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Further Notes on the Conservation of Heat Energy in Feed Systems.

By C. P. PARRY (Member).

The matter that follows is intended as complementary to the article by the writer which was published in the TRANSACTIONS of *May, 1933, and his reply to a critic which appeared in the †August TRANSACTIONS of the same year. These remarks are prompted by the apparent diversity of views in three recent papers published in the TRANSACTIONS.

Attention is called first to certain remarks in the paper on the Loeffler marine boiler in the "Symposium on High Pressure Boilers", appearing in the ‡April, 1935, TRANSACTIONS. The author writes:—"*The developments which aim at improvement in power generation in marine practice may be divided into two groups, one embracing the means of securing higher rates of heat transmission through heat absorbing surfaces with reduction of weight and space occupied by equipment, while the other deals with the efficiency of the power plant as a whole and seeks to reduce the large proportion of heat imparted to and lost with the circulating water*". He further claims as an advantage of the system he describes, *that the turbine being always under pressure, steam may be bled to drive the auxiliaries.* He appears to agree with the writer's views expressed in the 1933 TRANSACTIONS above-mentioned, in that any benefit due to feed heating is not in increased efficiency of the boiler but in reducing the amount of heat which is lost through the condenser circulating water. It is also satisfactory to note that the writer is not the only person who is of opinion that steam auxiliaries should be run on bled steam from the main engines, and if a further remark may be made on this subject, there does not appear to be anything to prevent the bleeding of the main engines to run most of the steam auxiliaries on any installation when the vessel is clear of harbour.

In the paper on "Modern Marine Condensing Plants and Feed Systems" published in the TRANSACTIONS of *May, 1935, there appears to be much to be condemned as wasteful operation of steam plant and contrary to the developments which aim at improvement.

The author of the paper on "Geared Steam Turbine Installations for Tramp Steamers" appearing in the TRANSACTIONS of †December, 1934,

*Vol. XLV, Institute Notes, p. 41.
†Vol. XLV, Institute Notes, p. 104.
‡Vol. XLVII, p. 63.

*Vol. XLVII, p. 109.
†Vol. XLVI, p. 277.

somewhat casually referred to the "economical auxiliaries" dealt with in his previous paper in the *1926/27 Session, on which the present writer commented in his reply to his critic in August, 1933. It appears obvious that the author of the first-named paper considers the auxiliaries described in the paper on "Modern Marine Condensing Plants and Feed Systems" as wasteful, because he advocates their suppression, and that their work be done at much less cost by the main engines as in many of the older marine installations. It is perhaps unfortunate that the author of the paper on "Geared Steam Turbine Installations for Tramp Steamers" did not fully discuss the matter of reject heat to the condenser circulating water, but fortunately it transpired during the discussion on the paper on "Condensers and Feed Systems" that actually the modern way of handling an auxiliary turbo-generator, in a first-class ship, is not as described in that paper or in the paper of 1926-27 as exhausting into a feed heater but into a condenser, as advocated by the present writer in 1933.

The main object of these further notes is to prove by direct calculations that auxiliary exhaust feed heating must impair the efficiency of the main engines by causing them to reject more heat to the condenser circulating water, and that these losses in the circulating water very much outweigh any probable loss of efficiency through impaired vacuum when exhausting the auxiliaries direct to the condenser. To that end the following data and tables are submitted, showing the steam used by main engines and auxiliary turbo-generators and the amount of steam condensed in the condensers under varying methods of operation. The main engines use saturated steam at 465lb. per sq. in. absolute and 460° F. temperature, and exhaust into the condenser at a pressure of ·5lb. per sq. in. absolute and temperature of 80° F., and are assumed to work without avoidable loss under the various conditions shown. The auxiliary engine works with saturated steam at 200lb. per sq. in. absolute and temperature of 382° F., and is also assumed to work without avoidable loss, excepting the losses which must occur when it exhausts into a feed heater instead of into the condenser. Superheating has been ignored as not appreciably affecting the issue. The h.p. of the auxiliary turbo-generator in the calculations is probably greater in comparison with that of the main engines of most steamers, but the particular ratio facilitates the calculations and the comparative costs are about on a par with the less economical auxiliaries described in the paper in the 1926/27 Transactions above referred to. The comparative heat rejected to the condenser under the different methods of operation is clearly shown in the weight of steam condensed per h.p./hour column in the tables. The fuel required is proportional to the total weight of steam required per h.p./hour for all purposes, taking into account any difference in temperature of the feed water.

Whether the main engine bled steam or auxiliary exhaust steam be condensed by the condensate which is thereby heated, the object is to return the heat that has not been converted into work to the boiler instead of its being lost in the condenser circulating water. The work done by the heating steam is done at the mere cost of the

Data Obtained from Marks & Davis' Tables.

MAIN ENGINE STEAM.	AUXILIARY STEAM.
Total heat of steam 1209 B.t.u.	Total heat of steam 1198 B.t.u.
Heat drop at 320° F. 129 B.t.u.	Heat drop at 240° F. 156 B.t.u.
,, ,, ,, 240° F. 215 ,,	,, ,, ,, 212° F. 191 ,,
,, ,, ,, 160° F. 310 ,,	,, ,, ,, 160° F. 256 ,,
,, ,, ,, 80° F. 415 ,,	,, ,, ,, 80° F. 366·6 ,,
Dryness factor at 320° F. ·884	Dryness factor at 240° F. ·876
,, ,, ,, 240° F. ·8255	,, ,, ,, 80° F. ·749
,, ,, ,, 160° F. ·77	
,, ,, ,, 80° F. ·715	

Latent heat at 460° F.	770	B.t.u.
,, ,, ,, 320° F.	894·2	,,
,, ,, ,, 240° F.	952·1	,,
,, ,, ,, 160° F.	1001·6	,,
,, ,, ,, 80° F.	1046·7	,,

equivalent heat, without any loss. Between the main engines and the auxiliaries there is, approximately, a fixed total amount of work to be done in unit time and therefore a fixed number of B.t.u. to be converted into work per unit time.

It is obviously of greater advantage to use bled steam at 240° F. in the feed heater than auxiliary exhaust steam at 240° F., because for each pound of steam used 215 B.t.u. have been converted into work without further expenditure, as against only 156 B.t.u. and as the dryness factor of the bled steam is less than that of the auxiliary exhaust steam the condensate can deal with a greater weight of bled steam used by the main engines than through the auxiliaries. Thus a greater proportion of the total work can be done at the cost only of the equivalent heat if done by bled steam than if done by auxiliary steam, and the average cost of all the work is correspondingly less.

It is evident from the above preliminary examination that it must be more economical to bleed the main engine further by the auxiliary condensate than to bleed the auxiliary itself to heat its own condensate, but as complicated calculations are avoided and the results are sufficiently convincing, the following tables are based on the auxiliary being bled to heat its own condensate in the bled steam results.

It is worth noting that in the low pressure auxiliary, one stage of bled steam feed heating at 240° F. increases the efficiency by 8·15 per cent. and reduces the fuel consumption by 7·5 per cent. against 6·6 per cent. higher efficiency and 6·2 per cent. saving of fuel in the higher pressure engine, considered without the auxiliary.

*Vol. XXXVIII, p. 1.

TABLE I.—MAIN ENGINE.

Condition of operation.	Work done per lb. of steam used. B.t.u.	Efficiency.	Steam used per h.p./hour. lb.	Feed temp.	Exhaust to Condenser per h.p./hr. lb. steam.	lb. water.
Rankine cycle	415	·35745	6·1325	80° F.	4·3847	1·7478
Carnot cycle (infinite number of bleedings)	318	·413	8	460° F.	3·4377	1·4703
3 bled stages at 320° F., 240° F. and 160° F.	363·91	·3951	6·9936	320° F.	3·733	1·4881
2 bled stages at 320° F. and 160° F.	358·61	·38936	7·067	320° F.	3·8069	1·5174
2 bled stages at 240° F. and 160° F.	387·64	·38726	6·5653	240° F.	3·8617	1·5393
2 bled stages at 320° F. and 240° F.	357·97	·38867	7·1095	320° F.	3·8348	1·5286
1 bled stage at 320° F.	348·39	·37827	7·3046	320° F.	4·0064	1·597
1 bled stage at 240° F.	381·17	·3808	6·6768	240° F.	3·9665	1·5811
1 bled stage at 160° F.	405·13	·3748	6·284	160° F.	4·0707	1·6226

TABLE II.—AUXILIARY ENGINE.

Condition of operation.	Work done per lb. of steam used. B.t.u.	H.P.	Steam used per main engine h.p./hour.	Exhaust to condenser per h.p./hour. lb. steam.	lb. water.
Exhausting at 240° F. into feed heater and heating main engine condensate at 240° F.	156	7.2 per cent. of main engine.	1·177	Nil	Nil
Exhausting into condenser with one stage of bleeding at 240° F.	332·7		·552	·3468	·1162
Exhausting into condenser. No feed heating	366·6		·5003	·3752	·1256

TABLE III.—ALL PURPOSES.

Condition of operation.	Steam used per h.p./hour. lb.	Feed temperature.	Exhaust to condenser per h.p./hour. lb. steam.	lb. water.
Main engine on Rankine cycle and auxiliary exhaust feed heating	7·3095	240° F.	4·3847	1·7478
Main engine bled in two stages at 240° F. and 160° F. and auxiliary engine bled in one stage at 240° F.... ...	7·1173	240° F.	4·2085	1·6555

The loss entailed in Table III by changing from bled steam feed heating to auxiliary feed heating is about 3 per cent. As compared with running the auxiliary with bled steam or doing the auxiliary work with the main engine the loss is about 3·8 per cent. Allowing for the reduction of power required to drive the auxiliaries these percentages would be 3·2 per cent. and 4 per cent. Also, in a hot climate the 4 per cent. extra weight of steam to condense in the condenser would cause a further loss of vacuum—without full calculations, say ½″ loss. This brings the losses to 6·25 per cent. and 7 per cent. respectively. Running the auxiliaries at sea with bled steam and with direct steam in port appears to be a happy compromise ensuring safety and economy.

It is obvious that the duty of modern condensers is considerably lighter than the duty in the older installations working at lower pressures, because not only does the modern engine use less steam per h.p./hour but it also condenses a greater proportion of the steam as heat is converted into work, as shown by the dryness fraction of the steam entering the condenser.

Various writers on steam turbines have stated that the efficiency of the turbine falls off about 6 per cent. for a loss of 1″ of vacuum. If exhausting auxiliaries into a feed heater instead of into a condenser is done to prevent possible air leaks into the condenser, it is evident that the remedy is worse than the complaint, as no disciplined engine-room staff on board ship would run the machinery with an appreciable difference between the vacuum actually carried in the condenser and that attainable.

The graphs Figs. 10 and 12 in the paper on "Condensing Plants and Feed Systems" are incorrect. There can be no loss of vacuum due to air in the condenser when there is no air leak, as residual air goes out dissolved in the condensate.

This fact was well understood 30 or 40 years ago, but many engineers preferred an Edwards type air pump as, when the air leakage was too great for it all to be dissolved in the condensate, the loss of vacuum was less than with the three-valve pump as there were no inlet valves to lift by rising air pressure. In the three-valve pump there is an appreciable head of water accumulated above the level of the foot valves on the inlet side when all air is taken out in solution and the foot valves are lifted by hydraulic pressure, but when the air leakage is at a greater rate than that at which it can be dissolved in the condensate it cannot pass into the air pump until it has accumulated in the condenser to a pressure about equivalent to the hydrostatic head that lifts the valves when there is little or no air leak, and forces the level in the condenser or pump inlet pipe down to about the level of the foot valves.

Anyone who refers to conserving the heat of the auxiliary steam in the feed water is deceiving himself and possibly others. It is obvious from the tables above that conserving heat from auxiliary steam in the feed, and so raising its temperature, causes a loss of a much greater amount of heat from the main engine steam in the condenser. A rise in temperature of 160° F. in the feed water due to auxiliary steam means a loss of approximately 8 per cent. in the efficiency of the main engines. Therefore if steam ejectors are used instead of air pumps, the main engine efficiency must be reduced by 1 per cent. by the ejectors alone as the ejectors use about 2 per cent. of the total steam used by the main engines, and raise the feed about 20° F. The futility of steam air ejectors, as now made, was manifest in the discussion on the recent paper on Condensers when it was shown that an air pump was necessary for manœuvring periods and that it took 20 minutes to obtain the vacuum on an auxiliary condenser with the ejectors only. Like an old style feed water injector, which choked with an excess of water and overflowed, so did the steam ejector choke itself with air at atmospheric pressure which simply overflowed back to the condenser instead of being discharged. Either the ejector should have had an adjustable combining nozzle or the injection valve should have been closed until the vapour temperature in the condenser was raised to something under 212° F., when the vapour would automatically expel the air from the condenser, and on reopening the injection valve the vacuum would be obtained automatically, as in the case of the ancient jet condenser which had blow-through valves and snifting valves for the purpose of creating a vacuum before the engines or air pumps were required to move. With good metallic packing for the condenser tubes, there appears to be no reason for any delay in creating the vacuum in the condensers of modern plant, even if they have ejectors in place of air pumps. Presumably the vacuum on the particular condenser discussed in the above-mentioned paper was created by the cold condensate gradually absorbing the residual air in the condenser, just as occurs with the last of the residual air on an air-tight condenser with a three-valve (or Edwards) pump, of whatever cubic capacity.

At an electric power station in Lancashire the turbines at present work with superheated steam at 300lb./sq. in. pressure. There are four stages of bled steam feed heating—the first at 160° F. and the fourth at 287° F. The hot feed water passes through economisers and probably is heated further by the gases to between 360° F. and 370° F. before entering the boilers. After leaving the boiler the gases are further cooled whilst passing through the economiser and again in tubular air heaters to a temperature of 240° F. before being discharged to the chimney. No gain in the boiler efficiency is found or expected from the hot feed water or hot air to the furnaces other than that due to the extraction of heat from the gases in the economiser and air heater, and that heat being utilised for the generation of steam. The condensers are surface condensers using water from a small river adjacent to the station, and for air extraction small ejector condensers are fitted which use fresh condensate circulating continuously through ejectors, storage tanks and coolers. It is stated that the full working vacuum is created in five minutes from starting the turbines and that an appreciable increase in the turbine efficiency results by the use of the ejector condensers instead of steam ejectors. All auxiliaries are electrically driven, so that the cost of the power is at the same rate as the main power less the usual loss in re-converting electrical into mechanical energy. New plant being installed will work with steam at 620lb./sq. in. pressure.

The above may be considered an extremely economical plant, but efficient air pumps, electrically driven, would give a further small gain. All injectors and ejectors are notoriously very inefficient machines mechanically, most of the energy being re-converted into heat; in the case of the ejector condenser above the heat generated is lost in the cooler. The power required to work air pumps would be much less.

The logical development in auxiliaries for extracting air from a condenser is double-acting vertical dry air pumps of the Edwards type, with means for maintaining them at lower temperatures than the condensate as necessary. These pumps should have, in addition to the valveless inlet ports, inlet valves as well as delivery valves at each end of the chamber, to ease the work when starting the pumps with no vacuum in the condenser. The inlet valves would be inoperative when the vacuum obtained approached the attainable vacuum. The inlet valves and pistons should be water-sealed. The pumps should be crank-driven, either by engines using bled steam expansively and exhausting into the condenser or electrically.

It would lead to clear thinking if, in a bled steam system, the heat exchangers (where heat is exchanged between the bled steam and the condensate) were called "regenerative condensers" instead of "feed heaters", as that is what they really are. The term "regenerator" cannot be correctly applied to a main condenser. It appears that the modern condenser suffers from passages of too small a section for an appreciable amount of air at inappreciable pressures to flow to the air pumps, which renders an appreciable amount of the cooling surface ineffective for condensing steam, so allowing air to collect in a portion of the condenser at sufficient pressure to feed the air pumps or ejectors. This means a loss of vacuum in tropical climates which might be prevented. The older condensers were, perhaps, not so well designed to distribute the steam to take full advantage of temperature gradients, and in some cases to permit overcooled condensate to function as the jet in a jet condenser—in assisting the cooling surface by condensing steam not in contact with the surface, and being reheated to the temperature corresponding to the vapour pressure, but the air outlets were of sufficient section and the air pumps were of sufficient cubic capacity to make an appreciable loss of vacuum only possible from serious neglect, except that with the three-valve type the loss had to be about $\frac{3}{4}''$ as soon as the air leakage exceeded a certain small amount.

It is satisfactory to note that the author of the paper on Condensers agrees that a second stage of bleeding at a temperature of 300° F. gives an improvement of about 2 per cent. in the thermodynamic cycle of efficiency. His claim that the boiler efficiency is increased by the hot feed water at 300° F., so that the actual gain is of the order of 5 per cent., is astonishing. A boiler is merely an apparatus for extracting heat from the products of combustion, carefully arranged so that the heat is used for the generation of steam and for superheating the steam in certain definite proportions as required. Similar physical laws govern the exchange of heat between water or steam and the gases in a boiler as govern the transfer of heat from one substance to another in any form of heat exchanger, and the lower the temperature of the substance receiving the heat, and the higher that of the substance giving up heat, the greater is the rate at which heat is exchanged. Modern boilermakers, as distinct from the manufacturers of steam feed heaters, realise that hot feed tends to decrease boiler efficiency, and are justly proud of the improvements in economisers and/or air heaters that have enabled them to maintain and actually increase boiler efficiency in spite of the hot feed water from efficiently bled engines.

Referring to the arrangement shown in Fig. 15 in the paper on Condensers and Feed Systems, a separate extraction pump and means for supplying cold sealing water to the Edwards air pump, dispensing with the vacuum augmentor and leading the auxiliary exhausts to the condenser, would be a much more efficient arrangement. The contact heater or a surface heater should take steam from the l.p. cylinder chest, and the secondary heater should take steam from the i.p. chest. It would be of further advantage to have another heater taking bled steam from the pipe between the l.p. cylinder and the l.p. turbine. An Edwards air pump, driven by the main engines, sweeps out sufficient volume to maintain the vacuum without the aid of a wasteful vacuum augmentor, and hardly needs cold sealing water and separate extraction pump. All it needs is an air inlet passage of equal section to that with which it was originally provided. Referring to Fig. 32 in the same paper, the system would still be a "closed system" with dry air pumps of the Edwards type in place of the ejectors, and with auxiliaries designed to take advantage of the vacuum and exhausting into the condenser. It would certainly be more economical, and still more so if the auxiliaries used steam bled from the main engines when clear of harbour.

The writer had hoped to include in these notes the results of measured tests on a twin-screw ferry steamer with triple-expansion superheated reciprocating engines equipped for exhausting the steam auxiliaries into the condenser or surface feed heater as desired, with the exception of the dynamo-engine, which can only exhaust into the condenser or to the atmosphere. Bleeding valves are fitted on the l.p. chests. There is no steam steering engine, the vessel being steered by Flettner rudders, which are worked by the waste energy of the propellers, i.e., by the main engines. The tests made were conclusive enough in so far as they show that auxiliary exhaust feed heating is wasteful as compared with bled steam feed heating, but it is anticipated that still more favourable results will be obtained with the bled steam feed heating by extending the bleeding over longer steaming periods. The vessel steams for about 60 per cent. of the working time with auxiliaries working for the whole time. The drain from the heater was led into the hotwell which precluded the bleeding (non-return) valves from opening during an appreciable part of the steaming time. The vessel is not on service at the time of writing, but the heater drain is being led to the wet air pump which will ensure the main engines being automatically bled whenever they are working, as against during perhaps only 50 per cent. of the steaming period formerly. It is hoped that results of tests on the machinery of this vessel, under correct conditions, will be available for publication before the end of the year.

Another (deep sea) vessel recently built has reciprocating engines with auxiliaries which can be exhausted into the condenser, the l.p. engine being bled into a contact heater, which should give better results except that the engine cannot be bled whilst manœuvring as with the surface heater in the ferry steamer above mentioned.

INSTITUTE NOTES.

CORRESPONDENCE.

To the Editor of the TRANSACTIONS.

Dear Sir,

Lubricating Oil Coolers.

I have at various times read with interest articles in the TRANSACTIONS and other technical publications on the various methods employed to clean lubricating and piston cooling oil coolers.

In vessels where the lubricating and piston cooling oil is used in a common system, it appears to be impossible (no matter how good the condition of the oil) to prevent a heavy deposit of soft scale on the cooler tubes. The tubes being of small diameter and invariably very closely spaced, it is impossible to clean any of them (except the top and bottom rows) by hand.

Various methods of removing this deposit are in use, but from personal experience I can recommend the following method as the most successful we have tried, which eventually reduced somewhat high temperatures to a reasonable figure. In addition the method possesses the added virtue of cheapness, and can be carried out with the gear already in the vessel.

A mixture of caustic soda (28lb. to 100 gallons of water) is put into the cooler and kept continuously circulating by means of a small hand pump, returning to a drum arranged as near the cooler as possible. As the mixture returns from the cooler to the drum, the heavy frothy deposit should be skimmed off with a suitable implement. A light flexible steam hose connection blowing direct into the cooler supplies the necessary heat to keep the mixture at practically boiling point. As the exhaust gas boiler in a motor vessel can be converted to oil burning in port, making the latter connection should not present any difficulty.

The mixture is kept circulating for at least twelve hours—longer if time permits. After this period the mixture should be run out and the cooler immediately refilled with fresh water, which should be brought to boiling point and then run out. The latter operation is *most important* and only occupies a few minutes. It is wise to repeat it at least twice. I may add that the proportion of caustic soda to water was arrived at after careful experiment over a period of three years. Any alteration in the quantity of caustic used gave totally different ultimate temperatures.

On the last occasion when this method was employed, the lubricating and piston cooling oil temperatures indicated a considerable and very welcome reduction. In the tropics, with the sea temperature varying fom 80/87° F., the highest recorded piston cooling oil return temperature was 169/170° F. Previously, with the sea at 80/87° F., these temperatures were recorded as high as 200° F.

Attention should also be paid to the water side of the cooler tubes and further efficiency obtained. Most marine engineers will, I think, agree that the removal of sea-water scale is an ever present problem, but I do not think it is quite so difficult as the removal of deposits from oil.—Yours, etc.,

LEWIS D. MCBEAN (Member).

ADDITIONS TO THE LIBRARY.

Purchased.

"Electric Elevators—Their Design, Construction, Operation and Maintenance", by F. A. Annett. McGraw-Hill Book Co., 2nd edn., 30s. net.

King's Regulations and A.I. Amendments (K.R. 2/35). H.M. Stationery Office, 4d. net.

"The Deterioration of Haulage Ropes on Service". Safety in Mines Research Board Paper No. 92. H.M. Stationery Office, 1s. net.

"Diesel Engines: Excessive Lubricating Oil Consumption", by Philip H. Smith. Constable & Co., Ltd., 3s. 6d. net.

"Air Conditioning Simplified". Edited by H. L. Alt. Domestic Engineering Co., 1900 Prairie Avenue, Chicago, $1.00 net.

Presented by Mr. J. A. Masson (Associate).

"Pumps and Pumping", by M. Powis Bale. The Technical Press, Ltd.

Presented by The National Physical Laboratory.

"Manœuvring of Single-Screw Ships: The Effect of Rudder Proportions on Manœuvring and Propulsive Efficiency", by G. H. Bottomley. (Selected Engineering Paper No. 175, published by The Institution of Civil Engineers). "Wake", by G. S. Baker, O.B.E. (published by The North East Coast Institution of Engineers and Shipbuilders). "The Effect of a Fin upon the Efficiency of Ship Propulsion", by F. H. Todd, B.Sc., Ph.D. (excerpt from the Transactions of the Liverpool Engineering Society).

Presented by the Publishers.

The British Electrical and Allied Industries Research Association. Sub-Committee J/E: Joint Committee: Steels for High Temperatures: Ninth Report from the National Physical Laboratory on the Properties of Molybdenum Steels at High Temperatures: Third Report from the National Physical Laboratory on the Properties of Complex Molybdenum Steels: Seventh Progress Report on the Corrosion of Steels in Superheated Steam.

Report of the Advisory Council of the Science Museum for the Year 1934. H.M. Stationery Office, 1s. net.

"Copper Data". Copper Development Association.

Amended Rules I and II: General Rules and Regulations. U.S. Department of Commerce, Bureau of Navigation and Steamboat Inspection.

British Standard Specification No. 621-1935 for Wire Ropes of Special Construction for Engineering Purposes, inclusive of Cranes, Lifts and Excavators.

Proceedings of The Institution of Mechanical Engineers, Vol. 128, 1934, containing the following papers:—

"High-Pressure Plant for Experimental Hydrogenation Processes", by Barber and Taylor.
"A Survey of Ships and Engines", by Pendred.
"Air Swirl in Oil Engines", by Alcock.
"Heat Insulation as Applied to Buildings and Structures", by Allcut.
"Design of Crane Hooks and other Components of Lifting Gear", by Gough, Cox and Sopwith.
"Achievements in High Specific-Speed Water Turbines", by Fulton.
"The Yield of Steel Wire under Stresses of Very Small Duration", by Mason.

"The Loss of Heat by Natural Convection from Parallel Vertical Plates in Air", by Carpenter and Wassell.

"Notes on Roll Failures with reference to Chilled Iron Cast Rolls Containing Chromium and Molybdenum", by Caswell.

Transactions of The Institution of Engineers and Shipbuilders in Scotland, Vol. 78, 1934-35, containing the following papers:—

"Controlled Acoustics in Meeting Rooms", by Harroway.

"Backing of Propellers", by Conn.

"Cinematograph Apparatus, with special reference to Sound Projection", by Hamilton.

"Trial Performances of a Torpedo-Boat Destroyer", by Yarrow.

"Marine Slipways: Unusual Developments of an Old System", by Glover.

"A New Type of Marine Steam Engine", by Grange.

"The Presentation of Ship Performance Data, with special reference to Service Log Abstracts", by Ayre.

"Prevention of Fire on Passenger Ships", by Taylor.

"Electric Arc Welding in General Engineering", by Orr.

"Reinforced Concrete as a Structural Material", by Faber.

"A Diesel-Electric Paddle Ferry Boat", by Denny.

"Paint-Making Machinery", by Maas.

"Brittleness in Ductile Engineering Materials", by Lewis.

"The Working, Heat Treating, and Welding of Steel", by H. L. Campbell, M.S. Chapman & Hall, Ltd., illus., 185pp., 11s. 6d. net.

This text-book forms a good introduction to the subjects of steel making and the thermal and mechanical treatment and testing of steel. A chapter on the classification of steels and the correlation of S.A.E. specifications to uses and applications will, of course, be of more service in America than this country. The photomicrographs are good and the diagrams correlating changes in grain size with various thermal and mechanical treatments excellent. There is chapter on the welding of steel in which equipment and procedure are clearly described, and another on the protection of steel from corrosion by coatings and various surface treatments.

The ground covered is large and the chapters somewhat short so that, as the author mentions in the preface, they can only be considered as an introductory study, but the subject matter is presented very clearly and should be of considerable service to teachers of ferrous metallurgy. There is a useful series of examination questions at the end of each chapter and the particulars of eighteen laboratory tasks with illustrations as to procedure form a valuable addition to the book.

"Meter Engineering", by J. L. Ferns, B.Sc. Sir Isaac Pitman & Sons, 2nd edn., 317pp., illus., 10s. 6d. net.

When the difficulties of "metering" the various types of supplies, loads and methods of charging are considered, we are led to agree with the author on the appropriateness of the title of his book. That there is a distinct demand for such a book is evidenced by the fact that the first edition was published as recently as 1932.

The book presents an adequate knowledge of the fundamental principles underlying the operation of all types of electricity meters. The reader, however, must possess a fair knowledge of mathematics to appreciate fully the theoretical portions of the book. The treatment of the subject is comprehensive, dealing as it does with electricity tariffs and the principles on which they are based, measurement of electrical energy, maximum power demand, power factor, instrument transformers, time switches, prepayment meters, and instructions and hints on the testing of all types of d.c. and a.c. meters. The equipment and routine of the meter department of a large supply corporation, as well as the repair shops, offices and stores, are fully explained.

The style throughout is particularly clear, but it is questionable whether it is altogether advisable to introduce into print such test room expressions as "shorted" and "o.k." The work is one we can thoroughly recommend to any meter engineer as a comprehensive, practical and comparatively cheap book dealing with the principles, construction, testing and installation of meters, and the routine of a large meter testing department.

"Report on the Treatment of Welded Structures by the Metallic Arc Process". The Institution of Structural Engineers, 2nd edn., 166pp,. copiously illus., 5s. net.

This book is divided into four parts. Part 1 is a critical view or description of electric arc welding, the three main factors to be considered, design, material and workmanship, being placed in the order of their relative importance. It is pointed out that good design is the fundamental essential in welded construction, and then what happens in the metallic arc and the various thermo-chemical actions and reactions are considered. The temperature of the arc zone is stated to be between 2,000° and 3,000° centigrade, which is considerably less than the maximum generally accepted, but the discrepancy may be due to taking an average. Reference is made to electrodes (particularly the covered alloy type), plant and accessories, welding procedure, the position of the welder and the amount of current as it affects penetration, quality of the work and the cost. The effect of plate thickness on correct amount of current, general principles of fabrication and the causes of distortion are also dealt with.

Part 2 covers the metallurgical study of welding and deals with electrodes, preparation and workmanship, the weld junction, heat conditions, corrosion, atmospheric corrosion and alloy electrodes. This section is very fully illustrated with a large number of excellent micro and X-ray photographs.

In part 3 the tests on welded members (which are illustrated) are of particular interest in view of the lack of information in this country referred to in the Welding Symposium held in May last.

In part 4 recommendations are formulated to cover the use of the metallic arc in structural work in the light of British Standard Specification No. 538 with certain additions and tables arising therefrom.

This is a useful contribution to welding literature and merits careful study. It is clearly written and will appeal to the practical man, for whom it contains much information on the present position of the art.

ABSTRACTS.

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

BOARD OF TRADE EXAMINATIONS.

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

Name.	Grade.	Port of Examination.
For week ended 4th July, 1935:—		
Bailey, Sidney J.	1.C.	Liverpool
Blundell, William G. ...	1.C.	"
Dodd, John E.	1.C.	"
Ruff, John R.	1.C.	"
Tuson, Charles W.	1.C.	"
Wilde, John R.	1.C.	"
Luke, Arthur	1.C.M.	"
Munn, John	1.C.	Dublin
Harding, William R. ...	1.C.	London
Plunkett, James E.	1.C.	"
Waugh, William G.	1.C.	"
Hulin, Wilfred J. F. ...	1.C.M.	"
Volke, Eric C. J.	1.C.M.	"
Boutflower, Herbert L. ...	1.C.	Newcastle
Fraser, James W.	1.C.	"
Hall, John	1.C.	"
Hunter, John W.	1.C.	"
Kennedy, Paul	1.C.	"
Wood, Norman H.	1.C.	"
Collins, Arthur L.	1.C.M.	"
Walker, Thomas L. ...	1.C.M.	"
Wright, Thomas E.	1.C.M.	"
Thorougood, Percy ...	1.C.M.E.	Liverpool
Stobbs, John	1.C.M.E.	"
Fieldhouse, Norman ...	1.C.S.E.	"
Anderson, John	1.C.	Glasgow
Catto, Robert J.	1.C.	"
Fleming, John	1.C.	"
Gorrie, David F.	1.C.	"
Gray, William J.	1.C.	"
Miller, Andrew B.	1.C.	"
Nimmo, Robert	1.C.	"
Orr, John	1.C.	"
Rankine, James	1.C.	"
Fullarton, John F. B. ...	1.C.M.	"
Jamieson, Robert	2.C.S.E.	"
For week ended 11th July, 1935:—		
Dickinson, Ronald H. ...	2.C.	Liverpool
Goodwin, Sydney R. ...	2.C.	"
Gray, Ronald W.	2.C.	"
Guy, Henry	2.C.	"
Kirby, John H.	2.C.	"
White, John	2.C.	"
Keenliside, Dugald C. ...	2.C.M.	"
Wilkinson, George L. ...	2.C.M.	"
Browning, Frederick S. ...	2.C.	London
Lansberry, Archibald J. ...	2.C	"
Sutcliffe, Frederic N. ...	2.C.	"
Carnaghan, James T. ...	2.C.M.	"
Weston, Herbert J.	2.C.M.E.	Newcastle
Collings, Archibald E. ...	2.C.	Cardiff
James, George P. C. ...	2.C.	"
McFarlane, William ...	2.C.	Glasgow
Murchie, Alexander ...	2.C.	"
Patterson, David B.	2.C.	"
Williamson, Charles ...	2.C.	"
Lenaghan, John	2.C.M.	"
Forder, John E. P.	Ex.1.C.	Newcastle
Fletcher, Gardner C. ...	Ex.1.C.	Liverpool
Forbes, Thomas H.	Ex.1.C.	"
Keenan, George	Ex.1.C.	"
Blenkarn, Thomas J. ...	2.C.	Newcastle
Gordon, Alexander	2.C.	"

Name.	Grade.	Port of Examination.
Noble, William I.	2.C.	Newcastle
Southern, Francis	2.C.	"
Willey, George P.	2.C.	"
Foley, William R.	2.C.M.	"
Allen, Bert	2.C.	Liverpool
For week ended 18th July, 1935:—		
Lewis, David J. D.	1.C.	Cardiff
Pelham, John H.	1.C.	"
Roch, George S.	1.C.	"
Roscoe, William N.	1.C.	"
McEwing, William M. ...	1.C.	London
Turnbull, Norman	1.C.	"
Vann, Charles E. A. ...	1.C.	"
Fawcett, Francis A.	1.C.	Liverpool
Hebden, Alfred J.	1.C.	"
Lewthwaite, John C. ...	1.C.	"
Allison, William B.	1.C.	Glasgow
McCallum, William	1.C.	"
Paton, Hugh Crawford ...	1.C.	"
Rankin, William F. A. ...	1.C.	"
Reid, John	1.C.	"
Smith, Francis	1.C.	"
Will, Adam	1.C.	"
Jamieson, George M. ...	1.C.M.	"
Alder, Ralph N.	1.C.	Newcastle
Dickson, John	1.C.	"
Merrick, Stanley F.	1.C.M.E.	Cardiff
McRobie, John S.	1.C.	Newcastle
Young, John R.	1.C.	"
Allen, Francis R.	1.C.M.	"
Harrison, John W.	1.C.M.	"
Robertson, George	1.C.M.	"
Wilson, Robert C.	1.C.M.	"
Gladstone, John A.	1.C.M.E.	"
Edmundson, Harry	1.C.M.E.	"
Dale, Stanley	1.C.M.E.	"
Boutflower, Herbert L. ...	1.C.M.E.	"
Bell, Frederick A.	1.C.M.E.	"
Mouat, John	1.C.M.E.	Liverpool
Todd, Arthur N.	1.C.M.E.	"
McMillan, Archibald H. ...	1.C.M.E.	Glasgow
Kirk, James	1.C.M.E.	"
McCaskill, Angus	1.C.S.E.	"
Jamieson, Robert	1.C.S.E.	"
Welsh, James A.	1.C.M.E.	London
For week ended 26th July, 1935:—		
Howie, James O.	2.C.	Glasgow
Ross, Charles W. T. ...	2.C.	"
Sime, William	2.C.	"
Campbell, Peter	2.C.M.	"
McLeish, James B.	2.C.M.	"
Irlam, Richard N.	2.C.	Liverpool
Watterson, Robert C. ...	2.C.	"
Anderson, John C. B. ...	2.C.	London
Wainwright, Lionel H. R. ...	2.C.M.	"
Cutchie, George W. ...	2.C.	Newcastle
Duncan, Harold H.	2.C.	"
Gilfoyle, Thomas	2.C.	"
Proudfoot, Harry	2.C.	"
Charlton, George D. ...	2.C.M.	"
Gilroy, Cecil Y.	2.C.M.	"
Porter, Christopher W. ...	2.C.M.	"
Ramsey, Walter S.	2.C.M.	"
Goodwin, Sydney R. ...	2.M.E.	Liverpool
For week ended 1st August, 1935:—		
Collins, Thomas F.	1.C.	London
Craft, William H.	1.C.	"
Leet, Alfred W.	1.C.	"
Field, Hector G.	1.C.M.	"
Jones, William E.	1.C.M.	"

Name.		Grade.	Port of Examination.
Roberts, Griffith J. ...	...	1.C.	Liverpool
Scragg, Eric Durose	...	1.C.	"
Whittaker, John E.	...	1.C.	"
Williams, John ...	...	1.C.	"
Graham, Jack V. ...	...	1.C.	Glasgow
Harvey, Alexander C.	...	1.C.M.	"
Rattray, John C. M.	...	1.C.M.	"
Bridges, Robert G. ...	...	1.C.	Newcastle
Henzell, Benjamin ...	...	1.C.	"
Hetherington, William	...	1.C.	"
Shacklock, Thomas H.	...	1.C.	"
Usher, William J. ...	...	1.C.	"
Young, William E. ...	...	1.C.	"
Forster, Edward W.	...	1.C.M.	"
Kent, Charles ...	...	1.C.M.	"
Whiting, William C.	...	1.C.M.	"
Bisset, James R. ...	...	1.C.M.E.	London
Handford, Robert P.	...	1.C.M.E.	"
Smith, John H. ...	...	1.C.M.E.	"
Orr, John	...	1.C.M.E.	Glasgow
Taylor, William E. U.	...	1.C.M.E.	London
Bell, James W. ...	...	1.C.M.E.	Newcastle

The "Normandie"—Vibrations and the Propellers.

"Engineering", 26th July, 1935.

As we mentioned last week, the ship is to be withdrawn from service at the end of the summer season and her after part is to be stiffened, to improve her from the point of view of vibration. This vibration, in the opinion of some competent observers, is in every way comparable with similar vibration experienced on other large modern liners, and speaking personally we have yet to travel on a high-speed ship in which vibration was absent.

The other matter to which reference may be made is the propellers. The original propellers were designed from the results of tank tests in Paris and Hamburg lasting from 1931 to 1934. As a result of preliminary trials, 12 different designs were got out. Three of these were of the four-bladed type, two with constant pitch and one with variable pitch. The remaining nine were three-bladed propellers, seven having constant pitch and two variable pitch. For each type two models of $\frac{1}{18}$ or $\frac{1}{24}$ scale were constructed and tested in free water and in cavitation tunnels. Four models of $\frac{1}{36}$ scale were tested by auto-propulsion. Free-water tests were made for all models at 24 revolutions per second, while tests made on the first propeller at speeds of from 24 to 41 revolutions per second showed results agreeing within 1 per cent. of the auto-propulsion tests. Additional trials were made to investigate the effect of giving different speeds to the shafts and of altering the direction of rotation of the propellers. It was as a result of this work that the designs were determined and the manufacture of the propellers was proceeded with.

In service the propellers were found to be eroding unduly, and after a few voyages they were removed and replaced by the spare set. The statement appearing in the daily press to the effect that the design has been changed and that four-bladed propellers have been fitted is not correct. There are no four-bladed propellers—and the spare set are almost of identical design with the first set. In view of the facts that the "Normandie" made record crossings in both directions on her first round voyage, and thus established her supremacy, and is now operating a schedule in conjunction with slower ships, she is able to take matters a little more easily, so that the spare propellers will probably serve her satisfactorily until the end of the season. The fact that this matter has been given undue publicity in the lay press can only be explained by the great amount of public interest that the "Normandie" has herself aroused. There is nothing new in the propellers of a large high-speed liner having to be changed and modified. Some very well-known vessels have had considerably more than three sets of propellers and in at least one well-known liner an attempt has been made to overcome difficulties by making the propellers of stainless steel. Probably no one is less surprised that full-scale experimental work has to be done on the "Normandie" propellers than experienced propeller designers and manufacturers. It may be said to be common experience and serves to illustrate the large amount of research work on this particular branch of naval architecture which still remains to be done.

Clemens Herschel's Invention of the Venturi Meter.

"Engineering", 2nd August, 1935.

Through the courtesy of the Unwin Memorial Committee, we are enabled to reproduce on the next page an interesting letter addressed by Clemens Herschel to the late Professor W. C. Unwin, on the subject of his invention of the Venturi meter. In case the handwriting should prove a little difficult to our readers, we give the text below, the letter being addressed from the Office of the Hydraulic Engineer of the Holyoke Water Power Company, and dated June 5, 1888, reference to a letter from Professor Unwin, dated May 18, being also given. The letter runs:—

Dear Sir, Since writing you I have tested, though rather crudely, a one inch Venturi Meter, under 210ft. head. It works all right. I am now satisfied that here is a new and pregnant principle to be applied to the art of gauging fluids, inclusive of fluids such as compressed air, illuminating or fuel gases, steam, etc. Further, that the shape of the meter should be trumpet-shaped in both directions; such a meter will measure volumes flowing in either direction, which in certain localities becomes a useful attribute. The form of piezometer connection originally used by me at the venturi or throat alone, should be used at either end of the main-pipe (where it joins the meter), also. Any parts projecting into the meter or pipe are objectionable, on account of foreign bodies catching upon them. Such a meter will cost extremely little, in comparison with the Deacon or any other, volumetric or "differential". And we are but in the beginning

HOLYOKE WATER POWER COMPANY.

OFFICE OF THE HYDRAULIC ENGINEER.

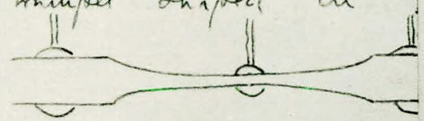
IN REPLY TO YOURS OF May 18

Holyoke, Mass., June 5 1888.

Prof. W. C. Unwin:
7 Palace Gate Mansions
Kensington, W.

Dear Sir:

Since writing you, I have tested, though rather crudely, a one inch Venturi Meter, under 210. ft. head. It works all right. I am now satisfied that here is a new and pregnant principle to be applied to the art of gauging fluids, inclusive of fluids such as compressed air, illuminating or fuel gases, steam &c. Further, that the shape of the meter should be trumpet shaped in both directions; such



a meter will measure volumes flowing in either direction, which in certain localities becomes a useful attribute. The form of piezometer connection originally used by me at the venturi or throat alone, should be used at either end of main-pipe (where it joins the meter), also. Any parts projecting into the meter or pipe are

PAGE 2 OF LETTER TO Prof. W. C. U. DATED, June 5 1888

objectionable, on account of foreign bodies catching upon them. Such a meter, will cost extremely little, in comparison with the Deacon or any other, volumetric or "differential". And we are but in the beginning of the art of measuring pressures and differences of pressure. When these shall be delicately measured, the Venturi Meter will have become as delicate in its lower limits of capacity, as any other, and it is on this score alone, that it is as yet inferior to some of the volumetric meters.

I am very grateful to you for having sent an abstract of the paper, to the Socy. Inst. C. E. for publication. You will find a description of the recording gauge, recording differences of pressure, in my application for an English patent, filed Apl. 17, 1888.

Yours very truly
Clemens Herschel.

of the art of measuring pressures, and differences of pressure. When these shall be delicately measured, the Venturi Meter will have become as delicate in its lower limits of capacity, as any other and it is on this score alone, that it is as yet inferior to some of the volumetric meters.

I am very grateful to you for having sent an abstract of the paper to the Secy. Inst.C.E. for publication. You will find a description of the recording gauge, recording differences of pressure, in my application for an English patent, filed April 17, 1888.

Yours very truly,
CLEMENS HERSCHEL.

This interesting communication has been found among papers very kindly placed at the disposal of the Unwin Memorial Committee by Miss Unwin, in view of the preparation by the committee of a Memoir of Professor Unwin's life and work. The letters thus made available promise to produce much interesting matter, since, through his early association with Fairbairn, Unwin's engineering connections extended practically from the beginnings of the industrial era through its whole range. The volume may, therefore, be expected to introduce many well-known names and to cover much interesting matter, as will be suggested by the letter now reproduced. As is known, the preparation of this volume is the lesser of the objects the Committee have in view, the main one being to increase by a substantial amount the Unwin scholarship, which is now of very small value, founded originally with Dr. Unwin's consent by old students when he retired from the Central Technical College in 1904.

Chemistry and the Naval Engineer.

"Engineering", 12th July, 1935.

"The skill of commanding and governing of ships is much more now than heretofore", wrote Pepys in his "Naval Minutes", "and . . . . there is more of knowledge to be required in the King's service than is to be learned in the merchants'." Whether the somewhat derogatory reference to the merchant service could be justified to-day, or even in the Seventeenth Century, is open to question, for seamanlike competence must be judged in the light of its circumstances and the difference between naval and mercantile conditions are wider now than they were then; but the demands upon the skill of those who command and govern ships grow ever more various and exacting according to their kinds, and are only very partially offset by the gradual obsolescence of knowledge once considered essential, which now is so no longer.

Of the sciences, as distinct from the arts, which the naval officer, and especially the naval engineer, has been obliged to make an integral part of his calling, chemistry, in a sense, is one of the oldest; for chemistry lies at the root of all steam engineering, and the combustion of fuels, corrosion, scale deposits in boilers and grease in condensers, made some sort of elementary chemistry a compulsory study even at the early stage when steam was still a somewhat uncertain auxiliary to sails.

In other directions, also, it had previously claimed the attention of executive officers, and Commander J. L. Bedale, R.N., who addressed the Society of Chemical Industry at Glasgow on July 2 on "Some Problems in Chemical Engineering which arise in H.M. Navy", was probably correct in dating the conscious employment of chemical processes from the inception of gunpowder, and their more systematic study from the introduction of copper sheathing and the discovery of its deleterious effect upon iron fastenings. More immediately interesting than the historical aspects of his subject, however, was Commander Bedale's survey of the fields in which the naval engineer now finds chemical knowledge a necessity, and his indications of the directions in which further advances would be particularly welcomed.

In general it may be said that the chemical combinations and reactions affecting the operation of ships are well understood, and therefore the problems arising from them are those of detection, control or prevention rather than of diagnosis. In many cases, also, there is a time element to be considered which rules out methods satisfactory in other respects. For example, the Winkler process for the measurement of oxygen in water is sensitive enough for naval requirements, and with care gives a dependable result without the need for calculation; but the test takes some 15 minutes to make, which is found to be a serious disadvantage, and it is suggested that there is a field for a continuous automatic recording instrument for this purpose, if one can be devised that is at once sensitive and sufficiently robust.

These are conditions not readily reconciled with the widely varying characteristics of warship operation. For much of its working life the propelling machinery of a naval vessel is not highly stressed, but it must be capable of being forced, at very short notice, to a degree almost unknown in the merchant service, and of withstanding for indefinite periods the rapid tactical variations in steaming conditions, which are not confined to alterations of speed. At times the prevention of smoke is all-important and boiler efficiency a secondary considertion, only to be succeeded at a moment's notice by a combination of full speed coupled with the production of dense volumes of smoke as a screen. The method of making smoke screens by admitting a large excess of fuel to the furnaces is mentioned as one reason why CO_2 recorders which have proved satisfactory in merchant ships are only a qualified success in warships and have now been discarded. Moreover, any instrument designed for naval use must be proof against the shocks of prolonged gunfire, as it is just when these are most severe that there is least opportunity to attend to the derangement of over-delicate apparatus.

Military considerations have introduced into warship operation a number of chemical effects possessing disabilities which would not be tolerated on any other grounds. For example, the alternative method of producing smoke screens by the use of a mixture of equal parts of chlorsulphonic acid and sulphur trioxide, discharged through pipes led to the stern of the ship, is very detrimental to adjacent steel work, which must be washed down immediately afterwards to counter the corrosive effect. Disinfection by sulphur, especially in the case of submarines, necessitates much labour in subsequent cleaning, for the same reason, and indicates another direction for research in the endeavour to produce equally good results without the present drawbacks.

Refrigerating plant has been for many years a a feature of the warship's internal economy, both for the preservation of foodstuffs and for magazine cooling, although it may be observed that the latter need is now less urgent, owing to improvements in the manufacture of explosives. Air-conditioning, often associated with refrigeration in cargo vessels, especially in connection with the carriage of fruit, is now attracting attention as a means of ameliorating the living conditions in submarines, more particularly those employed in tropical waters, although there are difficulties still to be overcome in its application. These are typical of the almost incidental demands for a fuller knowledge of chemistry on the part of the naval engineer, whose sphere now extends even to the maintenance of soda fountains in the larger ships.

The need to be independent as far as possible of shore specialists introduces additional duties, such as the gas-testing of empty oil tanks in which men are to work; a precaution almost invariably delegated to some local firm when oil-carrying merchant ships are surveyed and repaired. It may be supposed, however, that the constructive chemistry of anti-fouling compositions and anti-corrosive paints, although discussed at some length by Commander Bedale, is in practice a matter which concerns the manufacturer and the Admiralty chemists rather than the officers serving in the ships, but it offers such a wide field for further investigation that its inclusion in the paper was perhaps justified.

Returning, however, to the questions more directly associated with main propelling machinery, the processes still employed in cleaning condenser tubes invite some remark. The problem is two-fold, due to deposits of grease on the steam side of the tube and of hard scale, principally calcium sulphate, on the water side. Neither of the methods used to remove the scale, namely, shot-blasting, and pickling in 75 per cent. hydrochloric acid, can be regarded as entirely satisfactory, both being laborious in application, and liable to cause damage to the tube if continued longer than is necessary. It is found advisable, in fact, to carry out a preliminary test on a sample tube in order to determine the requisite duration of treatment, and on the basis thus ascertained, to time carefully the exposure of each tube to the cleaning process.

For removing external grease, naval practice still holds to the time-honoured method of boiling out the condenser with a strong soda solution, but here again the duration is a matter of individual judgment and the process suffers from several drawbacks. Chief among these are the very messy nature of the treatment, and the fact that, at best, it is never wholly effective, as part of the grease is redeposited when the condenser is drained. It is rather curious that no mention is made of the method, which has now been in use for some years, of degreasing with vaporised trichlorethylene, as described by Mr. Sterry B. Freeman, C.B.E., in a paper read before the Liverpool Engineering Society in 1931; the more so, as this liquid has valuable fire-extinguishing properties and is presumably amongst the agents used in the chemical fire appliances to which Commander Bedale makes a brief reference. To clean a condenser with trichlorethylene takes "about a working day", according to Mr. Freeman, but when the process is completed the condenser is completely free from grease, and if reasonable care is taken, there is little resultant mess to be cleaned subsequently from the tank top and engine room bilges. Turbines are now almost universal in the Navy, however, and grease deposits in condensers are so much reduced in consequence that the soda process may not be so frequently necessary as to be a serious disadvantage in practice.

Of the many improved devices and processes which Commander Bedale would like to see introduced, he selects five for particular mention, viz., an oil detector for testing boiler feed water; means to ascertain the presence of noxious gases; a continuous recorder of the oxygen content of water; a method of descaling condenser tubes; and a real solution to the problem of underwater fouling. All of these may come in the near future, but the indications are that their advent will not diminish, but rather increase, the degree of chemical knowledge required of the naval engineers who must use and maintain them.

The New Mersey (Road) Tunnel.

"The Engineer", 19th July, 1935.

The result of the first year's working of the Mersey Tunnel, which was opened on July 18th, 1934, has exceeded all expectations. The actual returns are expected to be close upon 3,000,000 toll-paying vehicles and over 3,600,000 passengers, with a revenue of close upon £250,000. A report is now being prepared on the use of the lower portion of the tunnel.

Solid Petrol!

"The Engineer", 19th July, 1935.

Solid petrol was recently exhibited at the Guggenheim School of Aeronautics at New York

University. It has been developed as a result of experiments begun in 1919 by Dr. Adolph Prussin, and is a reddish jelly-like substance. In a small test engine developing 2·26 h.p. at 1,085 r.p.m. the consumption of fuel was 0·71lb. per horse-power hour. Liquid petrol in the same engine produced 2·41 h.p. at 1,125 r.p.m., but the consumption of fuel was 0·92lb. per horse-power hour. The new fuel is not high in cost and it can be stored without danger of fire, and is, it is claimed, easy to handle.

Superheating Economies.

"Shipbuilding and Shipping Record", 27th June, 1935.

The advantages which may be expected to attend the provision of superheating equipment lie first of all in the additional heat which is contained in the superheated steam over its heat content in a saturated condition at the same pressure. In this way a direct increase in overall efficiency is possible with no increase in fuel consumption. In the second place, the performance of the engine, whether it be of the reciprocating or of the turbine type, stands to benefit because of the reduction in condensation during the expansion of the steam from the main inlet to the condenser. As one of the principal means of improving the performance of existing machinery available to-day, superheating formed the subject of one of our recent articles dealing with the modernisation of ships. Shipowners, naturally, are concerned to know, as a percentage, the improvement in performance which any outlay, either on the hull or the machinery of their ships, may be expected to give, and many owners must now be in a position to state with greater or less accuracy the percentage reduction in fuel consumption for a given degree of superheat under stated conditions.

The superintendent of a well-known Continental company which has undertaken machinery conversions involving the fitting of superheaters has written to us on the subject. He questions the figure of 25 per cent. improvement published in our article already referred to—a figure which is contained in the records of a leading British marine engineering company, which has carried out many superheating conversions for several shipowning firms. The particulars which our correspondent gives are interesting. His company converted four vessels—cargo and passenger ships—for the use of superheated steam a few years ago, no other improvements being made to the ships at the time. All the ships have Scotch boilers operated under Howden forced draught, and are propelled by quadruple expansion engines. Three of the ships are fired by coal and the temperature of the superheated steam is 540° F. at a pressure of 215lb. per sq. in. The fourth ship is an oil burner and the temperature of the superheated steam is 580° F. In the case of the coal-burning ships the fuel is taken in at the home port only, and consequently great accuracy in measurements of the consumption for a whole trip is claimed. The ships trade in a regular service, their mean voyage draught, slip, revolutions and power varying little from one voyage to another. After three years of continuous service on superheated steam a comparison with three previous years on saturated steam has been made, and the respective fuel economies on the total consumption at sea for the four ships are 11, 11·5, 11·8 and 12·1 per cent. These figures include the consumption of the auxiliary engines which were only partly converted to superheat and a certain amount of hotel load. Our correspondent makes the comment that as there is practically no extra upkeep cost due to superheating, this saving is quite sufficient to pay for the conversion, and that if the consumption of the superheated steam engines alone had been calculated, the percentage saving would have shown up a little higher—to the extent of, say, 1 per cent. While criticising the figure of 25 per cent., he admits that the degree of superheat in other ships may be higher than the moderate temperatures attained in the four cases to which he refers, but in his opinion the economy would not necessarily follow the increase in temperature, since a superheat of about 630° F. is the maximum temperature obtainable in a reciprocating engine without involving lubricating troubles. The opinion is therefore expressed that in the carrying out of a superheating conversion on a reciprocating-engined ship a reliable figure for the decrease in fuel consumption is between 11 and 15 per cent. Our correspondent also makes the comment that an economy of 25 per cent., if ever attained, could not possibly be attributed to superheating alone. It may be recalled that while giving the figure in question, we stressed this same point, namely, that it is difficult to assess the value of superheating, or for that matter of any other individual means of economy, inasmuch as the cases of ships in which only one improvement has been carried out during the laying up of the vessel for modernisation are very few. Nevertheless, 25 per cent. economy is the improvement which firms engaged in this work appear to be able to confirm. Obviously it is a case in which it is desirable to know the experience of as many superintendent engineers and marine engine builders as possible, and it would be of great interest to know how many could confirm the figure of 25 per cent. economy. On the other hand, there are doubtless those whose experience would lead them to agree with the much more moderate figure of our correspondent, while others again would declare his value to be an overstatement of the improvement possible.

The Jubilee Naval Review (with some particulars of foreign Navies).

"The Engineer", 19th July, 1935.

The largest naval force seen in home waters for many years assembled at Spithead during the week-end for the Silver Jubilee Naval Review by

H.M. the King. It comprises 157 vessels drawn from the Mediterranean, Home, and Reserve Fleets, and is manned by approximately 48,000 officers and men. Viewed in the beautiful and historic setting of Spithead roadstead, this vast concourse of ships presents a most impressive spectacle, amplified by the presence of twenty-eight vessels of the mercantile marine and fishing fleets. This display occurs at a time when the thoughts of the nation are turning once more to problems of naval defence. Almost everywhere except in this country large programmes of naval construction are actively in train or about to be launched. The United States is pressing forward with the Vinson plan, which aims at bringing the fleet up to full Treaty strength in every category of vessel. The U.S. Naval Budget for the new financial year is but little short of £100,000,000, and is by far the largest ever voted in times of peace. Japan, too, is building steadily to implement her claim to a much larger proportion of fighting tonnage than she has hitherto possessed. Her current expenditure on sea, land, and air armaments is equivalent to almost one-half of the National Budget. France, which has reacted unfavourably to the Anglo-German Naval Agreement, contemplates large additions to her fleet, the relative strength of which has been doubled in the last six years. As our French correspondent reported recently, this year will see the launching or completion of six powerful cruisers, well armoured, mounting nine 6·1in. guns, and capable of speeds up to 33 knots. Huge flotilla leaders, whose average of 2,500 tons displacement puts them in the light cruiser category, are built or building to the number of 32. France, in fact, will shortly have 50 post-war cruisers from 10,000 tons downward. In the heavier types she is building the "Dunkerque" and "Strasbourg", battle cruisers of 26,500 tons, and two, if not three, 35,000-ton battleships have been authorised for laying down this year and next. Finally, the French Navy possesses about 100 effective submarines, a flotilla unmatched by any other Power. Italy is another determined competitor in the naval race. She is at work on a pair of 35,000-ton ships of the battle cruiser class and is steadily adding to her lighter naval forces, including submarines. Even the Russian naval dockyards are in full activity. From Moscow comes the announcement that since 1931 the Soviet submarine arm has increased by 435 per cent. In addition, there are now on the stocks, or soon to be laid down, six cruisers, six large destroyers, and 25 submarines.

A further and most important development in the general naval situation occured last week, when details of the German shipbuilding programme were released in Berlin. Although such a programme was not unexpected, and, had, indeed, become inevitable, certain items in it came as an unpleasant surprise to British public opinion. The new vessels already in hand or to be laid down this year are: Two battleships of 26,000 tons each, with 11in. guns; two cruisers of 10,000 tons each, with 8in. guns; 16 destroyers of 1,625 tons each, with 5in. guns; 20 submarines of 250 tons, six of 500 tons, and two of 750 tons each. In all, therefore, 28 German submarines will be afloat or under construction before the end of the year. The number is indicative of Germany's unshaken faith in the potency of this weapon, which, however, she has solemnly bound herself never again to use in an unlawful manner. It seems clear that the 20 small boats are intended to serve primarily as training units. This first submarine programme will absorb a very large proportion of the tonnage ratio in this category to which Germany is entitled under the Anglo-German agreement. From this may be inferred her intention to build up to the full 35 : 100 in all types with the least possible delay, and especially in the submarine category in which she is allowed the higher ratio of 45. According to credible report, the two "battleships" are, in fact, battle cruisers with a speed above 30 knots and an armament of twelve 11in. guns. They are openly spoken of in Germany as a reply to the French "Dunkerque" class, of approximately the same tonnage, but with an armament of eight 13in. guns. Germany, it will be observed, adheres to her traditional policy of mounting the lightest gun consistent with long-range, armour-piercing requirements, preferring rapidity, and therefore volume, of fire to a smaller number of heavier guns. These vessels, it seems, are to be driven by steam turbines. The oil-engine plant installed in the three "pocket battleships" of the "Deutschland" class may have given entire satisfaction, but apparently that type of prime mover is not considered to be sufficiently developed for application to the new battle cruisers. That Germany should have elected to build two 10,000-ton cruisers, with a battery of 8in. guns, is rather surprising. Except in the United States this type of vessel, which owes its genesis to the Washington Conference, has fallen into disrepute on account of its dangerous want of protection. It is probably a safe guess that in the German version armour defence will not be neglected, even if it involves some sacrifice of speed. The details of the 16 destroyers, like those of the battle cruisers, point strongly to France as the Power which the German naval authorities had in mind when they drew up this programme. Reference is made above to the French "flotilla leaders", and it is evident that these German destroyers, with their generous displacement and formidable guns, are designed as counterweights to a specific type, which is more likely to be French than any other. We in this country cannot justly complain if Germany, within the limits of her agreement with us, develops tactical naval ideas of her own and gives them concrete form. But neither can we remain indifferent. Already we are facing the fact that Germany, within two or three years, will have at sea battle cruisers which in speed and fighting power are equalled by only one ship in the whole of the

Navy—H.M.S. "Hood"—that she will possess destroyers individually superior to our best types, and a strong flotilla of submarines including a number of ocean-going units. In all of this there may be no grounds for alarm, but there is certainly cause for vigilance. Germany's rearmament at sea is the last, and not the least, of the many new factors of recent origin which are driving Great Britain, much against her will, to strengthen her own defence forces. What appears to be an adequate plan of Air Force expansion is already well under way. It must now be the turn of the Navy.

How much there is to be done will be only too obvious to those who turn a professional eye on the Fleet at Spithead. Of the eleven capital ships present only the "Nelson" and "Rodney" are of post-war vintage, and even they were put afloat nearly ten years ago. The others are maintained in a seaworthy condition only by periodical refits at great expense. At any given moment at least three out of our total of 15 capital units are absent in dockyard, undergoing "large repairs". The cruisers at the Review make a brave showing, but only because a number of obsolete ships from the Reserve Fleet have been furbished up and manned for the occasion. Actually, no more than eight of those present are of post-war construction. As with the cruisers, the Reserve Fleet destroyers would be of dubious value in a national emergency, while the merest novice in naval affairs will be able to assess the fighting value of the auxiliaries, such as sloops and minesweepers, which help to swell the numerical strength of the Fleet at Spithead. The Jubilee Review is, therefore, even more an exhibition of what we lack than of what we have. Properly regarded, our present Fleet, with its huge proportion of worn-out material, is no more than the nucleus of the Fleet which we must at all costs have ready in the critical years to come. Conditions to-day bear a certain resemblance to those of the penultimate decade of the last century, when the gaps revealed in what was then, without question, our first line of defence shocked the nation and led to the passing of the Naval Defence Act of 1889. If anything, however, the outlook is even more serious. Naval competition in those days was localised in European waters; to-day, it is literally world-wide. Our task is to build up a fleet powerful enough to provide a reasonable margin of security for British interests in Home Waters, the Mediterranean, and the Far East. The cost must needs be heavy, but, as has already been shown by the almost unanimous approval of the expensive programme of Air Force expansion, the country will shirk no sacrifice in the cause of security. The Government, it is understood, has determined to repudiate the arbitrary limit imposed on our cruiser strength by the London Treaty. Unless the "escalator" clause is invoked, we must, of course, be bound by that treaty until the end of next year. After that, however, it is proposed to increase the number of cruisers from 50 to at least 60, and proportionately to enlarge the destroyer establishment and other light forces. There is no hope whatever of reaching a new, multilateral agreement which will effect any substantial reduction in foreign fleets. A large building programme for our own Navy is, therefore, inevitable, and in view of the number of capital ships now building on the Continent—no less than twelve have been laid down or authorised by France, Italy and Germany together—we must prepare for the construction of battleships, as well as of cruisers and smaller types. It is further to be noted that the majority of the capital units building abroad will displace from 26,500 to 35,000 tons. Clearly, therefore, the British Government's repeated attempts to restrict such vessels to 25,000 tons have definitely failed. Much as we may deprecate very large dimensions, it goes without saying that our new capital ships must be inferior to none in all the tactical qualities that count.

Safety at Sea.

"The Engineer", 26th July, 1935.

Speaking in the House of Commons on Thursday, July 18th, Mr. Walter Runciman, President of the Board of Trade, announced that he had appointed a committee of experts to inquire in the interests of safety at sea into the types of steering gear used by the steamships "Usworth" and "Blairgowrie", into whose loss public inquiries were recently held. The Chairman of the Committee, which will sit in private, is Mr. H. N. Gresley, the Chief Mechanical Engineer of the London and North-Eastern Railway Company, and its members are Mr. Maurice S. Gibb, managing director of the Central Marine Engine Works, West Hartlepool; Mr. J. Denham Christie, chairman of Swan, Hunter and Wigham Richardson, Ltd.; Captain Thomas, marine superintendent of the Furness Line; and Mr. W. R. Spence, the general secretary of the National Union of Seamen. The Mercantile Marine Service Association and the Imperial Merchant Service Guild, the societies representing British ship masters and navigating officers, have sent a joint protest to the President of the Board of Trade referring to the non-inclusion of direct representatives of masters and officers in the Committee. The inquiry into the manning of British ships, which Mr. Runciman stated will follow the recent findings of the court of inquiry into the loss of the "Usworth" and "Blairgowrie", will be made by the Board of Trade Merchant Shipping Advisory Committee, on which masters and officers are directly represented.

A "Mauretania" Memorial.

"The Engineer", 26th July, 1935.

A 15ft. model of the "Mauretania", weighing nearly 2 tons, has been placed in the Mariners'

Chapel in Winchester Cathedral, and was dedicated on Tuesday at the Annual Shipping Festival. President Roosevelt has directed that an 18ft. model of the "Mauretania" be placed in the Smithsonian Institution at Washington and remain permanently among the models of other famous ships.

The Increase in Two-stroke Machinery.

"The Motor Ship", August, 1935.

The list of motor ships of over 1,000 tons gross on order, published in this issue, totals 161 vessels. Of these, 120 are to be equipped with machinery of the two-stroke type, and only 41 will have four-stroke single-acting engines, the four-stroke double-acting type having now disappeared. Of the two-stroke units, 80, or two-thirds, will be of the single-acting design and 40 are double-acting engines.

There is not much doubt that the two-stroke Diesel engine has gained in favour compared with the four-stroke class. Until 1932 the latter represented considerably more than 50 per cent. of the total number installed during the year, the figure for 1932, for instance, being 58 per cent. In 1933 and 1934, only about one-third of the ships built were equipped with four-stroke engines, and at the present time those under construction to be propelled by such machinery represent about 25 per cent. of the whole. This development has been due, not only to the progress of the double-acting two-stroke design, but to the advance which has been made in the design and manufacture of two-stroke single-acting units, including many of the trunk piston type.

How Fuel Consumption has Improved.

"The Motor Ship", August, 1935.

The average improvement, taking oil engines as a whole, which has been effected in fuel consumption during the past 10 years is equal in percentage to the reduction in coal consumption with the newer types of steam machinery that have recently been developed, and about which so much has been written. This is a fact that has not been generally understood. Ten years or so ago it was normal to take 0·40lb. per s.h.p.-hour as the average fuel consumption for a large marine Diesel engine. Official tests have lately shown a consumption of 0·33lb. to 0·335lb. per s.h.p.-hour for a Sulzer and a Burmeister and Wain double-acting two-stroke engine, and 0·325lb. per b.h.p.-hour for a Doxford motor.

There is thus a remarkable similarity in efficiency between some of the most widely used Diesel motors of large power, and the small differences noted depend on the auxiliaries, which are directly driven. If, therefore, we take a figure of 0·35lb. per b.h.p.-hour, inclusive of the scavenging pump, lubricating oil and circulating water pumps, we shall have a fair representation of the fuel consumption of the modern Diesel engine; this corresponds to a reduction of some 12 per cent. compared with the figures normally obtainable 10 years ago.

In reality, the improvement is somewhat greater since the exhaust gases can be utilized for the provision of steam for heating or other purposes, and it is found in many ships that this is equivalent to a saving of between 3 per cent. and 6 per cent. The present-day marine oil engine, therefore, in practice, is at least 15 per cent. more economical than it was in 1925.

A Study in Economics.

"The Motor Ship", August, 1935.

Practically every country now subsidizes its shipping. The subsidies are paid in the different countries by the taxpayers, who are the purchasers of the produce carried by the ships. These purchasers, therefore, pay a certain amount extra for their produce, and they pay it to their Government in the form of tax. The result would be precisely the same if they paid it as extra freight direct to the shipowner. In other words, if freights were raised by a corresponding amount all subsidies could be abolished.

A Proposed New United States Liner.

"The Engineer", 26th July, 1935.

On his arrival from New York at Plymouth on Tuesday, July 23rd, Mr. James S. Mahool, the general passenger traffic manager of the International Mercantile Marine Company, announced that a new 30,000-ton liner, the largest and fastest ever built in the United States, will probably be running between New York and Europe in 1937. The plans for the ship have already been prepared, and she should be in commission within two years. Her designed speed will probably be two knots greater than that of the 20-knot liners "Manhattan" and "Washington". Mr. Mahool is returning to America on the "Normandie", but he does not think that although more Americans are travelling to Europe, there will ever be sufficient traffic to make such large ships as the "Normandie" and the "Queen Mary" paying propositions. This year's increase in the number of passengers is largely to be attributed, he says, to the Jubilee celebrations in England, but on the whole it seems that most visitors prefer to pay lower rates and to travel on slower and smaller liners.

S.s. "Egypt" Bullion Salvage—98 per cent.!

"The Engineer", 26th July, 1935.

The Italian salvage steamer "Artiglio" reached Plymouth on Friday, July 12th, and landed gold bars and sovereigns valued at £45,000, which had been recovered from the lost Indian mail steamer "Egypt" off Ushant. The treasure comprised ten gold bars of 400oz., eight bars of 100oz., and about

7,000 sovereigns, and was sent to London. Since the wreck was located seven years ago, approximately 98 per cent. of the bullion has been recovered representing a value of over £1,000,000.

The Largest All-welded Ship.

Constructional Details of the Motor Vessel "Joseph Medill," Equipped with High-speed Diesel Machinery Designed for Maximum Carrying Capacity.

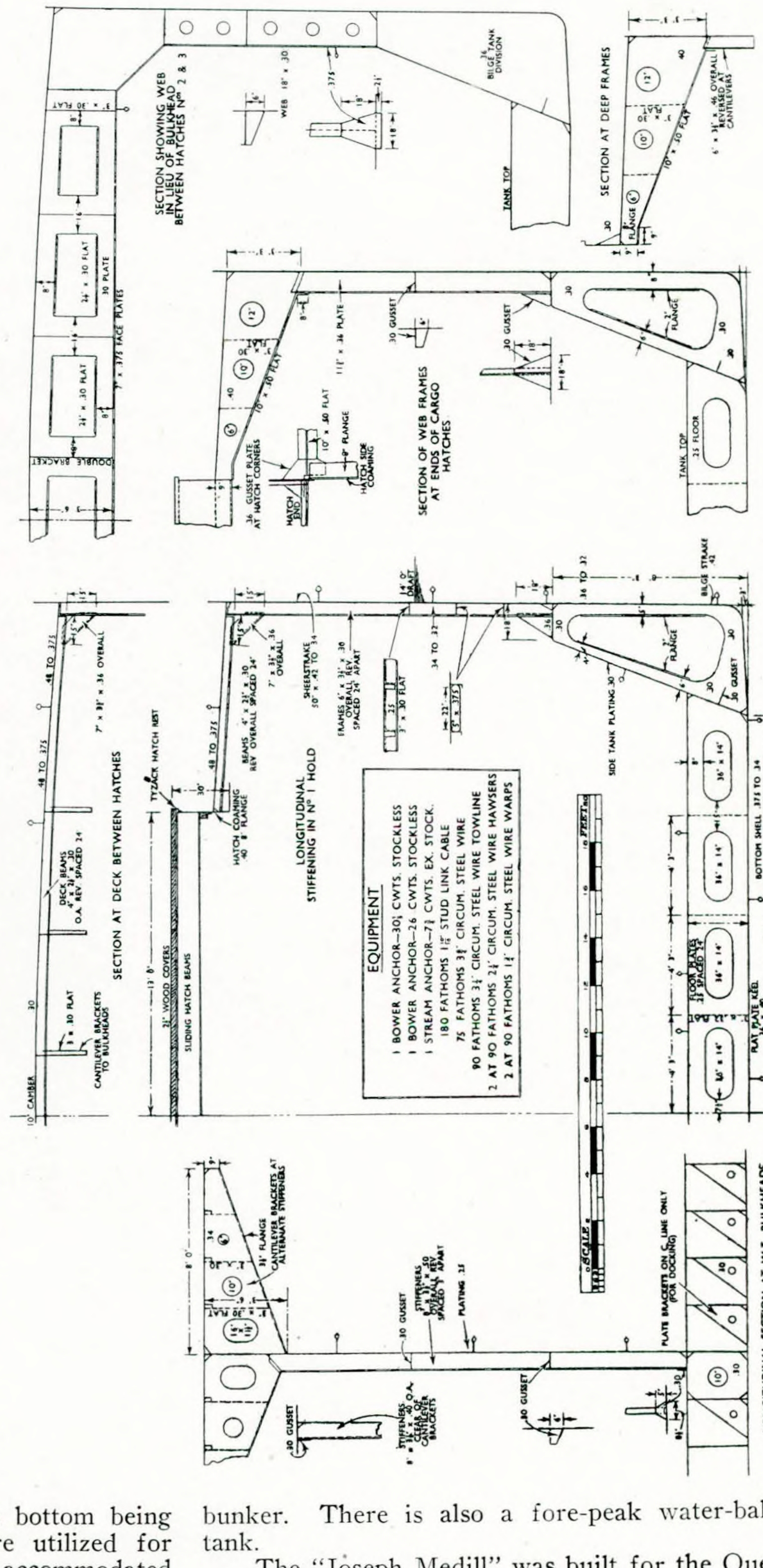
"The Motor Ship", August, 1935.

The conditions under which ships operate on the Great Lakes are exceptional, and it is necessary to take advantage of all possible developments in naval architecture and marine engineering to produce the most efficient type. Dimensions are limited, and any reduction in hull and machinery weight, or space occupied by the engines, naturally leads to favourable results in cargo-carrying capacity.

For this reason the "Joseph Medill", which was due to run trials at the end of July or beginning of August from the Wallsend shipyard of Swan, Hunter and Wigham Richardson, Ltd., is worthy of special attention. It is believed that she will represent the most efficient class of cargo carrier on the Great Lakes, and will have the maximum possible deadweight capacity within the imposed limitations of length, beam and draught.

She is the largest all-welded ship in existence, and the adoption of welding has substantially reduced the hull weight. Secondly, although designed for a trial-trip speed (loaded) of only 9½ m.p.h., she is propelled by two 500 b.h.p. Diesel engines running at 353 r.p.m. Mr. Walter Lambert, of Lambert and German, Montreal, who are responsible for the designs, informs us, however, that the propulsive efficiency of the ship at this relatively high engine speed will prove to be very satisfactory.

The new ship has two balanced streamlined rudders and a cruiser stern. There are three cargo holds and four hatches, the double bottom being divided into two tanks. These are utilized for carrying fuel, and some can also be accommodated in the after peak, which is normally used for water ballast. Above the after peak tank is another fuel bunker. There is also a fore-peak water-ballast tank.



Midship and other Sections of the "Joseph Medill".

The "Joseph Medill" was built for the Quebec and Ontario Transportation Co., Montreal, and will be employed in carrying pulpwood, newsprint, grain and other cargoes, on the Great Lakes.

The following are the main characteristics of the vessel :—

Length overall	259ft.
Breadth moulded at deck ...	43ft. 10in.
Depth moulded...	22ft.
Draught loaded in fresh water	14ft.
Corresponding deadweight ...	3,100 tons
Service speed loaded	9½ m.p.h.
Machinery power	1,000 b.h.p.
Engine speed	353 r.p.m.

With ships engaged in the Great Lakes service there is danger of a section of the bilge receiving damage when the hull touches the canal side or dock wall, and what is known as the Conduit bilge system has been employed with the object of diminishing this danger. This is an arrangement originated by Messrs. Lambert and German.

Transverse framing is employed throughout the ship, apart from the employment of cant frames in the forepeak, and special strengthening is provided at the forward end of the ship. Whilst a few parts are lap-welded, such as the brackets in way of the hatches, the main system throughout is butt welding. The bottom plates were erected separately, but much sectional welding was carried out on the special skids provided, this including the inner-bottom plating with floors, also the bilge-tank plating in sections of about 30ft. long. Moreover, the bulkheads were welded complete before being fixed into their position in the hull, where they were welded to the inner bottom shell and to the deck.

Many of the frames at the fore and after ends of the ship had to be erected individually, also a number of shell plates, due to the curvature. The welding in these cases was done after fairing up the structure in position. No rivets were employed, even for erecting purposes.

The designers decided that steam should be absent in the ship and electricity is, therefore, utilized, not only for the steering gear, windlass, winches, in the galley and for refrigerating machinery, but also for heating, electric radiators being provided in the accommodation. The water in the bathrooms is heated electrically.

The general arrangement of the accommodation may be gathered from the plans. A special owner's suite with a day-room and heating cabin and bathroom is provided. The officers and captain are berthed in the fore part of the ship, and the engineers and crew aft.

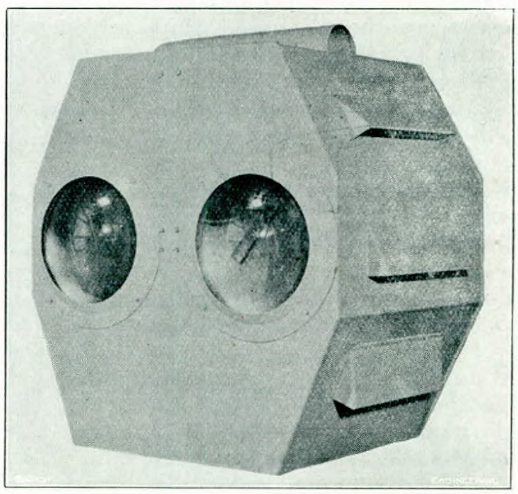
Two six-cylinder M.A.N. single-acting two-stroke engines are installed. They are of the airless-injection type. Each unit is of the five-cylinder trunk-piston direct-reversible type, and the cylinders are 300mm. in diameter, the piston stroke being 420mm. For the supply of electric power, two Ruston and Hornsby four-cycle engines are coupled to 58 kW. dynamos; they run at 1,000 r.p.m.

The work of superintending the construction of ship and engines at the builders' works and yard has been carried out under the personal direction of Mr. Walter Lambert and Mr. Lindsay Vipond for the owners.

The "Sinterae" Fog Beacon.

"Engineering", 5th July, 1935.

The lamp illustrated by the photograph reproduced on this page has recently been installed on the London Midland and Scottish Railway Company's section of the Port of London Authority pontoon at Tilbury. It is the invention of Mr. Leslie G. Toplis, Assoc.I.E.E., and is known as the "Sinterae" fog beacon, the lamp being made by Messrs. Sinterae, Limited, Avenue Chambers, Vernon Place, Southampton Row, London, W.C.2. The unit illustrated contains two 2-kW. gas-filled projector lamps, each of which is used in conjunction with a mirror and bull's-eye lens arranged to give a slightly divergent beam of white light. The special feature of the unit, however, is that it contains a motor-driven rotating shutter which occults the two lamps alternately at a frequency of 5·5 occultations per second. It is on this feature that the increased fog-penetrating power of the light, in comparison with an uninterrupted beam of equal intensity, depends, although it is difficult to



find a physical explanation for the observed facts. Probably the explanation is a physiological one, dependent upon the functioning of the human eye. Doubtless, the visual sensation produced by what Mr. Toplis describes as the "vibratory" light from the Sinterae lamp, differs from that produced by a flashing navigational light, owing to the higher frequency of the flashes of the former.

We understand that during the past winter some observations have been made on a Sinterae fog beacon at Newhaven Harbour by officers of the Marine Departments of the Southern Railway and of the London Midland and Scottish Railway. In one case during a grey fog in daylight, the light from an ordinary lamp of the same candle power, and having the same optical system as the Sinterae lamp, was lost sight of at a distance of 102 yards, while the corresponding figure for the Sinterae lamp was 167 yards. In another test made during a sea fog at night, the distances at which the light from a plain lamp and a Sinterae lamp were lost sight of were 380ft. and 500ft. respectively. In this latter test, observations were made at an angle of about 12° with the optical axes of the two lamps and the distances were determined by markings on the quay side. The observations, we are informed, were repeated several times, with differences of only two or three feet in each case.

The lamp installed at Tilbury is to be used in connection with the operation of the Tilbury-Gravesend ferry service, and it seems reasonable that it will enable service to be maintained in atmospheric conditions that would otherwise necessitate a suspension of traffic.

The Whitworth Society.

"Engineering", 5th July, 1935.

In view of the presidency of Mr. Charles Day, the Summer Meeting of the Whitworth Society was this year appropriately held at Buxton and Stockport, the proceedings commencing with an informal dinner at the Palace Hotel, Buxton, on the evening of Wednesday, June 26th. The next day a visit was paid to the works of Messrs. Mirrlees, Bickerton and Day at Hazel-grove, near Stockport. The journey from Buxton was made by road, and the opportunity was taken, by permission of Mr. T. Dearden, the Borough Water Engineer of Stockport, to inspect the new dam in course of construction by the Stockport Corporation in the Goyt Valley, which will form a reservoir several miles long to provide further water supply for the town. The dam is an earth structure with a puddle core, faced on the upstream side with rubble for the lower part and with dressed blocks laid in sand for the upper section, which will be exposed to the surface action of the water in the reservoir. Water can be drawn off at three levels, and two pipe connections are taken through a tunnel built in the dam, one supplying the town and the other, compensation water. A spill-way is provided at one side. A concrete screen wall was formed in a trench below the foundations of the dam, and extensive grouting in the neighbourhood of the foundations was also carried out. The remainder of the morning and the afternoon were spent in an inspection of the works of Messrs. Mirrlees, Bickerton and Day, lunch and tea being kindly provided by the firm. It is not possible in the compass of this note to attempt a description of Messrs. Mirrlees' works. The status of the firm in the manufacture of Diesel and solid-injection oil engines is, however, well known. Their standards range from 50 h.p. to 2,000 h.p. The position which the firm took from the first in the manufacture of Diesel engines has never been relinquished, and as evidence of the quality of the work turned out from the beginning it is sufficient to say that the first Diesel engine built in this country, and the third in the world, is still at work in the shops, being employed for driving a compressor for charging air bottles. The firm has recently taken up the manufacture of the Combustioneer automatic stoker for small coal-fired furnaces, and many examples were to be seen in the shops. We described and illustrated this appliance in our issue of May 17th, in the course of our notice of the British Industries Fair. As is the custom, the new president assumed office on this, the second day of the meeting, Mr. Day vacating the chair in favour of Professor E. G. Coker, the new president. As his first duty, Professor Coker expressed the thanks of the company to Mr. Day for his continual interest in, and work for, the Society, and particularly for the hospitality extended during the meeting. The visit was well attended, and the arrangements made by Dr. S. J. Davies, the hon. secretary, worked admirably and added to the success of a very enjoyable meeting.

The Engineer's Ratchet Brace.

"The Engineer", 12th July, 1935.

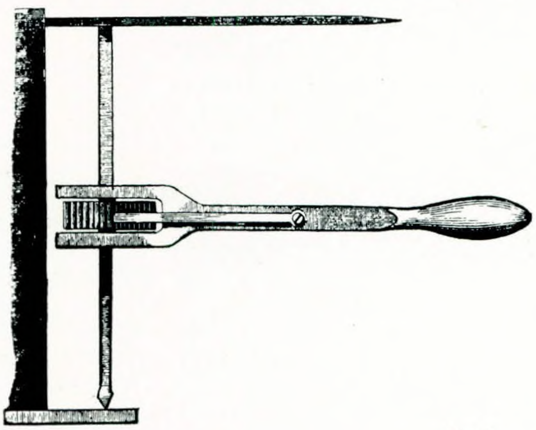
The origin of most of our hand tools is lost in the distant past, although some of the more specialised types belong to the historic period. In some instances, we do know the date of the developed form of a tool, and in the case of the ratchet brace we are able to say that it is just a hundred years old.

The first mention of the ratchet brace with a sketch, reproduced, occurs in a letter dated August 17th, 1835, from Mr. C. Davy, an architect, to the editor of the "Mechanics' Magazine", Vol. XXIII, 441. Under the title of "A Simple Drill", Mr. Davy says: "The above sketch represents a very simple and efficacious drill, the invention of a workman, I am informed, at Mr. Hague's manufactory. The inconvenience attached to the use of a large drill, when holes are required to be made in a confined situation, such as flanges, iron railings, etc. —it being in such cases impossible to accomplish the requisite motion—appears to have been the primary cause of this ingenious arrangement". He goes on to give a description which is too elementary to be worth quoting. As will be observed, the sketch shows no means for giving feed to the drill, and we are left to assume that there is a square hole in the ratchet wheel to take the shank of the drill.

Mr. Davy goes on to observe sententiously: "Numerous are the arrangements adopted by intelligent workmen for economising time and labour, and it is to be regretted that many of these contrivances never emerge from the workshop or factory in which they originate. Publicity would, in all probability, be the means of raising from a subordinate situation, artificers whose practical talents do honour to themselves, and reflect credit on the natural ingenuity of the working classes of this country".

John Hague was a well-known engineer and inventor, who turned out much sound work from his manufactory in Wellclose Square, Cable Street, E.1. It will be remembered that Trevithick went in 1828 to see Hague's compressed air crane at St. Katherine's Dock, and that Sir Frederick Bramwell was apprenticed to Hague.

The ratchet brace, thanks possibly to some extent to Mr. Davy, was not born to blush unseen, for an illustration of it, or rather of the ratchet lever alone, appeared in 1838 in a German periodical (*Mittheilungen des Gewerbe-Vereins für das Königreich Hannover,* 1839, page 183), under the title "Schraubenschlussel", in a paragraph headed "Communications from England", by Professor J. Schneider, who says: "It is to be met with in many English workshops, and is of great use in sundry cases". The square socket for the shank



"A Simple Drill", 1835.

of the drill is clearly shown but no nut or other feed device.

By 1846 the tool had got into the form familiar to us to-day, with a sleeve nut on the square-threaded feed screw and with a proper socket for the bit, because in that year John M'Mahon, a tool-maker of Fenchurch Street (the proximity of Cable Street may be remarked), registered a "double ratchet brace". The improvement consisted in the use of right and left-hand ratchets with three mitre wheels to reverse the direction of one so that almost constant rotation was given to the drill. M'Mahon's arrangement has not survived. This, by the way, is the first mention in print of the word "ratchet brace".

Holtzapffel, in his "Mechanical Manipulation", Vol. II, the preface of which is dated 1846, discusses, as one would expect, all these cognate tools (page 569). He illustrates the "common brace", the screw of which is held stationary at intervals by a tommy bar to give the feed; the "lever drill", a drill rotated by a lever like that of a vice; the "ratchet lever", which is what Mr. Davy describes above; and, lastly, the "ratchet drill", which he derives from the lever drill, and which we now call the ratchet brace. It looks as if, in the attempt to bore holes in places inaccessible to the common brace, in the course of development the lever drill was the first idea, but no doubt it proved too slow. Then came the idea of using a ratchet, and from the ratchet lever it was but a short step to the ratchet brace.

Thus it is clear that prior to 1846 the tool had become a commercial article, and it was not necessary for a fitter to make one for himself to add to his kit. No sooner was this the case than little gadgets began to be schemed. One of the first that we have come across was the "eccentric lever brace", registered in 1847 by Joseph Fenn, tool-maker of Newgate Street (*Mech. Mag.*, XLVII, 276), in which a nipping lever is substituted for the ratchet. There has been a succession of such devices, but few have survived, and the ratchet brace to-day is substantially what it was a hundred years ago.

A Large Glasgow Dock Scheme.

"The Engineer", 12th July, 1935.

At a meeting of the Clyde Navigation Trust, held on Tuesday, July 2nd, a scheme of dock improvement, which will probably cost £7,000,000, was formally approved. The scheme proposed will provide about 4½ miles of wharfage on the south bank of the river, along a river frontage of about 1½ miles. It provides for the layout of docks consisting of two basins to the westward of King George V Dock, with graving docks at the south end of the westmost basin, with a riverside quay running eastward from Renfrew workshops to the westmost basin, permitting of a widening of 200ft. in the river opposite. The Clyde is to be widened at one point by about 200ft., and the new docks will be constructed to the west of the large George V Dock. The Trust has no less than 279 acres of land at Shieldhall and Renfrew available, and is now looking into the question of securing suitable occupiers who desire industrial sites. In the discussion of the scheme, the City Treasurer, Mr. P. J. Dollan, welcomed the new project, which, he stated, was the biggest scheme of its kind put forward in Glasgow during the past ten years. Mr. Dollan said that he was tired of hearing about the decline of Clyde industry, and said that it was the continual preaching of unjustified pessimism which gave the impression that Clydeside was down and out. His view was that the Clyde was relatively in a better economical position than any other port in the world. The annual financial report submitted by Mr. W. F. Robertson showed that the figures for the preceding year were exceeded by £75,000, and the approximate increase in the inward cargoes was 126,000 tons and in the outward cargoes 218,000 tons.

The "Normandie". Fuel and Lubricating Oil Consumption.

"The Engineer", 12th July, 1935.

Speaking at the Oil Industries Club luncheon on Tuesday, July 2nd, M. Pierre de Malglaive, resident director of the French Line in London, said that under full power, when developing about 160,000 h.p., the consumption of the "Normandie" for all purposes had been found to be about 57-60 tons of fuel oil per hour. The energy contained in 1 ton of fuel had to be liberated each minute to propel the ship over a little more than half a nautical mile. Hundreds of firemen were replaced by six electrically operated oil pumps. The general lubricating system required, roughly, 18 tons of oil, which was circulated, cooled, and purified by centrifugal cleaners. In a trip to New York and back the same oil would have been used more than 1,500 times.

A Sister for the "Empress of Britain".

"The Engineer", 12th July, 1935.

Before he left for Canada on the "Empress of Britain" on Saturday, July 6th, Sir Edward Beatty, the president and chairman of the Canadian Pacific Railway, stated that an order for a sister ship, to give a better balanced service, would be placed two years prior to the withdrawal of the "Empress of Australia", and probably within five years from the present time.

Diesel-engine Development.

'The Motor Ship", August, 1935

Mr. Keller, designer of the Doxford engine, in his paper on "Marine Heavy Oil-engine Development During the Past Fifty Years" (at the Jubilee Meeting of the North-East Coast Institution of Engineers and Shipbuilders) indicated the advances which have been made in the efficiency of Diesel engines, from the time when the first motor of the type was built. He gave the appended diagram (Fig. 1), which illustrates in an interesting form the manner in which the heat balance has improved. Even this does not show the increase in what might be termed the commercial thermal efficiency of the oil engine, since it does not take account of the regeneration of heat in exhaust-gas boilers.

A second interesting diagram in Mr. Keller's paper was that shown in Fig. 2, illustrating the outline of a 3,000 b.h.p. Doxford oil engine in 1935, with the new welded-frame design, and a unit of the same power and cylinder dimensions built in 1920.

In some ships, particularly of the tramp class, the saving in fuel due to the utilization of exhaust heat for raising steam for driving the lighting sets, steering engine and occasional auxiliaries is greater than in big, high-powered passenger liners. Mr. Keller stated, for instance, that in vessels of the "Sutherland" type, the gain in fuel consumption was between 15 per cent. and 20 per cent., compared with motor ships utilizing oil-fired boilers and not employing the exhaust gases.

Mr. Keller gave a notable survey of the position, although he could not quite go back 50 years, since Diesel's original patent is dated 1892, or 43

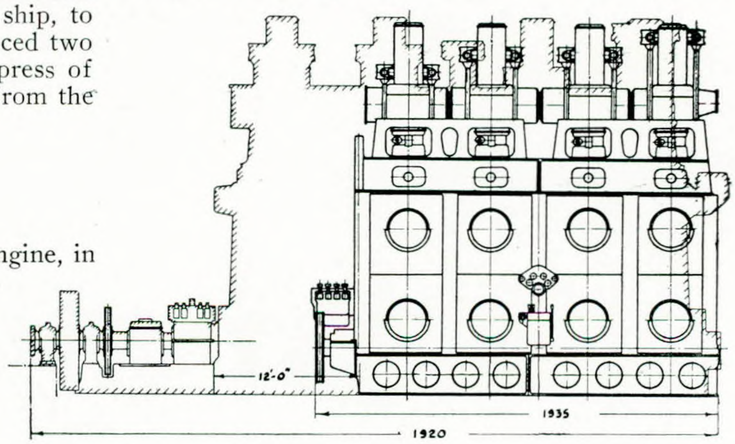


Fig. 2.—Outline elevation of Doxford engines of same cylinder dimensions and power built in 1920 and 1935 respectively.

years ago. Moreover, the first ship to be equipped with Diesel engines was not built until 1904, and the first ocean-going vessel not until 1910.

It was with justifiable pride that Mr. Keller referred to the fact that the experimental Doxford opposed-piston engine built in 1917 adopted airless injection, and has employed it ever since, although the practice did not come into universal use until ten years later.

A little humour is not out of place in a technical paper, as the following paragraph shows :—

"It is of interest to observe the effort

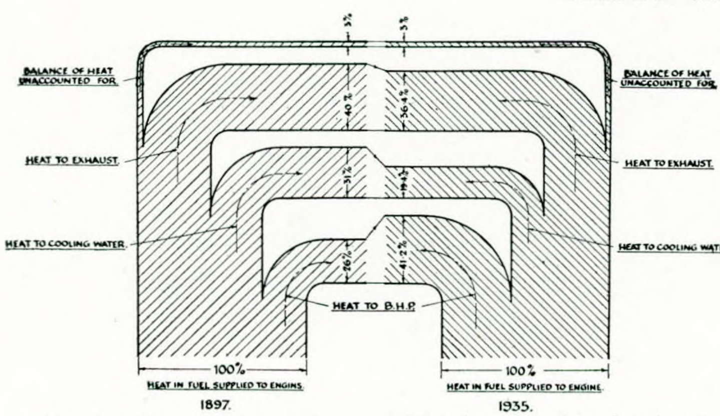


Fig. 1.—How the heat balance of Diesel engines has developed.

to control the currents of air and exhaust gases inside the working cylinders, not only with the view of avoiding mixture of the two, but of late years more to provide an organized flow of air through the sprays of the fuel oil as it enters the combustion chamber. The value of this recognition has been an important source of revenue to the Patent Office and has been mainly brought along through the adoption of airless injection".

The Boundary Friction of Oxidised Oil.

"Engineering", July 5th, 1935.

What is known as "thin film lubrication", is now becoming recognised as something distinct from the thick film type in which fluid friction alone must be considered. Friction in relatively thick films increases with an increase of viscosity due to oxidation of the oil, but considerable experimental evidence now exists showing that a diminution of friction accompanies the process of oxidation in exceedingly thin films. Friction in these films is affected also by the nature of the lubricated surfaces. Thin film lubrication dependent more on the chemical structure of the oil and the nature of the bearing surfaces than on viscosity, is associated usually with the boundary conditions that lead to seizure and is consequently thought to be unsuitable for use in practice. The factors controlling friction in thin films are not yet understood completely, nevertheless considerable progress, more especially in America, has been made with the application of this method of lubrication to practice. It is reported, for instance, that trans-continental motor coaches are now running on lubricating oil having an "S.A.E. viscosity number" (Society of Automotive Engineers) of 20, while here, oil of a lower number than 30 is not marketed for motor lubrication, and the viscosity numbers of the oils used generally are 40 and 50.

The journal bearing trials described by King and Jakeman,* afford an interesting example of thin film lubrication. The coefficient of friction in these trials was observed to be as low as 0·0005, although the load on the "arc of contact" was of the order of one ton per square inch and the running temperature of 250° C. and higher sufficed to reduce the viscosity of the oil to about that of water. The term "oxidation lubrication" was applied by King† to the conditions prevailing in the thin films and that aspect of lubrication was discussed at some length in our issue of March 8th last, page 257 *ante*. Experiments of Dr. Redgrove dealing with the boundary friction of oxidised mineral oils have been described since at a recent meeting of the Institution of Petroleum Technologists, and are an interesting contribution to our knowledge of the effect of oxidation on lubricating value.

The friction-measuring device designed and used by Dr. Redgrove comprised essentially a case-hardened steel plane slider resting on three steel balls fixed to a platform arranged to be inclined gradually until slip just occurred. Total friction in the circumstances is equal to the force acting to move the slider, the magnitude depending on the weight of the slider and the observed angle of inclination. The apparatus differs from that described by Wilharm* some years ago only in that the plane surface slides on the balls, instead of the balls sliding on the surface. Both methods are similar generally to that used by Hardy and Nottage, except that three bearing points are used, instead of one. They are assumed to measure the same type of friction, but the results obtained scarcely support this view.

The single spherical slider is supposed to penetrate the oil film and rest on the layer of oil absorbed by the plane metal surface, but no direct evidence has been given as to the actual thickness of the loaded film. Nottage† states that it is "probably bimolecular in thickness". The results obtained with the device show, however, that the friction obeys Amonton's law, μ being equal to friction÷load,‡ and that for a pure chemical substance μ is independent of temperature. The friction is then evidently not of the fluid type, and therefore it may be assumed safely to have been measured in a film so strongly attached to the metal surfaces that the properties of a fluid have been lost. The difficulty of measuring similar friction characteristics is enhanced when three spherical surfaces are used instead of one, because of the imperfections in terms of molecular dimensions of even the best plane surface. The accuracy of a very good plane surface of metal does not exceed two 10-thousandths of an inch, and if the whole surface were covered with oil to the level of the highest point, the variation in the thickness of the film would be represented by anything up to a length of 5,000 molecules of, say, oleic acid placed end to end. The probability of a film of oil of equal thickness in molecular dimensions prevailing under three spherical surfaces fixed rigidly together and placed at random on a plane surface would seem to be very remote, and the suitability of the apparatus used by Dr. Redgrove for measuring the friction on the absorbed or boundary layer is therefore open to question. This view is supported by the experimental results given by Wilharm showing

* King and Jakeman, "Lubrication in Oxidising Conditions", Aero. Res. Com. R. & M. No. 1517.

† King, "The Beneficial Effect of Oxidation on the Lubricating Properties of Oil", *Proc. Roy. Soc., A.*, Vol. 139, 1933.

* W. C. Wilharm, "The Rôle of Oiliness in Industrial Lubrication". *Industrial and Engineering Chemistry*, 463, Vol. 18 (1926).

† M. E. Nottage, *Boundary Lubricating Value of Mineral Oils of Different Origin. Technical Paper No. 2*, D.S.I.R. Lubrication Research.

‡ It is inadvertently stated by Hardy, para. 3, *Technical Paper No. 1, D.S.I.R. Lubrication Research*, that the *coefficient* varies directly as the load.

that the coefficient of friction measured by that type of apparatus increased with increase of load, and varied with the length of time the loaded slider rested on the plane surface.

Dr. Redgrove's apparatus is no doubt equally as satisfactory as the other three-bearing arrangements, such as that of Deeley, for determining relative "oiliness", the object of the experiments described being to determine the effect on lubricating value of the weak organic acids always formed in small proportion when mineral oils are used in oxidising conditions. The suitability of the apparatus for such purposes was verified by a redetermination of the familiar effect of organic acids such as oleic and palmitic to increase the oiliness of a substance (medicinal paraffin) deficient in that property. Friction measurements were then made using three oils procured from Russian crude, and one blend of Pennsylvania oils. The oils were so severely oxidised for a 12-hour period that viscosity more than doubled, asphalt formed freely in the non-paraffinic oils, and acidity increased from nearly zero to an amount requiring from 150mgm. to 200mgm. of KOH per 100 grams of oil, for neutralisation. Measurements of friction were made at temperatures varying from 20° to 110° by 10° steps, and at oxidation intervals of from 1 hour to 12 hours. The friction measurements were repeated after removing the hard asphalt from the oxidised oils, altogether several hundreds of friction measurements being required.

The experiments show that asphaltic products of oxidation increase friction, but that when they are removed, a beneficial effect remains, due presumably to the acidity developed during oxidation. The improvement of lubricating value thus obtained was slight. For example, μ for the paraffin base oil at 100° was 0·122 before oxidation. After oxidation for 12 hours, the value obtained was 0·1185, and removing the asphalt, μ was reduced to 0·113. It will be observed that even in the favourable instance quoted, the conclusion as to the beneficial effect of acidity rests on the measurement of small differences.

The experimental results are of interest in practice in so far as they show that used oils after filtration are not to be expected to have an appreciably enhanced lubricating value as compared with fresh oils. The references as to the experimental results confirming the work of Gilson and of King and Jakeman are really somewhat beside the point in issue. Gilson's* experiments showed that lubricating value was improved by the "act" of oxidation. Thus the friction of an enclosed journal bearing diminished with time if an oxidising atmosphere were maintained in the enclosure, and then increased when the bearing was run in a vacuum or in an atmosphere of hydrogen. The changes were found to be reversible. The beneficial effect of an oxidising atmosphere was, therefore, not due to the oxidation products themselves, but to the activity producing them.

* E. G. Gilson, "Some Little Understood Factors Affecting Lubrication". *Industrial and Engineering Chemistry*, page 467, Vol. 18 (1926).

Another Flexible Coupling—the "Elcard".

"Engineering", 19th July, 1935.

The flexible coupling shown in Figs. 1 and 2 below, has recently been developed by Messrs. Frank Wigglesworth and Company, Limited, Shipley, with the object of utilising the flexibility of the well-known flat laminated springs in transmitting driving torque only without subjecting them to the recurrent stresses which would occur should the coupled shafts be out of line either radially or angularly. The laminated springs, which are of Swedish clock-spring steel, are arranged in the

Fig. 1.

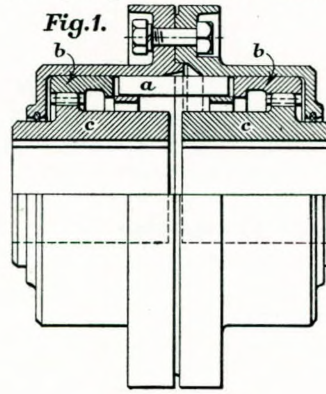
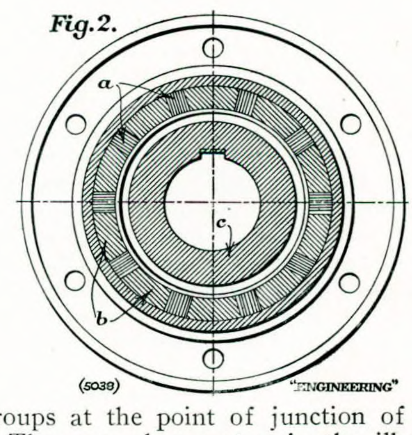


Fig. 2.



usual groups at the point of junction of the two shafts. They are shown at *a* in the illustrations but, instead of being housed in a coupling solidly attached to the shafts, they are carried in slots in the sleeves *b b*, being kept in place radially by internal rings and flanged covers. The sleeves are formed at their outer ends with a ring of internal teeth which mesh with teeth formed pinion-wise on the couplings *c c*, keyed to the shafts. The teeth are of a form such that, whilst transmitting torque, they permit the shafts to be displaced relatively to one another either in a radial or an angular direction. There is thus no other stress on the springs than that imposed by the drive.

The device, which is known as the "Elcard" coupling, has the further advantage that the shafts can be removed, when required, without having to remove the keyed bosses or to displace the shafts axially. The cover is made in halves, which are held together by bolted flanges and are provided with packing where they rest on the keyed bosses to retain the lubricant enclosed in the housing. In dismantling, the halves of the cover are drawn away from one another sufficiently far to enable the laminated springs to be withdrawn. The two shafts are then disconnected. When, however, the bearings are too close to the coupling to permit of this withdrawal, the covers are made with the joint in an axial direction. The keyed bosses and the sleeves are made of 45 tons to 50 tons tensile steel, and are accurately machined all over. The covers are of close-grained cast-iron, and are also machined all over. The coupling is made in 20 sizes, ranging from 1in. bore to 13in. bore, the normal transmission ratings being 0·8 h.p. and 2,720 h.p., respectively. The maximum speeds for which the limiting sizes are constructed are 4,300 r.p.m. for the 1in. coupling and 600 r.p.m. for the 13in. coupling.

Early Hydraulic Engineering.

"Engineering", August 2nd, 1935.

There is, perhaps, no more interesting kind of engineering literature than that found in some of the best presidential addresses to engineering societies. Written by men who have known the masters of the past, who themselves have achieved distinction and have been connected with great undertakings, these addresses are the outcome of long experience, and the considered judgments, no less than the facts they contain, are of the greatest value to the historian. One view of a presidential address was given by Dr. Unwin when addressing the Institution of Civil Engineers in 1911. "It is the privilege of a president", he said, "to be allowed in his address to take a retrospect—rather to gather some lessons from the past than to give new material for discussion". Speaking to the same body in 1929, Mr. W. W. Grierson said, "It is the usual practice of the president to select from his inaugural address that branch of engineering with which his professional career has been most closely associated, and having regard to the many specialised branches into which engineering science is now subdivided, the practice is one which is generally to be commended". When discussing the general subject of presidential addresses in our columns nearly thirty years ago,* we said that while remembering that the engineer giants of the past had not always been as skilful with their pens as with their tools, we could not but feel that, on the whole, even in their written addresses, they had done well, for they had left behind them what might be regarded as a history of their profession.

A presidential address which followed the practice referred to by Mr. Grierson, and which drew lessons from the past, was delivered before the Boston Society of Civil Engineers on March 20th, by Mr. Arthur T. Safford. For forty years Mr. Safford has been connected with the company known as the Proprietors of the Locks and Canals on Merrimack River, of Lowell, Mass., and in the course of his address on the Merrimack Valley Hydraulic Engineers, he did honour to the memory of a school of New England engineers whose work has profoundly influenced the progress of water power schemes the whole world over. It is easy to understand Mr. Safford's interest in the history of hydraulic engineering, for as he says, when in 1894 he accompanied Hiram F. Mills (1836-1921) to Lowell, he acquired by inheritance "a hydraulic library of several thousand volumes, an office and shops full of drawings, models and hydraulic instruments, which James B. Francis, Uriah Boyden, Asa Swain and Clemens Herschel had designed and used. There were also in use full-sized Francis, Boyden, Swain and other water wheels; and in place and in use early examples of the scroll, flume and open settings and many early draft tubes". The Merrimack, it may be explained, is not one of the great rivers of the United States. With its largest branch it is shorter than the Thames, but it has, nevertheless, played an important part in the industrial developments of several cities. Rising in the White Mountains of New Hampshire, it flows through the north-east of Massachusetts and enters the Atlantic in the Gulf of Maine. Draining an area of 4,553 sq. miles, it is 183 miles long. From Franklin southward, in a distance of 110 miles, it falls 269ft., and in doing so yields water power to Concord and Manchester in New Hampshire and to Lowell and Lawrence in Massachusetts. Another New England river to which Mr. Safford referred is the Connecticut, on which Holyoke is situated.

Though America, in the Eighteenth Century, witnessed nothing corresponding to our own Industrial Revolution a century ago, largely through the work of such men as Fulton, Fitch, Evans, Stevens and Whitney, inventions were multiplying apace, mechanical engineering was becoming an important industry, and the movement which was to make the United States the greatest manufacturing country in the world had already begun. Factories for the most part were situated on the banks of rivers, and water wheels were to be seen in considerable numbers. But, as elsewhere, these were slow, cumbrous and inefficient, and the modern history of hydraulic engineering in New England may be said to begin with the construction of a Fourneyron hydraulic turbine by Uriah Atherton Boyden (1804-1879), the oldest of the pioneers mentioned by Mr. Safford. Of Benoit Fourneyron (1802-1867) and his epoch-making invention, a sketch was given by M. Marcel Crozet-Fourneyron in 1923, in his work, the *Invention de la Turbine*. First used in 1827, and patented in 1832, the Fourneyron turbine, with its high

* See "Engineering", Vol. lxxxii, page 428 (1906).

efficiency, was soon adopted in France and Germany, and was followed by the invention of the Jonval, Girard, Fontaine and Thomson turbines. From Europe a knowledge of these machines spread to America, and in 1844 Boyden, whose earlier work had been chiefly concerned with railroad construction, designed a 75 h.p. turbine of the Fourneyron type for the Appleton Cotton Mills at Lowell; this had an efficiency of 78 per cent. In 1846, he built three other turbines of 190 h.p., and he subsequently introduced improvements in both wheels and their settings.

Almost contemporary with the work of Boyden came that of James Bicheno Francis (1815-1892), the originator of the well-known Francis turbine. British by birth, having been born in Oxfordshire, Francis, at 14, was assisting his father on canal construction in South Wales, and at 18 found employment on the Stonington Railroad, Connecticut, under Major G. W. Whistler. In 1834, Whistler became chief engineer to the Proprietors of the Locks and Canals on the Merrimack River, and Francis accompanied him to Lowell as a draughtsman. One of his first tasks, it is said, was to measure up an imported Stephenson locomotive. Whistler resigning, Francis, at the age of 22 succeeded him and, when a few years later the Proprietors undertook a commission to determine the amount of water drawn off by the mills on the Merrimack, to him fell the task of securing the data. From that time onwards, as chief engineer and manager, he looked after the firm's water interests and his work had much to do with the rise of Lowell as a manufacturing centre. Turning his attention to turbines, he devised one with a combined radial and axial flow, and this was the forerunner of the many fine Francis turbines described from time to time in our columns. He also made researches on the flow of water through draft tubes, along canals and over weirs, and formulated rules for runner and draft-tube design, his results being published in his *Lowell Hydraulic Experiments* of 1855. Many reports came from his pen, and his outstanding ability as an engineer was recognised by his election to the presidency of the Boston Society of Civil Engineers and the American Society of Civil Engineers.

Among those who profited by the researches of Francis was Clemens Herschel (1842-1930), whose work on hydraulics began in 1879. Starting life with advantages of education not enjoyed by his predecessors, at Boston he designed roofs, bridges and drainage schemes, but the work for which he will be remembered was done while chief engineer of the Holyoke Water Power Company, Holyoke, Mass. As such, he constructed a testing flume at Holyoke which marked the beginning of the scientific study of water, and to him we owe the invention of the Venturi meter, named after the Italian physicist, Giovanni Battista Venturi (1746-1822), whose experiments on water flowing in pipes and channels were made in the last decade of the Eighteenth Century. In this connection we may draw attention to the interesting letter* reproduced on page 110 of this issue of "Engineering", addressed by Herschel to the late Prof. W. C. Unwin, and very kindly placed at our disposal by the Unwin Memorial Committee. The latter reveals Herschel's great confidence in his invention, now so widely utilised though not exactly as he anticipated.

Though, in the course of half a century, the labours of these and other New England engineers had added much to the progress of hydraulics, when Mr. Safford became associated with the Merrimack Valley there was a general impression that much greater use could be made of the river, and much of his address was taken up by a review of the improvements in the canal system, the accumulation of fresh data regarding rainfall, run off and storage, the installation of new equipment for driving electric generators and the carrying out of new tests and experiments.

In all the experiments full use was made of the results obtained by Boyden, Swain, Francis and Herschel, and the address contained many practical comments on hydraulic investigations. The fundamental laws of practical use with a water power company, Mr. Safford said, are few and easily understood, but experience without knowledge of fundamental principles, or theories without the means of trying them out, have their limitations. If a hydraulic problem involved the expenditure of millions and the conditions were unusual, there were good reasons why much of the design should be tested out by models. In New England, however, questions are usually more simple and well within the training and experience of those he was addressing. Young engineers informed by examples of modern practice, might often miss the habit of thinking for themselves through lack of attention to the simple principles and the admirable experiments made by the early hydraulic engineers, which, in spite of the numerous modern investigations, are still of use.

The Institute of British Foundrymen—Man and Metal.

"The Engineer", July 12th, 1935.

To commemorate the presidency of Mr. C. Edward Williams, of Cardiff, in the year 1933-34, the Institute has founded an annual lecture, to be delivered each year by a prominent man in industry or science.

Sir William Larke delivered the first "Edward Williams" Lecture and chose as his title "Man and Metal". In it he surveyed briefly the development of the use of metals and their influence upon man's progress. When we considered our dependence on metals to-day, he said, their paramount influence on the development of mankind and our intellectual and material civilisation, it was remarkable that, although it was generally accepted that man first appeared on the earth 300,000 years ago, there

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* See page *130*.

was no conclusive evidence that he had any knowledge of metals earlier than 4,000-5,000 years before the Christian era—say, the last 7,000 years. It was only in the last 200 years that metals had rendered possible that revolution which had converted handicraft into industry.

During the present century more metals had been produced than during the whole period of historic time preceding 1900.

Copper was the first metal known in the ancient world, at least in Egypt and the East. The working of copper appeared to have reached a relatively high standard in very early times, and copper smelting was probably discovered about 4500 B.C., no doubt accidentally, probably following a camp fire which had been built in a circle of stones containing ore, when beads of copper were observed on the stones after the fire was extinguished and were recognised as being the same as the native metal.

Probably the discovery of gold preceded that of copper, but gold was used for decorative purposes about 3500 B.C.

The development of smelting brought more metals to the notice of man. Bronze appeared about a thousand years later than copper and represented a considerable advance, with its lower melting point and greater beauty and hardness. Lead, produced before 3400 B.C., in sheet form, was used as a damp-course in the walls of Babylon. It was not used to any great extent, however, until the sixth century B.C., when it was used for water tanks. Brass, probably also an accidental alloy, was known in Palestine as something distinct from copper about 1500 B.C. Mercury was imported into Egypt between the fifteenth and sixteenth centuries B.C., presumably from Spain.

It was the discovery of iron, however, which had given the greatest impetus to the development of man, both intellectually and materially. There seemed no doubt that the earliest iron worked by man was of meteoric origin. The date and place of the origin of iron smelting could not be definitely determined. There was evidence that iron was used in Babylon about 2500 B.C., and became comparatively common in 1400 B.C., in the form of steel showing carburisation. The smelting of iron as a craft appeared to have originated on the shores of the Black Sea, where there was available a particularly pure magnetic iron sand. The Taurus Mountains and the foot of the Caucasus were also suggested, as the local ore contained manganese and a good-quality iron was produced.

The Iron Age did not appear to have commenced in Britain until about 400 B.C. and Ault had suggested that from the general introduction of iron tools and weapons might be dated the development of man from a hunter into a farmer. As the result of storing food supplies, domesticating animals, and through the exchange of food for tools and weapons, he had become a trader and a capitalist. It was significant that iron was used as currency in the shape of bars in this country, a practice probably introduced from the East.

For the next 2,000 years, whilst the use of metals became more common, their application did not change in character. The principal advance was the introduction of cast iron about 1340 A.D. Cast iron was not converted into malleable iron until the invention by Cort of the puddling furnace 440 years later. As production was simplified and the use of metal tools for agriculture and handicrafts generally, as well as for weapons of war, became more widespread, they became available to a much greater number and thus unquestionably raised the standard of life of the people as a whole. No doubt this development also tended to create classes of society, since metal tools and weapons were a form of wealth which could be accumulated.

In this country there had been during the historic period, say, from the date of the Norman Conquest, three main phases of industrial development. The first and longest was a continued development of metal handicraft, and it had lasted until the early part of the eighteenth century. The second was the age of coal and iron; and the third, commencing with the present century, was the age of alloys and electricity.

Sir William traced the development during the last century or so, which had been made possible by the extended production and application of metals, and their influence on railways, motor cars, aircraft, and machinery generally, and on electricity and telegraphy. In this country the electricity grid already comprised 4,000 miles of transmission line and was the result largely of the development in the last twenty years of the production of aluminium, the most efficient electrical conductor per unit of weight, which was discovered only in 1825. It had become one of the most important metals, and seemed destined to fill even a more important *rôle* in the future. In the electrical grid in this country 12,000 tons of aluminium had been used for transmission lines and the supporting towers had required 150,000 tons of steel.

Although the present appeared to be dominantly a steel age, cast iron was still one of the most important structural materials. We were apt to forget what an important structural material it had become. The tube railways of London were built of cast iron sections, of which approximately 1,000,000 tons was already erected. The Mersey Tunnel contained no less than 80,000 tons of cast iron, and the road was paved with cast iron blocks having non-skid, glass-hard surfaces. All metals used to-day were first cast before they were otherwise treated or manipulated, and it was at the casting stage that the metals or alloys received their basic characteristics, on which depended their ultimate qualities. It was for this reason that there were no less than four important research organisations dealing with casting—the British Cast Iron Research Association, the Steel Castings Committee, the Heterogeneity of Ingots Committee, and the Non-Ferrous Metals Research Association.

Sir William recalled the discovery of manganese and silicon steel by Sir Robert Hadfield in the early 'eighties of last century, and said that modern electric transmission and the large generating units now used would have been impossible without the discovery of the properties of silicon steel for use in electrical transformers and machines. One of the most important metallurgical developments of the last twenty years was the production of chromium steels, the properties of which were discovered in the Brown-Firth Laboratories at Sheffield by Mr. Harry Brearley in 1913. He also referred to the development of tool steels and the hard alloys of non-ferrous metals, and said that the extension of power which these products had given to the engineer was almost incalculable.

Discussing the contribution of metallurgy to aviation, he said that the authorities he had consulted considered it probable that aircraft engines for ordinary service in the near future would be reduced to a weight of about 1lb. per b.h.p.

Of recent engineering triumphs based on steel, he mentioned the Sydney Bridge, having a span of 1,650ft., the arch of which contains 38,000 tons of special high-tensile steel, which alone might be said to have rendered the design practicable; the Iraq oil pipe line, 1,200 miles long, welded throughout; and the "Queen Mary", which, when launched, was claimed to be the largest mass—40,000 tons—ever moved by man unaided by mechanical power.

He also discussed the development of the duralumin series of alloys, invented in the present century, and the increasing use of the rarer metals. The application of these rare metals had enabled the efficiency of electric incandescent lamps to be increased from 3·1 to 11·5 lumens per watt within the last thirty years. Broadcasting also was ultimately dependent on the work of the metallurgist.

This summary, he said, showed that metallurgical progress in the present century had been almost as great as in the whole previous history of mankind. He exhibited a table, specially prepared by the Mineral Resources Department of the Imperial Institute, in which the world production of the various important metals since 1900 was given. From 1900 to 1929, the peak year, the world production of steel was multiplied more than four times, of copper approximately four times, and of aluminium thirty-five times. The rate of increase in the production of the rare metals was no less impressive and significant, although their quantities were smaller.

His survey served not only to demonstrate the important part which metallurgists had played in the development of our civilisation, but also to indicate the potentialities of the future and the consequent responsibilities resting on the metallurgical industries for continued research to meet the demands of engineering for new and improved materials. A new industrial revolution, almost unnoticed, was in progress, pregnant with far-reaching results for the future. It was based on the almost daily discovery of new materials, having new properties capable of standing increased stresses under varying conditions of static or dynamic load within wide ranges of temperature.

Sir William Larke exhibited a film illustrating ancient and modern methods of the production of iron. The ancient method was that still used by some tribes in India, the natives using a furnace having a small superstructure of puddled clay, with elementary tuyeres, and using goat-skin bellows, the latter being worked by the feet. The iron produced, which was extraordinarily pure, was in the form of a spongey mass.

The Diesel-electric Tug "Acklam Cross".

The Performance of the First British Tug with Electric Propelling Machinery.

"The Shipbuilder and Marine Engine-Builder", Aug., 1935.

As the first British tug to be equipped with Diesel-electric propelling machinery, the "Acklam Cross", which was built by Messrs. Hall, Russell & Co., Ltd., and ran trials off Aberdeen late in August, 1933, aroused widespread interest in marine circles at the time of her completion. As not unusual in new departures of this description, her machinery installation called forth a fair amount of sceptical comment, particularly in regard to her high-speed Diesel prime movers, which, it may be recalled, were designed for 900 r.p.m. continuous running. The vessel, which is owned by the Tees Towing Co., Ltd. (Messrs. Robinson & Crosthwaite, managing owners), of Middlesbrough, and was constructed to the designs and specification both as regards hull and machinery of Mr. R. Reid, consulting naval architect, of Hull, has now been in regular service on the Tees for nearly two years. During that period her performance has amply justified the enterprise of her owners, the efficiency and reliability of her propelling equipment having been effectively demonstrated.

The substance of the owners' report regarding the results obtained during the first 18 months' service is as follows:—

"The 'Acklam Cross' has now been in continuous service on the River Tees for 18 months, and has been engaged in assisting large passenger and cargo liners to and from the sea and in moving them about the docks and river. She has also been employed to tow hopper barges to sea and back—a distance of about 20 miles.

"She has carried out all the work entrusted to her in a thoroughly efficient manner. Her engines have run for 2,565 hours with a consumption of 17,545 gallons of fuel oil, i.e., 6·83 gallons per hour. The lubricating-oil consumption has been 382 gallons, i.e., 0·148 gallon per hour; while 15 per cent. of her work has been carried out with one engine only running.

"The engines were decarbonised after 1,000 running hours, and no mechanical or electrical defects have been found. The crew consists of a master, mate, engineer and boy, thus reducing labour costs to a minimum".

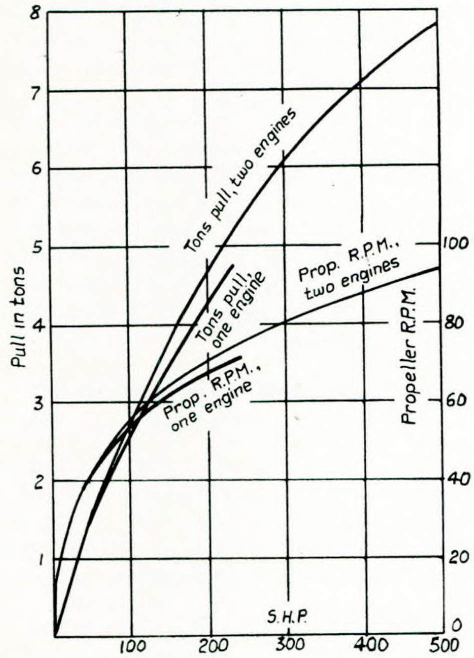


FIG. 1.—Curves of steady pull, from static tests carried out in closed dock using long tow-rope.

The vessel is a single-screw tug of 98ft. overall length by 22ft. moulded breadth by 11ft. 6in. moulded depth, working on a normal draught of 11ft. 10in. aft and having a speed when running free of 11 knots. Her propelling machinery consists of two sets of Diesel-driven d.c. generators coupled in series with a double-armature propulsion motor direct-connected to the propeller shaft, which has a slight downward rake. The two Diesel prime movers were manufactured by Messrs. Peter Brotherhood, Ltd., of Peterborough, and are Brotherhood-Ricardo six-cylinder, four-stroke cycle, sleeve-valve engines, each developing 300 b.h.p. at 900 r.p.m. and designed to run at constant speed in opposite directions. The whole of the electric-propulsion equipment is by the General Electric Co., Ltd., of Witton, Birmingham. Each Diesel engine drives a 200-kW. 250-volt, shunt-wound, d.c. generator, which supplies the propulsion circuit; while a tandem-coupled, overhung-type, auxiliary d.c. generator of 20 kW. output at 110 volts supplies current for excitation and auxiliary feeder circuits. Either auxiliary generator may also be used for charging two 56-cell banks of Exide storage batteries. The propulsion motor is of 500 h.p. output, with a speed varying from 90 r.p.m. ahead to astern when towing, and up to 115 r.p.m. when running free.

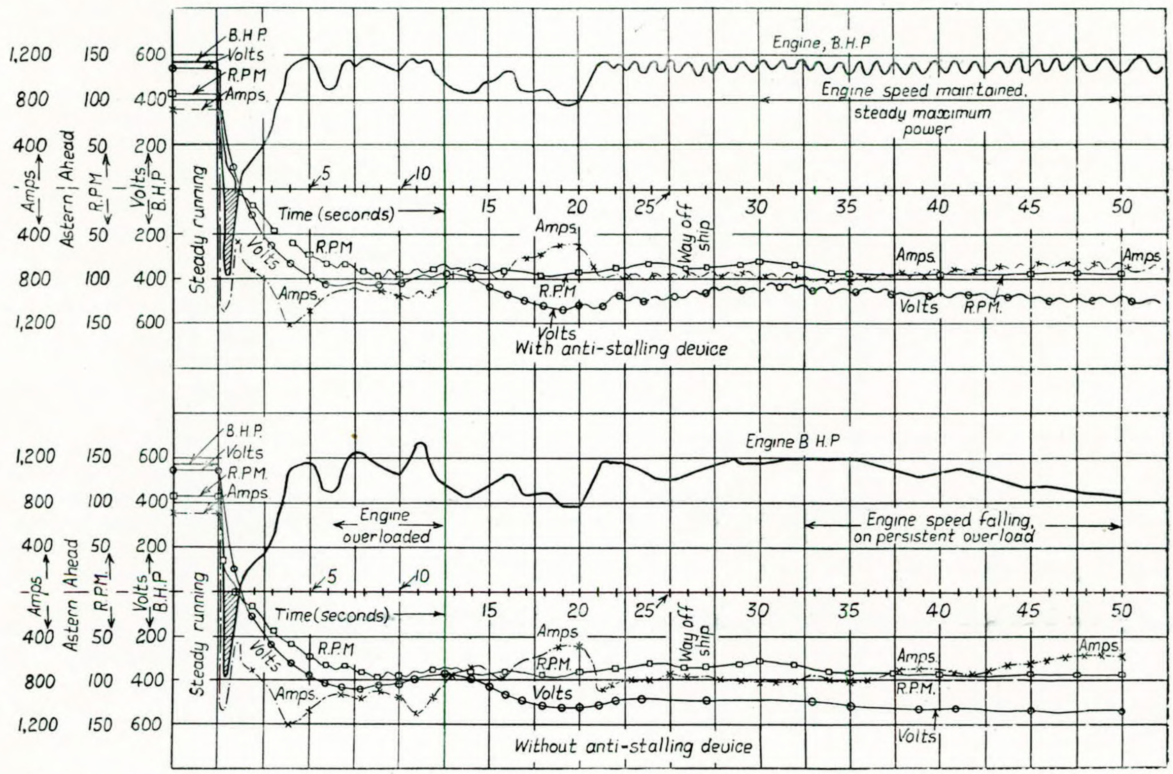


FIG. 2.—Curves for rapid manœuvre from full-ahead to full-astern, showing advantage of the G.E.C. anti-stalling device.

The propulsion control is on the Ward-Leonard principle, speed control and reversing being obtained by varying or reversing the separate excitation current supply to the main-generator fields. The control gear is designed so that one generator may be cut out of circuit for reduced running, while suitable links are also provided to enable either half of the propulsion motor to be isolated. The equipment in operation is normally remote-controlled from the bridge by means of mechanically-connected telegraph pedestals.

An interesting feature of the installation is the adoption of electric starting for the main engines, this being achieved by motoring the main generators when utilising current from the storage batteries previously mentioned. These latter also provide the necessary energy for port lighting.

The curves reproduced in Fig. 1 show the static pulls of which the "Acklam Cross" is capable. The tests were performed in still water within a closed dock to eliminate tide effects, and a 150ft. tow-rope was used fixed to a dock-side bollard and to a dynamometer at the tow-hook. It should be noted that the curves of tons pull represent a steady pull, which may be sustained indefinitely. As a typical reading the tug gave a sustained pull of 7½ tons, with a propulsion-motor output of 451 s.h.p. at 91 propeller r.p.m., equivalent to 1 ton pull/60 s.h.p. With one engine shut down the steady pull was 4·8 tons, or 1 ton pull/48 s.h.p.

The curves in Fig. 2 provide an interesting study of the rapid manœuvring ability of the tug, and represent a full-speed reversal from full ahead to full astern, the telegraph being pulled straight back and the vessel maintained as nearly as possible on a straight course. The top set of curves is with the G.E.C. anti-stalling device in circuit, and the bottom set without. These curves were obtained by means of a high-speed chart-recording instrument recording simultaneously volts, current and shaft revolutions. From the top curves it will be seen that from 107 r.p.m. ahead the propeller was stopped in 2 seconds, and reached 75 r.p.m. astern in 5 seconds and full-speed astern in 9 seconds. Due to the anti-stalling device, the power was never in excess of the output of the engines available for propulsion, i.e., the engines cannot be overloaded. The maximum current and therefore maximum torque, it will be seen, occurred during the early stages of reversing.

On the bottom curves without anti-stalling device, power peaks occurred as shown, and from about 20 seconds onwards the engine slowed down under persistent overload. The peak at about 20 seconds, just before the tug stopped, was the heaviest during the whole manœuvre, and was due perhaps to the downward rake of the propeller shaft pulling the stern down and to the forward moving wake welling up under the stern, the combined effect being to immerse the propeller more deeply.

It may be stated that the results obtained with this vessel cannot fail to stimulate further interest in the Diesel-electric drive for tugs, while the many advantages which make it so suitable for the towing class of ships also bring it into the range of powering considerations for other types of small craft.

As a further example of highly successful application of marine electric drive by the G.E.C., the "Acklam Cross" joins such outstanding vessels as the Canadian Lakes Diesel-electric bulk-cargo ship "Cementkarrier" (1930), the famous turbo-electric luxury liners "Monarch of Bermuda" (1931) and "Queen of Bermuda" (1933), and the West Highlands Diesel-electric passenger vessel "Lochnevis" (1934).

A British Foundry School.

"The Engineer", 5th July, 1935.

In a Seven-Day Journal note of April 5th, we announced the intention of the Birmingham Education Committee to consider a proposal to found a national school of foundry practice. We now learn that meetings have recently taken place which have resulted in the formation by the founding industry of a provisional governing body for the British Foundry School. If sufficient students present themselves, it will be opened in September of this year. From the prospectus that has been issued, we learn that the school is intended for those men engaged in the founding industry, who have already had some practical experience, and who wish to qualify for, or who have already shown their capacity in, managerial and supervising posts. The school provides a full-time day course of one year's duration, and succesful students will receive the diploma of the school. It is expected that the diploma will receive endorsement by the Board of Education. Out of a net running cost (total expenditure less receipts from students' fees, fixed at £30 per annum) of £2,000 per annum, the Board of Education has undertaken to provide £1,500 in the form of a grant, providing the remaining £500 is forthcoming from the industry. Of this latter sum nearly one-half has been promised by a group of institutions representing the industry, which is supporting the school, and which has nominated representatives to the governing body. The industry is now invited to contribute the remainder, about £300 per annum. It is felt that the industry will welcome the opportunity of showing its sense of the need for the school by contributing this comparatively small sum. It is well known that vacancies for foundry managers and foremen who can combine metallurgical and technical knowledge with managerial experience are difficult to fill. Eleven leading institutions connected with this industry are supporting the school.

Non-magnetic Cast-iron.

Special Metal for the Electrical Industry.

"Journal of Commerce", 1st August, 1935.

In the construction of electrical plant and machinery it frequently happens that metallic structural components are used in positions where they are exposed to the influence of fluctuating or alternating magnetic fields. The influence of such fields on the common materials of construction is to produce serious losses and over-heating, firstly, on account of the magnetic hysteresis effect in the magnetic metals, and, secondly, on account of the eddy currents set up.

Hysteresis losses are a function of the magnetic properties of the metal used, and may be minimised or eliminated by the use of non-magnetic metals. Eddy current losses, on the other hand, are closely related to the electrical resistance of the metal in question, and to minimise these it is essential to maintain a high electrical resistance. Many of the non-ferrous alloys, such as brasses and bronzes, satisfy the first of these conditions, but their electrical resistance is low and they therefore fail in the second requirement.

High Electrical Resistance.

A satisfactory solution of the problem has now been found in the use of the high alloy non-magnetic cast-irons. These irons contain sufficient alloys to render the structure of the metal austenitic. Some of the compositions giving this structure produce castings which have the desired combination of non-magnetic properties with high electrical resistance. In addition, special compositions have marked resistance to corrosion and heat.

Perhaps the best known of the non-magnetic cast-irons is the high nickel nickel-manganese austenitic cast-iron known as Nomag, developed by Mr. S. E. Dawson and Messrs. Ferranti, Ltd. This firm supply large quantities of non-magnetic castings.

Nomag has a magnetic permeability as low as 1·03, which means that for all practical purposes it is completely non-magnetic. This figure is given in the table below, in which Nomag is compared with other engineering materials. The table, taken from the "Nickel Bulletin", gives comparative figures for specific resistance and temperature coefficient of resistance.

Materials.	Magnetic Perme-ability. Maximum.	Specific Resistance, Micro-ohms per cm. cube.	Resistance Temp. Coefficient between 0° C. and 100° C. per 1° C.
"Nomag"	1·03	150	0·00045
Cast-iron	240·00	95	0·0019
Steel (Siemens-Martin)	8,350	18	0·003
Brass (annealed) ...	approx. 1	7·0	0·002
Pure copper (annealed)	approx. 1	1·59	0·00427
Pure aluminium ...	approx. 1	2·62	0·00423

This metal is soft and easily machinable. Its tensile strength is similar to that of ordinary grey iron, but it is distinctly tougher and more resistant to shock. The lower electrical and magnetic losses render it particularly suitable for such castings as alternator end rings, cable and terminal boxes, covers and fittings for oil switches and transformers. As an example of the usefulness of the iron in these applications, it may be mentioned that on test the temperature rise in a cast-iron ring through which was threaded a conductor carrying an alternating current of 1,000 amperes for 30 minutes was 50° C., whilst the Nomag ring under similar conditions gave a temperature rise of only 4° C.

The White Engine.

"Shipbuilding and Shipping Record", 25th July, 1935.

Very good results are claimed to have been obtained from the White engine, which has been running in the steamer "Adderstone" in the North Atlantic trade for 15 months, covering in that period about 70,000 miles. Her average speed was 10·1 knots on a daily consumption of 13·5 tons of oil for all purposes.

Annual Survey of Lloyd's Register.

"The Marine Engineer", August, 1935.

A valuable service is rendered to the shipping, shipbuilding and marine engineering communities by Lloyd's Register of Shipping through the comprehensive information which is published by its committee at regular intervals. Lloyd's Register Book for 1935-6, which has just been issued, is the 102nd annual edition since the Society of Lloyd's Register was reconstituted, and as in the past some interesting facts emerge from the statistics contained therein. The number and tonnage of existing vessels recorded in the new edition of the Register Book which are now or have formerly been classed by the Society, or for which classification is contemplated, is 14,370 of 40,048,457 gross tons, which forms an impressive measure of the paramount importance of the work of the Society.

During the twelve months from June, 1934, to June, 1935, there has been a decrease in the steam tonnage owned in the world of 1,330,640 tons, and an increase of 700,165 tons in the motor tonnage, resulting in a *net* decrease, after allowing for sailing vessels and non-propelled craft, of 690,640 tons in the total tonnage of the world. It will thus be seen with what rapidity the means of propulsion of the merchant fleets of the world are changing in favour of the internal-combustion engine. Between June, 1933, and June, 1934, it may be recorded, there was a *net* decrease of 2,343,573 tons.

A very interesting table compares the relative standing of the merchant fleets of the world for the years 1914, 1925 and 1935. It shows that from June, 1914, to June, 1925, the net increase in the world's steam and motor tonnage was 16,976,000 tons, equal to 37·4 per cent. of such tonnage in existence in 1914, and that the net addition since 1925 amounts to 1,347,000 tons, equal to 2·2 per cent. of the tonnage at 1925. A comparison of the figures for 1914 and 1925 shows that the largest increases took place in the United States (9,905,000 tons), Japan (2,212,000 tons), Italy (1,501,000 tons), France (1,398,000 tons), and Holland (1,116,000 tons). The only decrease during this period was that in the case of Germany (2,129,000 tons). Since 1925, the largest increases have taken place in Norway (1,349,000 tons), Greece (816,000 tons), Germany (687,000 tons), British Dominions (383,000 tons), and Sweden (287,000 tons); on the other hand the sea-going tonnage of the United States has decreased by 2,267,000 tons, and that of Great Britain and Ireland by 2,007,000 tons. There have also been decreases in France (331,000 tons), Italy (93,000 tons), and Holland 34,000 tons). Since June, 1914, there has actually been a ***net*** decrease in the tonnage belonging to Great Britain and Ireland of 1,594,000 tons, or 8·4 per cent. of the tonnage owned in 1914, whereas the aggregate increase of tonnage owned in other countries during the same period represents more than 75 per cent. of the pre-war tonnage owned abroad. Notwithstanding increases of 2,352,000 tons from June, 1921, to June, 1925, and of 687,000 tons since June, 1925, the present totals for Germany are still 1,442,000 tons below those for June, 1914.

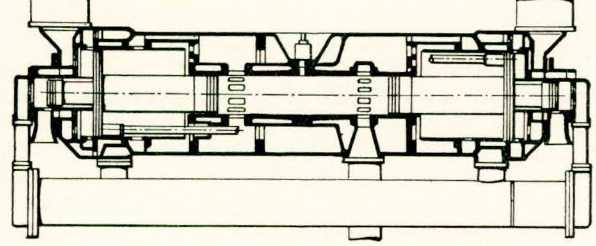
Regarding the type of machinery used, figures show the extent of the great development which has taken place in the use of steam turbine engines and of internal-combustion engines. There are now 1,522 steamers of 10,928,473 tons fitted with turbine engines or a combination of steam turbines and reciprocating engines, and 5,511 vessels (including auxiliary vessels) of 11,304,691 tons, fitted with internal-combustion engines, as compared with 730,000 tons and 220,000 tons respectively in 1914. While during the last twelve months there has been an increase of 700,000 tons in the tonnage of motorships, and of 36,000 tons in the tonnage of vessels fitted with steam turbines, there has been a reduction of 1,366,000 tons in steamers fitted solely with reciprocating steam engines. Since June, 1925, there has been an increase of 8,591,000 tons in the motorship tonnage. It is stated that of 8,896,437 tons of oil tankers, of 1,000 tons gross and upwards, 5,161,342 tons are steamers and 3,735,095 tons are fitted with internal-combustion engines. While the total motor tonnage amounts only to 17·4 per cent. of the aggregate tonnage owned in the world (in Great Britain and Ireland 16·6 per cent.), the highest percentages are to be found in the following countries, viz.: Norway 48·6, Denmark 41·8, Sweden 36·5, and Holland 33·0. Among the principal maritime countries, the United States and France have the smallest proportions of motor tonnage, viz.: 5·8 and 8·1 per cent. respectively. An analysis of the type of machinery now employed also shows that there are recorded in Lloyd's Register Book 300 vessels, with a total tonnage of 1,866,596 tons which are fitted with a combination of steam turbines and reciprocating engines. Another interesting particular is that in the case of 99 vessels, with a tonnage of 601,497 tons, electric propulsion has been adopted, the motors being supplied with current from generators which are driven either by steam turbines or oil engines. Auxiliary electric drive has also been adopted in a number of other cases. Of the 99 vessels mentioned above, 60 of 286,761 tons are owned in the United States. Of electrically-driven vessels exceeding 20,000 tons gross, five fly the British flag, two are owned in the United States, and one is owned in France. Of the 29,071 steamers and motorships of 100 tons gross and upwards recorded in Lloyd's Register Book, 3,668 are twin-screw vessels, and 115 have triple or quadruple screws. Although few paddle steamers are now built, there are still in existence and recorded in Lloyd's Register Book 356 such vessels, of 265,553 tons.

As the question of utilising coal more fully for the propulsion of British merchant ships has been very much to the fore of late, we may refer to the 3,880 steamers of 19,885,070 tons, which are recorded in the new Register Book as being fitted for burning coal or oil fuel, of which 807 of 5,244,082 tons are registered in Great Britain and Ireland. At present slightly over 50 per cent. of the tonnage of the world's merchant marine depends entirely upon coal, whereas in 1914 the proportion was nearly 89 per cent.

An Unusual Compressor Design.

"The Marine Engineer", August, 1935.

By a combination of the well-known Junkers opposed-piston Diesel engine and a compressor an arrangement possessing many advantages has been secured. As shown in the illustration there is no crankshaft since the two power pistons are themselves the compressor pistons, so that no shafts, connecting rods or flywheels are required. The result is a great saving of space, and no special foundation is needed; there is a complete absence of vibration. The "free piston" compressor shown running



Section through the unusual opposed-piston Diesel-compressor described.

at the Leipzig Fair was suspended on a rope while in operation to demonstrate this claim.

The absence of power-absorbing bearings reduces the fuel and lubricating oil consumption quite apart from the favourable fuel consumption usually associated with opposed-piston engine combustion chambers. Starting is accomplished by moving the two pistons by hand to their outermost clumsy solution, but the "screened grid" systems, born of the desire for a compromise, often tended to combine the disadvantages of both systems with the benefits of neither. Recently a more promising method has been proposed—along the lines of using air circulation for all cargoes, but minimising its amount by employing a "jacket" in which the "exhaust" air from the hold removes the heat of leakage.

The most striking change in the application of refrigeration to food has still to be mentioned. The refrigerating engineer is now being called upon to control, not merely temperature, but the whole physical environment. "Humidity", as an inescapable subsidiary problem of refrigeration, was recognised in the earliest days, and its crude biological implications—the growth of moulds on one hand, and desiccation of the commodities on the other—were realised. But the control of other constituents of the atmosphere, or the provision of artificial atmospheres, had scarcely received attention 25 years ago. To-day, the calamitous effects on fruit that may follow the accumulation of carbon dioxide, and the beneficial effects of "gas" storage in atmospheres where the amounts of oxygen and carbon dioxide are controlled, are known to everybody. It is not, perhaps, so well realised that the composition of the atmosphere, humidity, and temperature are all so intimately related in their biological effect, that an optimal value for no one of them can be fixed without reference to the others.

The control of humidity encounters special difficulties in its application to a closely-stowed stack of evaporating material, packed as it often is in hygroscopic materials (wood, paper, cardboard). By comparison, control of the composition of the atmosphere is simple. Moderately gas-tight construction sufficed for the introduction of "gas" storage for home-grown apples, and there are now between 30 and 40 "gas" stores with a total capacity of 7,000 tons. The application of gas-storage methods to the overseas transport of beef is still more recent; but it is already enabling chilled Australian beef to enter this country in competition with the Argentine product.

Fuel.

By Sir Harold Hartley, C.B.E., M.C., F.R.S.

"Engineering", May 3rd, 1935. Silver Jubilee Supplement.

In 1910 the consumption of coal in Great Britain was 180 million tons, in 1933 it had fallen to 147 million tons, while in the same years the imports of petroleum oils increased from 345 million gallons to 2,751 million gallons. These quantities of oil are equivalent, on a heat basis, to 2 million tons and 17 million tons of coal, so that converted to a basis of equivalent coal, the annual heat requirements of the country have fallen from 182 million tons of coal in 1910 to 164 million tons in 1933, a drop of 18 million tons, which corresponds very closely to the decrease in the consumption of coal by the iron and steel industries.

In the past quarter of a century there has been an increase in the population of 10 per cent. The use of power and heat in manufacturing processes has been widely extended to secure an increased production from human effort. Road transport has been revolutionised by an increase of motor vehicles from 150,000 to 2,500,000. Important new industries have come into being and domestic requirements for light, heat and power have increased to higher standards. The striking fact therefore emerges that in Great Britain the additional energy required as a result of these years of progress has been secured with practically no increase in the consumption of fuel.

This is an achievement which reflects great credit upon the engineer, the chemist, and the metallurgist. Despite the increased demand for petroleum oils, due largely to the development of the internal-combustion engine, 90 per cent. of the energy requirements of the country are still derived from our national coal resources. The energy from some 40 per cent. of this coal is made available by combustion in the furnaces of steam boilers and it is here that some of the most important contributions to fuel economy have been made.

Much of the credit for the development in boiler practice must go to the electrical industry, which increased enormously the size of the unit and raised the efficiency of both fuel combustion and steam production. Improved design of boiler and furnace, better refractories, the introduction of mechanical stokers and pulverised coal, better methods of control, and waste-heat recovery have all contributed to the successful result. Whereas the output from a Lancashire boiler in 1910 did not exceed 10,000lb. per hour and from the largest water-tube boilers 20,000lb. per hour with efficiencies of 55 per cent. to 65 per cent., at the present time the unit size of water-tube boilers has been raised to 1,250,000lb. per hour and the efficiency to 90 per cent. At the same time the development of the turbine has led to the increase of boiler pressures from 200lb. per square inch to as much as 1,500lb. per square inch, while steam temperatures have risen to about 750°. In the subsequent employment of the energy in the steam, the substitution of electrical transmission for mechanical driving, the use of pass-out turbines with the employment of exhaust steam for process work, and the elimination of inefficient private power plants in favour of supplies from public sources, have all tended towards a reduction in the amount of fuel required.

Similar progress in fuel economy has been made in both sections of the carbonising industry. In 1910 the amount of gas sold by statutory gas undertakings was 178,000 million cub. ft., whereas in 1933 the amount had risen to 286,000 million cub. ft. Nevertheless, the quantity of raw coal required by the gas industry only increased from 15·1 million to 16·7 million tons per annum. This result was due to an increase in the efficiency of carbonisation to 84 per cent., owing to the use of higher temperatures and steaming, to improved retorts, better control, and the recovery of waste heat. In addition to the coal used by the gas industry, some 14 million tons per year are to-day carbonised in coke ovens for the manufacture of iron and steel. In 1910, only 20 per cent. of this coal was treated in regenerative coke ovens with by-product recovery, while at the present time 95 per cent. is so carbonised, with the result that the loss of by-products has been practically eliminated, while a greatly increased amount of coke-oven gas is available for use in steel works or for distribution to other gas consumers. In the Newcastle and Sheffield districts, 16,000 million cub. ft. of coke-oven gas are utilised in this way.

Similar instances of fuel economy are to be found in almost all branches of industry. In the manufacture of iron and steel, the amount of coal required to produce a ton of pig-iron fell from 2·06 tons to 1·78 tons during the past twenty years, while the fuel required to produce 1 ton of finished iron and steel has fallen by more than 40 per cent. In cement works, where the old-fashioned open kilns have been replaced by modern rotary furnaces, fired internally by pulverised fuel, large economies have been effected, and in brick works the continuous type of kiln has reduced the coal consumption by 77 per cent.

In striking contrast to the decrease in coal is the sevenfold increase in the consumption of oil in this country. This is due chiefly to two causes—the development of the internal-combustion engine and the displacement of coal by oil as a boiler fuel, particularly for marine purposes. The growth in the utilisation of liquid fuel has effected radical changes in every kind of transport, owing to the high thermal and weight efficiencies of the internal-combustion engine and the advantages of liquid fuel when it has to be carried in a vehicle or a ship. The increased demand for petrol has only been met by the introduction of cracking and hydrogenation processes in the refining of crude oil, while the high anti-knock rating of modern petrol has made possible the high compression ratio of the present spark-ignition engines used in motor transport. Simultaneously has come the development of the compression-ignition engine with a still higher efficiency using heavy-oil distillates, applied originally to stationary and marine purposes, but now used in large numbers for road vehicles.

The influence of oil fuel has been particularly striking in marine propulsion. In 1914, nearly 90 per cent. of the gross tonnage of the world was coal-burning; by 1934 this percentage had fallen to 52, no less than 46 per cent. of the remaining tonnage using oil fuel either under steam boilers or in compression-ignition engines.

To sum up, the main features of the past twenty-five years have been the increased efficiency in the utilisation of the energy in fuel, the reduction in the quantity of coal consumed in spite of the increased demand for energy, and the increasing production of high-grade fuels from crude materials. The economies have been secured largely by burning fuels in a form which enables them to be fed mechanically at a controlled rate into the area of combustion. Coal now shares with oil and gas the natural advantages they enjoy in this respect by its use with chain grates and mechanical stokers or in a pulverised form, and great advances have been made in improving raw coal by cleaning, sizing, and blending. The use of raw coal in the home is a national institution, which is still responsible for much direct and indirect waste of fuel, as well as for three-quarters of the smoke nuisance in the country, the cost of which is heavy. The increasing domestic use of gas, coke and electricity is steadily improving the position, and further developments in the production of easily combustible coke and open grates of suitable design will accelerate the improvement; for instance, the output of smokeless fuel by low-temperature carbonisation has increased from 152,000 tons to 222,000 tons in the last two years.

The hydrogenation process for producing oil from coal is the latest advance in the up-grading of coal. It has now reached the stage of commercial development in this country, and the plant just erected at Billingham may well be the beginning of a radical change in the fuel policy of Great Britain.

Perhaps the best augury for the future is the growing tendency among the different sections of the fuel industry to co-operate with one another, and thus to realise the ultimate goal visualised by the Royal Commission on the Coal Industry in 1925: "The object to be aimed at", they said, "is the most economical and efficient way of utilising the energy contained in coal. The question is not the co-ordination, as is often supposed, of two industries—coal and electricity—but of several, coal, electricity, gas, oil, chemical products, blast furnaces, and coke ovens".

Naval Construction.

By Sir Arthur W. Johns, K.C.B.

"Engineering", May 3rd, 1935. Silver Jubilee Supplement.

The success of "Dreadnought" (1905) was followed by laying down three battleships a year. By 1910, six were complete, and the second stage in evolution reached in "Orion", with five twin 13½in. in place of 12in. turrets. Compared with "Dreadnought", her tonnage was 22,500 against 17,900; shaft horse-power 27,000 against 23,000; 4in. in place of 12-pdr. guns; and increased protection. "King George V" (1911) and "Iron Duke" (1912) had the main armament of "Orion", but the later ship had 6in. in place of 4in. guns. All were of 21 knots speed. "Queen Elizabeth" (1913) represents the third stage with four twin 15in. turrets, 25 knots speed, and stowing oil fuel only. "Royal Sovereign" (1914), of 23 knots, was similarly armed, but four anti-aircraft guns were added. Both classes have since been "bulged". "Nelson" and "Rodney" (1922) conform to the Washington Treaty. Of 33,500 tons and 23 knots, the armament is nine 16in, twelve 6in. and six anti-aircraft guns. The three triple 16in. turrets close together forward, the centre training over the others, and the 6in. guns in twin turrets are marked departures from previous types.

The "Invincibles", the first battle-cruisers, were succeeded by "Indefatigable" in 1909, and "Australia" and "New Zealand" (presented by those Dominions) in 1910. "Lion", "Princess Royal" and "Queen Mary" (1909-10-11) had four twin 13·5in. turrets, and a speed of 28, against 25 knots in "Invincibles". "Tiger" (1912), with the same main armament, modified to allow two turrets to fire aft, had 30 knots speed and a tonnage of 28,500—11,000 more than "Invincible". "Renown" and "Repulse", 26,500 tons and 31½ knots, ordered January, 1915, as a sequel to the Falkland Islands engagement, have twin 15in. turrets—two forward and one aft—and seventeen 4in. guns. "Hood" (1916), has a tonnage of 41,200 and speed of 31 knots, her armament being twin 15in. guns, two forward and two aft, twelve 5½in. and four anti-aircraft guns. With the speed of a battle-cruiser, she has the armament and protection of a battleship.

Aeroplanes officially entered the Navy on March 1st, 1911, when four officers were appointed for training at Eastchurch. Lieutenant Samson, one of the four, flew off "Africa" at anchor on January 10th, 1912, from a runaway over the fore deck, repeating the exploit in May from "Hibernia" under way. "Hermes", fitted with a runway and carrying two seaplanes, took part in the manœuvres of 1913. In October, 1913, the First Lord announced the decision to develop seaplanes for Fleet work. Shortly after, "Ark Royal" was purchased and re-designed to stow ten seaplanes, with cranes for operating them, completing early in 1915. Her speed of 11 knots was insufficient to accompany the Fleet. At the outbreak of war, fast steamers were fitted aft with hangar and cranes for seaplanes, and later others were equipped with a hangar and runway forward. "Campania" had a forward flying deck with hangar below it, seaplanes flying off with detachable trolleys under the floats. By 1917, it was clear that aeroplanes were preferable to seaplanes for naval uses, and that high-speed carriers were essential. "Furious" (31 knots) and "Vindictive" (30 knots) were fitted with a flight deck forward, and "Vindictive" with a short landing deck aft. Flying-off in "Furious" was not difficult, but landing on the same deck was prohibited after a fatality. A landing-on deck was added later, but disturbed air abaft the funnel made landing-on risky. In August, 1916, a steamer was purchased and redesigned as a carrier. Benefiting by the experience on "Furious", he was fitted with a flush deck, the boiler products being led aft through ducts under the flight deck. Named "Argus", she completed in September, 1918. "Hermes", designed as a carrier, was ordered August, 1917, and soon after 'Eagle" was purchased for conversion to a carrier. They completed in 1924, with full-length flight decks and "island" on the starboard side, trials on "Argus" having shown that a streamlined "island" obviated air disturbance. "Furious" was later reconstructed with a flush deck extending to three-quarters of her length with a lower flight deck forward. "Glorious" and "Courageous" were also converted, the flight decks being as in "Furious", but with short "islands". Arresting gear is now used to bring alighting aircraft to rest on the after portion of the flight deck, leaving the fore end clear for flying-off. Catapults for launching seaplanes and cranes for hoisting them on return are fitted in several warships.

In 1910, three types of 25-knot cruisers were building—"Boadicea", "Bristol" and "Weymouth", the first armed with ten 4in. guns and the last with eight 6in. In Chatham (1911) the thick protected deck of previous cruisers was lightened and the weight used for protective plating on the sides, a feature of all later cruisers. Chatham stowed 1,250 tons of coal and 250 of liquid fuel, but starting with "Arethusa" (1912) oil alone was carried. This, and later the adoption of geared turbines, raised cruiser speeds from 25 knots to 29 knots, and in "E" class (1918) to 33. During the War, broadside fire was strengthened by placing the guns higher and along the centre line, allowing them to train on either beam. The guns were generally 6in., but in "Hawkins" (1916) seven 7½in. guns were fitted, six bearing on either broadside. "Glorious" and "Courageous" (1915), of 18,600 tons and 31 knots speed, were lightly protected, but mounted twin 15in. turrets, one either end, and eighteen 4in. guns. The Washington cruisers "Kent" (1924); "London" (1926) and "Norfolk" (1927), of 10,000 tons and 32 knots speed, have twin 8in. turrets, two forward and two aft, and four A.A. guns. "Leander" (1930) and "Arethusa" (1933) are armed with twin 6in. turrets, four in the former and three in the latter. Aircraft, catapult, and A.A. guns occupy the waist, thus forcing the turrets to the ends.

The building of sloops used in the War for minesweeping and other purposes was resumed in 1927. Of 1,000 tons, 2,000 s.h.p. and 16½ knots, they mount two 4·7 or two 4in. and smaller guns, and carry out the duties of small cruisers.

The first destroyer "Havock" of 240 tons, 26 knots speed, completed early in 1894, was the forerunner of many others of increasing tonnage and military qualities. By 1910, 120 were complete, 30 were building, and in that year 20 were ordered. These, "Acorn" class, were of 770 tons, and 27 knots, armed with two 4in., two 12-pdr. guns and two torpedo tubes. During the War, over 300 destroyers were completed, their offensive power being progressively improved, this being facilitated by the geared turbine (1915). The last of this period were of 1,320 tons, 27,000 s.h.p., 34 knots, with four 4·7in. and one 3in. A.A. gun, and six torpedo tubes. "Amazon" and "Ambuscade" (1924), the first post-war destroyers, have the main armament just quoted and a speed of 37 knots. Five classes have since completed, the latest of 1,375 tons, 36,000 s.h.p., 35½ knots, armed with four 4·7in. guns and eight torpedo tubes. Twice the standard tonnage of "Acorn", the engine power is 1⅔ and the speed 8½ knots more, and they carry six times the armament. The flotilla leader appeared in 1914 in "Lightfoot" and "Marksman" of 1,310 tons and 34 knots speed. They are larger, faster, and more heavily armed than destroyers. "Codrington" and "Exmouth", the first and last completed post-war leaders of 1,540 and 1,475 tons, are half a knot faster and mount one more 4·7in. gun than contemporary destroyers.

By 1910, 67 single-hull petrol-driven submarines had been built. "D" class (1907), with circular pressure-hull and saddle tanks had Diesel engines. "E" class (1911), of the same shape as "D's", had engines of 1,600, and motors of 840 h.p., speeds of 15 and 10 knots, and were of 660-810 tons. They had five torpedo tubes. This class bore the brunt during the early months of the War. Several new types were built between 1914 and 1919: "J" class, with three shafts and 19 knots; "K" class, with steam turbines (10,000 s.h.p.) and 24 knots; "R" class, with submerged speed of 14 knots; "M" class, with a 12in. gun.; and L.50 class, the first with six bow tubes. Post-war submarines include four types: Fast patrol, 1,800-2,500 tons, with speeds of 22 and 10 knots; larger patrol, of 1,475-2,060 tons, with speeds of 17½ and 9 knots; smaller patrol, of 640-940 tons and 14 and 10 knots; and the minelayer type, of 1,500-2,060 tons and 15 and 9 knots. All have six bow and some two stern tubes, and are fitted with indicator buoys, air locks and escape apparatus.

Twenty-five Years' Progress.

By Lord WEIR, P.C., G.C.B.

"Engineering", May 3rd, 1935. Silver Jubilee Supplement.

The Silver Jubilee of King George's Reign presents a fitting opportunity for a survey of the progress and development of engineering during the last twenty-five years. Such a review is always useful; it marshals the factors in an orderly and systematic way, and it demands from us a sense of proportion when we come to assess the value of our achievements. "To direct the great sources of power in nature to the use and convenience of man"—so runs the familiar definition of engineering and the responsibility of the engineer, and in the pages which follow many distinguished men associated with the several aspects and developments of the art will unfold the tale of its progression. My task is to deal with the more general features and tendencies of the period in a co-ordinating survey of our activities. From the angle of sheer human interest, to have witnessed the drama of the period from 1910 till 1935 is an experience which later generations may well envy us. Few periods of the same duration have been filled with such stirring and unprecedented events, and to have lived through these years is to have seen an acceleration in the *tempo* of life which even now shows no signs of relaxation.

Looking back on 1910 it is difficult now to realise how stable and secure the position seemed to the man in the street. The fruits of the Nineteenth Century were being garnered. In every sphere of activity individualism was still supreme, and the era of co-operation and rationalisation was afar off; trade and commerce were active, and in engineering there was a spirit of enterprise which was exploring the possibilities opening up in various new and promising directions. The internal-combustion engine had reached a stage of development which clearly indicated the tremendous influence it was to exert on the development of transport generally. In 1909 Bleriot had flown the Channel, and the key to the air through the heavier-than-air machine had been demonstrated. In steam engineering the turbine had recorded its advantages as against the reciprocating engine and was beginning its long and successful career. The Diesel engine was still in its experimental stages, but clearly held in its design a principle with far-reaching and almost unpredictable effects. Electrical supply and its many applications had registered their value and importance, but progress in this country was handicapped by ill-considered and shortsighted legislation. Scientific method in design and production had become increasingly recognised, but expenditure on research in industry was still small, and its value and importance had only been somewhat grudgingly accepted in a few quarters. The status and field of the metallurgist was beginning to be realised as higher temperatures and pressures were encountered. The Navy and its needs were prominent in their demands on engineering and metallurgy in a way which is not infrequently forgotten to-day, and the lessons learned in meeting naval requirements exercised a very wide and important influence on peace-time products and practice.

No one who reviews the period from 1910 till 1914 can fail to be struck by the immense part played by what are termed "Armaments" in the general engineering of the time. There is also to be noted the rise of a new factor in the situation—the internationalisation of engineering progress. Other nations, and especially Germany, were no longer content to sit at the feet of British engineers and technicians, but were striking out on their own, and were proving difficult competitors in markets where Great Britain had long held a dominant position.

Upon this steady trend of calm and useful development broke the disrupting cataclysm of the World War. 'The use and convenience of man" called for a new concentration, and a new direction of the great sources of power in nature. Relative values in the social and economic hierarchy underwent a rapid transformation, and on all hands there was a forced recognition of the importance of the engineer and of his scientific training. It was found that the engineer's type of mind and method of thought were peculiarly applicable to the thousand and one problems that overwhelmed our authorities. By his knowledge of scientific planning and production, the new and colossal demands made upon industry were met in an amazing way, and from this there grew a recognition of the status and personnel of a profession which was capable of responding so worthily to the enormous demands placed upon it.

The lessons of the War and the experience gained in mass production have undoubtedly given form and direction to the structure and methods of post-war engineering and industry. The analysis of process necessary to permit of the use of unskilled labour has also had a permanent and directive effect on all classes of repetitive manufacture. To all these influences the machine makers of our country have ably responded, and accordingly their designs to-day are inferior to none. Another development on which the War acted as a catalyst was the production and use of new materials, and especially the steels of different characteristics according to their specific uses. This has been extended in many directions until to-day the engineer has a range of material unequalled in variety and still growing in respect of qualities and application.

The influence of this on design is especially noticeable, and the metallurgist of the post-war years has contributed in no small degree to the progress which has been made. The problems of strength at high temperatures, of erosion, creep, and chemical action, are all intensified as we go higher up the scale, and for the time at least material seems to be the factor of limitation in progress. The War contributed also to the development of the Diesel engine, and the experience gained in submarines was reflected in a rapid improvement in various designs, and its increasing adoption for cargo and passenger vessels, while its latest application to road traction opens up a field of vast extent. In the great processing industries, such as chemicals, gas, the newer textiles, and food preparation, the demands on engineering and the engineer daily become more intense and discriminating in technical and scientific quality and variety. In marine circles, despite discouraging trade conditions, the spirit of engineering enterprise has not been idle; new types of boiler, oil fuel for steam raising, turbo-electric propulsion, exhaust turbines and auxiliary services on new lines have all been adopted and given satisfactory results.

In the sphere of transport and communication we find one of the greatest and most important effects of the War. The aeroplane was in its infancy in 1910, but its intensive development during the War period placed it in a unique position, and to-day the new fields which are unfolding before the inventor and engineer in this department of activity make present achievements seem almost negligible. The progress of the electrical industry, both on the supply and equipment side, aided by wiser legislation, has been remarkable, and the twin offspring—wireless and television—are two healthy children still in their infancy but capable of effecting marvellous changes in the social life of the future.

In viewing the whole field of effort in which the engineer is engaged to-day, there is one aspect which cannot fail to arrest the attention of those responsible for the conduct of enterprise on any scale. It is the lack of that generation of youth which perished in the War. These would to-day have been at their best in training and experience for the filling of those administrative posts in industry where leadership and imagination have the best chance to display themselves. We mourn them and we miss them, for even the best organisation depends ultimately on the character and personality of one man or another, and 1914-1918 left a gap which is still apparent in our industrial administration.

The younger men of to-day are, however, worthily fulfilling their obligations and shouldering their responsibilities. One seems to detect in their sympathy with labour, and their endeavour to improve the relationship of employer and employed, a new hope for a better understanding and a more enlightened mutual association. They are the trustees of the future of our profession and industry, and looking back on the long and fateful procession of events over the last twenty-five years, it is no mere spirit of optimism, but a steadfast faith in the genius and character of our people, that convinces me they will not fail us, but will be true to the tradition and spirit of our race.

The Mechanisation of Industry.

By Sir Richard A. S. Redmayne, K.C.B.

"Engineering", May 3rd, 1935. Silver Jubilee Supplement.

The Lord said unto Adam, "In the sweat of thy face shalt thou eat bread", and, necessity being the mother of invention, man has, ever since he became a thinking animal, sought to devise means for the mitigation of his manual labour, or if not for the easement of the labour itself, at any rate towards securing an enhanced return thereon. First the spade, then the wheel—the latter perhaps the greatest of all man's engineering conceptions, entering as it does, as an integral part, into every mechanical contrivance concerned with locomotion. We have reached a stage in engineering development beyond which, some think, there will be little, if any, further evolution in mechanics—whatever may be the advances in pure science. It may be so, but one hesitates to pronounce on the point in the face of the falsification of like prophecies which have been made in the past. Even the great James Watt, it will be remembered, derided the probability of steam locomotion.

The late Sir Alfred Ewing, judging from his notable James Forrest Lecture in 1928, seemed to think that we were nearing the termination of our advance in mechanical engineering. It is conceivable, however, that some completely new and unforeseen scientific discovery relative to matter or force may entirely alter our standards and conceptions in regard to the generation, transmission and utilisation of energy. Well, *tempus omnia revelat!*

For hundreds of years engineering progressed not at all. In "civilian" engineering there was small advance as between, say, the methods and appliances practised by the Romans and those in application in the Seventeenth Century. Consider coal mining—that branch of engineering as to which I can speak with most certitude—which after agriculture is the premier industry of Great Britain, dating from about the late Thirteenth Century. During the Fifteenth, Sixteenth and Seventeenth Centuries few improvements of any sort were introduced. In the early Seventeenth Century we find picks, mandrels, wedges and shovels, the latter shod with iron, being used in mines just as in earlier years, the method of raising men and mineral being still the jack roll or the horse whim. In the days of Telford, the first President of the Institution of Civil Engineers—before the advent of transport by steam—civil engineering was practically limited to the making of roads and canals, the sinking and development of mines, the construction of bridges and the impounding and distribution of water. But the introduction of steam and consequential developments in mechanical engineering, and later still the practical use of compressed air and of electricity, widened vastly the scope of engineering.

The advance in "civilian" engineering which inaugurated the Industrial Era—less than two hundred years ago—has, within the last seventy years, been little less than stupendous. Seventy years ago the telegraph (first used in 1834) was a fairly modern innovation, the telephone was not yet established, the use of electricity was restricted to laboratory experiments, and the technique of aeronautics was limited to the occasional flying of a balloon—frequently with disastrous results to both balloon and balloonist!

Again taking coal mining as an exemplification of the magnitude of the advances made in quite recent years, in the mechanisation of industry, the most arduous work in the mine—perhaps the most laborious of all work—is that of hewing the coal by pick and filling it into the tub or tram by shovel in a more or less confined space. It is due to recent advances made in the generation and transmission of electrical energy that we are chiefly indebted for the great expansion in the use, in recent years, of mechanical coal cutters. In 1900, only 1·47 per cent. of the British coal output, and 24·9 per cent. of the United States of America output was cut mechanically, whereas in 1932 this had risen to 38 per cent., and 68·3 per cent. in the United States, natural conditions, however, in the two countries not being strictly comparable. In the Rühr coalfield the mechanical pick has found great favour, and whereas in 1913 2·2 per cent. of the entire output was cut mechanically, in January, 1929, 90 per cent. was so obtained, 84 per cent. being cut by mechanical picks and 6 per cent. by mechanical coal cutters.

The transport of the cut coal from the coal face to the shaft bottom is a matter of importance to the mine manager, secondary perhaps only to that of the actual "getting" of the coal. To-day, through the perfectability in design and construction which has been attained in electrically actuated plant, not only is the haulage on the main haulage roads carried out electrically, but in great measure in the secondary haulage it has been substituted for horses and ponies. It is probable that the electrically driven locomotive will before long come largely into use underground for purposes of main road haulage. Transport of coal along the face, from the coal hewer or filler to the tubs by means of conveyors has been greatly extended within the last twenty-five years— in many cases along the gateways also, almost to the point of the main haulage.

Largely owing to the action of the engineer, civilisation, in so far as the creation of the wealth and the increase in the leisure and comfort of the mass of mankind are concerned, has been greatly advanced in the Industrial Era as compared with the state prior thereto. For the mechanisation of industry has undoubtedly led not only to increase in wages and decrease in the hours of labour, but, as everyone knows, has brought about certain amenities of life, common to all classes, quite unknown two hundred years ago.

Turning again to coal mining for an example, during the last one hundred and thirty years wages have risen by 320 per cent., with a decrease of 37 per cent. in the daily time of work, the return on capital remaining, on the average stationary. So that in this, as in other branches of industrial activity, the chief beneficiary, under a system of mechanisation, has been the operative, i.e., the manual worker.

Referring to another, and totally different branch of industry one may quote a remarkable experiment, the result of a system of rationalisation. It was recently shown in a report on the experimental working of the five days' week at Messrs. Boots' works at Nottingham that, generally speaking, owing to the system of mechanisation *cum* reorganisation which was introduced into the works, it was found possible not only to make a series of reductions in the prices of commodities, but to introduce a five-days' week by elimination of the Saturday as a working day, without lowering the financial return to the shareholders or diminishment of the weekly earnings of the workpeople.

How far the experiment, so pre-eminently successful at Messrs. Boots' works, is capable of application to other industrial concerns with like chance of success, it is difficult to say. Where, as in the case of Messrs. Boots, production and distribution are vested in the same concern—a most desirable condition from every point of view—and where the proportion that wages' cost bears to total cost is small, it is easier to carry out such a decrease in working time than in an industry where the reverse is the case.

The effect of rationalisation in any given industry, unless the hours of work per individual are reduced, must necessitate a decrease in the number of employees. It might at first sight appear that the net result of the *general* rationalisation of industry will be the enhancement of unemployment of labour, but a little further consideration will show that the consequential lowering of the price of the commodity, its more effective distribution (leading to the creation of new or ancillary industries), together with the increase in wages and leisure (creating an increase in demand), will result in more than the absorption of the overplus of labour.

There can be little doubt that the general tendency is towards the increase of wages and of leisure, rendered possible by the mechanisation of industry, so that in the process of years there will be brought about, naturally and without the application of what is commonly called revolutionary methods, an uplifting of the operatives to a higher level of material well-being. Indeed, it is conceivable that we may enter before very long, owing to this *"Deus ex machina"*—the substitution of the machine for the man—upon an age of leisure, so that one of the problems of the future may well be that of the best utilisation of that leisure; for, inasmuch as "man does not live by bread alone", the material things of life will not alone suffice to promote the true advancement of the human race.

Fractures in Water Tube Boiler Drums.

A Discussion on the Various Causes of Failure of the Material of Boiler Drums.

By Edward Ingham, A.M.I.Mech.E.

"Engineering and Boiler House Review", January, 1935.

Water tube boilers are sometimes described as safety boilers. They are no more entitled to be so described than are other types of boiler. Explosions of the tubes are not by any means rare; nor are disastrous drum explosions out of the question. It is true that the evaporation is mostly effected in the tubes, and that these are of small capacity, wherefore, in the event of a tube failure, the quantity of water liberated (on which the destructive results principally depend), will be very small, and the explosion therefore of a comparatively mild character. But even if a boiler is subject only to explosions of a mild type, it is scarcely entitled to be described as a safety boiler; and since an explosion of a drum, which contains a large volume of water, and therefore a large amount of explosive energy, is not out of the question, the term "safety", as applied to a water tube boiler, is singularly inapt. Indeed, to speak of a water tube boiler as a safety boiler is inadvisable, for it may lead to a false sense of security on the part of those in charge, so that the boiler may not receive the vigilant attention it would do if its explosive possibilities were fully realised.

During the past few years, a number of disastrous drum explosions have occurred, the consequence of fractures in the plates, and the subject of our article should then be of interest to all concerned with boilers of the water tube type.

In America and on the Continent, drums of welded construction appear to be extensively used, but in the United Kingdom, they are almost invariably of the riveted type, except for unusually high pressures, for which only drums forged from solid steel are suitable; hence, our remarks will be confined to riveted drums.

Causes of drum fractures include (1) faulty material; (2) unsatisfactory features of design; (3) punishment received by the plates during construction; (4) chemical embrittlement of the plates.

Faulty Material.

It has long been the practice to specify that the material used in the construction of drum plates shall be made by an approved process, and that it shall not contain an undesirable amount of certain elements, such as sulphur and phosphorus, which are known to be detrimental; further, that the finished plates shall be free from laminations, surface flaws, etc. Specimens must also be subjected to various tests, with the object of ensuring that the plates will be entirely satisfactory. The result is that the plates are generally sound and originally free from defects, and hence, fractures from the use of faulty material are somewhat rare.

Many fractures have been attributed to excess of sulphur or phosphorus in the steel, but whether or not always rightly so may be questioned. For a long time, it was not suspected that nitrogen has a tendency to make steel unreliable, and it may be that this element has been the main cause of certain plate failures which have been put down to other elements. A very small quantity of nitrogen renders steel brittle, and since basic open-hearth steel is liable to contain an undesirable amount of this element, it cannot be wondered at that leading authorities are against the employment of such steel for boiler plates, and insist on having the more reliable open-hearth acid steel.

Unsatisfactory Features of Design.

To be entirely satisfactory, a water tube boiler drum ought to be truly circular and of uniform thickness throughout; whilst the end plates should be suitably cambered, and have an ample radius where the edge of the plate is flanged over for attachment to the shell, i.e., at the rounded or corner part of the flange. When these conditions are not complied with, the drum is likely to be subjected to undue stresses which may sooner or later cause cracks and fractures.

The employment of the lap joint for the longitudinal seams throws the drum out of true circularity, and leads to straining at the seam which may ultimately be responsible for grooving and fracture. Butt-jointed drums are unquestionably less liable to fracture than are lap-jointed drums, and are almost invariably adopted in the best practice.

Pronounced or sudden changes of thickness of circular drum plates, such as are sometimes made at parts where the tubes are to be expanded into the plates, have a tendency to induce straining and consequently grooving, and for this reason should be avoided as far as practicable.

For similar reasons, the pressing of flats into the plates for the reception of tube ends must be regarded as undesirable; fractures are by no means uncommon at the parts where the form changes through the provision of these flats.

End plates are subject to a breathing or "drum head" action owing to the changes of pressure and temperature which take place within the drum under working conditions. This action is more pronounced the flatter the plate, or the larger the radius of the camber, and its tendency is to induce more or less severe straining at the corners of the flanges. This straining is indeed a common cause of grooving and fracture in end plates. An actual case is illustrated by Fig. 1, which shows grooving and cracking in one of the end plates of a large drum of a water tube boiler.

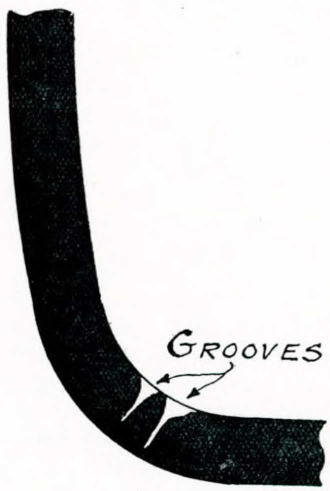


FIG. 1.—Typical fracture in water tube boiler drum.

Obviously, the radius of the camber ought to be as small as practicable. If it is made one-half the diameter of the drum, the end plate will be hemispherical, and this form of end plate is certainly the best so far as strength and immunity from the developments of defects are concerned. If the adoption of the hemispherical end is impracticable, the cambered end ought to have a radius of about two-thirds of the drum diameter, and never more than the drum diameter.

The tendency to straining and grooving in a cambered end plate is greater the smaller the radius of the flange corner. When the radius is too small, there is not only excessive straining at the corner under working conditions, but the flanging of the plate during construction seriously distresses the material about the corner. Indeed, with an unduly sharp corner, subsequent grooving and cracking are almost inevitable. Hence, the radius should be as large as practicable. A leading authority on boiler construction recommends that the internal radius of the corner should be one-eighth the radius of the camber (which, as already stated, should be about two-thirds of the drum diameter), but in no case less than two inches.

Punishment of Plates During Construction.

During the construction of the boiler, the drum plates have to be bent to the circular form, riveted and caulked, whilst the end plates have to be dished, flanged, etc. These various operations are a severe test on the material, which is consequently very likely to be injured unless the work is most carefully carried out by high-class machinery and highly-skilled men. There is no doubt that a considerable proportion of the fractures which have developed in boilers of all kinds, are largely the consequence of punishment the plates have received during construction.

The bending of thick drum plates to the circular form is a more drastic operation than the bending of the shell plates of large cylindrical boilers, because the diameter of a drum is comparatively small. If the bending is done cold, serious internal stresses may be induced in the material. A suitable heat treatment applied afterwards will relieve any such stresses, and minimise the danger of fractures later.

A boiler shell is weakest at the seams, because of the weakening effect of the rivet holes, and it may therefore be easily imagined that, if excessive riveting pressures are applied to the rivets, or if the practice of drifting is resorted to for the purpose of bringing the holes fair with one another (i.e., inserting a taper tool of circular section in the holes, and driving it up with a sledge hammer) the material may be seriously injured. The most dangerous fractures are those which occur at the longitudinal seams, and they may often be traced to careless riveting and to drifting.

As already mentioned, end plates may be severely distressed by flanging, especially when the radius of the corner is small. They may also be damaged by the careless operation of the pressing-out tool which is sometimes used to press out the flange against the shell plate in order to make it a good fit before the riveting is commenced. Thus the tool may be applied with excessive force, or it may be applied beyond the straight portion of the flange, so that it makes an indentation in the root of the flange. Any such indentation is a most serious defect, because it leads to concentration of stress at a part which is subjected to repeated straining under working conditions.

Caulking of the riveted seams, i.e., "burring" down a strip of metal at a plate edge on to the adjacent plate, with the object of making the seam tight, is an operation which may engender dangerous fractures if it is not done with care. The tool used is similar to the ordinary chisel, as used for metalwork, but it has a flat narrow edge, commonly with sharp corners. In modern boiler shops, the tool is worked by pneumatic pressure, delivering violent blows to the plate edge. Want of care may clearly result in the sharp edges of the tool indenting the adjacent plate. As regards the internal caulking of a drum, there is always the difficulty that, owing to the rapid curvature of the drum, the operator is compelled to hold the tool at a rather steep angle when caulking the longitudinal seams, and the danger of indenting the plates is therefore considerable. The risk can be much reduced by making the tool of a suitably curved form, instead of the usual straight form, and slightly rounding the corners to remove sharp edges.

There is nothing more liable to injure the plates than "flogging" them, or hammering with sledge hammers to adjust or shape them. The practice of hammering the ends of shell plates to bring them to the circular form of the shell (when the bending rolls have been of the type which is incapable of bending the plates right up the edges), and also that of hammering the flanges of end plates to make them fit up against the shell, cannot be too strongly condemned.

In various kinds of boiler operations, the greatest care needs to be taken to avoid working the plates at a "blue heat", i.e., at temperatures between a red heat and cold; otherwise, the material may be injured and liable to fracture.

Plates into which the tubes are expanded may be injured by the application of excessive force from the expanding tool. Excessive expanding reduces rather than increases the holding power of the plates on the tubes, and when resorted to is very prone to induce cracks at the edges of the tube holes, as well as to split the ends of the tubes. A tube plate in particular requires careful treatment, because it is materially weakened by the numerous tube holes.

Chemical Embrittlement of the Plates.

Within recent years, it has been definitely established that the presence in the feed water of certain chemicals may cause boiler plates to become brittle, and hence very liable to fracture. The consequence is that there is a strong tendency nowadays to regard chemical embrittlement as a common cause of boiler plate fractures. Actually, it is not a common cause, but rather an occasional one. Punishment received by the plates during construction is probably far more often responsible for fractured plates than is chemical embrittlement.

The chemical mostly responsible for the trouble in question is caustic soda. It has been amply demonstrated that if steel specimens in a state of strain be immersed in a caustic solution, they soon become decidedly brittle. A state of strain appears to be a necessary factor for the production of a brittle condition.

Soda in one form or another is largely used in the treatment of feed water. In some cases, caustic soda is employed; in others, the carbonate of soda. It is to be noted that if the carbonate is used and not the caustic soda, this does not ensure freedom from the danger of caustic embrittlement, because the carbonate, under high-pressure boiler conditions, may give up its carbonate acid, when it is converted into caustic soda, and in a water tube boiler, thanks to the high rate of evaporation, the water may then soon become heavily charged with caustic. If this water penetrates the riveted seams, the caustic becomes very highly concentrated, so that the conditions are favourable for engendering brittleness and fractures at vital parts.

As might be expected, the parts which generally suffer from chemical embrittlement are the riveted seams below the water level; but seams above the water level are not immune from trouble if priming occurs. It is one of the claims made for drums of welded construction that they are immune from the danger of chemical embrittlement, because there are no riveted seams into which the water can penetrate.

"Engineering and Boiler House Review", February, 1935.

There seems good reason to believe that if the riveted seams could be perfectly closed by the riveting and internal caulking, danger of chemical embrittlement would be largely eliminated, but this appears to be impossible. A plan which is sometimes adopted to prevent infiltration of the water into the joints is to introduce between the plates a liquid cement which afterwards sets and maintains tightness. The objection to this is that it tends to make the work of discovering constructional defects more difficult for the boiler inspector.

The indiscriminate use of soda and boiler compositions, most of which are largely composed of soda, is manifestly something to be avoided, and quite apart from other reasons, users of water tube boilers should treat their feed water according to the advice of a fully qualified chemist or water analyst.

Water tube boilers are specially designed to withstand rapid steam raising, sudden changes of load, etc., conditions which, especially in some types of boiler, induce serious straining and a tendency to set up incipient fractures. Nevertheless, they should be guarded as far as practicable against sudden changes of temperature, particularly sudden cooling of hot plates, for the stresses induced by rapid contraction are always excessive and dangerous.

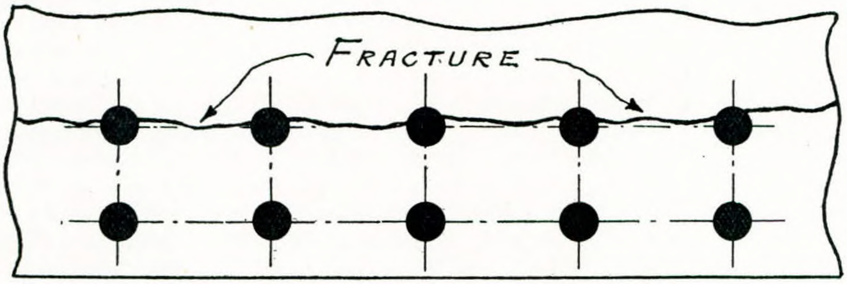


FIG. 2.—Dangerous type of plate fracture between the rivet holes.

The Detection of Fractures.

Since fractures in drum plates may be followed by calamitous consequences if they are not discovered in good time, regular and close inspection of all parts where they might develop is imperative. Fractures which merely run from the edges of rivet holes to the edge of the plate are not usually of much importance, because they do not appreciably reduce the strength of the drum. Those which extend from holes into the main body of the plate must be regarded as more serious. The most dangerous type of fracture is that which extends from rivet hole to rivet hole for a considerable distance (see Fig. 2). This type is all the more dangerous because, far more often than not, it starts from an inner surface of plate, i.e., at a surface which is covered by a lap in the case of a lap joint, or by a butt strap in the case of butt joint (see Fig. 3), so that it is not open to inspection, wherefore there is the possibility that it may remain undiscovered and extend until explosion results. Fortunately, however, these fractures are usually of very slow development, and as they almost invariably cause leakage, the danger of explosion can be almost eliminated if those responsible for the safety of the boiler will keep a constant look-out for leakages, and regard any leakages which are detected as being a possible indication of fracture. Leakage may of course arise from several causes, such as imperfect riveting and caulking, improper bedding together of the plates at the seams, overheating, sudden changes of temperature, and the presence in the feed water of certain salts. In most cases of leakage, indeed, the cause is not a fracture, and the men in charge, knowing this, may naturally attach no significance to a leak, especially if it is not a pronounced one, and so disregard it. In doing so, they may be incurring risk of explosion. The safe plan is to look upon every leak at a riveted seam as being possibly due to a fracture, and have the cause investigated. In most instances, a little light caulking (when the boiler is not under pressure) will remedy the trouble; but if the leakage persists, the advice of the insurance company should be sought. It may be necessary to withdraw some of the rivets, or even remove the butt straps, in order that a satisfactory examination can be made; and the steam user who is advised by his insurance company to do this will be wise not to demur, on the grounds of trouble and expense, as some do.

It is a feature of riveted seam fractures that they are frequently of a very fine nature, resembling hair lines, so that even when they are accessible to inspection, they are sometimes so difficult to detect by ordinary methods of inspection, that there is not a little risk of their being overlooked unless some special means are employed. Unfortunately, it has long proved an almost insuperable difficulty to devise a reliable means for disclosing very fine and hidden fractures in boiler plates on the site. The X-ray was recognised as a possible means as soon as it was discovered before the end of last century, and experiments were carried out by a well-known boiler insurance company, but were not attended with success. Although notable advances have been made within recent years in the application of the X-ray to the discovery of defects in castings and forgings, the method still appears to be open to certain objections so far as the detection of fine cracks in boiler plates is concerned.

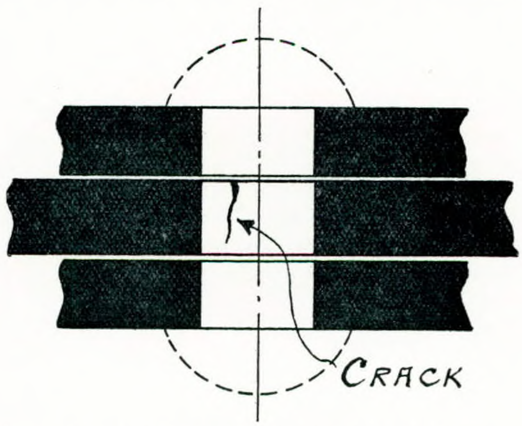


FIG. 3.—Concealed crack in lap joint.

Not long ago, a method of disclosing boiler plate fractures was developed by the Vulcan Boiler Insurance Co., Ltd., of Manchester, who state that no fracture, however slight, can escape detection by this method. A powerful magnet is applied to the plate under examination, which is thereby rendered magnetic, and a special liquid consisting of a mixture of light oils containing a suspension of finely divided iron (reduced by hydrogen), is poured on the cleaned surface, whereupon the iron dust immediately accumulates along any lines of fracture owing to the change in the local distribution of the magnetic flux. In the October, 1934 issue of the "Vulcan", the following instance of the application of the method to the drum plates of a water tube boiler is given: Leakages at the longitudinal seam suggested the possibility of a fracture there. The butt straps were removed, but there did not appear to be anything wrong with the plate. When, however, the magnetic test was applied, cracks were disclosed at various positions along the seam. As several fractures were revealed, the drum was subsequently removed; and a metallurgical investigation which was afterwards carried out on the defective drum showed that the cracks had all commenced at the rivet holes on the outer surface of the plate, and had progressed both along the surface and through the thickness of the plate.

Welded Steam-driven Tanker "Moira".

"The Marine Engineer", August, 1935.

The steam tanker "Moira" was recently completed by the Wallsend shipyard of Swan, Hunter & Wigham Richardson, Ltd., for the Marna Co., Oslo. The "Moira" is 245ft. in length, 42ft. 2in. broad, and is designed to carry a deadweight of 2,240 tons. She has been built to Lloyd's Register's survey to carry petroleum in bulk, and has five main oil tanks divided into ten compartments by a centreline longitudinal bulkhead. Two horizontal duplex oil pumps deal with the cargo, and the tanks have been constructed without internal stiffening so as to leave a perfectly flush surface to facilitate easy drainage and cleaning.

One of the main points of interest in this ship is the fact that she is constructed throughout entirely without riveting, the whole structure having been connected together by the electric arc-welding process. She is the largest all-welded ocean-going ship built in this country up to the present time.

A special installation of apparatus for cleaning the tanks known as the Arnesen patent is fitted, and consists of a telescopic tube fitted on the crown of each tank. It has an inner tube which is capable of being lowered and turned. Two swivelling arms attached to the lower end of the inner tube are fitted with sprayers which enable the cleaning fluid to reach all the internal surfaces of the tanks, resulting in a very effective and rapid cleaning operation.

A special type of electric-hydraulic steering gear is fitted, this gear having been described in this paper. With it the rudder responds rapidly and steadily to all the various tests which have been carried out in this and other vessels provided with the new gear. This gear is so arranged that when the ship is in open water the electric motor may be disconnected and the pump worked by the steering wheel.

The propelling machinery, which is placed aft, consists of a turbo-compound installation, i.e., a reciprocating engine working in conjunction with a Bauer-Wach low-pressure steam turbine, which has proved to be both highly economical and reliable.

Most comfortable accommodation for the captain and deck officers is provided in the midship deckhouses, the engine-room staff and crew having quarters aft.

The trial was eminently satisfactory, a speed in excess of the designed speed of 10 knots being obtained.