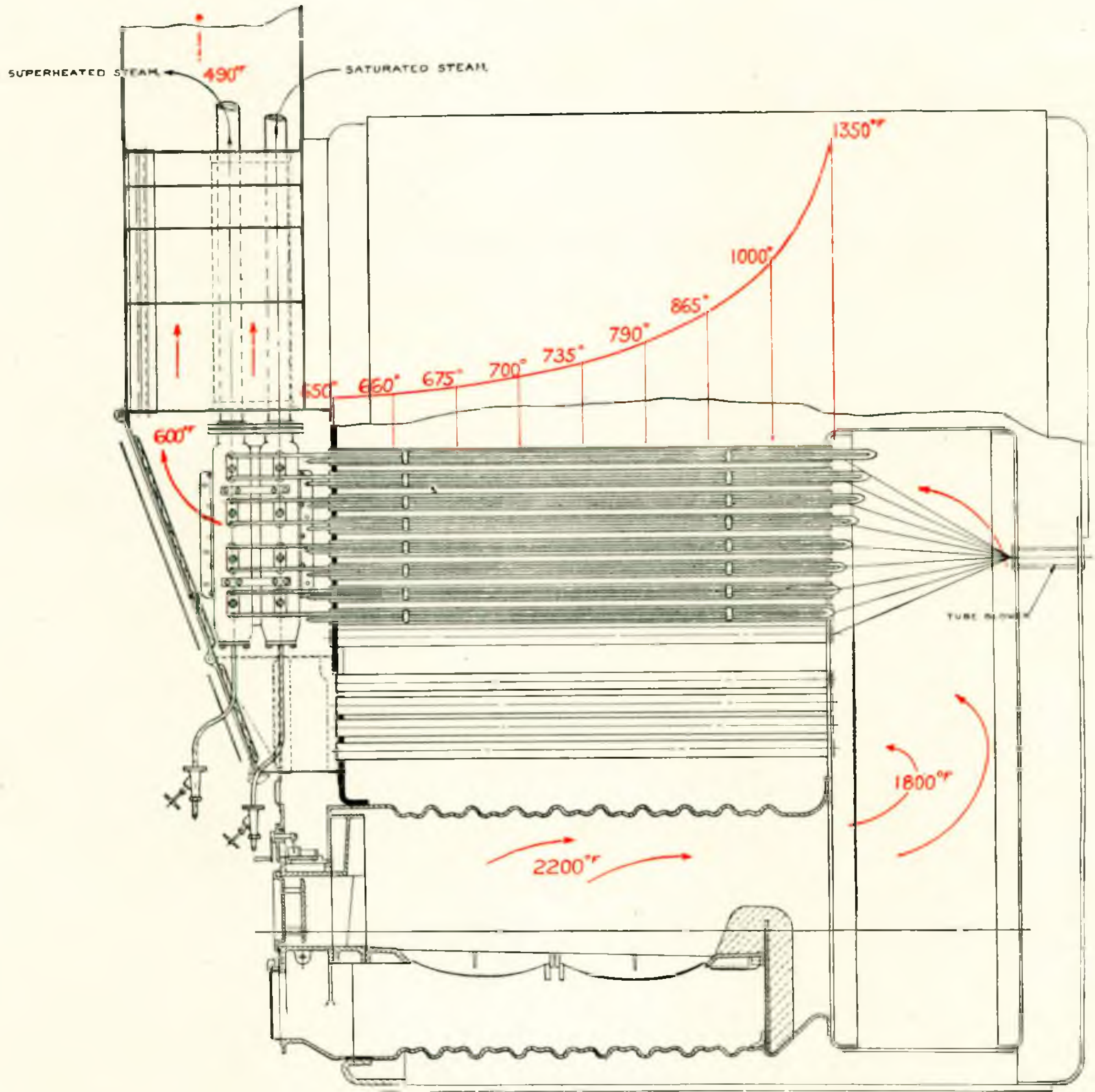


FIG. 3.—Figures in red indicate gas temperatures.

more troublesome than was desirable, so much so that when weighing the question of economy and reliability, high superheat was often abandoned in favour of a more moderate degree. The uptake superheater as illustrated in Fig. 4 was particularly suited to the lower superheat, for not only was it capable of obtaining up to 80° F. of superheat without subjecting the elements to very high gas temperatures, but it also had the advantage of simplicity. Furthermore, the boiler was accessible for examination, cleaning and expanding tubes without interfering in any way with the superheater.

These early difficulties with materials, however, have been so far overcome that superheated steam at 600° F. is commonly used by reciprocating engines and at 700° F. or more by turbines. But the demand for these higher temperatures cannot be met by the uptake superheater without either the provision of an impracticably large heating surface or very high smoke-box temperature with consequent low boiler efficiency. For steam temperatures up to about 600° F. the smoke-tube type (Fig. 5) is very commonly employed. It consists in principle of a series of loops or elements of solid-drawn steel tubing from $\frac{3}{4}$in. to $\frac{7}{8}$in. external diameter inserted in the smoke-tubes and connected to headers or collectors at the front of the boiler. Saturated steam from the boiler stop valve enters the saturated steam header and, circulating through the elements in parallel, returns superheated to the superheated steam header and thence to the engine. The elements are therefore in the direct path of the gases flowing from the combustion chamber to the smoke-box. Fig. 6 shows an individual element

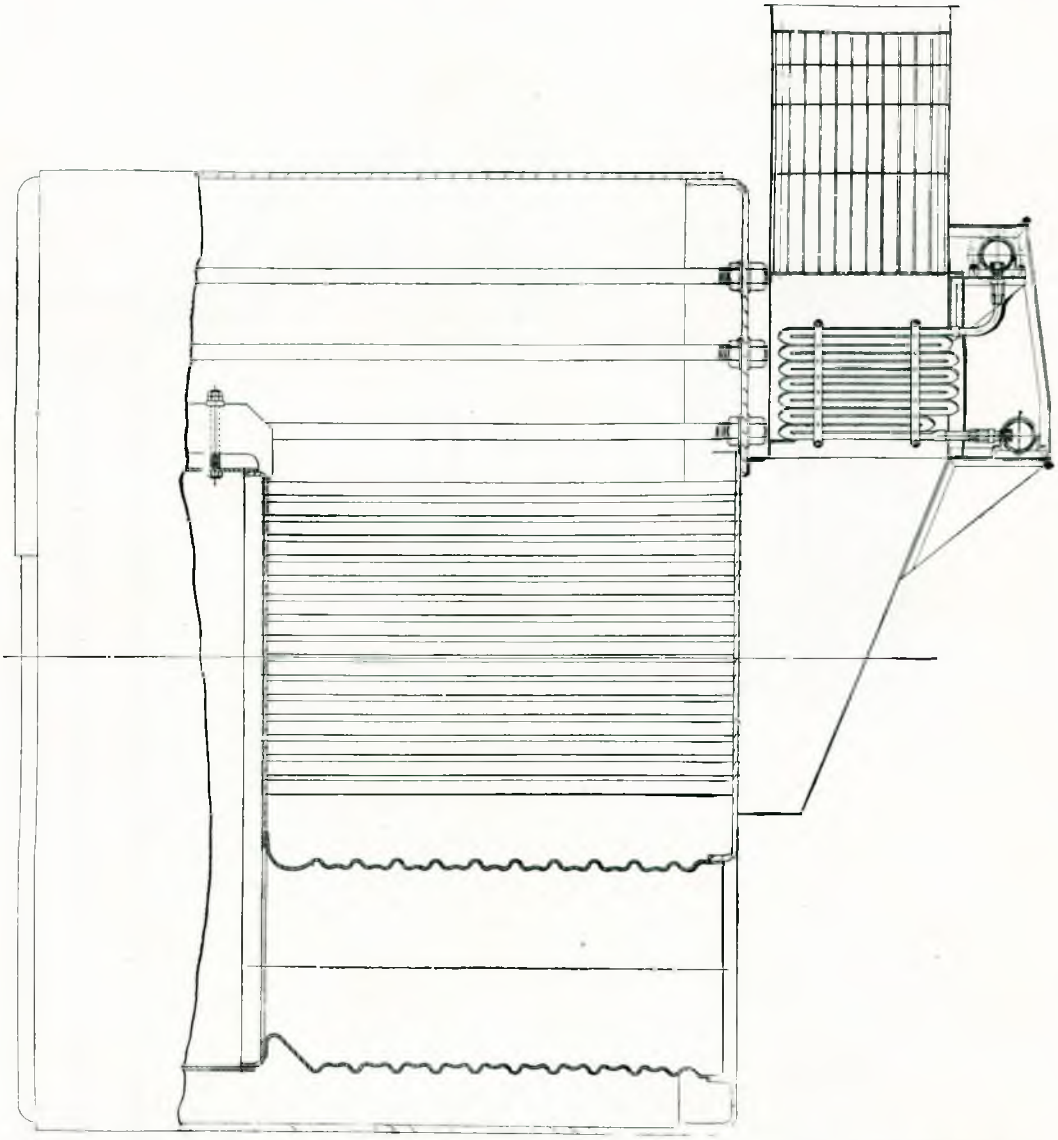


FIG. 4.—Section through boiler showing relative positions of the uptake superheater and air heater.

complete with collars. These elements are attached to the headers through the collars expanded on the elements which fit into machined recesses in the header where a steam-tight joint is made with a jointing ring. The collars are held in place by steel dogs (see Fig. 7), each dog securing two collars and screwed down to the header by stud and nut as shown. The dog method of clamping not only ensures a maximum pressure on the jointing surface but the spring in the dog provides the necessary locking action and prevents steam leakage under the most severe conditions of high temperature, pressure or mechanical vibration.

As the external diameter of the smoke-tubes is within the limits of $2\frac{1}{2}$in. to $3\frac{1}{2}$in., the element tubes require some method of returning other than by bending the tubes back upon themselves. Such junction between the tubes is effected either by acetylene welding a stamped cap to the tubes, or by machine forging the tubes to form a return bend. (see Fig. 8.) The headers are either of cast steel or are pressed steel forgings of rectangular section. Fig. 9 shows four stages in the machining of a header of the pressed steel type. It is pressed from the solid ingot and the flange is screwed and expanded to the neck of the header. The base is fitted with removable sludge doors, to the centre of which the drain valves are attached. It will be noted that the element recess holes are staggered, which permits the removal of any individual inside element without disturbing the outer ones. In a later development the elements are extended into the com-

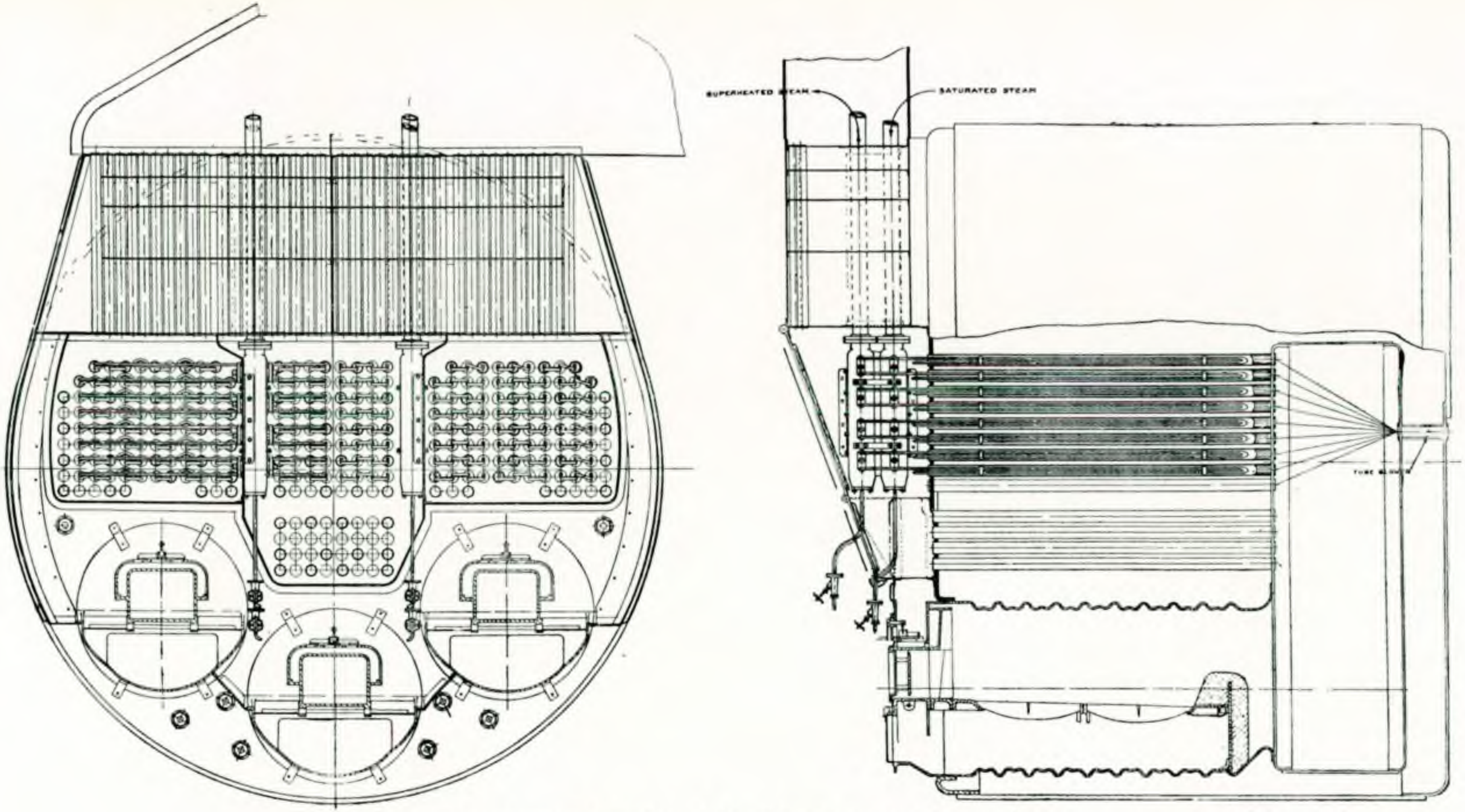


FIG. 5.—Three-furnace boiler, forced draught, with smoke-tube superheater.

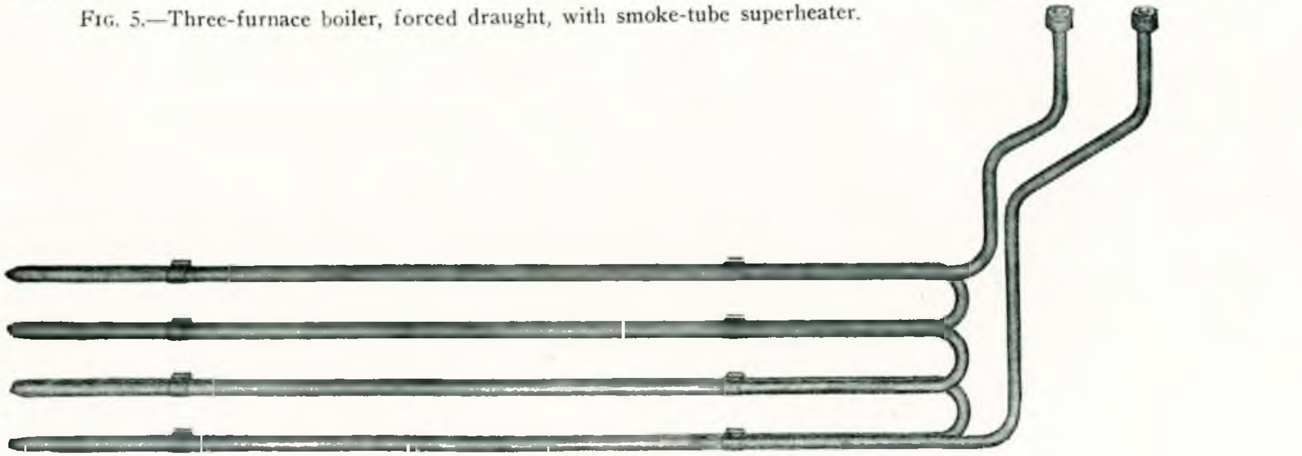


FIG. 6.—"S" type superheater element.

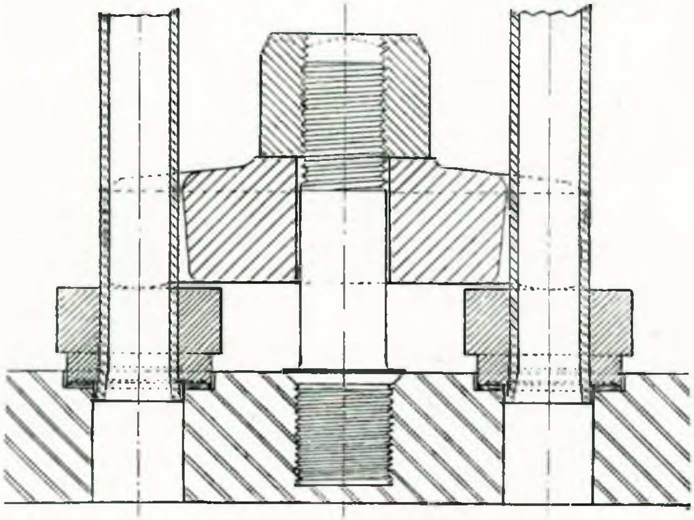


FIG. 7.—"S" type joint.

bustion chamber, thus enabling steam temperatures of 650° F. to be maintained, although the objection is sometimes raised that this prevents the use of the tube expander at the back end without withdrawal of elements.

In marine work where water-tube boilers are employed, steam temperatures of 700-750°F. have been in use for a sufficient length of time to establish the reliability and durability of the superheating apparatus. In a large proportion of tonnage, however, particularly of the cargo and intermediate classes, Scotch boilers are still preferred.

The standard smoke-tube super-heater, even though the ends of the elements be extended into the combustion chamber, is restricted to a steam temperature of about 650° F. The reason for this limitation is that the higher the steam temperature demanded, the more the number of elements has to be increased, so that temperatures in the region of 750° F. would require elements in practically the whole of the smoke-tubes. Unfortunately, the smoke-tube superheater reduces the draught area through the boiler tubes. It is this reduction of draught area as the number of elements is increased that limits the range of the standard smoke-tube superheater.

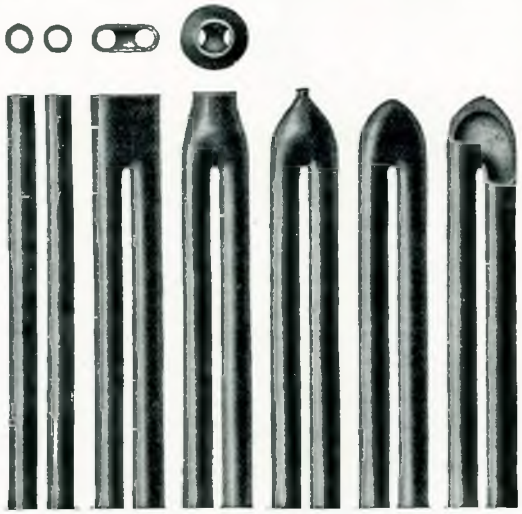


FIG. 8.—Steps in the manufacture of integrally machine forged return bends.

To meet the demand for temperatures beyond the range of the smoke-tube superheater, the combustion chamber superheater (Fig 10) has been designed. The disposition of this type is such that it is subjected to the action of the inert products of combustion whilst they are at high temperature. The elements are disposed vertically; experience has shown that this is the ideal arrangement to avoid distortion, to minimize the adhesion of soot and to eliminate complicated spacing and supporting arrangements. The compactness of the design makes it quite practicable to incorporate the whole of the necessary heating surface in less than the total number of furnaces available, thus providing the important advantage of being able to raise steam without risk of overheating the elements. The connections between the inlet and outlet limbs and the elements are made by union joints, below which and above each furnace throat is a short baffle of heat-resisting steel, which compels the gases to pass over a considerable portion of the superheater before they encounter the joints. The joints are therefore in a comparatively cool zone, as they are not exposed to furnace gas until the temperature has been reduced by passing through the superheater.

Howden-Johnson Boiler.

Fig. 11 shows one of the latest developments of the Scotch boiler. The design is the outcome of an effort to produce a steam generator having the virtues of both Scotch and water-tube boilers. The normal type of combustion chamber with its inherent weaknesses has been eliminated, a dryback combustion chamber enclosing a series of tubes forming a water wall taking its place. The combustion chamber superheater is designed to produce steam at a temperature of 750-800° F. The location of this superheater renders it most essential to maintain a continuous steam circulation. To this end provision is made whereby *all* the steam used, whether for main or auxiliary use, is passed through the superheater. This is done by taking the auxiliary steam from the superheated steam header and admitting it to a de-superheater to reduce the temperature to that required for use in the auxiliaries. The de-superheater, as can be seen in this view, comprises a set of coils within the boiler water space, through which the superheated steam passes from the superheater to the auxiliaries, giving up heat to the boiler water. In this way, even if the main stop valve is closed, all the steam required for auxiliaries will still pass through the superheater.

Superheaters for Water-Tube Boilers.

Constructional difficulties limit the working pressure of the Scotch boiler to about 300lb. per sq. inch. When pressures exceeding this limit are specified, it follows that water-tube boilers must of necessity be adopted. Furthermore the advantages of higher steam pressures and temperatures are so marked that merchant service prejudice against the water-tube boiler is steadily being overcome. The best known water-tube boilers in the merchant service are Babcock & Wilcox and the Yarrow types.

Babcock & Wilcox Type.

Fig. 12 shows a Babcock & Wilcox mechanical stoker-fired water-tube boiler with superheater. The superheater which is referred to as the overhead or superposed type is placed in the gas path above the boiler tubes and between the first and second passes. Before reaching the superheater, a considerable proportion of the heat in the gases has been extracted by the boiler-tube surface in the first pass so that, unless this type of superheater has a very large surface area, the superheat obtainable is moderate. A certain amount of control over the final steam temperature is sometimes obtained by means of a plate damper, which can be lowered or raised to regulate the quantity of gases passing the superheater. This type of superheater has usually two drums into which are expanded the ends of seamless steel U-tubes. The top drum has a diaphragm or bulkhead in the centre of its length. Steam enters the top drum as far as the centre diaphragm and passes through the one half of the U-tubes into the lower drum or header; the lower header having no diaphragm, the steam makes its way along the header and back again through the second half of the U-tubes to the top header and thence to the prime mover, the steam thus making four passes. The tendency in the past has been to regard the boiler and superheater as separate entities, whereas they are really complementary parts of the steam raising and conditioning equipment.

The interdeck superheater (Fig. 13) is evidence of the greater attention being given to the superheater and its position in relation to boiler heating surface. To obtain high superheat with a reasonable amount of heating surface and also to ensure practically constant temperature over the normal range of duty, the superheater is placed near the furnace above a shallow bank of boiler tubes. In this lower bank of tubes, most of the steam is generated and heat is absorbed by radiation as well as by convection. The superheater elements are thus subjected to the same variations of gas temperature as the lower bank of tubes. Therefore the heat absorption by the boiler and superheater varies in the same proportion and a steady final temperature is obtained irrespective of the rate of evaporation.

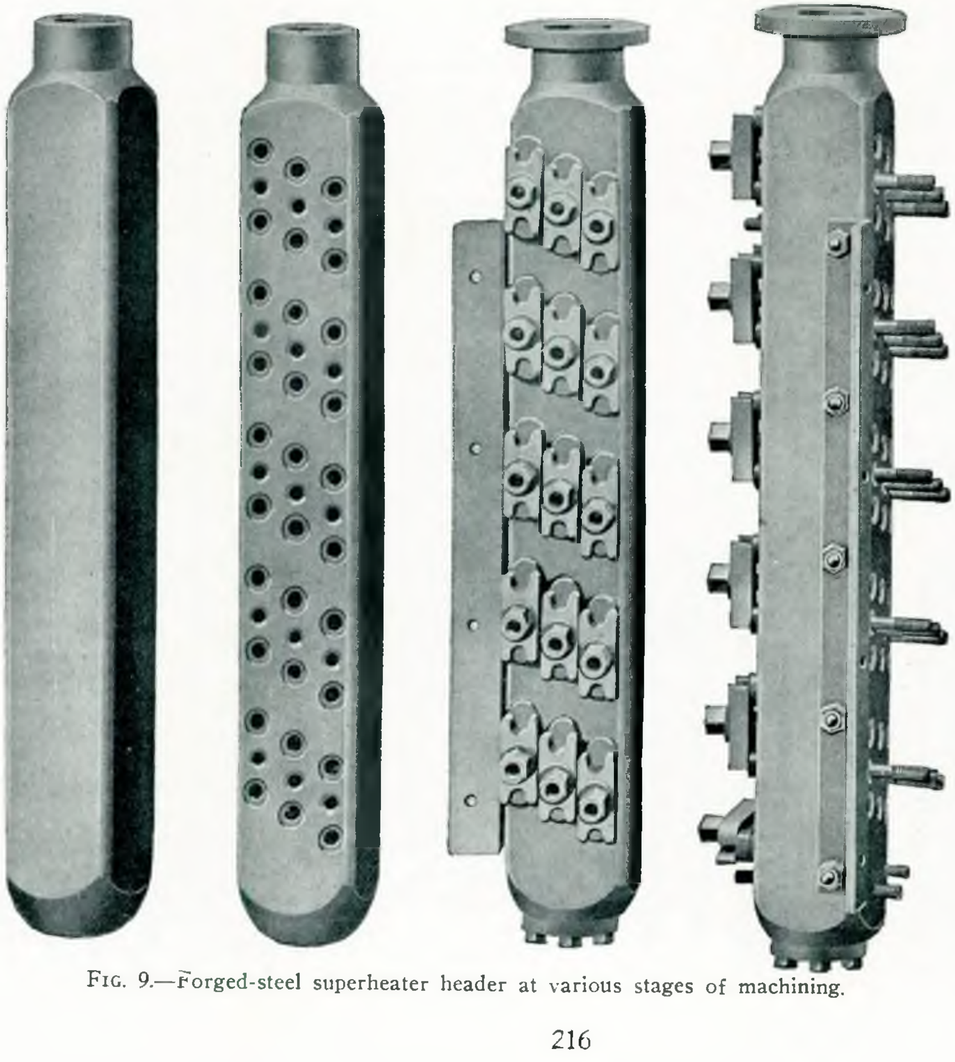


Fig. 9.—Forged-steel superheater header at various stages of machining.

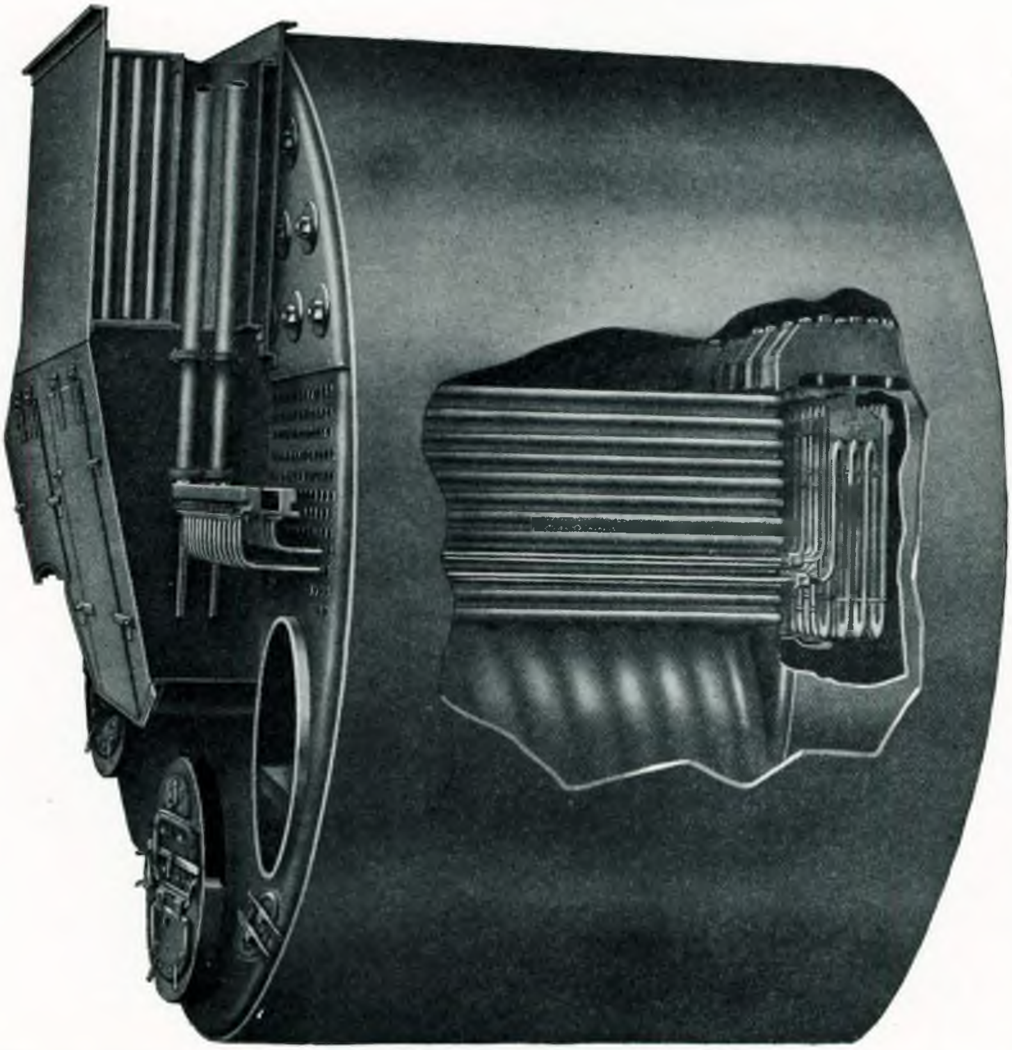


FIG. 10.—Arrangement of combustion chamber superheater in three-furnace boiler; elements fitted in wing chambers only.

only from the furnace gases after the temperature has been lowered considerably by the intervening bank of generating tubes, and is suitable when only a moderate superheat is required. The temperatures of steam delivered from a superheater of this type will rise somewhat with increase of power, but with moderate superheat this may not be a severe handicap.

With the high steam temperatures now being adopted, it is an advantage, in view of the smaller margin between the working and safe maximum temperature, that the temperature of steam from the superheater be reasonably constant over a fairly wide range of duty. It was towards this desirable end that the arrangement of the Yarrow boiler was altered so as to accommodate the superheater in the most favourable position. Fig. 15 shows such a boiler and is one of a type fitted in a number of modern vessels. It will be observed, in order that the superheater can be placed in a high temperature zone to enable high superheat to be obtained together with a flat superheat-load characteristic, that one of the banks of tubes is divided into two parts, each provided with a separate water drum. By so doing, space is provided for the accommodation of the superheater. The boiler shown is of the double-flow type, the gases passing on both sides of the saturated steam drum. The damper at the junction of the two uptakes regulates the gas flow over the superheater and so enables the final steam temperature to be controlled.

The single-flow type Yarrow boiler, as shown in Fig. 16, has a single gas exit on the superheater side of the boiler. The tube bank on the opposite side absorbs heat by direct radiation from the furnace. As in this type of boiler all the gases

The boilers for the Orient Line vessel "Orion" (Fig. 13) are constructed for a blow-off pressure of 450lb. per sq. inch and superheat temperature of 725° F. Points of interest in connection with the superheater are the handholes in the headers giving access to the tube ends for expanding, etc. and, secondly, the method of supporting the superheater elements by means of sling stays from the top return tubes.

Yarrow Boiler Superheaters.

As with other boilers the recognition of the importance of the position of the superheater upon its characteristics has largely influenced the design of the Yarrow water-tube boiler, particularly in respect of the water drum and tube bank arrangement. To illustrate this Fig. 14 shows the pressure parts of a Yarrow boiler without superheater. Later a similar boiler was arranged with a superheater after the generating tube nest on one side of the boiler. This superheater receives its heat by convection traverse the superheater, for a given degree of superheat the surface required is less than in the double-flow type where only part of the gases serves the superheater. The superheater itself differs from the Babcock superheater in the respect that it has a single drum. The drum is large enough to be entered for the purpose of expanding elements and is fitted with removable internal baffles to direct the steam through the requisite number of passes. The elements of the Yarrow superheater being very steeply inclined are self-draining and practically self-supporting. Fig. 16 illustrates one of six Yarrow boilers of the five-drum single-flow end-fired type fitted in the "Viceroy of India". The safety valves it will be noticed are attached to the superheater drum as a protection in the event of a sudden stoppage of the main machinery, the lifting of the safety valves providing a flow of steam through the elements.

Johnson Water-Tube Boiler.

Figs. 17 and 18 show one of the Johnson type boilers as installed in the Royal Mail Line's "Asturias" and "Alcantara". The re-engining of these two vessels was largely made possible by the very small space requirements of the modern water-tube boiler, and enabled steam machinery of over 50 per cent. greater power than the original Diesel machinery to be accommodated without increase of space occupied.

The working pressure of these boilers is 425lb. per sq. inch and the designed superheat 750° F. The superheater differs from those of the previous water-tube boilers dealt with in that it is of the single-pass multiple loop type, that is to say, it is very similar in arrangement to the Scotch boiler smoke-tube superheater, whereas the Yarrow and Babcock superheaters are of the single-loop multiple pass type. An advantage claimed for the single-pass superheater is that all elements being of equal length, they offer the same resistance to the flow of steam.

An interesting feature of the design of this superheater is that the elements are bifurcated, each consecutive pair being united at their ends to form a single outlet at each end of the pair, thus requiring only half the usual number of joints. The superheater elements are close enough to the furnace to obtain the designed superheat with a reasonable amount of heating surface, but are protected from excessive radiation by three rows of boiler tubes. The superheater is on one side of the boiler only and in a similar manner to the Yarrow double-flow boiler, the final steam temperature is controlled by means of uptake dampers. It will be observed

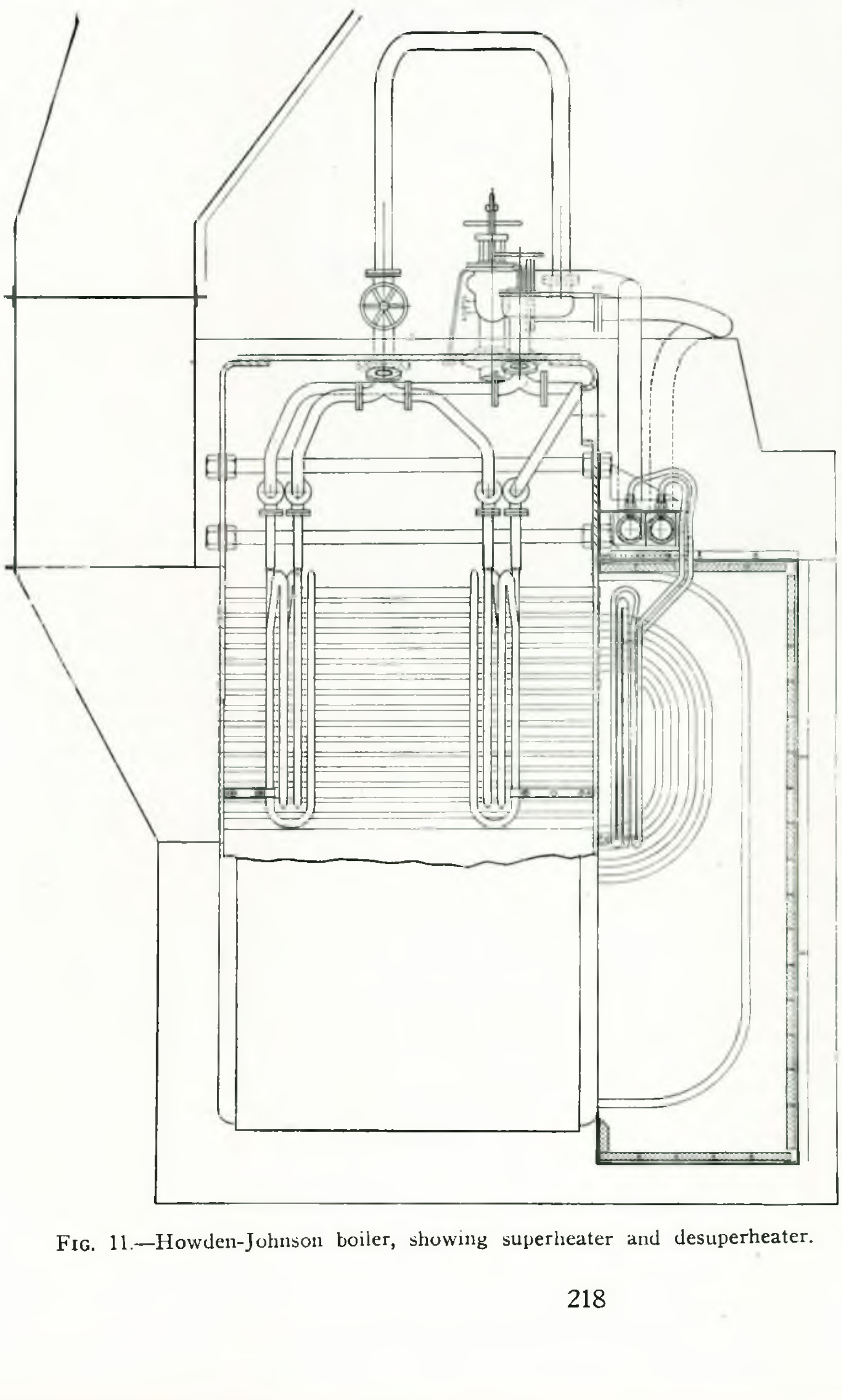


FIG. 11.—Howden-Johnson boiler, showing superheater and desuperheater.

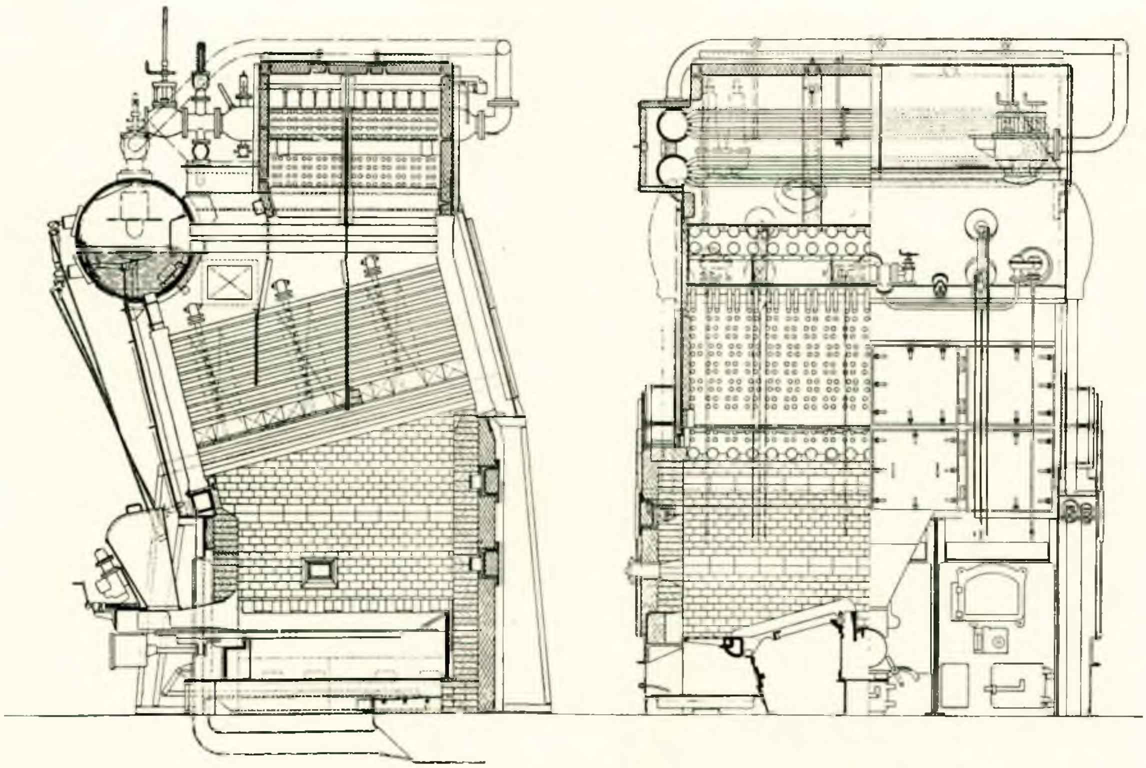


FIG. 12.—Babcock & Wilcox boiler with overhead superheater.

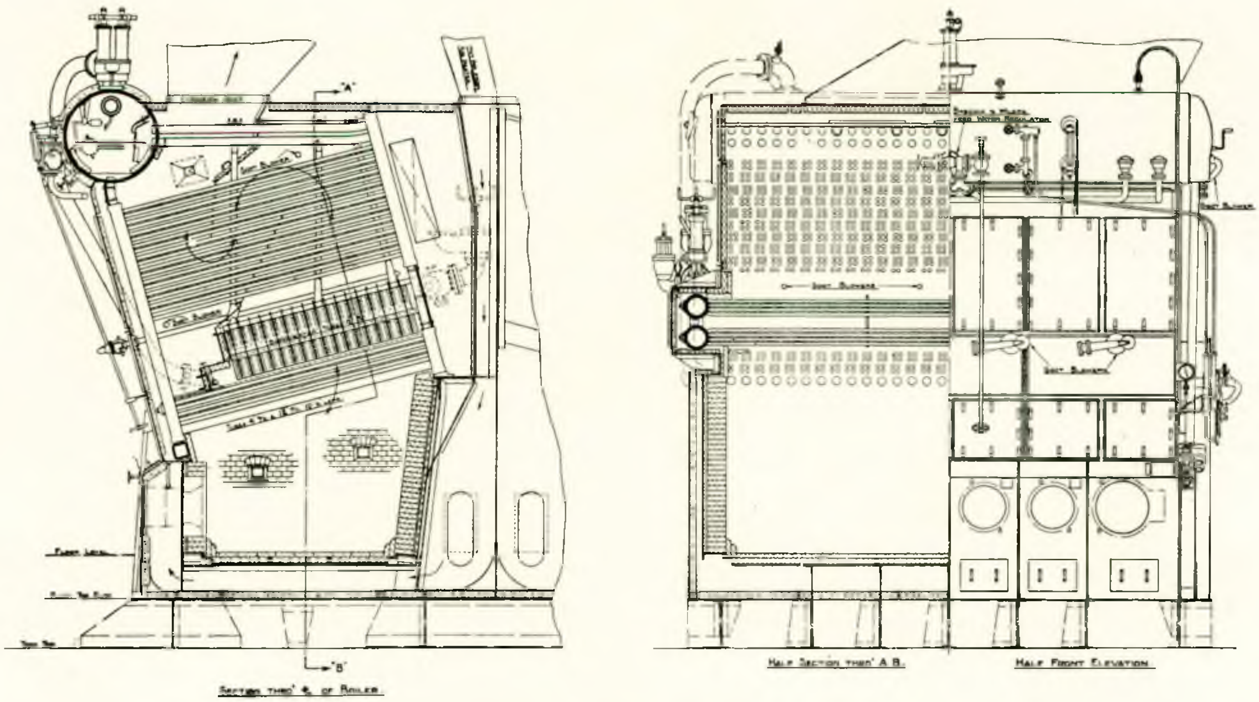


FIG. 13.—Babcock & Wilcox boiler with interdeck superheater.

that the elements are not expanded into the headers as in the water-tube boilers previouslv described, but are connected by means of metal to metal ball joints.

Operation of Superheaters.

To ensure freedom from trouble, careful attention must be paid to the superheat installation, particularly when raising steam. During this period the condition arises where no steam is flowing through the superheater, although the elements are in contact with gases at high temperature. The old practice of flooding the superheater with water has been discarded as being dangerous, protection during steam raising now being effected by steam circulation.

Fig. 14.—Yarrow boiler without superheater.

Before lighting up, the superheated steam header drain should be opened and allowed to blow as the pressure rises until the boiler is coupled to the line. It is true that until some rise in pressure occurs, there will be no circulation but during this time the temperature of the gases is so much reduced by the cold boiler heating surface that there is no danger if the fires are set away very steadily until steam is issuing from the drain.

In the case of boilers fitted with superheaters in the wing combustion chambers or tube nests, danger is avoided by raising steam by the centre furnace only.

Temperature Control.

The fluctuating conditions that occur when manœuvring render it advisable to lower the superheat. With boilers of the Scotch type the temperature at the engine stop valve is reduced by admitting a proportion of saturated steam through "mixing" valves into the superheated steam pipes. As this bye-passing method, however, has the disadvantage of reducing the steam flow through the superheater, the mixing valves should be opened no more than is required to maintain the desired temperature at the engine; in fact, the mixing valves are usually arranged with a restricted lift to avoid this danger. At sea the mixing valves should be closed and the temperature at the engines kept as high as is safely possible, not only on account of economy, but also to ensure an adequate flow of steam through the superheater. This superheater should be so proportioned that when developing full power the desired maximum working temperature is not exceeded with the mixing valves closed.

In the case of water-tube boilers, two distinct methods of control are employed, viz.: (1) by providing sufficient surface area to give the desired final temperature at low powers with an arrangement for cooling the steam at higher rates by desuperheaters, and (2) by regulating the gas flow over the superheater by means of dampers in the uptake. The cooling of superheated steam or desuperheating is carried out either by injecting a spray of water into the steam or by passing the steam through a convection heat exchanger.

Boiler Priming.

A number of superheater failures have occurred in the past by choking and subsequent overheating of the elements as a result of excessive priming and carry-over of sediment from the boilers. An internal steam dryer is now usually fitted to limit the priming, but much can be done by the operating engineers in keeping the water level as low as is safely possible and by careful attention to the boiler water density. Priming not only endangers the superheater but also materially reduces its efficiency—1 per cent. of moisture is equivalent to about 15 degrees loss of superheat.

Cleaning Tubes.

The obstruction caused by the elements of the smoke tube superheater means that not only does soot tend to accumulate more rapidly but that the deposit cannot be removed by sweeping. Cleaning is effected by blowers using dry or superheated steam and it is most important to blow the tubes while the boiler is hot, for if either the steam jet be wet or the boiler cold, a paste of soot and water will be formed which, when dry, can only be removed with difficulty and which will seriously reduce the efficiency of the superheater. At sea the tubes should be blown at least every 24 hours.

Port Use.

If the boilers used in port are fitted with superheaters, sufficient steam must circulate through the elements to avoid overheating. To this end, certain of the auxiliaries and often the deck machinery are arranged to use superheated steam. Steam winches can safely use steam up to 450° F. without special provision being made beyond a mixing valve to control the temperature.

Design Details.

The application of superheated steam calls for special consideration being given to details of design. Space will not permit more than a brief reference to the most important of these.

As superheated steam has the properties of a dry gas, its specific volume increases proportionately with temperature. This is a fact of prime importance in the design of superheated steam plant. For instance, if the steam supply to an engine, without any other alteration being made, is changed over from the saturated to the superheated supply, it

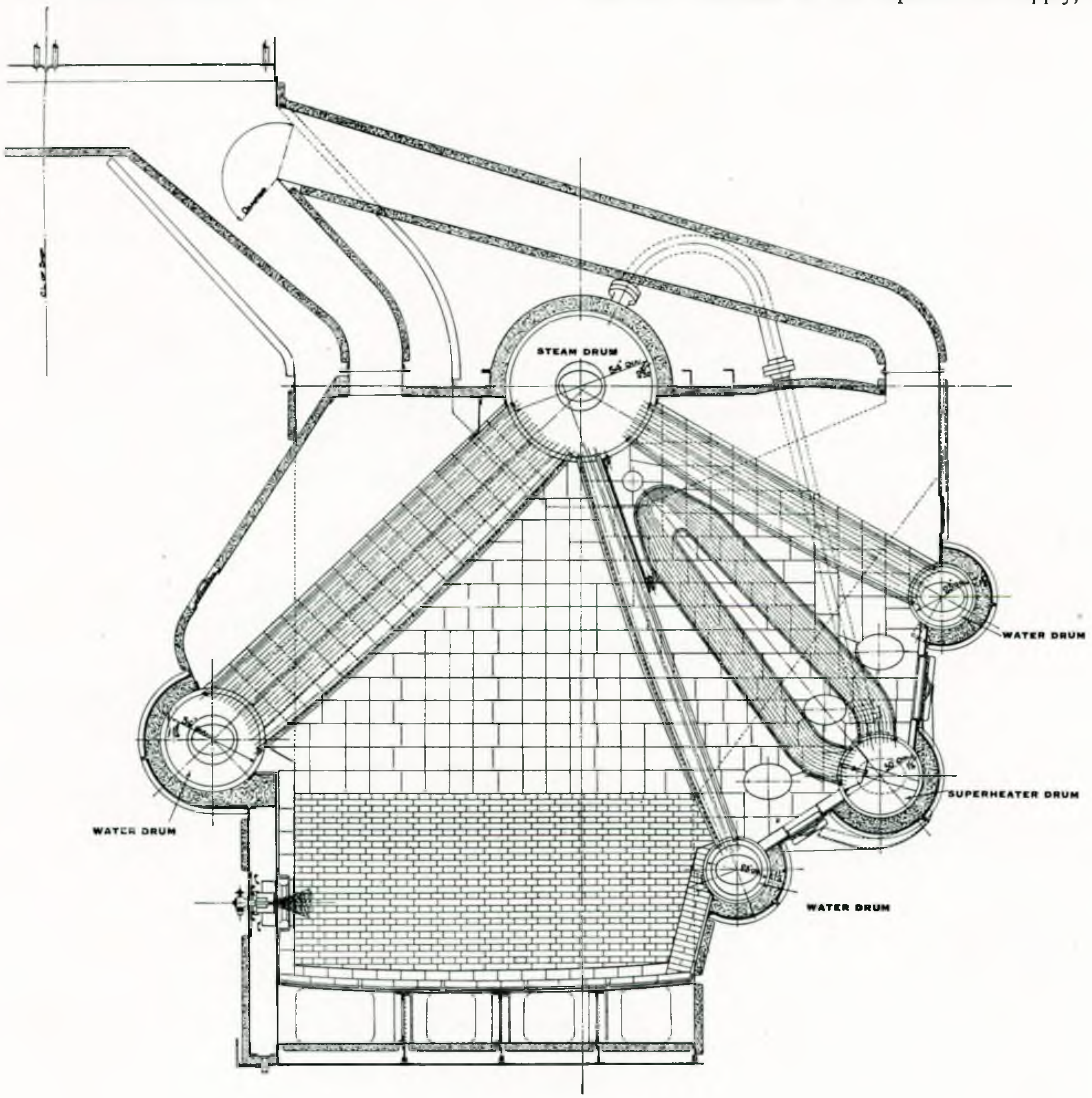


FIG. 15.—Yarrow boiler of the double-flow design, in which the gases pass both sides of the saturated steam drum.

will be found that the power developed is less on superheated than when using saturated steam. This is easily explained if it is borne in mind that although the point of cut-off which governs the *volume* of steam used per stroke is unchanged, yet the *weight* of steam upon which the power depends is reduced by the increased specific volume. To counterbalance this effect the cut-off must be 8-10 per cent. of the stroke later for the same power on superheated steam.

The area of safety valves required to pass a given *weight* of superheated steam must also be greater than that to discharge a similar weight of saturated steam in the ratio of the respective specific volumes. All superheaters must have one or more safety valves, although if there are no stop valves between the boiler and superheater the superheater safety valves may be considered part of the total boiler safety valve requirements.

The greatest obstacle to the progress of super-

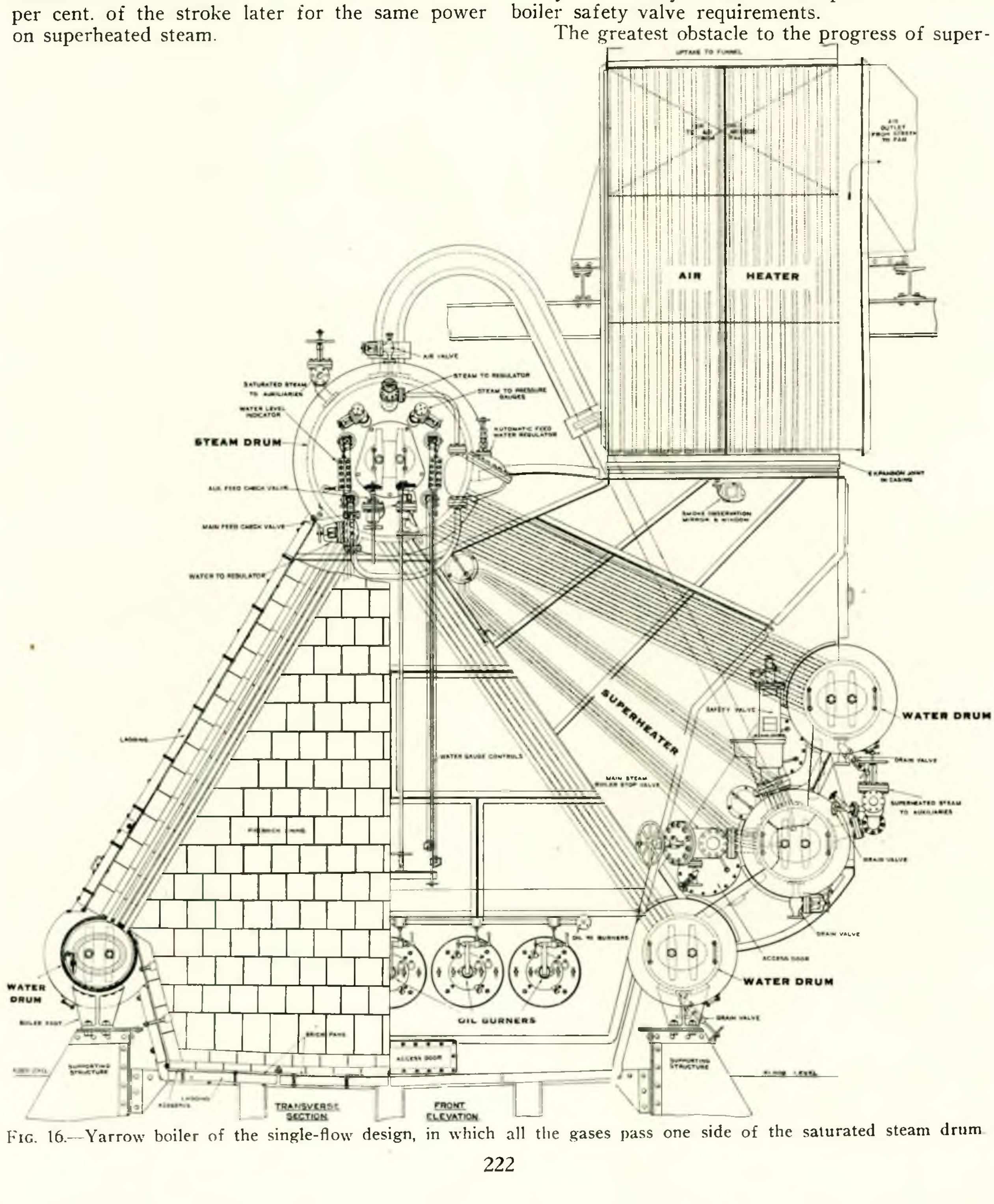


FIG. 16.—Yarrow boiler of the single-flow design, in which all the gases pass one side of the saturated steam drum

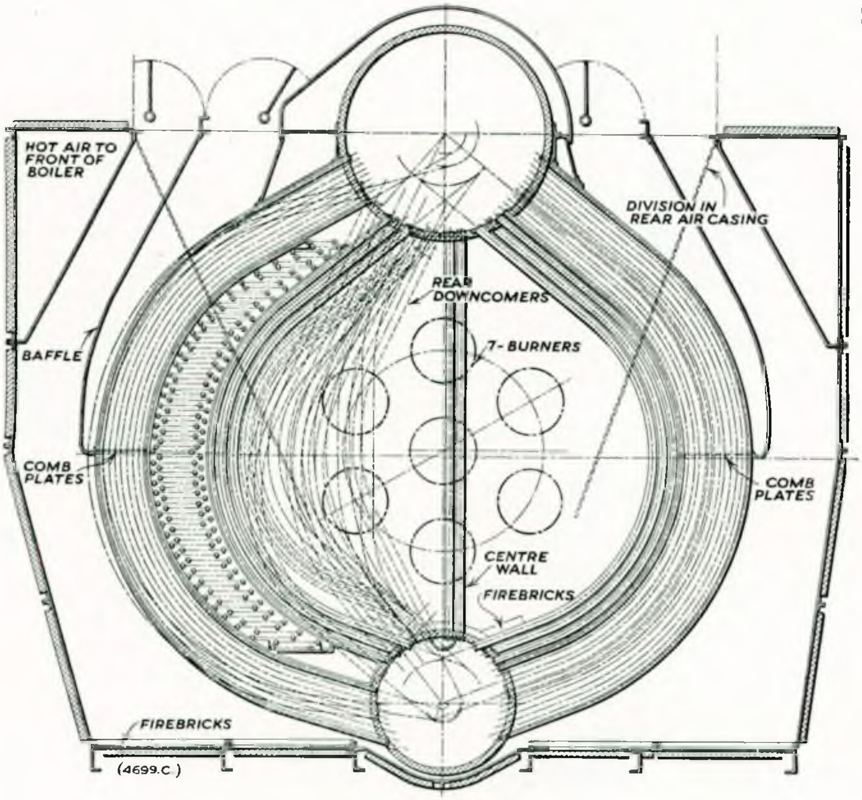


FIG. 17.—Sectional elevation of Johnson boiler.

Steels for Superheater Elements.

When Mr. T. Burnham read his paper* on "Steels in Marine Engineering Service" he enumerated the desirable qualities of superheater tube material as follows :—

(1) Resistance to oxidation and attack by furnace gases.

(2) Resistance to corrosion and attack by superheated steam.

(3) High limiting creep strength.

(4) Ease of working, flanging, bending, expanding, etc.

(5) Absence of temper, brittleness or deterioration from continued operation at high temperature.

(6) Coefficient of expansion of the same order as the headers into which the tubes are expanded.

* TRANSACTIONS INSTITUTE OF MARINE ENGINEERS, Vol. XLVI, 1934, pp. 1-41.

heated steam has been its effect upon materials of construction. Under the influence of high temperature some of the commoner metals and alloys change their physical properties so much as to severely limit their use with superheated steam. The strength of ordinary cast-iron diminishes so rapidly with the increase of temperature that it cannot be used in the manufacture of valve bodies and steam pipe fittings when the temperature exceeds 425° F. Ordinary carbon steel castings are usually recommended for this purpose, although alloy steels are used for very high temperatures. Brass, too, is very weak at high temperatures; an excellent substitute for valves and valve seatings is Monel metal (an alloy of nickel and copper). Monel metal has a coefficient of expansion similar to that of cast steel.

Cylinder and valve liners must be of a hard close-grained cast-iron and the piston and valve rods ground perfectly true and fitted with metallic packing. The materials used for the wearing rings of high-temperature rod packings are either special cast-iron or high-temperature bronze. Turbine h.p. casings, nozzle boxes and rotors should be of cast steel, and the blading of a material resistant to the erosive effect of superheated steam such as phosphor bronze, manganese copper or an alloy steel.

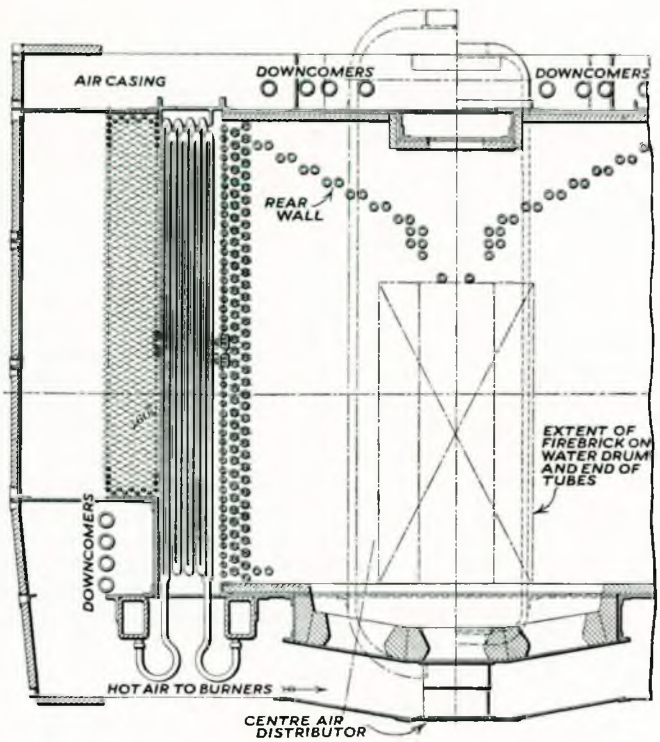


FIG. 18.—Part sectional plan of Johnson boiler.

There are very few marine installations operating with steam temperatures exceeding 750°F. Up to this temperature the foregoing qualities are possessed by carefully selected ordinary low-carbon mild steel, but it is generally agreed that a steam temperature of 850° F. is the safe working limit for mild steel; above that figure the use of alloy steels is desirable.

The supporting of elements to prevent sagging and distortion is a point in design which calls for special attention. The supports should be designed and arranged so as to offer minimum resistance to gas flow. Unless the supports are welded to the superheater elements so that heat is conducted from them, they will attain the temperature of the furnace gas with which they are in contact. For this reason the supports are usually of heat-resisting steel.

Lubrication of Piston and Valve Faces.

Under saturated steam conditions, sufficient lubrication of the piston and valve faces is provided by the moisture in the steam; superheating unfortunately robs the steam of this property. Lubrication under superheat conditions is generally effected by injecting directly to the working faces a small quantity of pure mineral oil of high flash point by a mechanical injector. The quantity required amounts to about 1½ pints per 1,000 i.h.p. per 24 hours, this being gradually reduced to a bare minimum as good working faces are attained. This will, of course, eventually contaminate the condensate and provision must be made to prevent its entry into the boilers. A gravitational filter of very ample proportions is usually installed between the condenser and hotwell for this purpose.

Poppet Valves.

To enable the reciprocating steam engine to utilize more highly-superheated steam than was permissible with the normal type of h.p. piston valve, the poppet valve engine has been designed. The usual h.p. piston valve is replaced by double-beat valves, four to each cylinder, with separate steam inlet and exhaust at both top and bottom. These four valves are operated by a cam shaft worked by a crank and connecting rod from the ordinary Stephenson link motion. This type of valve is suitable for steam temperatures up to 650° F.

The author acknowledges his indebtedness to The Superheater Co., Ltd. and Messrs. Yarrow & Co., Ltd., for the loan of blocks of several of the illustrations, and to Messrs. Babcock & Wilcox. Ltd. for the loan of drawings.

STUDENTSHIP EXAMINATION, 1936.

The following are the papers set in the recent Examination :—

ENGLISH AND GENERAL KNOWLEDGE.

Monday, June 8th, 1936. 7.0 p.m. to 10.0 p.m.

SECTION I.

Write an essay 500 to 700 words in length on *one* of the following subjects :—

(*a*) The Influence of Trade Conditions on Marine Engine Development.
(*b*) The Tudor Kings.
(*c*) The Suez Canal.
(*d*) Democracy.
(*e*) Impressions of a First Visit to the Engine Room of a Ship.
(*f*) Free Trade.
(*g*) Polar Exploration.

SECTION II.

Not more than *five* questions to be attempted. All questions carry the same marks.

1. Give lists of the principal exports of Canada, Sumatra, the Argentine and Norway, and describe the geographical conditions which favour *one* of those exports.

2. Choose *three* of the following and write a short paragraph on each one that you choose: Archimedes, Leonardo da Vinci, Newton, Faraday, Watt, Lord Rutherford.

3. Describe the main achievements of one of the following :—Edward I, Clive, John Wesley, Florence Nightingale, Disraeli, President Wilson.

4. Mention five novels, plays and poems selected from the works of Milton, Goldsmith, Byron, Sir Walter Scott, Thomas Hardy, Galsworthy, George Bernard Shaw. Then write a paragraph about eight lines in length concerning one of the works in your list.

5. What are latitude and longitude? Why does the shortest distance between two places on the earth's surface appear as a curve on a chart drawn to Mercator's projection?

6. State briefly what you know of *one* of the following :—
(*a*) The Wars of the Roses.
(*b*) The Reformation.
(*c*) 1715.
(*d*) The Factory Acts.
(*e*) India since 1850.

7. Describe a character from *one* of the following plays and novels :—Midsummer Night's Dream, Macbeth, Vanity Fair, Oliver Twist, Heart of Midlothian, Journey's End, Kim, The Middle of the Road, Richard of Bordeaux.

8. Choose *five* of the following and write an explanatory sentence about each one chosen :— mixture, compound, solution, emulsion, colloids, latent heat, Boyle's law, spectrum, Ohm's law, X-rays.

9. Explain briefly *two* of the following :—

(*a*) Why does a stick appear bent when it is partly immersed in water?

(*b*) What properties must a material possess to enable it to transmit sound?

(*c*) How can you determine whether a body is charged with static electricity?

10. Give the names of two important ports in each of the following countries :—U.S.A., China, Australia, Spain, Egypt. Describe briefly one of the sea routes from England to one of the Australian ports in your list.

ELECTROTECHNOLOGY.

Tuesday, June 9th, 1936. 7.0 to 10.0 p.m.

Not more than *seven* questions to be attempted. All questions carry equal marks.

1. Describe the construction and action of a simple Leclanché cell. What are the advantages and disadvantages of this type of cell and for what services is it specially suitable?

2. A lighting installation consists of the following loads :—50, 150-watt; 150, 100-watt; and 200, 60-watt lamps. These loads are fed from a distribution board at which the supply pressure is maintained at 230 volts. The two mains from the dynamo to the distribution board have each a resistance of 0·025 ohm. What must be the pressure at the dynamo terminals?

3. Six single-core cables pass in the same direction through a large inspection box or chamber. Four of the cables are not carrying current but two have direct current flowing along them between a main switchboard and a distribution board.

Explain how you would ascertain which pair of cables is carrying current, and which of this pair is the positive or outgoing cable, and which is the negative or return cable.

4. Define the terms *watt* and *horse-power,* and state the relation between them.

A motor takes a current of 160 amperes at 460 volts from a D.C. supply. If the efficiency of the motor is 85 per cent, what would be its brake-horse-power output at this load?

5. State Ohm's law as applied to D.C. circuits. How is it expressed algebraically?

Three resistances of 2, 5 and 12 ohms respectively are connected in parallel, across a 230-volt D.C. supply. Give a diagram showing the connections and calculate

(*a*) the current flowing through each resistance,

(*b*) the total current taken from the supply,

(*c*) the total resistance of the circuit.

6. State as simply and briefly as possible what you understand by the following :—

(*a*) a 100-watt, 230-volt, gas-filled type, metal-filament lamp.

(*b*) a 40-watt, 110-volt, vacuum-type, metal-filament lamp.

What are the advantages of the gas-filled, compared with the vacuum type of filament lamp?

7. Describe any *four* of the following :—

(*a*) circuit-breaker;

(*b*) double-pole, quick-break, knife switch;

(*c*) distribution board;

(*d*) tough-rubber-protected cable;

(*e*) cut-out or fusible cut-out;

(*f*) 3-pin plug and socket-outlet.

8. What does the electromotive force generated by a dynamo depend upon? Calculate the value of the electromotive force induced in a 4-pole armature, having four parallel circuits, if the armature core has 150 slots with 4 conductors per slot, and revolves at 360 revolutions per minute. The useful magnetic flux per pole is 8·0 megalines.

9. A standard regulation respecting the installation of cables is as follows :—

> "Cables carrying alternating current, if installed in metal conduits, shall always be bunched, so that the outgoing and return cables are drawn into the *same* conduit".

State and explain the reasons for this regulation.

10. What is meant by *resistivity* or specific resistance of a conductor?

A 37/·072 inch cable has a cross sectional area of 0·15 square inch, and a maximum current-carrying capacity of 152 amperes. What is the greatest length of this cable (lead plus return) which may be used with maximum current flowing so that the pressure drop does not exceed 2 volts? (Resistivity of copper = 0·00000066 ohm per inch cube).

11. Why is it necessary to use a "starter" in conjunction with a D.C. motor?

Give a simple diagram showing the connections of a D.C. series motor to starter and main supply.

For what class of work is this type of motor specially suitable?

12. What do you understand by the terms "Direct Current" and "Alternating Current"?

What are the essential differences in the construction of a generator which supplies D.C. and one which supplies A.C.?

MATHEMATICS.

Thursday, June 11th, 1936. 7.0 to 10.0 p.m.

Not more than *six* questions to be attempted. All questions carry the same marks.

1. Solve the equations :—

(*a*) $\left.\begin{aligned} 2x+3y+z &= 2 \\ x-2y-z &= 5 \\ 5x+4y &= 7 \end{aligned}\right\}$

(*b*) $x^2-6px-5p^2=0$

s and θ are two quantities connected by the laws $s=a\theta^n$. Write this equation in a form connecting log s and log θ, and find the value of n if $s=5{\cdot}2$ when $\theta=2{\cdot}7$ and $s=6{\cdot}7$ when $\theta=3{\cdot}3$.

2. Define the logarithm of a number to the base 10, and from your definition prove that

$$\log_{10}\left(\frac{a^m}{b^n}\right)=m\log_{10}a-n\log_{10}b.$$

Use logarithms to evaluate s from the formula

$$s=\frac{2\pi}{T}\sqrt{\frac{K^{1\cdot4}-a^{1\cdot4}}{Ka}}$$

given $\pi=3{\cdot}142$, $T=8{\cdot}713$, $K=1{\cdot}723$, $a=0{\cdot}987$.

3. Prove the formula which is used to convert common logarithms to Napierian logarithms. Use your formula to find

(i) $\log_e 1{\cdot}973$.

(ii) $\log_e 0{\cdot}8$.

The capacity C per foot of a wire is given by the formula

$$C=\frac{33{\cdot}9}{2\log_e\frac{L}{r}-0.62}$$

Find the value of c if $L=215$ and $r=0{\cdot}18$.

($e=2{\cdot}718$).

4. Plot the graph of $y=\frac{12}{x^2}+x$ between the limits $x=1{\cdot}5$ and $x=5{\cdot}5$.

Determine as accurately as your graph permits the least value of y in this interval, and the value of x for which this least value occurs. Use your graph to find the two positive roots of the equation $4x^3-21x^2+48=0$.

5. What is meant by the slope of a straight line graph? Show that the slope of the line $y=mx+c$ is m.

The following table gives pairs of values of quantities p and d, which are connected by a law of the type $p=a+bd^3$.

d	=	1·21	1·35	1·42	1·51	1·58
p	=	5·25	6·76	7·65	8·93	10·02

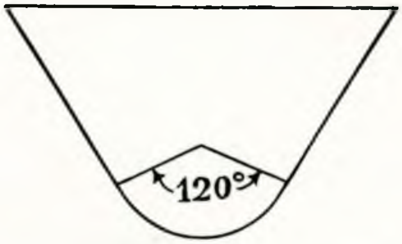
Plot a graph with values of p as ordinates and values of d^3 as abscissae. From your graph determine the best value of b. Use this value of b to determine that of a.

6. Prove that in any triangle the sides are proportional to the sines of the opposite angles.

P and T are two landmarks, T being in a direction N.27°W. from P. From a point A the bearings of P and T are N.38°50′E. and N.17°28′E. respectively. From a point B 210 yards due East of A the bearing of P is N.12°30′E.

Calculate the distance PT and the distance from A of the point at which a line due North and South through T cuts the line AB.

7. A truck for carrying ballast has a uniform cross-section of the form shown in the diagram.



The curve at the bottom is an arc of a circle of radius 1ft. and subtends an angle of 120° at its centre. The total depth is 2ft. 9in. while the width at the top is 4ft. If the length of the truck is 5ft. 6in. calculate its carrying capacity in cubic feet.

(Neglect the thickness of the material).

8. The base of a channel is a horizontal rectangle 4ft. wide by 100ft. long, and its sides slope outwards from the bottom at 40° to the vertical. If the depths of the channel at its ends, which are vertical planes perpendicular to its length, are 5ft. and 7ft. 6in. and its upper edges are straight lines, find the areas of the end sections and of the half way section.

Using Simpson's Rule, or otherwise, estimate the weight of earth removed if 1 cubic yard weighs 28cwt.

9. If ABC is a triangle in which the angle A is acute, prove that

$$a^2=b^2+c^2-2bc \cos A.$$

M and N are the feet of two vertical chimneys PM and QN and A is a point on the same horizontal plane as M and N. The angles of elevation of P and Q from A are found to be 50°30′ and 33° respectively. If AM=250ft., AN=280ft. and angle MAN=41°, calculate the inclination of the line PQ to the horizontal.

10. Prove the formula $\Delta=\frac{1}{2}$ bc sin A for the area of a triangle.

ABC is a triangle having AB=3in., BC=4in., and CA=6in. P, Q and R are points on BC, CA and AB respectively (not produced) so that the areas of the triangles ARQ, BPR, and CPQ are each one fifth that of ABC. Obtain three equations involving the lengths AR, BP and AQ and solve these equations.

APPLIED MECHANICS.

Friday, June 12th, 1936. 7.0 to 10.0 p.m.

Not more than *six* questions to be attempted. All questions carry the same marks.

1. State Newton's First Law.

A stone is thrown out horizontally from the top of a cliff with a velocity of 50 feet per second. It reaches the sea 2½ seconds later. Neglecting air resistance, calculate

(*a*) the height of the cliff above sea level, and

(*b*) the angle at which the stone strikes the water.

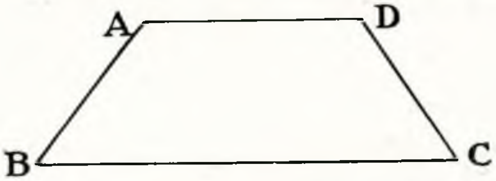
2. Distinguish between a Vector quantity and a Scalar quantity. A flywheel 4 feet in diameter is revolving steadily at 300 revolutions per minute. Calculate the acceleration of a mark on the rim, and give its direction. Prove any formula you use.

3. Sketch the arrangement of a Weston pulley block, or any other type of differential pulley block, and show how to calculate the velocity ratio of effort to load. With a particular block the effort moved 24 times as fast as the load. If 19½ pounds effort lifted 154 pounds load calculate the efficiency for this load.

4. Explain how an accurately made scale pan balance ensures that the observed weight of a body shall not depend on its position on the scale pan during weighing.

Sketch an arrangement of levers suitable for a platform weighing machine, or a multiple lever testing machine, or ordinary weighing scales, and show that the arrangement gives accurate weighing.

5. A piece of flat sheet metal is cut into the shape of a trapezium ABCD. AD is 4 inches long, BC is 6 inches long and AB=DC= 4 inches. The angle ABC and DCB are equal to one another. Set the shape out on your paper and find the position of its centre of gravity graphically. If the piece of metal is suspended by a thread at A which point on BC will hang vertically below A?



6. State Newton's Second Law.

A motor car weighing 1 ton and moving at 30 miles per hour is brought to rest in a distance of 40 feet. Calculate its deceleration assuming this to be uniform, and obtain also the stopping force due to the brakes.

7. A weight of 10 pounds is placed upon an inclined plane the angle of which can be varied. If the angle is increased until the body just begins to slide down, calculate the angle of slope. The co-efficient of friction is ·6. If the angle is adjusted to be 45 degrees, show on a diagram the forces acting on the body if it is prevented from sliding down by means of a string parallel to the slope of the plane, and calculate the tension of the string.

8. Explain how you would proceed to find the modulus of elasticity of a long steel wire experimentally. If the modulus of elasticity of steel is 30×10^6 pounds per square inch, how much will a steel rod, which is 20 feet long and 1 square inch sectional area, stretch if a tensile force of 7 tons is applied to it.

9. Define bending moment.

A beam 20 feet long, simply supported at its ends, is loaded with 2 tons and 5 tons at 6 feet and 16 feet respectively from the left hand end. Calculate the forces on the supports and the values of the bending moments due to the loads at the points of application. Sketch the bending moment diagram.

10. A beam of rectangular section 2 inches wide × 4 inches deep is used as a horizontal cantilever. It is 6 feet long from the fixed wall end. A load of 200 pounds is suspended from its outer end. Calculate the highest tensile and compressive stresses in the material due to this load. State the assumptions underlying your formulæ.

MACHINE DRAWING.

Monday, June 15th, 1936. 7.0 to 10.0 p.m.

Section A and any *two* questions from Section B should be attempted.

Section A.

The accompanying sketches give details of a piston for a steam engine cylinder of 42 inches diameter.

You are required to draw to a scale of 3 inches to 1 foot the following views:—

(*a*) Elevation, half in section on the centre line, and half outside view.

(*b*) Half plan (the half which lies below the centre line).

[In these two views, dotted lines may be omitted; also the junk ring is to be shown bolted in place, but the packing ring is to be omitted].

(*c*) A detailed view, ***half full size,*** of a section on the line AA, showing edge of piston, packing ring, junk ring, bolt and special nut, etc., all properly assembled and ready for service.

On the most convenient views you are to show:—

(i) A method of locking the main piston rod nut.

(ii) A method of locking the junk ring bolts and nuts.

(iii) The materials used for the various parts.

The details and dimensions of the main piston rod nut, and the junk ring bolts and nuts are left to your discretion.

Note that the packing ring need not be drawn accurately as regards detail, but only as regards overall sizes.

Section B.

Attempt any *two* questions in this section.

1. What is the general composition of the alloy known as "white metal"? What are its main advantages as a bearing surface?

Describe some method of "lining" a cast steel bearing with white metal.

2. Compare the characteristic properties of cast iron, wrought iron, and mild steel. Discuss the way in which these properties determine their employment for the various parts of an engine.

3. Poppet valves are sometimes used to control the distribution of high pressure superheated steam. Discuss the advantages and disadvantages of this type of valve compared with the slide valve type.

4. Sketch the various types of screw thread in common use and state the purposes for which they are generally used.

HEAT ENGINES.

Tuesday, June 16th, 1936. 7.0 to 10.0 p.m.

Not more than *six* questions to be attempted. Callendar's Steam Tables, and Entropy diagrams, are supplied for the use of candidates. All questions carry equal marks.

1. One pound of air at 120 degrees Centigrade and at a pressure of 80 pounds per square inch absolute expands to 40 pounds per square inch absolute according to the law $PV^{1 \cdot 2}$ = a constant. Given R (the gas constant) equals 96·3 foot pounds per pound per degree Centigrade, find (*a*) the initial volume, (*b*) the final volume, (*c*) the final temperature, and (*d*) the work done in foot pounds during the expansion.

2. The following figures were obtained on a test of a double acting condensing steam engine, with the cut-off constant but with the initial pressure varied for each load :—

I.H.P.	12·5	21	28·8	43·2
Steam consumption in lb. per hr. ...	451	608	752	1040

The inlet steam pressure for an indicated horse power of 30 is 180 pounds per square inch absolute, the dryness fraction 0·92, and the exhaust vacuum 26·32 inches of mercury; the barometer reading is 30 inches. Find the indicated thermal efficiency for the above indicated horse power.

3. A tank contains 120 gallons of fresh water at 12 degrees Centigrade. It is required to heat this water to 82 degrees Centigrade by blowing in steam at 80 pounds per square inch absolute and of dryness fraction 0·88. What will be the final weight of water in the tank? Explain how the above method can be used to determine the dryness fraction of a sample of steam and state what precautions should be taken in order to obtain a good value for the dryness fraction.

NOTE.—1 gallon of fresh water weighs 10 pounds.

4. Describe, with the aid of a diagrammatic sketch, how forward and astern running are obtained by means of a Stephenson's link motion. What is meant by "linking up"?

5. The mean pressure during the expansion stroke of a four cylinder oil engine, working on the four stroke cycle, is 122 pounds per square inch, and during the compression stroke 38 pounds per square inch. The engine develops 40 brake horse power when the speed is 250 revolutions per minute, and the mechanical efficiency is 80 per cent. If the stroke is 1·25 times the cylinder bore find the cylinder dimensions. Assume the suction and the exhaust to take place at atmospheric pressure. If the fuel consumption is 0·42 pound per brake horse power hour, calculate the weight of oil delivered by the fuel pump to each cylinder per cycle.

6. The analysis of the coal used on a boiler trial gave 86 per cent. of carbon, 3·8 per cent. of hydrogen, and 4 per cent. of oxygen. Determine, from first principles, the amount of air theoretically required for the complete combustion of 1lb. of this coal. State the constituents of the flue gases, and explain why more air is used per pound of coal in practice than is theoretically necessary. (Atomic weight: C, 12; O, 16; and H, 1. Air contains 23 per cent. of oxygen by weight).

7. Sketch the theoretical pressure-volume diagram for a Diesel engine operating on the four-stroke cycle, and describe, in correct sequence, the events of the cycle. Make a drawing of a valve-timing diagram for the engine and indicate clearly thereon the periods of opening and closing of the various valves.

8. The speed of the blades of a de Laval steam turbine is 1,200 feet per second, and the inclination of the axis of the nozzle to the plane of rotation of the wheel is 20 degrees. The velocity of the steam leaving the nozzle is 3,400 feet per second. If the steam enters the blade passages without shock find the blade angle at inlet.

Assuming no change in the magnitude of the relative velocity of the steam in passing through the blade passages, find the force on the blades for a steam flow of one pound per second. The blade outlet angle is the same as the blade inlet angle.

9. Explain what is meant by "equivalent evaporation from and at 212 degrees Fahrenheit".

Two boilers of a certain ship were fitted with mechanical stokers of the underfeed reciprocating ram type and the following readings were obtained on a trial of six hours duration :—

Steam pressure, 215 pounds per square inch absolute; dryness fraction, 0·94; feed temperature, 200 degrees Fahrenheit; water evaporated, 138·9 tons; coal used, 14·72 tons; calorific value of the coal, 13,070 B.Th.U. per pound. Find the thermal efficiency and the equivalent evaporation from and at 212 degrees Fahrenheit per pound of coal.

10. You are required to carry out a series of tests on an internal combustion engine with the object of determining the fuel consumption per brake horse power hour and the brake thermal efficiency at increasing loads. State the apparatus you would require, and make out a log sheet for the insertion of the readings. Set down a list of the necessary deductions from the readings, and carefully explain how each item is calculated. Show typical curves plotted to a base of brake horse power.

INSTITUTE NOTES.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, July 6th, 1936.

Members.

David Blair Coupar, 64, Eltham Road, Lee, S.E.12.

Alexander Arthur Christian, The Nook, Four Marks, Alton, Hants.

Marinos Georgiadis, 6, via Galata, Genoa, Italy.

James Hamilton, 10, Dudley Drive, Glasgow, W.2.

John Mackintosh, 3, Carriagehill Drive, Paisley.

Ewart Alfred Palliser, 22, Charlotte Street, Redcar, Yorks.

George Henry Paulin, Cottesloe, Bilton, Rugby.

Robert Taggart, 200, Cansfield Grove, Ashton-in-Makerfield, Wigan.

William Charles Ogilvie Taylor, 19, Castellan Avenue, Gidea Park, Romford, Essex.

Prudent Constant van Steene, Rue Emile Banning 32, Antwerp.

Associate Member.

Leonard Vernon Kicks, Eastwood, Arnold Road, Gravesend, Kent.

Associates.

John Andrew Beckwith, 40, Stephendale Terrace, Newcastle-on-Tyne, 6.

Horace Frederick French, 23, Chadwell Road, Grays, Essex.

William Jack, 19, Croftside Avenue, Glasgow, S.4.

Eric Pemberton, 24, Walton Crescent, Lower Walton, Warrington.

David Richardson, Hewley, Granville Avenue, West Hartlepool.

Robert Wood, 83, Brunswick Road, Ealing, W.5.

Students.

Victor Ernest Beecher Bannister, 121, Hesperus Crescent, Millwall, E.14.

Robert William Reader, 6, King's Avenue, Rochester, Kent.

ADDITIONS TO THE LIBRARY.

Purchased.

Classification for Works on Pure and Applied Science in The Science Museum Library. 3rd edition. H.M. Stationery Office, 5s. net.

Oil in Navigable Waters Act, 1922. H.M. Stationery Office, 3d. net.

King's Regulations and Admiralty Instructions (Amendment K.R.5/36). H.M. Stationery Office, 3d. net.

Presented by the Publishers.

The following British Standard Specification :

No. 679-1936. Protective Glass for Welding and other Industrial Operations.

Transactions of The Institution of Engineers and Shipbuilders in Scotland, Vol. 79, 1935-36, containing the following papers :—

"Radio in Relation to Shipping", by Gill.
"Recent Developments in Steel Frame Construction", by Kavanagh.
"The Voith-Schneider Drive", by Clerc and Goldsworthy.
"Electrification of the Glasgow District Subway", by Bruce.
"Diesel-Electric Paddle Boat 'Talisman'," by Inglis.
"Echo Sounding Equipment for Ships", by Hutchings.
"The Application of Light Alloys in General Engineering Design", by Clavey.
"Modern Marine Auxiliary Plant", by Hillier.
"The Corrosion Problem in Steel", by McCance.
"Ship Ventilation", by Glass.
"The Development of the Autogiro", by Weir.

"Patents for Inventions", by J. E. Walker and J. Roscoe. Sir Isaac Pitman & Sons, Ltd., 243pp., 15s. net.

This is essentially a book of reference. The Authors are barristers-at-law, with B.A. and B.Sc. degrees, who have specialised in Patent Law, and have here set out clearly and concisely the practice relating to patents for inventions, the steps an applicant must take to obtain a patent, the difficulties he may encounter, and the way to meet them.

It is shown that in the case of a really new, useful, and ingenious invention there is no great difficulty in obtaining a patent which may be of considerable value, and of establishing its validity if challenged. Lists of cases of "sufficient" and "insufficient" inventive ingenuity are given and a study of these is recommended before the would-be patentee expends too much time and trouble on a new device which may or may not turn out to be profitable. For instance, the use of steam at high pressures where it had been previously used at ordinary pressures for the same purpose was considered to possess sufficient inventive ingenuity, as also were the application of a truss as used in bridges to the framework of a bicycle saddle, and the use for aluminium welding of a flux previously used for soldering. On the other hand, making a surface adapted for a spirit level on an old article, adapting a side guard previously used for trams to motor omnibuses, and putting celluloid flanges on eyelets of boots, were held to be of insufficient inventive ingenuity to merit the grant of a patent.

The lesson to be drawn from a perusal of this volume is that one would be well advised to consult a reliable patent agent as soon as a likely invention begins to take shape in one's mind, and it is particularly desirable before so doing to set out as clearly as possible by written description and sketches what are considered to be the novel features. In this connection another book by the same publishers might be found useful, viz., "Practical Advice to Inventors and Patentees. Inventions and How to Patent Them", Linley, 3s. 6d. net.

Quite frankly one must say that the larger book here reviewed is rather more comprehensive and legal than is required by the ordinary practical engineer. Very full information is afforded on every aspect of the subject, including the rights and liabilities of patentees, with innumerable footnotes and references. Members will be glad to know where this valuable knowledge can be found.

"Deep Diving and Submarine Operations", by Robert H. Davis. The Saint Catherine Press, Stamford Street, S.E.1, 510pp., illus., 18s. net.

The task of reviewing Mr. Davis' book on deep diving and submarine operations has been an exceedingly pleasant one. The book itself, besides being a mine of information on the subject, is also extremely entertaining. Produced as "a manual for deep sea divers and compressed air workers", the volume is essentially informative and primarily a textbook for all engaged in diving or having responsibility for work involving diving. Incidentally, the word "diving" may be taken to include not only the ability to remain safely in liquids, but also the ability to remain safely in spaces filled with poisonous gases.

It is impossible in a short review to do more than hint at the scope of the book, but, briefly, it is divided into two parts, the first presenting a summary of the present state of the art of deep diving, research in deep diving, poison gas and high altitude problems, the second, a section entitled "Secrets of the Deep" and containing a long and intensely interesting series of stories and records of important salvage and like operations.

The book is a large handsomely produced volume on art paper, copiously illustrated and running to over 500 pages.

"Maintenance of High-speed Diesel Engines", by Arthur W. Judge, A.R.C.Sc., D.I.C., Wh.Sc. Chapman & Hall, 192pp., illus., 10s. 6d. net.

Now that high-speed Diesel engines of similar type to those used for road transport are beginning to be used as auxiliaries on board ship, this book dealing with their maintenance should be found useful by the marine engineer. The author has drawn upon the experience of most of the manufacturers of engines of this type and also on that of makers of the most commonly used accessories, such as Messrs. C. A. V. Bosch, the makers of fuel injection equipment.

Before dealing with maintenance proper, the working principles and a description of the best known makes of engines are dealt with in the first two chapters. Chapters III to IX deal with maintenance of the engines with special reference in many cases to individual makes. One point that the marine engineer will not find to his liking is that the author has quoted maintenance schedules specially prepared by the various makers for road vehicles, giving periods between the overhauls required in miles traversed by the vehicle, whereas the marine engineer is concerned with the running hours of the engine.

Chapter X should be found very useful as it describes the procedure for starting the various types of engines and gives a fairly comprehensive list of troubles that may occur and corresponding probable causes of the particular trouble experienced. This list is summarised in the fault-finding chart given at the end of the book.

The maintenance and a description of various accessories such as glow plugs, filters and fuel injection equipment are given in the last two chapters, XI and XII.

Generally, the book is well-written and should be easily understood by the engineer in charge of these types of engines, but it is regrettable that several mistakes have occurred in the printing of this first edition. On page 7, in dealing with fuel pump setting, all angles should read in degrees whereas several have been printed in error as seconds. This same error occurs again on page 92 with reference to valve face angles.

On page 58 the sixth line from the bottom should read:—"The speed is 35 r.p.m., with two *feeds,* viz., ·020 in per".

The author quotes on page 42 a specification for lubricating oil recommended by the makers of A.E.C. high-speed Diesel engines, in which the specific gravity at 60° F. is defined as not to be below 0·900 nor to exceed 0·901. There must be a mistake in one or possibly both of these figures as it is very unlikely that an oil could be obtained to fall between these extremely narrow limits for specific gravity. Also it is not made clear that although this specification is approved by the makers of A.E.C. engines, oils of other specifications may be equally satisfactory for the A.E.C. engine and also for other makes. The best method of determining whether a certain oil is satisfactory or not, is to submit its specification to the engine maker concerned for approval.

The book does not deal in any way with supercharged high-speed engines which are now more frequently installed where compactness and lightness are essential. A chapter dealing with superchargers would be a very useful supplement to the future editions which the worth of this book ensures will be published in due course.

"The Testing of Internal Combustion Engines", by S. J. Young, B.Sc., and R. W. J. Pryer, B.Sc. The English Universities Press Ltd., 200pp., illus., 8s. 6d. net.

The book describes in detail various tests on small internal-combustion engines up to 60 b.h.p. The tests are more thorough than those usually carried out by students taking a course in heat engines. The Authors rightly stress the importance of accurate observations and the necessity for sufficient time to tabulate and analyse the results.

The tests deal with fuel consumption and efficiencies at various loads and speeds, also the effects on these of alterations to ignition and valve timing. Various methods of measuring fuel consumption, air consumption and brake horse power are given, and several types of indicator are described.

The work is well set out, and numerous diagrams, graphs and illustrations amplify the text. The book should appeal to all students interested in internal-combustion engines. The marine engineer will find the book interesting, but it will be of little use to those desiring information on the practical running and adjustment of the types of internal-combustion engine used in marine practice.

"Steam Turbine Operation", by W. J. Kearton, D.Eng. Sir Isaac Pitman & Sons, 2nd edn., 346pp., illus., 12s. 6d. net.

Although numerous text-books exist on the design and construction of steam turbines, their operation, including installation, repairs and upkeep, is a relatively neglected field. Mr. Kearton's authoritative work on this subject was first published in 1931, and its deserved success has resulted in the present new and enlarged edition.

A wealth of practical instruction, fully illustrated with sectional drawings, diagrams and performance charts, is contained in the chapters on heating and drainage, glands and gland sealing, lubrication, governors, starting and stopping turbines and their inspection and overhaul. There are also chapters on turbine troubles and testing, and on the Ljungström turbine. Two new chapters dealing with the practice of regenerative feed-heating in power stations and the erosion of blading in the low-pressure stages of steam turbines of large output are noteworthy.

Although mainly devoted to land power station practice, the contents of the book in all essentials are equally applicable to marine work. It is a volume that we warmly commend to all members as a desirable addition to the marine engineer's library.

"Air Conditioning and Engineering". Edited by the Engineering Staff of The American Blower Corporation and Canadian Sirocco Co., Ltd., Detroit, Mich., U.S.A., 332pp. illus., $5 net.

This practical book is of American origin. It is obviously written as an aid to the instruction and guidance of those who may have but a limited knowledge of the subject, and as a book of reference for those who are more familiar with the technical side of this important branch of engineering science. Much data on the subject is to be found throughout the various technical and scientific publications, but, as is well known, it is always difficult of access just when wanted and to correlate by reason of being isolated or scattered, and there must be much more as yet unpublished remaining on private files and in note-books. With American thoroughness and frankness the publishers have collected and presented in one volume just that which is of value for an intelligent study and understanding of this most important science, and have systematically arranged the subject matter so as to form a valuable book of reference. Research and mathematical accuracy combined with experience are a basis for development towards efficient methods in the application and design of apparatus, and there is here given the accumulated data resulting from the long and varied experience of the publishers in this special branch of engineering.

The book is divided into two sections, one being devoted to technical matters and the other to apparatus and equipment. Section I, which deals with technical considerations, comprises twenty-two chapters, each dealing with essential subject matter relevant to the completed work, while chapter twenty-three is devoted to ready reference tables and conversion factors; there is also given an index which proves useful. From a careful reading of the text one is impressed by the method of presenting the subject matter in readily understandable form, an indication that the work has been prepared by experts. It would be difficult to find elsewhere, within the limits of a single volume, such a wealth of ready and reliable information.

Section II is devoted to apparatus, equipment, dimensions and capacity tables, and by its very nature forms a most complete catalogue. The illustrations, performance curves and tables are well worthy of the high standard demanded of such an important publication. A welcome innovation is introduced by giving concrete examples, fully worked out, together with hints on the selection of the most suitable equipment to meet the given conditions. This is invaluable to users. In fact the whole contents is presented in such a practical manner that users of air-conditioning equipment, by the aid of this book, may solve their engineering problems, leaving to the experienced engineers the solution of only the most intricate applications.

The publishers and the editorial staff are to be congratulated on the excellence of their joint efforts in dealing with this subject, embracing as it does such varied and comprehensive applications.

While principally dealing with land applications the book is not without interest to marine engineers and naval architects. On board ship similar air conditioning problems present themselves in ventilation, heating, cooling, refrigeration, temperature control, combustion and mechanical draught, all of which are becoming increasingly important and call upon this science for assistance in the solution of the many complex problems. To all engineers this publication will be found invaluable; it will be a welcome addition to every engineer's library, and especially so in the case of those who are interested in air-conditioning and engineering.

"Combustion Chamber Design for Oil Engines", by Paul Belyavin. Constable & Co., Ltd., 88pp., illus., 3s. 6d. net.

No doubt the fact that there are so many different types of combustion chambers fitted to Diesel engines has prompted Mr. Belyavin to write this book. The author is well-known for his work in connection with research on the Diesel engine, and this small volume which, as the title suggests, deals entirely with the design of combustion chambers, can be recommended to all those interested in this difficult problem.

The book, which is well and clearly written, opens with a brief historical survey of early types of combustion chambers fitted to hot-bulb and semi-Diesel engines. Chapters are devoted to the basic requirements of the design, heat losses during combustion, the importance of the correct shape, efficiency of fuel injection, and the work concludes with a survey of existing combustion chambers of the pre-combustion and open type. The author evidently favours the open type combustion chamber and on this question he states that "they require very efficient fuel injection and design to get the best out of them, but this best is worth striving for". In the chapter dealing with combustion chamber efficiency a number of interesting curves relating to fuel consumption and mechanical efficiencies are given. The author is to be congratulated upon the lucid manner in which he deals with his subject.

"Foundations of Technical Electricity", by E. Mallett, D.Sc., and T.B. Vinycomb, M.C., M.A. Sir Isaac Pitman & Sons, 188pp., 89 illus., 5s. net.

As the authors state in their preface "yet another textbook on electricity and magnetism may seem to call for some justification", for their number is legion and every teacher of this subject appears to think that all other methods of approaching and teaching the subject are at fault, and his own, alone, modern and worthy of publication. There is often much to be said for traditional methods. They are usually the result of long experience, but are not always directly applicable to present-day needs and rapid development.

The reviewer quite agrees with the authors in starting their course with the electric current. He himself has practiced this for many years and recommends it, if for no other reason than that it grips the interest of the student at the outset. It is a sound axiom of education to proceed from the known to the unknown.

There is not the slightest doubt that the book will be a success. Somewhat of the nature perhaps of the huge success which attended the publication of "Castle's Practical Mathematics" many years ago, though to equal this there will have to be in like case many changes in examination syllabuses to suit the more modern teaching and requirements. The call for the book is under somewhat similar circumstances, but there are many who now recognise the fact that the more direct method advocated, although apparently easier and more practical, is not always the best and shortest. The more intelligent students will ask questions not answered by this method, and sooner or later time must be spent on the omitted portions. Even the authors, while deprecating the early teaching of the ebonite rod and piece of flannel, refer on the very first page of the book to the production of electricity by the rubbing of amber or jet, and give an appendix on units of more than seven pages (mainly for teachers) to show the way in which the subject as developed in this book may be linked up with the historic or classical method. The whole idea of the book is *time-saving,* and the authors quite rightly contend that their method of treatment and teaching results in "that part of the subject which is essential in all applications of electrical engineering being reached much earlier than by the old method". Since this is of paramount importance to the evening student, we have no hesitation in recommending the book both as a starting point and a stepping stone to more specialised work.

The book contains only five chapters of which a very brief outline is given below:—

I. Electric current—conductors, electrolysis, Ohm's law, Wheatstone's bridge, etc.

II. Condensers and electrostatics—condensers in series and parallel, in a.c. circuits, capacitance, etc.

III. Electromagnetics—the motor effect: magnetic fields, etc.

IV. Electromagnetics—the generator effect: e.m.f. inductance in a.c. circuits, etc.

V. Chemical action—primary and secondary cells.

At the end of each chapter is given a series of experiments on the subject of the chapter. In keeping with the rest of the book these are of practical utility, though the use of "calories" might with advantage be supplemented by "British thermal units" in expt. 2, p. 35, and on p. 9. The exercises, given advantageously at the end of each chapter, together with answers, are both numerous and carefully chosen.

The importance of the book lies as much in what is omitted as in what it contains, and the reviewer would seriously recommend its perusal by all teachers of electrical engineering and telecommunications.

"Electrical Engineering Materials, Tables and Properties", by Frank G. Sublet, M.E.E., B.Mech. E. Oxford University Press (Humphrey Milford), 147 pp., 10s. 6d. net.

The tables which comprise this book contain a great deal of useful information, and the section on materials is particularly good. A large proportion of the information contained in the book is useful from a marine point of view. Unfortunately, the book contains little or no information on V.I.R. and other types of cables. The tables are in British units, but conversion factors are included in the book.

SIXTH ANNUAL GOLF COMPETITION.

The Sixth Annual Competition for The Institute of Marine Engineers' Cup, presented in 1931 by Mr. John Weir, was held at Addington Park, Surrey, on Friday, June 19th, 1936, by kind permission of the Addington Palace Golf Club.

The weather was fine throughout the day. Twenty-six members took part in the morning round for the Cup, which was won by Eng. Rear-

Addington Palace.

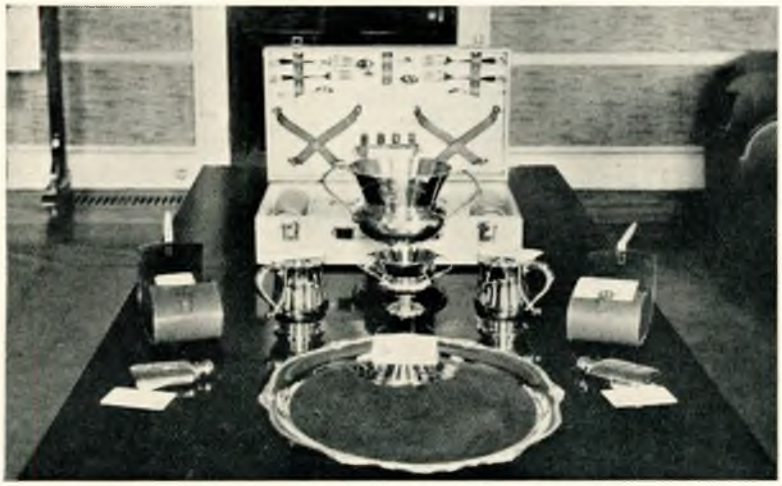
Admiral J. Hope Harrison, after a tie with Mr. R. Rainie, each scoring 71 net. The issue was decided on the score for the last nine holes, Mr. Rainie thereby obtaining the second prize, presented by Mr. T. A. Crompton. The third prize, presented by Mr. A. E. Crighton, was won by Mr. A. J. Walker, with a net score of 72.

A four-ball bogey competition was held in the afternoon, in which 24 members participated. The two first prizes, presented by Messrs. A. Robertson, C.C., and A. F. C. Timpson, M.B.E., were won by Messrs. D. J. Harris and A. R. Langton, who finished 5 up; the second prizes, presented by Mr. W. L. Roxburgh, were won by Eng. Capt. R. D. Cox and Mr. R. M. Gillies, who finished 4 up; and the third prizes, presented by Mr. G. F. O'Riordan, B.Sc., were won by Messrs. W. E. Loveridge and J. A. Rhynas, who tied with Captain Cox and Mr. Gillies, the latter winning a toss for the second prize.

The prizes were presented by Mr. A. H. Mather, Vice-President, who congratulated the winners on their form and the players generally on their very successful and enjoyable meeting. He also voiced the thanks of the Council to the donors of the handsome prizes, and to the Committee and Secretary of the Addington Palace Club for their excellent accommodation of the visitors.

The members present expressed a unanimous desire that a further meeting be held at Addington Palace in the autumn, and the Committee have since arranged that this meeting will take place on Friday, September 25th.

Eng. Rear-Admiral J. Hope Harrison, Winner of the Cup.



The Prizes.

The following members participated in or were present during the day's events:—Messrs. E. F. J. Baugh, F. P. Bell, F. M. Boyes, Eng. Capt. R. D. Cox, T. A. Crompton, B. C. Curling, D. M. Denholm, R. M. Gillies, J. A. Goddard, J. W. Harrington, D. J. Harris, Eng. Rear-Admiral J. Hope Harrison, E. C. Hatcher, R. E. Huggan, E. B. Irwin, W. C. Jones, A. R. Langton, L. J. Le Mesurier, W. E. Loveridge, A. H. Mather, Eng. Rear-Admiral W. R. Parnall, S. Pearson, R. Rainie, J. A. Rhynas, A. Robertson, J. Robinson, H. J. Savage, W. Tennant and A. J. Walker.

ABSTRACTS.

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

Compression-actuated Injection Systems.

"The Oil Engine", May, 1936.

Wherever Diesel engineers meet there is almost invariably keen controversy upon injection topics. All are agreed that the modern jerk-type fuel pump is a highly efficient piece of mechanism, but it has certain arbitrary characteristics which hamper progress. One of the optional methods of delivering metered quantities of fuel to the engine cylinders is by employing part of the compressed air in those cylinders as the operating force for simple metering pumps.

One of the advantages of this principle is the opportunities for cost reduction which it offers. This is particularly important for the conversion of air-injection engines to airless fuel-supply. Several designs are now being tested in this connection, and we deal briefly with three of them as indicative of this trend.

Differential Piston Used.

Generally speaking, the moving portion of these compression-actuated pumps consists of a two-diameter, or differential piston, as it is called. The larger diameter works in a suitable cylinder, and is operated by the engine compression.

The smaller end constitutes the actual pump plunger, and works in a barrel fitted with the usual intake and delivery ports and valves. Thus it will

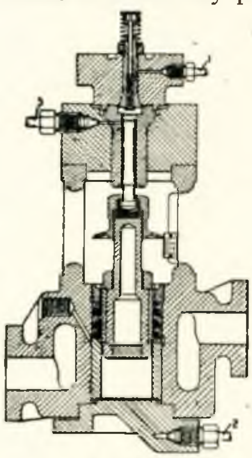


Fig. 1.—The Krupp design with special piston rings for the lower piston.

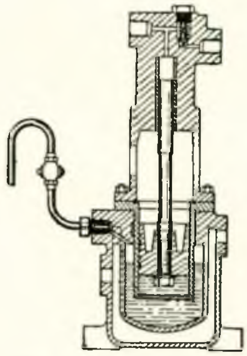


Fig. 2.—The Harland and Wolff pump with hydraulic actuating medium.

be seen that the injection pressure is a definite multiple of the cylinder pressure, and rises and falls in unison therewith. Moreover, the timing of the injection is also of necessity in phase with the cylinder compression.

The first design (Fig. 1) comes from the well-known German concern of shipbuilders, Fried, Krupp, Germaniawerft A.G. The differential-piston principle is employed, the lower piston being subject to engine compression arriving via the pipe (2). This piston and its cylinder are cooled by surrounding water jackets.

The upper plunger forms the fuel pump, receiving oil under pressure-feed from the supply line (1) and discharging into the injection pipe via the connection (3) The patent is based on the special piston rings used on the larger diameter. These, instead of being carried in the moving part, are held in grooves in the cylinder, and are made so as to spring inwardly on to the piston.

The second design comes from V. Mickelsen

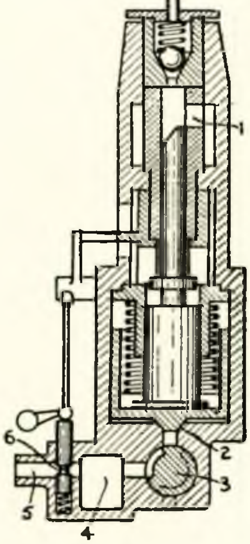


Fig. 3.—Koster and Dussman's design includes a rotary valve for the air.

and F. E. Rebbeck, of Harland & Wolff, Ltd., Belfast. In this arrangement (Fig. 2) the upper pumping portion needs no explanation, the chief novelty resting in the construction of the larger piston and cylinder.

The object of the scheme is to prevent the hot air or combustion products from reaching the working parts, therefore there is a column of liquid between the pressure supply and the piston.

In the illustration the pressure arrives via the pipe on the left, and passes into an annular space around the cylinder, so that the piston is in fact, operated by the rising column of liquid. The liquid presumably would be lubricating oil.

Rotary-valve Control.

Two German engineers, W. Köster and A. Dussman, employ a differential-piston pump operating in a rather different manner. The source of working pressure is not necessarily the engine compression, but any convenient source of high-pressure air. Moreover, the output is controlled by the usual method of a helical control edge on the plunger co-operating with ports in the barrel.

Fig. 3 shows a section of one element of a multi-cylinder pump. Compressed air from an outside source enters the bore (5) and passing a cut-off valve (6) reaches a chamber (4) common to all the elements.

A rotary valve (3) then performs the function of the camshaft in a conventional injection pump, distributing the power to each unit in turn. The air then lifts the valve (2) and raises the large piston, which operates the pump plunger.

"Hammer-blow" Injection.

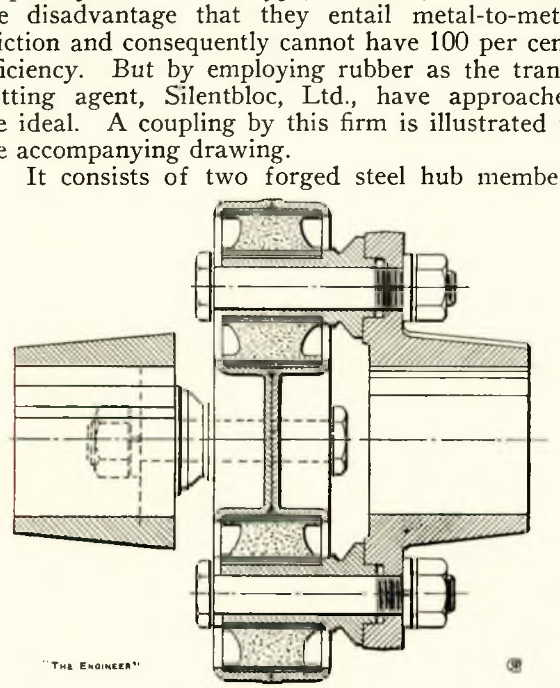
An important feature of this pump is the unusually long fuel inlet port (1). When the plunger rises, it meets with little resistance until this port has been covered, and during this preliminary movement it attains a high velocity, which, in conjunction with its large mass, starts the injection period with practically a hammer blow. This feature is claimed to give extremely fine atomization, coupled with a very short injection time, so little as 3 degrees to 4 degrees of crank angle being claimed to be possible.

The Silentbloc Flexible Coupling.

"The Engineer", 8th May, 1936.

There are many forms of flexible coupling for connecting together driving and driven shafts, which may not be in exact alignment, and of them the Hooke's joint is probably the most classic example. Joints of that type, however, suffer from the disadvantage that they entail metal-to-metal friction and consequently cannot have 100 per cent. efficiency. But by employing rubber as the transmitting agent, Silentbloc, Ltd., have approached the ideal. A coupling by this firm is illustrated in the accompanying drawing.

It consists of two forged steel hub members



Flexible coupling.

mounted on the shafts to be connected. Between these is carried a floating centre to which each hub is separately connected through a pair of resilient rubber trunnion blocks. These trunnion blocks 90 deg. apart, are set under pressure into a two-piece riveted housing of pressed steel. The blocks are moulded over and permanently fastened to steel cores or bushings. These steel cores in opposite pairs are rigidly bolted to the end hub members of the coupling. The outer section of the rubber block, as shown in the illustration, is a fabric ring, so that it is securely held in the pressed steel centre. The shape of the rubber itself has been carefully designed to give uniform stress and deflection throughout its entire area. This feature is naturally of extreme importance and adds greatly to the life of the coupling.

The coupling is made in a variety of sizes which are rated to transmit up to 20 H.P. at 100 r.p.m. At higher speeds they will, of course, transmit greater powers.

Combination Machinery.

"The Marine Engineer", July, 1936.

The recent decision to recondition the well-known Australian liner "Ceramic" is of particular interest, owing to her being one of the last survivors of the outstanding group of ships produced by Harland & Wolf, Ltd., during the immediate pre-war period, and powered with combination machinery. It is not generally realised that, prior to the advent of the "Queen Mary", three* out of the four largest British-built merchant ships had been constructed at Belfast, and engined on this system, while still further developments were stopped by the outbreak of hostilities. The introduction by Denny's (into the "Otaki" and "Rotorua") of a triple-screw installation of reciprocating engines on the wing shafts, which exhausted into a low-pressure turbine in the centre, was carried a stage further with the first "Laurentic", of 1909, and rapidly reached its zenith when the "Olympic" was commissioned in June, 1911. Other notable Harland & Wolf installations of that time included the Royal Mail and P.S.N. liners of the "Arlanza" and "Orduna" class, the "Euripides" and "Katoomba" and the first "Statendam", which was launched shortly before the war, and subsequently lost as the "Justicia". It is, perhaps, of interest to recall that this ship was 740ft. in length, and had a gross tonnage of 32,120 tons. The "Minnekahda" and "Belgenland" appeared during the latter part of the war, and Barclay Curle's built the C.P.R. "Meleta" and "Minnedosa" at about the same time. In addition to the triple-screw installations, the system was developed in France on a quadruple-screw basis and adopted in this country by Swan, Hunter & Wigham Richardson for the 10,000-ton Spanish Trans-Atlantic liner "Reina Victoria Eugenia", of 1913. At the same time Denny's built

* "Olympic", "Titanic" and "Britannic", of 1915.

a similar vessel, the "Infanta Isabel de Borbon", but retained the original propeller arrangement. The French ships included the C.G.T. "Rochambeau", of 1911, the "Lafayette", of 1914, and the "Flandre", of 1913, the reciprocating engines of the first-named following British practice by being of the four-cylinder triple-expansion type, while four-cylinder compound sets were fitted in the others. The combination system was also adopted in the 15,000-ton Compagnie Sud Atlantique liners "Lutetia" and "Massilia",† the latter representing a further development with a four-shaft arrangement, in which three-cylinder triple-expansion engines exhausted into wing turbines. The advent of geared turbines, and subsequently of high-pressure steam, terminated the principle of operating the propellers independently, but improved transmission systems, whereby both sets of machinery are coupled to a single shaft, have resulted in modified versions such as the Bauer-Wach exhaust turbine equipment and the White combination engine, both of which are becoming increasingly popular. The old combination system, of which Mr. W. J. Willett Bruce, the erstwhile superintendent engineer of the White Star Line, was such a staunch advocate, was very economical and reliable, and many of the older marine engineers will regret its passing.

Geared Propulsion Universal in Germany.

"The Motor Ship", June, 1936.

Under construction in Germany for German owners at the present time are nine cargo ships of 63,000 tons d.w.c. to be propelled by geared Diesel machinery. With the direct drive is one vessel of 2,000 tons d.w.c., although there is a very large tonnage of direct-driven cargo and oil carrying ships for foreign ownership. Details of the orders have been given in "The Motor Ship" from time to time, but it is not yet realised by British shipowners and shipbuilders that in Germany geared Diesel propulsion is being *almost exclusively* adopted for cargo vessels. And in Germany alone.

Until this recent development, gearing in combination with high-speed Diesel engines had been under a cloud for some years. It has never attracted the least attention in this country, at any rate so far as practical results show. In Holland, a few steamers have been converted to geared Diesel drive, but only one among the dozens of Scandinavian owners who are now relying wholly on motor ships has employed the gearing system.

The significant fact remains that in Germany, the only country having extensive experience with gearing in oil-engined vessels, the system is now being standardized for new tonnage. We record the fact without, at the moment, expressing an opinion, except that it is clear the policy cannot be ignored. In Germany there is not that ingrained objection to high-speed engines such as exists in this country, and it is also well-known that more attention has been devoted in Germany than in the United Kingdom to the building of large fast-running Diesel motors and suitable gearing.

Whether the geared Diesel propelling plant has definite commercial advantages has yet to be demonstrated. The engine room is apparently not reduced in length, but the height of machinery is less although it is doubtful if there is any saving in weight. The fuel consumption is, if anything, higher, although efficiencies of the gearing and hydraulic coupling of 95 per cent. are claimed, but there is possibly a small economy in capital cost, especially if considerable numbers of engines are built. The lighter weight of the parts to be handled is an asset in operation, and it is notable that all the new geared Diesel installations are to be made with two-stroke machinery.

The subject is, perhaps, one to which a little more attention might be devoted outside Germany; it is, therefore, of special interest that the new Norwegian American Line transatlantic liner will have geared Diesel machinery, and the first large geared Diesel cargo ship for Swedish owners was ordered in Sweden last month; in the latter instance hydraulic couplings are to be replaced by electrically operated clutches.

Corrosion Fatigue in Pistons.

"The Motor Ship", June, 1936.

The problem of corrosion fatigue in piston rods of double-acting two-stroke engines is very fully understood and there is no likelihood of the recurrence of the difficulties which disturbed engine builders and shipowners a few years ago. Hitherto nothing has been heard of the similar troubles in pistons, but recently in a ship equipped with high-speed machinery having water-cooled pistons it was found that cracks developed in the pistons after a certain time, and this time was approximately equal in each instance. It would therefore seem that this represents another case of corrosion fatigue and that its appearance in the particular instance was probably due to the rapidity of heat transference. With a slight reduction in the engine revolutions the trouble did not arise.

It would be interesting to know whether in other cases piston cracks have developed, the causes of which have remained somewhat uncertain. There are obvious means of countering the difficulty, but the utilization of special steel does not seem to be one of them.

The Bulbous Bow.

"Engineering", 3rd January, 1936.

Seven years have elapsed since the launching of the Norddeutscher Lloyd liners *Bremen* and *Europa* brought into prominence the peculiarity of ship form now known as the "bulbous bow", the result of combining fine lines at the water level with

† A third ship, the "Gallia", was lost in war.

U sections in the region of the forefoot. The interest then created will, doubtless, be still remembered, if only for the adroit manner in which a purely technical development was exploited until its publicity value promised to rival that of the more popular features of speed and passenger accommodation. The atmosphere of secrecy was maintained to the very day of launching and, even then, the official photographs were taken from such positions that the exact form of the bow below water was effectively masked by the scaffolding supporting the launching platforms.

In the subsequent years this method of minimising wave-making resistance has been adopted in a number of other fast passenger vessels, notably the *Rex, Conte di Savoia,* and *Normandie.* It has not, so far, found favour with British designers of merchant ships, but the persistence of the ram in high-speed warships, long after its tacit abandonment as a weapon of attack, may be taken as evidence that naval architects were generally aware that some benefit attached to a bulbous bow formation some time before Admiral D. W. Taylor drew attention to the fact, in a paper read before the American Society of Naval Architects and Marine Engineers in 1911.

Two years later reference was made, at the Institution of Naval Architects, to some similar experimental work carried out at the National Physical Laboratory, but, apparently, in neither case was the investigation continued to the point of determining the best form of bulb for particular service conditions, although further American experiments demonstrated that the advantage to be expected was closely connected with the proportions of the bulb and its position in relation to the water line and the forward perpendicular. Experience with ram-bowed warships had shown that the mere presence of a ram was no guarantee of reduced wave-making; for example, the battleships *Swiftsure* and *Triumph,* originally the Chilian *Constitucion* and *Libertad,* although provided with rams not greatly dissimilar from those of their British contemporaries, were conspicuous for the exuberance of their bow waves.

Within comparatively recent years considerable progress has been made in developing mathematically the resistance of totally submerged bodies of simple forms, and also the surface disturbance caused by them when immersed in a uniform stream. In particular it was observed that the surface disturbance due to a sphere moving through water at a constant speed always began with a wave trough immediately abaft the sphere, suggesting that a bulbous flow might act similarly, thus producing a wave trough tending to cancel the bow wave and so to reduce the wave resistance. The supposition has been investigated mathematically, and tested by means of model experiments, by Mr. W. C. S. Wigley, M.A., of the William Froude Laboratory whose conclusions were presented on November 29, before the North-East Coast Institution of Engineers and Shipbuilders, in the form of a paper on "The Theory of the Bulbous Bow and its Practical Application".

Taylor, in his 1911 paper before the American society, had noted that the bulbous formation showed to particular advantage with values of $\frac{V}{\sqrt{L}}$ ranging from 1.0 to 1.2. The early experiments at the National Physical Laboratory, however, indicated that some benefit might be expected at lower speeds, and one of the objects of Mr. Wigley's investigation was to ascertain approximately the speed range over which a bulb could be usefully applied to reduce wave-making; as well as to obtain general guidance as to its proportions and position, having due regard to the necessity of fairing the bulbous formation with the lines of the hull. The method adopted involved a number of assumptions, designed to simplify the calculations, and all effects of turbulence, viscosity and variations in the attitude of the models were neglected, but it was found possible to deduce sufficient information to serve as a useful guide both to further research and to the examination of practical proposals.

The work of Michell provided means for obtaining an expression for the wave resistance of a naked form, symmetrical fore and aft, and that of Havelock gave a similar expression for the resistance of a bulb. On the hypothesis that the energy expended by a body in overcoming wave resistance must reappear as the energy in the wave profile, Professor Havelock showed in a paper before the Institution of Naval Architects in 1934, that a relation could be established between the resistance of a ship and the wave profile at a distance astern of it. By applying this method to the respective resistances of the hull and the bulb, the wave profile due to each was determined and the combined wave profile obtained by a process of simple addition. By substitution it was then found that the combined resistance was the sum of the hull resistance, the bulb resistance and a third factor denominated the "interference resistance" of the hull and bulb, the value of the interference resistance being either positive or negative, according to the relative positions of the hull and bulb, and the speed.

For the addition of a bulb to result in a reduction of the total resistance it is evident that the value of the interference resistance must not only be negative, but sufficient to outweigh the sum of all the resistances introduced by the presence of the bulb. From the equations it was found possible to deduce the best position and size of bulb to satisfy this requirement, the conclusion being that, for a reasonable ship form, the best position would be with the centre of the bulb at the bow, involving a projection forward of the hull. It may be noted that none of the instances previously mentioned of bulbous bows in recent liner practice actually incorporates any forward projection, the forms adopted being approximately those of ram bows "snubbed", in the American phrase, in the sectional plane of the stem and suitably faired.

The necessity of fairing the bulb into the form of the hull is the chief factor operating to limit its size, the effect of variations in beam and vertical height being comparatively unimportant at the deeper immersions. The length of the bulb should be kept as small as possible, for reasons of wave-making. From approximate calculations which the model tests confirmed, Mr. Wigley suggested as a working rule that the upper surface of the bulb should not approach nearer to the surface than a distance equal to its own thickness and that the maximum thickness should be kept as low as possible. In any particular case, however, the beneficial effect would depend to some extent upon the wave-making resistance of the hull itself, the largest gain occurring with a bad form of hull and at speeds where its own wave resistance was high.

The applicability of the results, and their interest for those concerned in the operation of ships, are best illustrated by the useful speed range of the bulb, as deduced from the calculations and supported by the Tank experiments. At low speeds it was found that the bulb produced an increased resistance, owing to the dominance of the resistances due to the form and surface friction of the hull and the bulb. As the speed increases the interference resistance increases rapidly and, if the form and position of the bulb have been well chosen, the total added resistance becomes negative at a value of $\frac{V}{\sqrt{L}}$ of about 0.8 for a full-size vessel. The benefit continues until very high speeds are reached, giving values of $\frac{V}{\sqrt{L}}$ in excess of 1.9. Such a value in the case of an Atlantic liner would correspond to a sea speed of over 50 knots. It may be said, therefore, on the basis of Mr. Wigley's investigations, that some realisable advantage is to be expected from the adoption of a bulbous bow in any "express" liner likely to be built in the near future and in the majority of vessels of the intermediate class with a speed of 19 knots or more. The case of the channel steamer was not specifically discussed. For some it might be beneficial, but in many, if not most instances, limitations of draught might operate to nullify the theoretical advantage of the bulb except under smooth water conditions; and it is a matter of common observation that this requirement is all too seldom satisfied.

Embrittlement of Boiler Steel.

"The Engineer", 15th May, 1936

The troublesome phenomenon of what is known as "caustic embrittlement" of boiler plates is receiving extensive experimental study in order to find some preventive measure. It has been established that caustic soda in the water in contact with steel at high temperatures produces serious embrittlement of the metal. In experiments by the United States Bureau of Mines it was found that sodium hydroxide alone produces either no embrittlement or only a slow and moderate weakening. Commercial sodium hydroxide used in previous experiments was found to contain substantial amounts of sodium carbonate, sodium chloride, sodium silicate, and various metallic oxides. When tested separately as combined with chemically pure sodium hydroxide, the sodium silicate was the only one having noticeable embrittling effect. Steel tubes filled with sodium hydroxide solution at 250° Cent. carried a load of 75,000lb. per square inch for 43 days without failure. But with commercial caustic soda solution failure occurred in less than one day under a load of 70,000lb., or in two to three days under 55,000lb. A corresponding effect was caused by chemically pure sodium hydroxide with 0·15 to 3·0 per cent. of sodium silicate added to the caustic soda solution. A characteristic of the action of silicate-hydroxide solution is the production of a large number of almost completely intercrystalline cracks in the steel. In these tests, flange steel was used, of 58,000lb. tensile strength, 28,000lb. yield point, and 40 per cent. elongation. Stress concentration intensified the weakening effect, as shown in tests with tubes having an eccentric groove turned in the outer surface in order to produce unequal distribution of the tensile stress. Where the active solution was a mixture of silicate and hydroxide, fairly rapid failure resulted even at average loads as low as 20,000lb. per square inch. In practice the trouble occurs usually with alkaline waters containing free sodium carbonate. Both stationary and locomotive boilers are affected.

Inventions and Patents.

"The Engineer", 20th March, 1936.

It is to be hoped that every young engineer who reads the wise and lucid monograph on "Rights to Invention", recently issued to its members by the Institution of Mechanical Engineers, will also read, and ponder upon, the address which Dr. Herbert Levinstein delivered to the Institution of Chemical Engineers on March 6th. Despite the caveat with which it concludes, the "Mechanicals' " monograph, taken with other activities of the Institution, may almost be regarded an an incitement to seek the protection of inventions afforded by our patent laws. Dr. Levinstein shows how unprofitable that course usually is and reveals the financial net which is laid to catch the unwary patentee. There are still many thousands of people who believe that to be able to secure a patent for an invention is the mark of genius and the first step on the road to fortune. Nothing could be further from the true facts. Under the existing system the Patent Office will give its protection to any invention, however obvious, provided there is some element of novelty, however small, in the arrangement of the parts or in the process. No genius is called for in the production of such inventions; a little ingenuity, a little imagination, much patience, and sufficient drawing paper usually fills the list of requirements. It is not surprising that the financial returns for such patents are generally as tenuous as the protection afforded by the patents themselves. Indeed the probability of winning a few pounds in a football pool is far greater than in the "patent pool". Even the really sound patent, as Dr. Levinstein shows, is in a barely better case. For the more valuable it is the more likely is it to be challenged or infringed. It is rarely, indeed, that a patent is both above rubies and above dispute.

An analysis made by Dr. Levinstein provides a means of estimating the chances that one has of making money by a patented invention. In the period 1919 to 1932 only 17·7 per cent. of patents were deemed worth the fee that would have kept them in existence for ten years and only 3·7 per cent. for the whole course of sixteen years. "It may be assumed, therefore", says Dr. Levinstein, "that less than 800 patents are granted annually (out of over 37,000 applications and some 17,000 grants) which are worth while or justifiable, and that approximately 20,000 patents are allowed to become void every year". Whilst it must be admitted that the value of a patent is not necessarily measured by the length of its life, for even in the course of a few years it may have given a profit to its owners, it is very certain that by far the greater proportion of the 20,000 which are sacrificed annually are not worth the cost of renewal for even a single year. Of those that remain it is equally certain that many are held by rich firms and corporations and are of the class that has been aptly described as "keep off the grass". They are not used by the holders themselves, but prevent others from employing the same invention. Fortunately, that is rarely of much consequence, for, on the one hand, it may be said that if an invention is not used it is not essential; and, on the other, that if an equally serviceable alternative were not available infringement would be risked. The latter observation brings out a point to which the Institution of Mechanical Engineers has done well to call the attention of would-be patentees. "Most inventions", it says, "are merely alternatives to others, and if the alternatives can be used freely and are equally useful, or even approximately so, the inventor cannot expect a great reward for his invention". Many and many a "poor inventor" who thinks he is hardly treated by manufacturers has overlooked that point. We may hazard the guess that if every invention could be covered by a master patent then every nation in the world would be extremely cautious in the grant of such monopolies. Fortunately, in mechanical engineering particularly, there are always several ways of attaining a desired object, and the grant of a patent very rarely gives an absolute monopoly to the holder.

But even with the reservation suggested by these considerations, it is almost beyond question that the wholesale granting of patents for inventions is a handicap on progress, and Dr. Levinstein, after giving examples of their ill effects, notes with satisfaction two remedies initiated by the Business of the Courts Committee, whose report was published recently. These two remedies are: To stop at the source any patent the claims of which have not a reasonable chance of being upheld in court: and to make it easier and much less costly to obtain a decision in the courts upon the validity of a patent. At the present time the Patent Office examiners reject about one-half only of the applications for protection. Dr. Levinstein asserts that a much greater number might be turned down. We agree with him. Let anyone study for a few weeks the abstracts of specification which are given in our own and other publications, and they cannot fail to reach the conclusion that in many cases there is little or no novelty in the inventions and certainly nothing that merits protection by the grant of a monopoly. There is only one thing to be said for the present system—it brings revenue to the Crown. It is true that owing to the fundamental worthlessness of the patents the grant in the majority of instances does little or no harm. But there remain others, whose effect, according to Dr. Levinstein, "is very serious on the industry of this country".

Treatment of Fouled Turbine Blades.

"The Engineer", 19th June, 1936.

The fouling of turbine blades in power stations has been the subject of an investigation by the Engineering Experiment Station at the University of Illinois. According to a bulletin recently issued on the subject, in many large stations this trouble has become of major importance, losses of capacity as high as 25 per cent. being reported. The most common type of fouling is that in which there is apparently a deposition of solids carried over in the steam from the boiler water; another less common type is that in which there is apparently a chemical reaction between chemicals in the steam and the material in the turbine blades. As a result of the investigation the following conclusions were drawn:—(1) The basic material causing the fouling of steam turbine blades is sodium hydroxide; (2) certain inorganic salts, such as sulphates, chlorides, and carbonates, if present in sufficient amounts, will prevent the fouling; (3) certain organic salts, such as pyrogallol, sodium benzoate, and sodium gallate, if present in sufficient amounts, will also prevent the fouling. The application of the inorganic salt treatment, while still in the experimental stage, to one large central power plant, reduced the number of turbine washings from twelve a year to four. The cost of the treatment has been very low, being less than $500 per year, and the savings have been materially high, since corrosion also has been prevented.

Extreme Low Temperatures.

The Approach to the Absolute Zero.

"Engineering", 19th June, 1936.

The last of the series of lectures in connection with the Exhibition of Very-Low Temperature Apparatus at the Science Museum, South Kensington, was delivered by Professor F. Simon, Dr. Phil., of the Clarendon Laboratory, Oxford, on May 27th. A particularly interesting feature of the lecture was the demonstration given of the utilisation of the magnetic properties of certain salts for the attainment of temperatures closely approaching the absolute zero. For the experiment, the lecturer used a small helium liquefier of the expansion type, which first produced liquid helium at a temperature of 4° C. absolute. By pumping off the gaseous helium, however, a temperature of 1° C. absolute was obtained. Liquid hydrogen, the temperature of which was also reduced by pumping, was used for pre-cooling the helium. Inside the helium liquefier a small quantity of the paramagnetic salt iron-ammonium-alum had been placed, and the effect of applying a magnetic field to this salt was to change the orientation of the molecules with a liberation of heat. This heat was absorbed by the cooled liquid helium, so that the crystal, with the field still applied, returned to the temperature of 1° absolute. The field was then removed and the molecules of the salt, in returning to their original random orientation, absorbed sufficient heat to reduce the temperature to 0·12° C. absolute. Professor Simon explained that with larger magnets and pumps of higher capacity than those actually employed in the demonstration, still lower temperatures could be reached. In the course of his lecture, Professor Simon said that in experiments which he had carried out in conjunction with Kürti, Rollin and Lainé at the Académie Française, it had been shown that the paramagnetic salts used became ferro-magnetic at very low temperatures. Experiments had also shown that the limiting temperature region for the method referred to lay between 0·01° and 0·001° C. absolute. He mentioned, however, a new method involving the utilisation of nuclear paramagnetism, and expressed the view that this would provide valuable new information regarding the properties of atomic nuclei. In conclusion, Professor Simon remarked that there would be a temperature limit to this new method, and although the space between this limit and the absolute zero would be very small when measured in degrees, it was, nevertheless, in reality, an "infinity". We did not know yet what to expect in this region, but if new phenomena continued to occur, we should be able to penetrate into it.

The Evolution of Wheels.

"Engineering", 19th June, 1936.

Writing many years ago, Macaulay said that among the other results of invention were that "it has accelerated motion; it has annihilated distance; it has facilitated intercourse, correspondence, all friendly offices, all despatch of business", and that it had enabled man "to traverse the land in carts which whirl along without horses; to cross the ocean in ships which run many knots an hour against the wind". Though he lived to see the construction of many railways and the launching of many steamships, yet perforce of circumstances, his own journeys were often by coach or chaise, and while he saw that the law of invention was progress, he probably never dreamt of the marvels of the motor vehicle or the aeroplane. The history of transport goes back to the dawn of civilisation, and the extraordinary ease, speed and regularity by which we travel to-day are but the outcome of centuries of human endeavour and the work of thousands whose names have long since been forgotten. It is well, therefore, for us to be occasionally reminded of those early and difficult steps by which progress was first made. In our museums and galleries are preserved many objects illustrating the subject and the abiding interest in the matter of travel is shown by such recent broadcast talks as that on "Speed", by Mr. Max Beerbohm, and on "Travelling in the Seventeenth Century", by Mr. A. W. Bryant. How tedious, uncomfortable, slow and dangerous was a journey less than three hundred years ago was well shown by Mr. Bryant in his description of the adventures of his imaginary traveller from a small town in the northern midlands to London.

There are many aspects of the history of travel and transport, for just as local conditions led to the construction of an immense variety of boats and ships, so there arose in various parts of the world many types of sledges, barrows, carts, chariots and wagons. Surely, among the world's greatest benefactors were the inventors of wheels, for as Berthold Laufer wrote in 1914, "Whatever our modern progress in the perfection of land transportation may be, whether we consider our steam engine or motor cars, they all depend upon the basic principle of the wheel—that wonderful invention of prehistoric days, of the time, place and author of which we are ignorant". This quotation we take from Mr. Carl Mitman's "An Outline Development of Highway Travel, Especially in America", which has been reprinted from the Smithsonian Report for 1934. "There are", says Mr. Mitman, "two schools of thought regarding man's discovery of the wheel. The older one, thinking along evolutionary lines, believes that by slow degrees the roller under the sled became a revolving axle, with thin sections of larger logs or discs attached to its ends, and that by and by the discovery was made that when a hole was cut through the centre of the disc, it could revolve freely on the axle.

The second, and newer school, believes that as soon as the value of the roller became known, some individual proceeded directly to perfect a wheel by forming a circle of twisted reeds which was kept in shape by cross braces.

Quite the most interesting of ancient wheels is that preserved in the Cairo Museum of Antiquities, and of which a replica is to be seen in the Science Museum. It is a chariot wheel, and was found in the tomb of Yuaa, father-in-law of Amenophis III, who lived about 1400 B.C. With its six oval spokes morticed into the bent wood rim, its triple tyre of leather, and its axle bearing protected from sand by a leather sleeve, its construction would have done credit to the old carriage builders of Long Acre. The Assyrians, Persians, Greeks and Romans all contributed to the development of wheels and of wheeled vehicles, the Romans having besides chariots, the *cisuim,* a two-wheeled gig; the *clatabulare* a four-wheeled freight and passenger wagon; the *rheda,* a long-distance coach; and the farm cart called the *plaustrum.*

In the Western hemisphere progress by wheeled vehicles was slow until the introduction of the horse from Europe. By the end of the seventeenth century coaches were being imported and as time went on special types of vehicles were developed, of which the Conestoga wagon, the two-wheeled chaise immortalised by Oliver Wendell Holmes as the "one-horse shay", and the four-wheeled buggy are examples. The Conestoga was a ponderous vehicle capable of carrying a load of from 2 tons to 4 tons, which originated in the Conestoga Valley, Lancaster County, Pennsylvania. The buggy was the greatest achievement of American carriage-makers. "American ingenuity", said one writer, "was lavished upon these waggons, and they have arrived at a marvel of perfection in lightness. The perch, axle-trees, and carriage timbers have been reduced to thin sticks. The four wheels are made so slender as to resemble a spider's web. . . . The whole is so slender and elastic that it 'gives'—to use a trade term—and recovers itself at any obstacle". There was a fine show of carriages at the International Exhibition at Philadelphia in 1876, of which Doolittle wrote: "America stood foremost in carriage wheels of best materials and beautiful workmanship, bent rims, turned and finished spokes, morticed hubs, steel tires". At about that time English carriage-makers were advertising to build light carriages "on wheels imported from America".

The horse-drawn carriage, like the sailing ship, was then attaining its highest degree of perfection, and, Mr. Mitman said, one writer on vehicles in 1895 predicted that the buggy, because it was so admirable in all respects and inexpensive, would not go out of use for "at least another century". Already, however, the makers of bicycles and the pioneers of motor-cars were opening up a new chapter in the history of the wheel and its application to vehicles. The wire-spoked wheels of Reynolds and Mays, the tangent-spoked wheel of Starley, the pneumatic tyres of Thompson and Dunlop, were paving the way for the modern motor-car wheels, the most remarkable examples of which are found in racing cars, in which, as Colonel Davidson pointed out in his presidential address to the Institution of Mechanical Engineers, the centrifugal force on the treads of the wheels at a road speed of 300 miles per hour is so high that their thickness has to be reduced to under $\frac{1}{8}$ in.

Though it was outside the scope of Mr. Mitman's review, it may be remarked that the wheels for locomotives have a history of no less interest than that of wheels for road use. From the first, locomotive wheels provided work for the founder and smith rather than the wheelwright. The earliest drawings of Stephenson's Killingworth locomotive show cast-iron wheels with simple straight spokes. At one time wheels were made with cast-iron hubs, wooden spokes and wrought-iron rims. In 1838, a representative of the Paris-Orleans Railway visiting England reported that "The construction of wheels is at this moment the object of interesting research, generally their manufacture in wrought-iron is being attained, with the exception of the hub, which continues to be in cast-iron. Nevertheless there are examples of wheels entirely in wrought-iron, in a single piece, but they may be considered as veritable *tours de force*". Much interesting information on such wheels is contained in the late Mr. Warren's paper, "John Nuttall's Sketch Book with Notes on Wrought-Iron Details and Wheels for Early Locomotives", in vol. xi of the *Transactions of the Newcomen Society.* Accompanying that paper is Nuttall's sketch of the "First wrought-iron wheel that was made" and an appendix on the "Processes in the Manufacture of Wrought-Iron Locomotive Wheels as made up to 1900". The wrought iron locomotive wheel was probably the finest example of the art of the smith, just as the wheel of the American buggy demonstrated the highest skill of the wheelwright. It would, perhaps, be difficult to find another simple device upon which more ingenuity has been expended than the wheel.

Diesel Machinery for High-powered Liners.

"The Motor Ship", July, 1936.

The subject of the installation of Diesel machinery in very fast, large passenger liners in which a total engine output of 160,000 b.h.p. is required, is discussed in an article by Mr. Robert Sulzer, of Sulzer Bros., published in a special Oil Engine issue of the *Bulletin Technique du Bureau Veritas.* Figs. 1, 2 and 3 show such an installation, Fig. 1 with a direct drive, Fig. 2 with mechanical gearing, and Fig. 3 with electrical transmission.

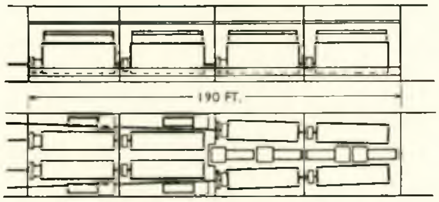


Fig. 1.

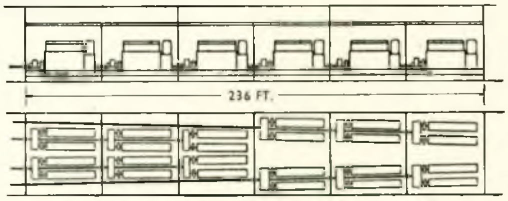


Fig. 2.

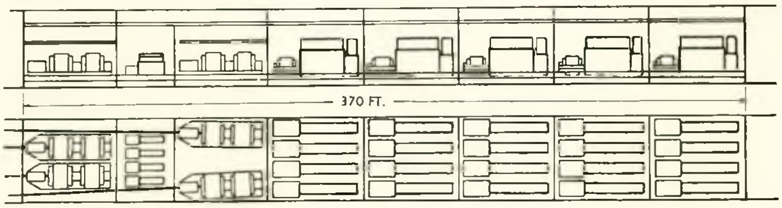


Fig. 3.

Engine-room plans of a proposed 33-knot liner with 160,000 b.h.p. Diesel machinery. Fig. 1, direct drive; Fig. 2, geared Diesel drive; Fig. 3, Diesel electric drive.

It will be noted that the direct drive shows substantially the smallest engine-room length.

The enormous saving in length compared with any system of steam machinery comes as a surprise. In the "Normandie" the total output of the turbines is 160,000 b.h.p. and the combined length of the three boiler rooms, the turbo alternator room and the propelling motor space is 500ft.

In the "Queen Mary" the total output is about 180,000 b.h.p. and the length of the machinery and boiler rooms is rather greater than in the "Normandie".

In the three arrangements proposed by Mr. Sulzer, the first (Fig. 1) comprises eight ten-cylinder two-stroke double-acting engines each with a diameter of 680 mm.

In the second proposal (Fig. 2) there are 24 engines of 6,600 b.h.p. each, grouped on four shafts through mechanical gearing. In the third plant (Fig. 3) there are 20 engines of 8,000 b.h.p. apiece, driving dynamos and supplying power to four electric motors. The total weight of the machinery, including the auxiliaries, varies between 50lb. and 75lb. per b.h.p., the lightest being the direct-drive proposal. The vessel for which these suggestions have been put forward is a 33-knot passenger liner.

Divided Cylinder Covers.

"The Motor Ship", July, 1936.

The gradual disappearance of cylinder-cover troubles with Diesel engines, at one time recurrent with enough frequency to bring about important technical researches, is welcome even though the solution has been discovered in various ways by different designers. Fundamentally, however, an agreement has been found, largely, if not entirely, in dividing the cover into separate portions. This arrangement was adopted a good many years ago, of course, but the methods chosen could not be made universal.

One curiosity about the whole development is that the more complicated covers—those of the four-stroke engine—are not very different in their main design now from the parts used, say, 20 years ago in marine Diesel-engine practice, for the majority of builders of this type still favour a cover in a single piece. In fact, for some years, the Werkspoor cover and cylinder liner, in the largest type of engine, was in one portion, although the makers eventually returned to the separate cover design for their standard machinery, at all events. Beginnings of a departure were seen when the M.A.N. combined with their four-stroke engine cover a lower, intensively cooled part, but in general it seems as though the four-stroke-engine cylinder cover is better designed in one piece.

On their two-stroke unit Krupps fix a water-cooled buffer between the cover and the combustion chamber; the cover, with its attached member, is held on the top flange of the liner through the medium of an external cover piece, which binds on the inner cover shoulder near the top. Thus there are, in this entire cylinder cover, three portions. The Polar Diesel engine designers were among the first to recognise the merits of the two-piece cover—the outer part lifting clear from the inner portion, and thereby exposing the whole of the water jacket surfaces. This design has met with considerable approval among marine engineers. The latest Sulzer practice (exemplified in the new Armstrong-built engines described in this issue) is to employ a complete inner cover, water-cooled in the usual way, and to secure this in place by a second cover used solely as a retaining piece and normally uncooled.

This is by no means even a brief history of the cylinder cover design, but it may serve to throw light on what was at first unexpected in Diesel-engine development—that the more involved design survived intact and the simpler part became the better for a measure of complication.

Modernizing Motor Ships.

"The Motor Ship", July, 1936.

It is, perhaps, a little early to talk of modernizing motor ships, but in one respect the machinery of the majority of oil-engined vessels afloat is already out of date. No shipowner would think of building a vessel equipped with air-injection engines, but more than half of the world's motor fleet is propelled by such machinery.

It is a comparatively simple matter to convert four-cycle air-blast engines to the mechanical injection type. A vessel on which the work is carried out need scarcely be out of service more than a few days, and it is not at all difficult for the shipowner to assess the advantages achieved on so exact a financial basis that he can tell beforehand whether or not the process of conversion will be economically sound.

Apparently many owners have already discovered that it is. The number of ships in which the machinery has been transformed from air injection to the airless system is considerable and is rapidly increasing. The shipowner has the option, either of saving fuel or of increasing power, and the choice can be exercised at any time.

If, for example, we take the case of a 10,000-ton cargo ship with 4,000 b.h.p. machinery, consuming, as an air-injection-engined vessel, about 17 tons of oil daily, the annual fuel bill with oil at 50s. per ton is roughly £10,000. Results achieved in service over a considerable period show that an economy of 7 per cent. may be achieved when the engines are converted to the airless-injection principle and develop the same power as before. This represents a saving of £700 per annum. The age of the vessel naturally comes into consideration, but it would appear that for almost any normal ship under ten years old the conversion is worthy of the most careful consideration. The fact that the speed can be increased, if desired, without increasing the fuel consumption, is an asset that may become of much value in many instances.

Cylinder Wear in Diesel Engines.

"The Motor Ship". July, 1936.

"Cylinder Wear in Diesel Engines" was written by G. D. Boerlage and B. J. J. Gravesteyn, and the authors recently read a lecture at the annual meeting of the American Society of Mechanical Engineers on the same subject, giving some information supplementary to that which appeared in this journal.

Tests were made on a single-cylinder Diesel engine of 50 h.p. with air injection and, secondly, with a unit of 40 h.p. with airless injection. The results were more or less similar, and the main conclusions may be summarized. With decreasing load wear decreases, but increases again with very light loads within specified limits. With heavy fuels there is rather more wear than with lighter fuels and an addition of 0·005 per cent. of quartz dust into the injection air multiplies the wear six times. Organic acids added to the fuel do not affect the wear, and the temperature of the cooling water has very little influence. If 2 per cent. or more of distilled water be added to the fuel, the wear is approximately doubled, thus emphasizing the importance of centrifugal purification.

Comparison of the Propulsive Performances of Single- and Twin-screw Cargo Liners.*

"Shipbuilding and Shipping Record", June 18th, 1936.

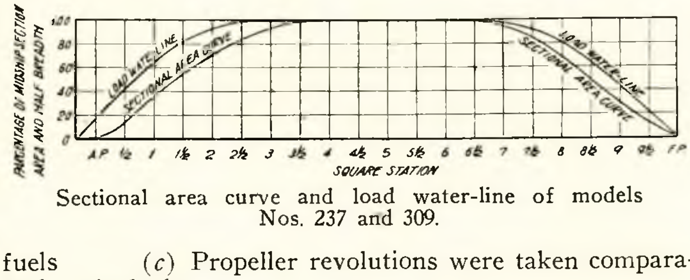
More than 20 cargo liners for transpacific express service, whose service speeds range from 16 to 17 knots, have been recently built in Japan. The leading particulars of some typical ships and their main engines, associated with the attainable speeds, Admiralty constants based upon shaft horse-power, and propulsive coefficients, i.e., efficiency horse-power (naked hull) shaft horse-power, at their normal engine-powers, which have been predicted at the Teishinsho Ship Experiment Tank, are given in the accompanying table:—

	A	B	C	D
Length pp. in m....	137·158	137·158	148·739	152·397
Breadth moulded in m.	18·593	18·897	19·812	19·812
Load draught in m.	8·330	8·246	8·711	8·870
Block coefficient ...	0·684	0·682	0·705	0·731
Prismatic coefficient	0·692	0·690	0·715	0·740
Rudder adopted ...	contra	Teishinsho	Oertz	contra
B.H.P., normal ...	7,000	7,600	7,600	9,000
R.p.m.	122	110	110	125
Speed in knots ...	17·22	17·47	16·59	16·75
Admiralty constant	464	446	434	400
Propulsive coefficient	0·770	0·758	0·746	0·758

It may be said from this table that their propulsive performances are exceedingly good. To the question of why the propulsive economy has been so improved, I have always enumerated the following facts as the principal reasons:—

(*a*) In spite of high engine powers, ranging from 7,000 to 9,000 normal brake horse-power, they were built as single-screw ships without an exception.

(*b*) As seen in the previous table, the breadths and load draughts of ships were taken comparatively large, in order to diminish their coefficients of fineness.



Sectional area curve and load water-line of models Nos. 237 and 309.

(*c*) Propeller revolutions were taken comparatively low.

(*d*) Each hull form, especially after body

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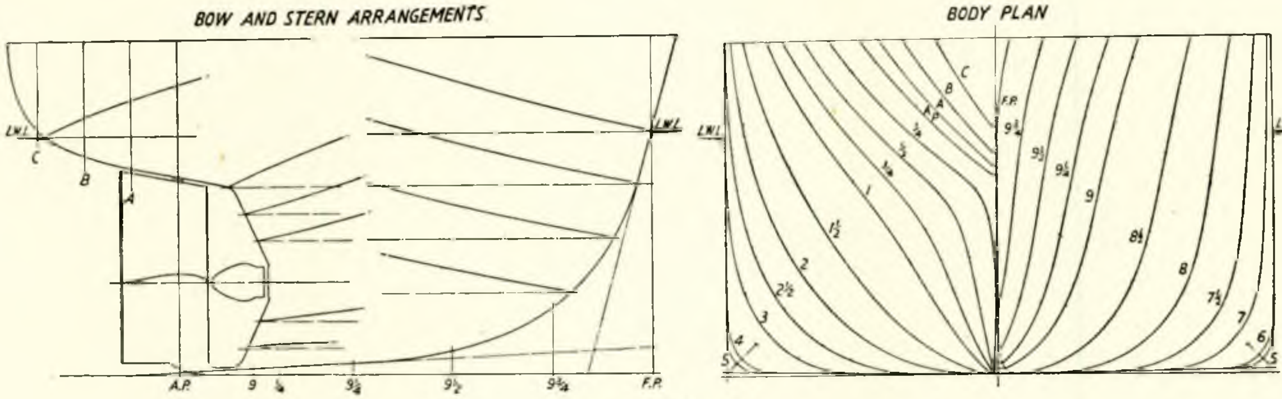
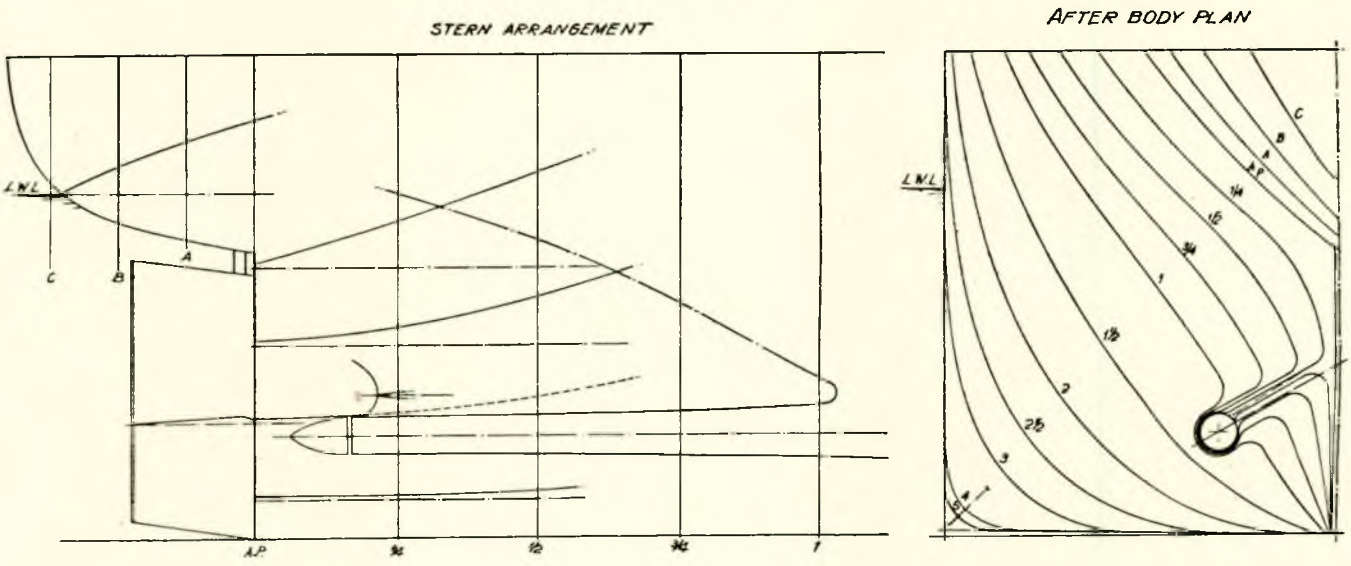
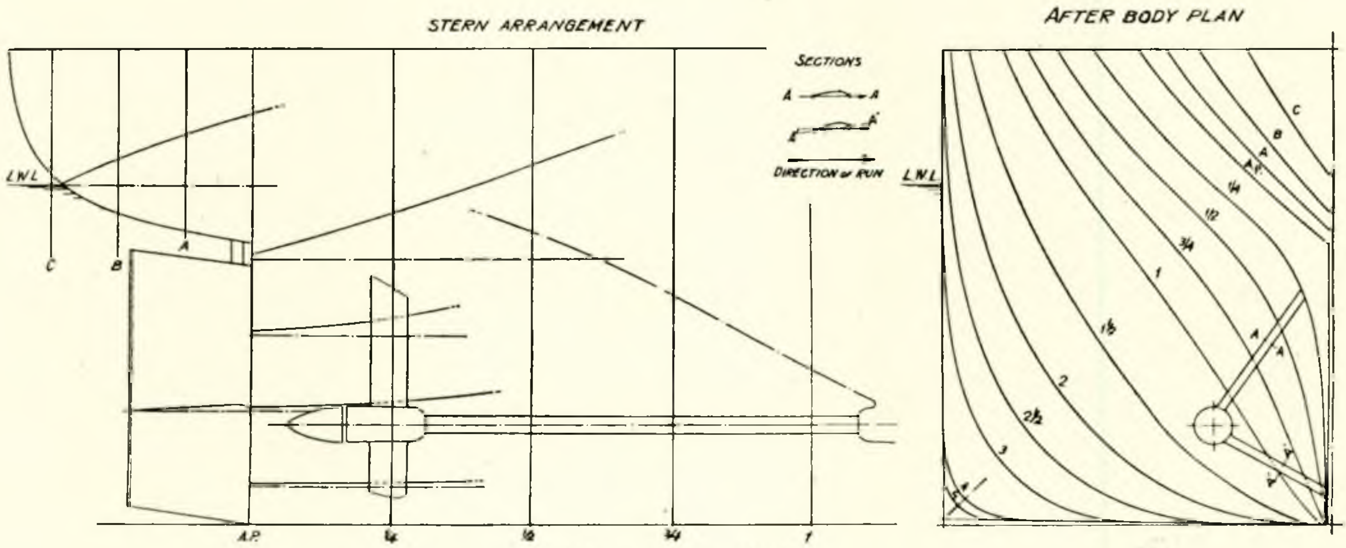
*Abstract of a paper read at the Third Engineering Congress, Tokyo, April, 1936, by Masao Yamagata, of the Teishinsho Ship Experiment Tank, Tokio, Kogakushi, Member.



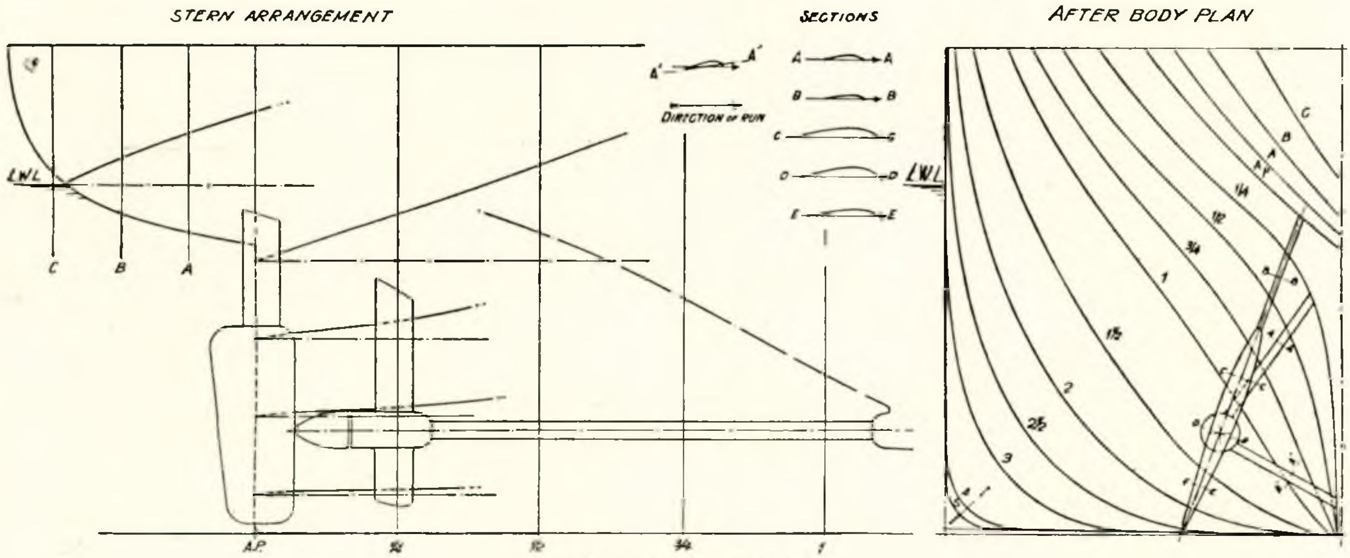
Ship model No. 237.



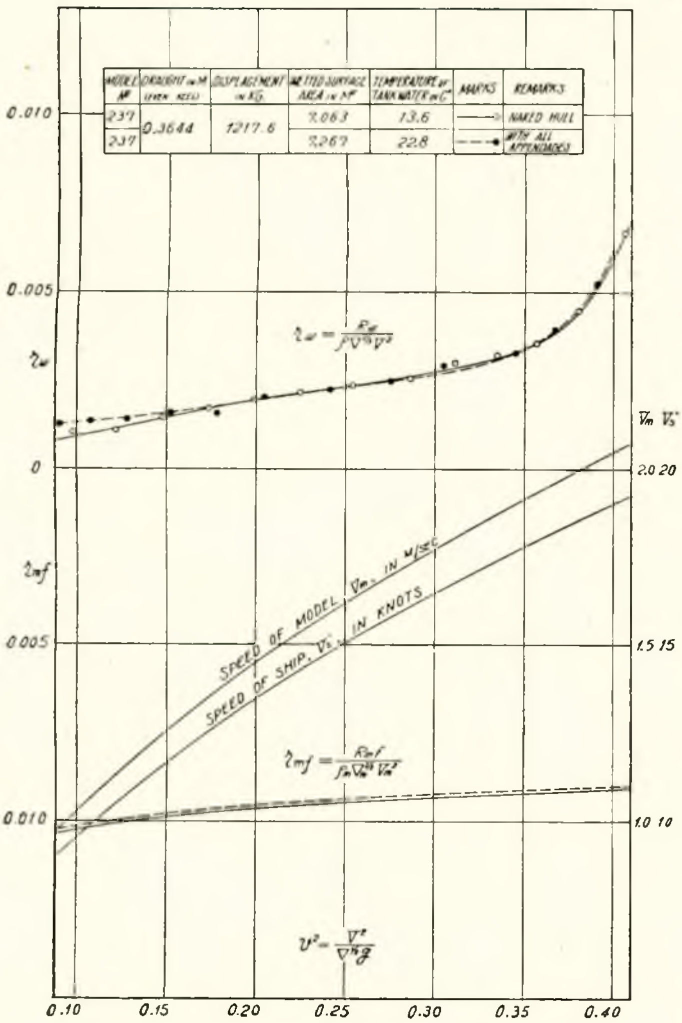
Ship model No. 309.



Ship model No. 309 A.



Ship model No. 309 B.



Results of resistance tests of model No. 237.

form, was not designed without regard to the number of revolutions of the propeller to be fitted.

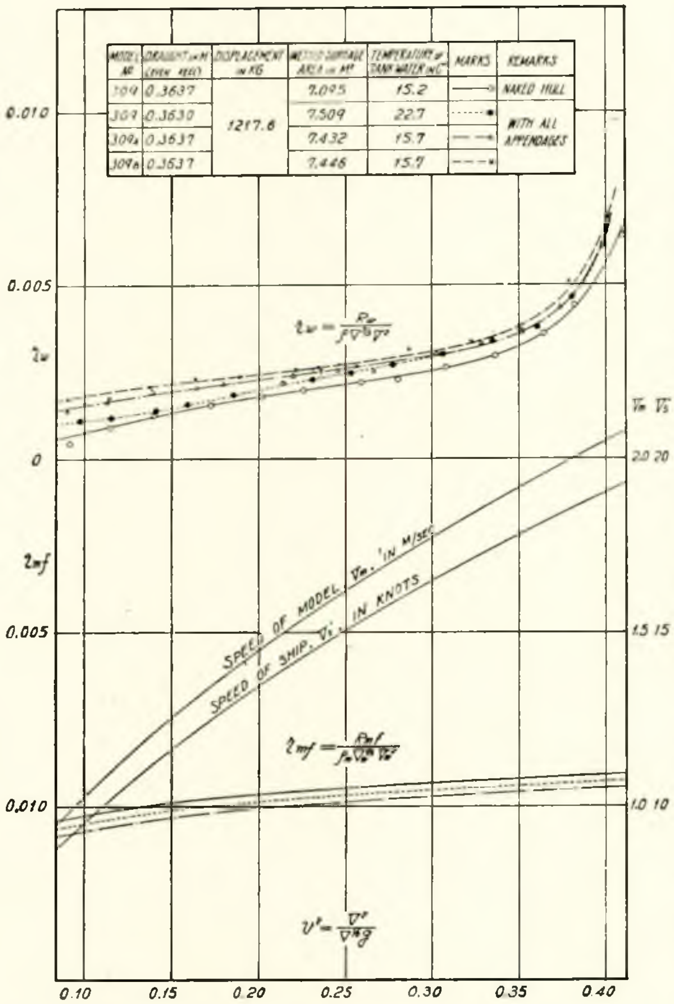
(*e*) Each of the after body forms and propellers was necessarily designed, taking the interaction between these into consideration.

(*f*) The radial variation of propeller pitch was determined with regard to the rudders adopted as well as the wake distribution measured by blade-wheels. In general, decreasing pitch propellers were adopted for contra, reaction and Teishinsho rudders, while increasing pitch propellers were adopted for ordinary streamline rudders, such as Oertz and Simplex rudders.

It can safely be said that, among these (*a*) served most effectively to obtain the good propulsive performance. But, on the other hand, some troubles, such as the erosion of propeller blades due to cavitation, have been experienced with these ships. Moreover, for the faster cargo liners, which will, I think, be planned in our country in the near future, the advantage of single-screw ships should be diminished by the restriction of propeller diameter. It seemed, therefore, to be quite necessary to investigate how the propulsive performance of twin-screw ships could be improved to the same level as that of single-screw ships, though this might be a very difficult problem.

The present paper communicates the results of some experiments, which were, as the preliminary experiments of this investigation, carried out at our Tank, with the object of comparing precisely the propulsive performances of single- and twin-screw cargo liner forms nowadays at different propeller revolutions.

The experiments were made on two ship models, i.e., Nos. 237 and 309, which represented 137·158-m. single and twin-screw cargo liners of fairly normal forms with cruiser sterns, intended



Results of resistance tests of model No. 309.

to run at over 16 knots, when fully loaded. These were made to a scale of 1 : 22·860 in paraffin wax, and the leading particulars of their naked hulls were as follows :—

Model No.	237	309
Length p.p. in m.	6·0000	6·0000
Breadth extreme in m. ...	0·8151	0·8151
Load draught in m.	0·3644	0·3637
Load displacement in kg. ...	1,217·6	1,217·6
Block coefficient	0·683	0·684
Prismatic coefficient	0·691	0·692
Midship section coefficient ...	0·988	0·988
Longitudinal C. B. from amidships in m.	0·031 abaft	0·031 abaft

These models had the same form of fore body; the after body forms of models Nos. 237 and 309 were of single- and twin-screw ship types respectively, though the difference was confined to the shape of frame lines at the square stations Nos. ¼, ½, ¾ and 1. Their sectional area curve and load water-lines are shown on page 61. They were fitted with all appendages, whose names and numbers are tabulated below :—

Model No. ...	237	309	309 A	309 B
Bilge keel ...	2	2	2	2
Shaft bossing...	1 (small)	2	2 (small)	2 (small)
Shaft bracket...	0	0	2	2
Propeller boss	1	2	2	2
Outboard shafting ...	0	0	2	2
Rudder... ...	1×I	1×II	1×II	2×III

Rudders I and II were the ordinary stream-line rudders for single- and twin-screw ships respectively, and rudders III were the twin rudders, having ordinary streamline horizontal sections. The body-plans, together with the bow and stern arrangements, are illustrated on pages 62 and 63.

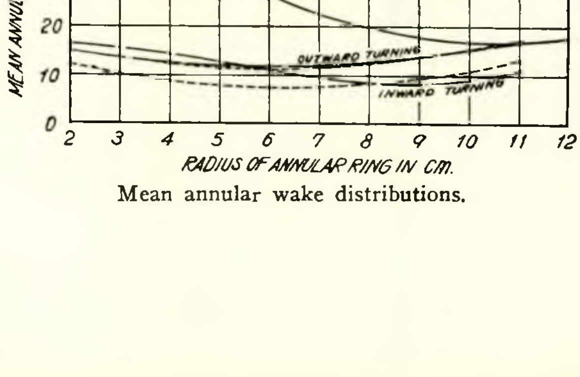
Each of the ship models without and with appendages was run in smooth water on level trim at the load displacement to ascertain its resistance. In the diagrams on pages 63 and 64 the results are plotted in our standard non-dimensional form, and on pages 65 and 66 are shown the effective horse-power curves of actual ships, calculated from the results shown on this page by Froude's skin friction constants corrected to the standard temperature of 15° C. to correspond to clean-ship conditions in salt water without any allowance for wind and wave resistances, are given on a base of speed in knots. These figures show that :—

(*a*) Effective horse-power of model No. 309 is about 2 per cent. less than that of model No. 237 at their naked conditions.

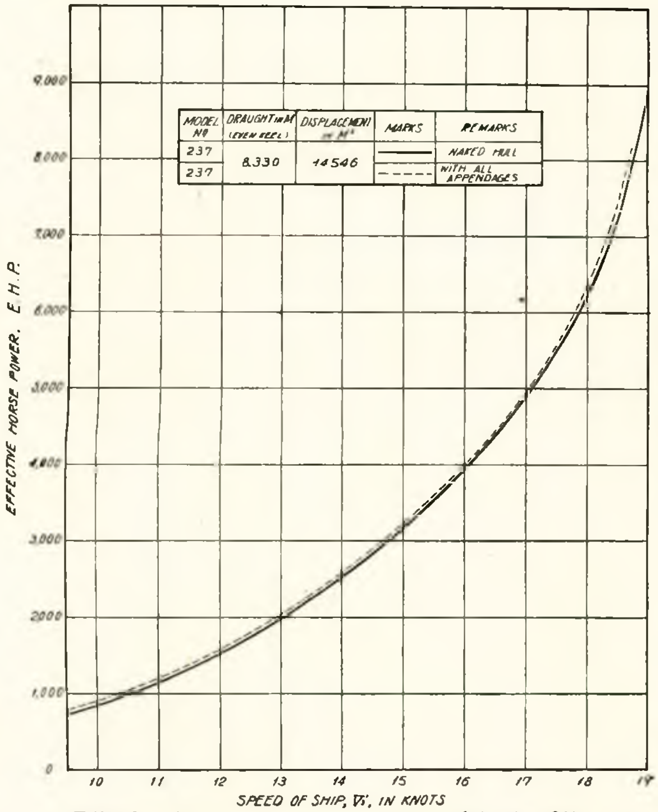
(*b*) The additional resistance of the appendages of model No. 237 is only 1 to 1·5 per cent., while those of models Nos. 309, 309A and 309B amount to about 8, 8 and 9·5 per cent., respectively.

(*c*) Therefore, effective horse-power of models Nos. 309, 309A and 309B are about 4·5, 4·5 and 6·5 per cent., respectively, more than that of model No. 237 at their so-called "with appendages" conditions.

In order to obtain the necessary information for designing propellers, the mean annular wake distribution at the propeller position was measured by blade-wheels on each ship model fitted with all appendages except rudder or rudders, whose exis-



Mean annular wake distributions.



Effective horse-power curves of model No. 237.

tence would complicate the experimental arrangement, at a model speed of 1·8m. per second, corresponding to 16·37 knots of actual ship. Therefore, the wake measurement on model No. 309B could, as a matter of course, be omitted. On this page the results are shown in the form of mean annular wake friction, expressed in terms of model speed, on a base of the radius of annular ring. It will be observed that :—

(*a*) As the radius of annular ring decreases, the excess of wake of model No. 237 over those of models Nos. 309 and 309A increases rapidly.

(*b*) The wakes of models Nos. 309 and 309A measured by outward turning blade-wheels are practically the same.

(*c*) In general, the wakes measured by outward turning blade-wheels may be said to be a little greater than those measured by inward turning blade-wheels.

Four speeds of propeller revolutions at 7,000 s.h.p. were aimed at for each ship, namely, 120, 150, 180 and 210 per minute. All propellers were of the four-bladed type with aerofoil section, the expanded area ratio being taken as 0·392 and blade thickness ratio 0·045, paying, for the sake of simplicity, no special consideration to strength, cavitation, etc., for full-sized propellers.

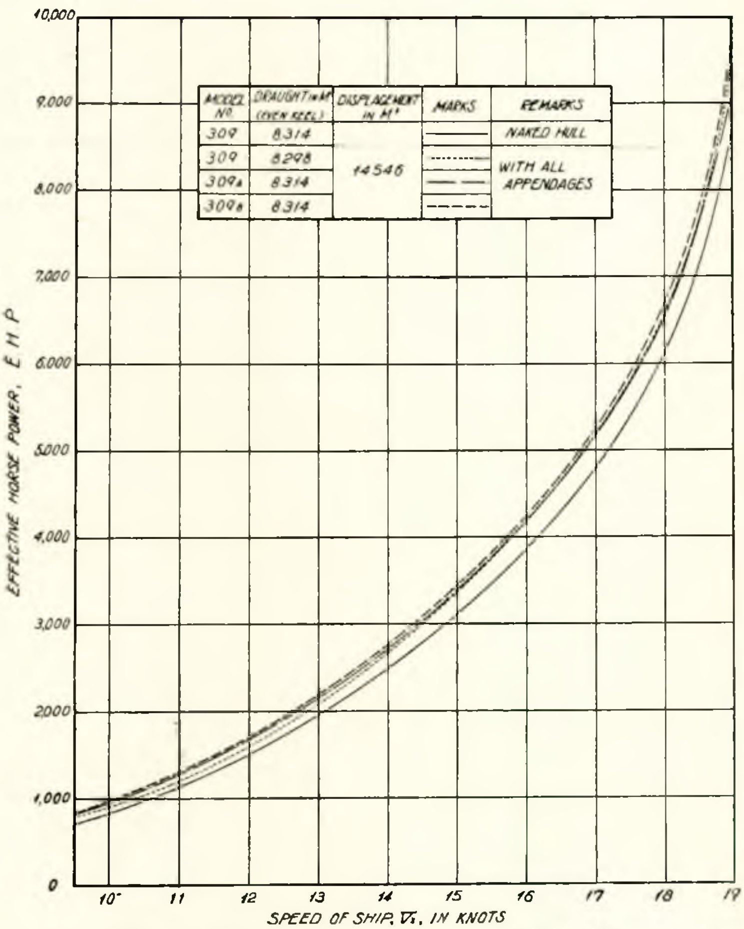
Propellers Nos. 249 and 182 to 184, which had the rake and skew back, were those designed by the normal method at our Tank for model No. 237, and propellers Nos. 185 to 188, which had no rake and skew back, were those designed similarly, as outward turning, for models Nos. 309 and 309A, whose wake distributions measured by outward turning blade-wheels were, as mentioned before, practically the same. Though four propellers should be designed for model No. 309B, which were fitted with twin rudders just behind propellers, propellers Nos. 185 to 188 were, for the sake of convenience, also employed for this model, modifying a little the cap form of propeller bosses, to bring propellers close to twin rudders. The dimensions and particulars of these propellers are tabulated below :—

Propeller No.	R.P.M. aimed at.	Diameter in cm.	Boss ratio.	Pitch ratio (variable) at 0·7 R.	Direction of turning.
249	120	24·00	0·237	0·784	Right-handed.
182	150	21·50	0·264	0·708	,,
183	180	19·72	0·288	0·648	,,
184	210	18·28	0·311	0·580	,,
185	120	19·40	0·191	1·042	Outward.
186	150	17·38	0·213	0·941	,,
187	180	15·62	0·237	0·887	,,
188	210	14·14	0·262	0·858	,,

Under the same conditions as those of the resistance tests, each ship model was tested, self-propelled with each of its four propellers, by our normal method of self-propulsion tests, namely, at what is known as the ship point of self-propulsion, not allowing for foul bottom, wind, wave, etc. It should be borne in mind that since in these tests, for the sake of convenience, the positions of the centres of propeller models were taken unaltered on ship models irrespectively of the size, as shown on pages 62-63, the working positions of the smaller propellers for model No. 237 were higher than those in actual cases, and the blade-tip clearances of the smaller propellers for models Nos. 309, 309A and 309B could be said to be too large. Moreover, at the self-propulsion tests of models Nos. 309A and 309B, the long stern tubes, were

Analysis of Test Results at 7,000 s.h.p.

Model No.	Prop. No.	V_s'	N_s'	η_u	η_a	t	w	η_h	η_p	η_p'	η_r
237	249	17·14	121·5	0·72	0·73	0·215	0·32	1·145	0·62	0·635	1·025
237	182	16·97	150·0	0·695	0·705	0·215	0·365	1·24	0·56	0·565	1·01
237	183	16·78	180·0	0·67	0·675	0·215	0·38	1·265	0·51	0·54	1·055
237	184	16·43	212·5	0·62	0·625	0·215	0·405	1·32	0·435	0·47	1·08
309	185	16·73	118·0	0·645	0·70	0·15	0·195	1·055	0·67	0·665	0·995
309	186	16·55	147·0	0·62	0·67	0·155	0·19	1·04	0·645	0·645	1·00
309	187	16·37	178·5	0·595	0·65	0·16	0·195	1·045	0·62	0·62	1·00
309	188	16·05	211·0	0·555	0·605	0·145	0·18	1·05	0·60	0·58	0·965
309A	185	16·81	120·0	0·655	0·71	0·145	0·175	1·04	0·67	0·68	1·01
309A	186	16·61	149·5	0·63	0·68	0·145	0·16	1·02	0·655	0·665	1·02
309A	187	16·39	179·5	0·60	0·65	0·135	0·17	1·04	0·62	0·625	1·00
309A	188	16·01	212·0	0·55	0·60	0·145	0·165	1·03	0·605	0·585	0·97
309B	185	16·85	120·0	0·665	0·73	0·15	0·19	1·05	0·66	0·69	1·035
309B	186	16·63	148·0	0·63	0·69	0·16	0·195	1·04	0·64	0·665	1·035
309B	187	16·41	176·5	0·60	0·66	0·155	0·215	1·075	0·61	0·615	1·005
309B	188	15·99	208·0	0·55	0·605	0·15	0·205	1·07	0·59	0·565	0·965



Effective horse-power curves of model No. 309.

fixed to shaft brackets and model hulls at both their ends, the model propeller shafts rotating in the stern tubes. Analysing each test result at 7,000 s.h.p. by Froude's method, which would be adopted at all experiment tanks except our tank, the wake fraction *w*, hull coefficient η_h, propeller efficiency (open) η_p, propeller efficiency (behind) η_p' and relative rotative coefficient η_r, together with speed of ship, V_s', in knots, propeller revolutions, N_s', per minute, two sets of propulsive coefficients, i.e., η_u and η_a, and thrust deduction fraction *t* are tabulated on page 65. These analysed results would be useful to other tank experimenters for comparing the present experiment data with their own.

As seen in the table, the propeller revolutions at 7,000 s.h.p. do not exactly coincide with those aimed at, the maximum departure being 2 per cent.

Big Ship Rudders.

"Shipbuilding and Shipping Record", 18th June, 1936.

A noticeable feature in both the "Queen Mary" and "Normandie" is the adoption of a streamlined unbalanced rudder, almost rectangular in shape, and having only a very small proportion of the after deadwood cut away. This is a distinct departure from the previous practice in large transatlantic liners and some interesting comparisons can be made, the "Bremen", for example, having a plain Oertz rudder preceded by a distinctive aperture and stern-post. In the "Empress of Britain" the semi-balanced rudder with cut-away deadwood is somewhat similar to the after underwater profile of the "Aquitania" and "Mauretania", although the cruiser stern of the more recent ship does not permit of quite as attractive a contour as was possible with the older design of counter stern and totally submerged rudder. The latter arrangement was also favoured in the two large German pre-war liners, which subsequently became the "Leviathan" and "Majestic", while in the "Imperator" a hybrid type of semi-balanced rudder was adopted with the blade carried above the waterline on somewhat similar lines to that of her French contemporary, the C.G.T.'s "France". The rudder fitted to the "Olympic" conformed strictly to the orthodox, and was no doubt largely governed as to shape by the position of the central screw, particularly as the after part of the "Britannic" of 1915 was identical in design. The partially balanced rudder and reduced deadwood was also one of the features of the later battleships and cruisers of the White era, and it is of interest to note that the balanced spade type rudders subsequently adopted by warship designers have rarely appeared in North Atlantic merchant ships, one of the few examples being the Fairfield-built Allan liner "Calgarian" of 1913.

Streamlined Superstructures.

"Shipbuilding and Shipping Record", 25th June, 1936.

Some discussion has taken place in the Press recently regarding the supposed neglect of naval architects in not considering properly the effects of streamlining the superstructures of ships in order to reduce resistance. The advantages of streamlining in motor-cars is instanced as what might be applied in the realms of ship design, especially in vessels of high speeds. It might be said in defence of ship designers that the subject has not been lost sight of and the importance of wind resistance in affecting power and speed has been the subject of observation and experimental investigation. Investigations into the relative importance of superstructure resistance in three types of vessels, namely, a cargo ship, a cross-channel vessel and a liner, showed in the first case a 30-knot wind increased the resistance of the vessel when steaming at 10 knots by 28 per cent., in the cross-channel steamer the increase in resistance when steaming at 20 knots was 9·15 per cent., and in the case of the liner the increase in resistance when steaming at 20 knots was only 7·3 per cent. That is to say, the larger and faster the vessel the smaller is the percentage increase in power due to wind resistance. It appears, therefore, that the straining after streamlining to an extreme degree in large and fast passengers ships is of minor importance, the main problem being concerned with under-water form and efficient propulsion.

Fault Detection in Steel.

"Shipbuilding and Shipping Record", 2nd July, 1936.

One of the simplest and most effective methods of locating defects in engine parts made of steel is by the use of the variation in magnetisation caused by the defects. By this means surface cracks on such details as Diesel engines springs can be readily detected, although they may be invisible to the naked eye. A well-known British engineering firm has been investigating this problem and has developed a method which, with slight variation in procedure, can be applied to steel articles ranging from turbine rotors and wheel discs to engine valves and springs. Briefly, the method consists of magnetising locally the material to be tested and applying to the surface a mixture of iron dust and oil. The mixture which must be kept agitated to prevent the dust from settling out, can be either sprayed or poured on, but in either case the oil drains away from the surface under test leaving it covered with a coating of magnetic particles. Owing to the interruption in the magnetic flux of the material by surface cracks and other faults, these are clearly shown up by the clinging of the iron dust to the affected parts. The method can be applied before machining is undertaken but the smoother the surface the more sensitive the method becomes. A development of the method employs a shallow circular dish with a transparent cover carrying the mixture of oil and iron dust. This is laid on the surface to be tested after agitating the mixture, and the poles of a portable electro-magnet arranged on either side, when not only hair cracks on the surface but faults laying ½in. below are made visible.

Fuel Injection Problems.

"Shipbuilding and Shipping Record", 2nd July, 1936.

One of the most difficult problems confronting the designer of the heavy-oil engine is the choice of a suitable system for injecting the oil into the cylinders. Actually, of course, the problem is a two-fold one, since it involves not merely the injection of the fuel into the clearance space against the compression pressure, but the atomisation of the fuel in such a manner that it is intimately mixed with the air, so that, as far as possible, instant ignition of the whole charge and its rapid and complete combustion is effected. In the original engines, as built by Dr. Diesel himself and his immediate successors, the injection of the fuel and its atomisation was carried out at one and the same time by means of compressed air in conjunction with a suitably-designed fuel valve. The air, at a pressure of about twice the compression pressure, not only forced the fuel into the clearance space, but owing to its sudden expansion on leaving the nozzle of the fuel valve, succeeded in breaking up the fuel into a very fine spray, in which condition the particles were ignited and more or less complete combustion followed. It may be mentioned that there are many engineers who would limit the use of the term diesel engine to those engines in which air under pressure is used for fuel injection purposes.

There are two principal objections which may be urged against the air-injection system, the first of these being that it involves the use of a heavy and costly air-compressor, the second being that owing to the sudden expansion of the air from the pressure before injection, say, 1,000lb. per sq. in., down to the compression pressure in the clearance space, say, 500lb. per sq. in., the temperature falls considerably, with the result that each little particle of oil is surrounded by a sheath of relatively cold air, which not only retards the ignition, but reduces the efficiency of the subsequent combustion. To eliminate these two disadvantages, the solid or airless system of fuel injection was developed in which, as the name implies, the air-compressor is dispensed with. Unfortunately, in order to ensure efficient atomisation of the heavy oil fuel, a very high injection pressure is demanded, in some designs figures as high as 10,000lb. per sq. in. having been employed. So high a pressure may not be absolutely essential, although it must be remembered that not only has the fuel to be atomised, but each particle must be projected into the combustion space against the compression pressure, and the outermost particles of the spray should be projected with such a velocity that they reach the confines of the clearance space. It is the production of a pump which, in addition to its high working pressure, has to be capable of delivering the very small volume required for each working stroke at the exact instant before the piston reaches the top of its stroke, which presents the greatest difficulty to the designer who would adopt the airless system of fuel injection for his engines. In any case, for the high powered, slow-speed marine heavy oil engine, either the air injection or the airless-injection system can be satisfactorily employed, although judging from current practice, the balance of favour seems to lie with the latter.

With the coming of the high-speed compression ignition engine, such as is being increasingly adopted for the propulsion of small craft and for the driving of auxiliary generators on larger vessels, the problem becomes more difficult owing to the shorter time available for the complete combustion process and the smaller volume of oil required per working stroke. A vast amount of research has, as a consequence, been carried out with a view to understanding the exact nature of the process which goes on in the clearance space from the instant when the fuel enters until combustion is finally completed. In this connection, the work of Ricardo is very prominent, and the designs of engine with which his name is associated have proved very successful. But the problem is far from being solved. There are those who advocate the use of a simple symmetrical design of combustion space formed between the concave surfaces of the cylinder cover and the top of the piston, whereas others suggest that some form of pre-combustion chamber communicating with the clearance space is necessary in order to ensure that turbulence which is essential to efficient combustion.

Paint Research.

"Shipbuilding and Shipping Record", 4th June, 1936.

Probably in no industry is the subject of paint of greater importance than in shipbuilding. Thus, in the reports of the various investigations which are being carried out into the corrosion of iron and steel, mention is frequently made of the protective effect of different pigments such as red lead. It will, however, be at once appreciated that the so-called red lead paints which are available have widely differing compositions and there is plenty of scope for an investigation into the effect of variations of the proportions of the various constitutents upon the protective properties of the paint. This is only one of the many researches which may be mentioned as indicating the field of practical usefulness which is open to the new paint research department of the National Physical Laboratory, which was inaugurated last week. It has already been stated that investigations are being carried out in order to produce paints which can be successfully applied in the cold damp atmosphere of a British winter, and the results of this work will be obviously of particular interest to shipbuilders, as also will the research into the effect of fineness of grain as obtained by the use of modern grinding machines upon the adhesive properties of the paint. To a lesser extent the shipbuilder is also interested in such questions as the production of beautiful and stable shades of colour, the production of high-gloss finishes and so on, and it is apparent that the new department has a career of great practical usefulness before it.

Machining Stainless Steel.

"Shipbuilding and Shipping Record", 4th June, 1936.

The various grades of high-tensile stainless steels which, on account of their power to resist corrosion, are being used to an increasing extent in marine engineering for the construction of pump rods, etc., possess such great strength and hardness that to machine them is often a matter of considerable difficulty. When it is remembered that certain grades of stainless steel may have a tensile strength exceeding 100 tons per sq. in., it will be appreciated that the metal may be harder than the cutting tool itself. For the guidance of the engineer, a firm which specialises in the manufacture of stainless steels has recently issued a little booklet dealing with the procedure to be adopted in order to facilitate machining, from which we gather that, as a general principle, if the steel is to be heat treated to a maximum stress not in excess of 50 to 60 tons per sq. in., it can be machined in that condition, but where a stress in excess of this figure is required, the material should be annealed, machined in that condition, and then heat treated before the final operations of grinding, lapping or polishing. Since the coefficient of expansion of stainless steel is greater than that of ordinary steel, allowances must be made for expansion and distortion, and the work should be kept as cool as possible by the use of copious supplies of cooling fluid at the point where cutting is taking place. In general, all tools used for machining stainless steel should have increased rates over those used for machining ordinary steels, and it goes without saying that only the very best grades of high-speed tool steels should be used.

Form and Resistance.

"Shipbuilding and Shipping Record", 11th June, 1936.

Sir Westcott Abell in his paper dealing with the Southern Railway's ferry steamers, read at last year's meetings of the Institution of Naval Architects, drew attention to the peculiar features which demanded solution by tank experiments. It was clear, he said, that model experiments were necessary, particularly where the under-water form must be fine in view of the speed; where the ratio of length to breadth is small and the ratio of breadth to draught large; and where, moreover, owing to the low freeboard, the shape of the above water form had a large influence on wave-making. Hitherto the resistance of ships has been thought to be determined by the area of shell surface, dominating the frictional, and the shapes of the load water line and the sectional area curves dominating the residuary resistance. These are still the principal features, but it has been found that the above water form in the region of the bow wave has a material effect on the power required. During the tests on this particular model Sir Westcott thought there was too much water in the bow wave. Mr. Baker, managed, by alteration of the model, to get rid of this and 10 per cent. came off the resistance. A similar reduction in resistance was effected in connection with a fast cargo liner recently. When the model was being observed during its run the bow wave looked "heavy", but a fining of the above-water form brought about a remarkable change and a decided improvement in result. Attention to points of detail like this gives, at times, unexpectedly large returns in diminution of resistance with corresponding increase in speed or reduction in power.

Astern Trials.

"Shipbuilding and Shipping Record", 11th June, 1936.

It is frequently specified that the steering gear of a vessel is to be sufficiently powerful to allow the rudder to be put over to 35° when a given fraction of the ahead power is being developed. In order that provision may be made for this contingency it is necessary to make an estimate of the astern speed with the stated power. This entails the adoption of a number of assumptions unless experimental data is available, such as the effective horse-powers of the ship with appendages at different speeds and data regarding the influence of astern propulsion on the wake and thrust deduction values and the propeller efficiency. When all these factors are taken into consideration it is found that it requires roughly 50 per cent. more power to drive a vessel astern at a given speed than is necessary for the ahead condition. It is seldom that any verification can be had of the assumptions made, and only in one case. The "Twickenham Ferry" was a case where runs were made on the measured mile astern. During the preliminary runs of the ship, astern trials were carried out and the double run over the measured mile gave a mean speed of about 11·8 knots at 172 revolutions. It is interesting to note that in the preliminary investigations with a self-propelled model astern trials were carried out and the forecast from these experiments was 11½ knots at 170 revolutions. This close agreement suggests that valuable guidance can be given to the makers of steering gear from tank results towards the elucidation of the problems which they are frequently called upon to solve.

Care of Steam Pipes.

"Shipbuilding and Shipping Record", 11th June, 1936.

We have frequently had to call attention to accidents on board ship which have been caused by water hammer, and the statistics issued by the Board of Trade in their annual summary of the investigations held under the Boiler Explosion Acts show how, in spite of frequent warnings, such accidents still occur. One of the large boiler insurance companies has recently issued a short list of instructions on the care of steam pipes which merit very careful attention. After stressing the necessity of preventing accumulation of water, it is suggested that water should be drained off, as far as possible, as it is formed, to which end when any section of a steam range is shut down all drains should be opened and left open. Each drain discharge should be visible and separate, so that the engineer on watch can always satisfy himself that the drain is operative. Before admitting steam to the range, the steam valve should be first eased off its face and the drains kept open until it is apparent that all water has been blown off. The drains can then be shut and the steam valve fully opened. It is also suggested that an automatic air valve should be fitted at the highest point of each section from which steam can be shut off, but this is hardly essential, since if the drains are kept open as soon as there is a tendency for a vacuum to form, due to the cooling off of the pipes, the air will find its way through the drain pipes.

Surface Conditions and Fatigue.

"Shipbuilding and Shipping Record", 11th June, 1936.

It has for some time been known that the condition of the surface of steel has a marked effect on the power the material has to resist the effects of fatigue. In particular, surface scratches, pits, machining marks, &c., as well as surface decarburisation during heat treatment, result in a very pronounced reduction of the fatigue resistance. How serious this reduction may be is shown by the results of experiments communicated in a paper by Messrs. G. A. Hankins, M. L. Becker and H. R. Mills, read at the recent meetings of the Iron and Steel Institute. The authors give the results of fatigue tests on two typical spring steels, which show that surface grooves of only one-ninth of a millimetre radius, together with surface decarburisation, lowers the fatigue limit of a high-class silico-manganese steel from ± 46 tons per sq. in. to ± 11 tons per sq. in. Surface recarburisation was found to increase the fatigue limit in some cases, but such treatment is not recommended for general commercial application. The effect of the unmachined surface on very high-tensile steel forgings is very marked, the endurance fatigue limit being less than that of unmachined mild steel, although it is found that the effect of the unmachined surface on the fatigue strength of mild steel is not important. It follows, therefore, that it is most inadvisable for high-tensile steel forgings to be subjected to fatigue stresses in service, when the surfaces are in the as-forged heat-treated condition.

Performance of Supercharged Diesel Engines.

"The Motor Ship", April, 1936.

Among the group of 12 tankers which were ordered by the Anglo-Saxon Petroleum Co. two years ago and completed last year (commencing with the "Ancylus"), were several constructed in Germany; they were equipped with the first M.A.N. four-cycle Diesel engines provided with supercharging arranged by closing in the lower part of the cylinder. Another modification from the normal design was the adoption of chain-driven rotary pumps, as with the rest of the engines built for the Anglo-Saxon tankers.

TEST RESULTS OF SUPERCHARGED MARINE DIESEL ENGINES.

Speed r.p.m.	Mean Indicated Pressure. Atmos.	Mean Indicated Pressure. lb. per sq. in.	Mechanical Efficiency.	Indicated Output H.P.	Effective Output H.P.	Supercharging Pressure. Atmos.	Supercharging Pressure. lb. per sq. in.	Cooling Water Temperatures. Piston. Inlet. °C.	Piston. Inlet. °F.	Piston. Outlet. °C.	Piston. Outlet. °F.	Cylinder. Inlet. °C.	Cylinder. Inlet. °F.	Cylinder. Outlet. °C.	Cylinder. Outlet. °F.	Exhaust Temperature. °C.	Exhaust Temperature. °F.	Fuel Consumption per B.H.P.-hour. gm.	Fuel Consumption per B.H.P.-hour. lb.
115	7·503	106·3	0·8	3,563	2,850	0·34	4·85	14	57	37	98	2·5	36·5	12	54	260	500	—	—
116	7·985	114	0·811	3,825	3,100	0·2	2·8	38	100	41	106	33	91	40	104	330	626	165	0·365
120	8·318	118	0·82	4,122	3,380	0·36	5·1	33	92	37	98	22	72	34	93·5	340	644	163	0·360
124	9·667	137	0·846	4,950	4,190	0·37	5·3	40	104	47	117	39	102	46	115	425	800	187	0·415
127	9·999	142	0·85	5,244	4,450	0·38	5·4	29	84	40	104	3	37·5	15	50	470	878	—	—

Some test bed and sea results were given of an engine of this class built by the Fijenoord Co. in "The Motor Ship", August, 1935, and similar details of the performance of three tankers equipped with engines of the same type, but built at Augsburg, have just been published by Mr. P. Schuler. They are of interest as showing particulars of performance over a range of output from 2,850 b.h.p. to 4,450 b.h.p., this latter representing an increase of 27 per cent. beyond the guaranteed maximum output when supercharged. Compared with an unsupercharged engine of the same dimensions, the increase is equivalent to approximately 73 per cent.

The engine has eight cylinders with a diameter of 650mm., the piston stroke being 1,400mm. At the maximum power mentioned, viz., 4,450 b.h.p., the mean indicated pressure was 142lb. per sq. in., and it is stated that the exhaust was quite smokeless. The fuel used in the trials was a Diesel oil having a specific gravity of 0·9 and which had to be preheated before use.

BOARD OF TRADE EXAMINATIONS.

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

Name.	Grade.	Port of Examination.
For week ended 4th June, 1936:—		
Awbery, Robert G.	1.C.	London
Boddy, John F.	1.C.	„
Evans, William L.	1.C.	„
Norris, John B.	1.C.	„
Tabbitt, Cyril O.	1.C.	„
McDonald, William J. ...	1.C.M.E.	„
Thomas, Warren H. ...	1.C.M.E.	„
Stone, Hugh M.	1.C.M.E.	„
Hiscock, Charles H. ...	1.C.M.E.	Glasgow
Bolton, John B. F.	1.C.M.E.	„
Pottinger, William M. ...	1.C.M.E.	Newcastle
Griffiths, William	1.C.M.E.	Liverpool
Stephens, Garfield	1.C.M.E.	London
Munro, Arthur C.	1.C.M.E.	Liverpool
Smith, Thomas W.	1.C.M.E.	Newcastle
Hughes, William R. ...	1.C.	Liverpool
Pemberton, Eric	1.C.	„
Roberts, John A.	1.C.	„
Johnson, James F.	1.C.	Newcastle
Mead, Gerald S.	1.C.	„
Ottley, George B.	1.C.	„
Treliving, Harold	1.C.	„
Davison, Fred.	1.C.M.	„
Lyon, James E.	1.C.M.	„
Richmond, Lloyd	1.C.M.	„
Rispin, Charles H.	1.C.M.	„
Leslie, Hugh A.	1.C.	Dublin
Batha, Kaikhushroo A. ...	1.C.	Glasgow

Name.	Grade.	Port of Examination.
Duff, Thomas G.	1.C.	Glasgow
Keay, James	1.C.	„
McWilliam, Adam	1.C.	„
Watson, William H. ...	1.C.	„
Rees, David G.	1.C.S.E.	Liverpool
Mavin, Stanley	1.C.S.E.	London
For week ended 11th June, 1936:—		
Gorham, Woolvett E. R. ...	2.C.	London
Warren, Walfred T. ...	2.C.	„
Hope, John L.	2.C.M.	„
Anderton, Charles E. ...	2.C.	Liverpool
White, Leonard G.	2.C.	„
Jenkins, Harold L.	2.C.	Cardiff
Anderson, William S. ...	2.C.	Glasgow
Biggart, Samuel C.	2.C.	„
Freer, John D.	2.C.	„
Harkiss, James	2.C.	„
Livingston, William R. ...	2.C.	„
Logan, Alexander McL. ...	2.C.	„
McGugan, James	2.C.	„
Simpson, James G.	2.C.	„
Stewart, James	2.C.	„
Caldwell, Hendry McN. ...	2.C.M.	„
Gray, Frederick B.	2.C.M.	„
Hutchings, Adolphe J. ...	2.C.M.	„
MacKay, James	2.C.M.	„
Ritchie, Steven S.	2.C.M.	„
Dixon, Sydney S.	2.C.	Newcastle
Valder, Geoffrey C. ...	2.C.	„
Able, George E.	2.C.M.	„
Brown, John R.	2.C.M.	„
Emerson, George R. ...	2.C.M.	„
Nichol, Robert H.	2.C.M.	„
Taylor, Thomas R.	2.C.M.	„
For week ended 18th June, 1936:—		
Boalch, Archibald B. ...	1.C.	Cardiff
Constant, Leslie H.	1.C.	„
Calder, Donald	1.C.	Liverpool
Peat, Septimus A.	1.C.	„
Riddle, William	1.C.	„
Whitham, Harry	1.C.	„
Bek, Louis P.	1.C.	London
Dales, Albert	1.C.	„
Gauci, Emmanuel	1.C.	„
Hollingworth, Alfred G. ...	1.C.	„
Kinloch, Joseph F.	1.C.	„
Tigg, William R.	1.C.	„
Shand, George H.	1.C.M.	„
Webb, Morris W.	1.C.M.	„
Spensley, William W. ...	1.C.	Newcastle
Richings, Charles W. ...	1.C.M.E.	London
Lawson, William	1.C.M.E.	Newcastle
Beckwith, John A.	1.C.M.E.	„
Burnett, William	1.C.S.E.	„
Dorrance, James	1.C.S.E.	Liverpool
Wright, Harold	1.C.S.E.	Newcastle
Finlinson, Harold M. ...	1.C.S.E.	Liverpool
Goddard, Wilfrid	1.C.M.E.	Newcastle
Lynd, Ernest C.	1.C.M.E.	London
Lamberd, William	2.C.M.E.	Newcastle
Bryson, Archibald	1.C.	Glasgow
McKersie, William H. ...	1.C.	„
Ritchie, Henry C.	1.C.	„
Keith, Donald	1.C.M.	„