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Research at the William Froude Laboratory.

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The purpose for which the Tank was constructed is given in the words of Sir Alfred Yarrow in his letter of April 1st, 1908, containing his offer to cover the cost of building the Yarrow Tank: ". . . if the Tank were placed at the National Physical Laboratory . . . and largely devoted to research work, it would prove of great value in indicating the direction for possible advances in Naval Architecture".

Any conception of research in naval architecture must depend upon the individual concerned. With us the view has been taken that a research must have a purpose, *viz.*, indicating the direction for advance. This may be modified as the work proceeds, but must not be given up. Exploration will always bring to light interesting side vistas, but these can be investigated better when a main road through the region has been found. It is because of this conception that the division and separation of research into "pure" and "industrial" has never been made here. Such work has always taken the course of the discovery and study of the basic fundamentals of any phenomena, and then the application of them to design. This placing of pure research as a mere servant to industrial research has been most successful and has led to a number of innovations in the past, and there is no reason why the continuance of research on these lines should not lead to more useful developments.

The organisation is of a kind which lends itself to easy expansion to cover any problem which may arise and could be expanded to include any new work in naval architecture.

The programme of research work at the Tank is supervised and reviewed from time to time by an Advisory Committee on which all branches of shipbuilding and shipping are represented. The cost of the work up to the present has been covered by subscription from various firms and institutions, and by a "pound for pound" grant from Government funds.

The research work was at first confined to model towing tests, owing to lack of equipment, but has now spread to any matter connected with the industry.

Altogether 102 papers have been published from the Tank in the transactions of various societies. The earlier ones were collected together and published in two* volumes by H.M. Stationery Office. (This has been discontinued in later years in the interests of economy). A list of descriptive publications is given as an appendix to

*(1) Vol. 16, 1921, of the Collected Researches of the National Physical Laboratory (now out of print). (2) Vol. 23, 1932, of the Collected Researches of the National Physical Laboratory.

this paper. These papers have been gathered together under main headings and it is proposed to discuss briefly the principal results obtained and the possible future extension of such work.

Form of Merchant Ships

The Tank has published a mass of data for a methodical series of models varying in fullness from 0·62 to 0·83, with three different forms of cross section area curves. One set of models with varying beam was included in these tests. The data has been published under one cover by H.M. Stationery Office. This work was completed twenty years ago and to some extent requires revision. The series itself brought to light a low resistance high-speed form which has since formed the basis of research work here and in America, and intensive research during the period has shown that the parent form of the series could be improved by roughly 10 per cent. for all full forms. Proposals have already been considered for a new series of medium fullness models of modern form, which would be generally related, but for which the parent form for each fullness would have an area curve more or less appropriate in shape for its fullness. It is hoped to make a start with this shortly. There can be little doubt that some increase of speed will be desirable in the near future even with vessels carrying raw material, and there will also be a large increase both in the number of fast cargo liners and in their speed, and for these there is not a great amount of data in existence. As a direct result of the research work completed, the resistance of all properly designed cargo ships is now about 10 per cent. lower than it was twenty years ago, the improvement being due to better stream-lining of the under-water form, the use of a cruiser stern, etc. More recently, a limited series of models has been in hand, in which the form of bow was varied, the bow contour being given various slants up to 45 degrees. Two papers on this have been published, and the work is now approaching completion. The final paper on the subject will be read by Mr. Emerson at the Spring Meetings of the Institution of Naval Architects.

In addition to the above, a great improvement has been effected in the seaworthiness of modern ocean-going merchant ships, largely as a result of the careful study of the behaviour of ships at sea and of their models in rough seas made in the tank. Much work remains to be done in this study of sea behaviour. Up to the present, exploration has been mainly confined to the pitching and heaving of hulls and the increase in resistance arising from the weather. From this, broad conclusions have been formed about the best shape of hull and suitable lengths for given types of seas, and the effect of fullness and of speed. More recent work has been connected with propulsion in rough weather, the effect of propeller size and design, and the effect of and possibility of using power margins on ships of various service speeds. A paper on this subject has just been read by Messrs. Kent and Cutland at Glasgow. So far, a little of this work has been done with cross-channel types, but most of it has been concerned with the fast cargo ship type (14 knots on 400ft.). It remains to extend this to the slower cargo ships and to intermediate liner types. Very little research has been done on rolling, but a statistical survey has shown the features on which resistance to rolling depends, and data on this subject has been recently published. Such features as height of centre of gravity above water, stability in rolling, etc., have not been considered at all so far.

Coastal ships are rather different from ocean-going ships, being relatively broader as a rule, and for a given length and fullness required to make a faster speed. To cover the demand for data on these types, a separate series of tests has been made on models varying in fullness to cover both the slow coal boat and the fast passenger and cargo type. Allied to these are our trawlers and drifters, and some data on these was recently published by Dr. Todd and Mr. Edwards. Most of this work has been on the hull design, and for smooth water. No attempt has yet been made to carry out methodical tests in rough water, and only a little propeller work has been done for the class.

One other class of ship which will have to receive attention in this country is the high-speed motor boat, capable of keeping the sea for long periods. These would not be pure hydroplanes but a mixture of their qualities with those of the destroyer. In Russia, the attempt to attain high speed has led to the development of a twin-hull design. This vessel, the "Express", is reputed to have a top speed of 47 knots as a river passenger steamer. There is no doubt that these high speeds are coming and that methodical research to meet the demand is required.

Air Resistance.

Closely allied to the design of hull is the question of air resistance. The power lost from this cause amounts to around 2 per cent. in still air, but increases rapidly with head winds, and in some cases leads to serious difficulty in course-keeping, particularly with a quartering gale aft. A good deal of general research work on this has been done, mainly in connection with methods of reducing air resistance of superstructures as now used by shaping, regrouping them, or stepping back of the different layers. This work was completed some years ago, and up to the present has had little effect on ship design, and the work has been discontinued. There is a good deal of exploration required in connection with the flow ensuing from stream-lining and development of new types of design of above-water hulls, particularly for passenger ships. The full effects of the changes made in a few such vessels to reduce air resistance have obviously not always been appreciated by the designers, and must lead to other troubles. Air resistance must be studied for high-speed motor boats, as in any reasonable head wind this resistance absorbs as much power as wave making, and is increasing with speed, whereas the latter is falling.

Before leaving the hull a few words might be said on the subject of friction resistance. Any industrialist wishing to throw stones at general research has one to his hand here. For despite the very large number of research workers on the subject, particularly in aeronautics, except in one direction, the author knows of no *practical* advance during the last ten or fifteen years.

Even where knowledge has existed for many years, practice has not kept pace in the marine world. The increase in resistance due to a rough surface was apparent in William Froude's "Greyhound" experiments. The increase due to lapped butts and joints was measured by the Tank in 1915. In the effort to discover the cause of discrepancies between ship results and tank estimates, the condition of the wetted surface of a number of ships has been examined recently. In many cases the roughness, as represented by abrupt changes in level of surface, was quite serious, particularly at and near the forefoot, where the smoothest surface should exist. One other area over which the roughness exceeded good practice was on the flat bottom amidships, where on 50 per cent. of the ships examined, paint blobs and rust cones abounded, protruding up to a quarter inch from the hull. In a few large ships plastic material behind the butts and at plate edges has been used to smooth the surface, but this cannot be better than a good flush butt surface. A few months before the war commenced, a start had been made with the study of painting conditions, the type of fouling found on different ships, and the use of various anti-fouling paints. This work is necessarily in abeyance during the war, but already interesting facts on fouling have come to light, and in any case, existing knowledge shows that an appreciable reduction of resistance is possible by care in construction. There is little doubt that the study of the fouling and biological conditions on various main routes, associated with paint tests for the conditions found, would offer a good return after a few years.

Propulsion of Merchant Ships.

Research on this subject has lagged behind the work on hull form. This was partly due to the complete absence of any satisfactory theory which could be applied to the actual design of a propeller for a particular job, and partly to lack of facilities and funds for such research work. The result has been that some of the earlier efforts have not always shown the same type of result for a given change in design. Froude's theory is so general that it gives only broad guidance to the main factors, and the Glauert Goldstein or any variation of this theory, useful though it is in regard to detail cause and effect, is so restricted by assumptions that it cannot be used as a sole guide. In any case no theory exists for dealing with the vexed question of variable wake and thrust deduction. This statement is made despite Horn's work on this aspect of the matter, which in the author's opinion has no good foundation. But there is now enough good theory to guide one in the planning and comparison of experimental work.

Experimental work was not commenced at the Tank until about 1920. Froude's method of carrying the screws on frames suspended behind the ship hull was first tried, but this was given up after a year or two and all tests have since been made with models propelled by recording inboard mechanism. Before the start of this experimental work, however, work on the basic data and ideas for screws had been commenced, and as a result a specially-designed screw having what are now generally called "aerofoil blades" was tried on a single vessel in 1917 under the control of Messrs. W. Esplen, Son & Swainston, Ltd. Soon after the last war aerofoil screws were tried on the "Empress of Australia", and their success led to similar screws being fitted when she was re-engined a year or two later.

A large series of various-shaped aerofoil screws have since been tested at the Tank and results published, and various special types of such screws under suggestive trade names are now on the market. No methodical series of screws covering any pitch range has been undertaken at the Tank as it is considered that Taylor's and Froude's data for circular-back blades and the more recent Troost data for aerofoil blades cover the ground sufficiently for present purposes. Our own recent work can be divided roughly under three headings.

First, the obtaining of lift and drag for a number of blades having cross sections used in or useful for the design of screws. There is a large amount of such data for air wing sections, but very few such sections can be adopted for marine work, and most of this data is at too low a Reynold's number and shows too much variation between different establishments to be taken as accurate. Unfortunately, this work has stopped for the duration of the war.

Secondly, it is clear that the higher the revolutions to which an engine can be run on service, the lighter is the engine and the greater the deadweight ratio. Hence our studies, particularly on single-screw ships, have been concentrated recently on low pitch ratio screws necessary with high revolutions. Tests with two forms of blade section, circular back and one aerofoil, have been made down to 0·6 pitch ratio, and some rules governing the thrust that can be accepted have been framed and published. New work is now in hand with pitch ratios of 0·5, mainly to see what type of blade is most useful in this region. This latter work is not quite complete, but has progressed sufficiently to give guidance to any firm with a particular problem involving such pitch ratios.

The third heading is the placing of screws relative to the ship. With single screws, the use of a fin behind the screw, introduced by the Tank, has now become common practice, as is also the allowance of good blade tip clearance and the "clearing up" of rudder resistance. Model work has shown that these changes can account for a gain of 3 to 10 per cent. in efficiency, according to the vessel. But with twin screws the author knows of only one ship—of quite shallow draft—that has ventured to try a fin aft of the screws. In fact, we have very little data of a methodical character about the effect of position of screws relative to the hull and its fittings on twin-screw vessels, and a start has been made to remedy this state of affairs. The number of variants is large and includes spread of centre lines, height relative to keel and free surface, fore and aft position, blade tip clearance, and bossings or "A" brackets as alternative means of support; and overriding all these is the question of big diameter and small pitch *versus* small diameter and large pitch.

A fair amount of work has been completed and the data published, covering tests behind a large hull representing a moderate speed liner, and a third instalment of this research will be presented by Dr. Hughes at the Spring meetings of the Institution of Naval Architects. These publications deal with the effect of screw diameter, spread of shaft, and height relative to the free surface—which has a fairly marked effect. New data on the merits of "A" brackets and bossings will be given in the above-mentioned Spring paper, and it is hoped to make progress with some of the other variations during the coming year.

A new research begun during the last two years is that connected with singing propellers. Two lines are being pursued. One is to study the possible modes of vibration of a blade and the effect of various changes in blade shape on these modes. The other is the analysis of singing propeller data in the light of the pressure changes which take place on the blades. An attempt is being made to formulate rules governing the maximum rate of change of pressure which can be allowed without breakdown and to tie these to the shape of blade section. Propeller measurements in a number of cases have shown a general agreement with the theoretical separation of quiet and unquiet blades, but to settle margins such a study involves experiment as well as analysis, and we have now reached a stage where the opportunity to cure singing on a propeller would be very welcome.

Steering

One other large block of research data obtained at the Tank is that connected with steering and the design of rudders. The work has covered all the rudder types in common use on single- and twin-screw ships, shows the best type of rudder to be used in any case, and gives data from which the stresses on the rudder can be calculated. Tests have been made in smooth and rough water, and with moving rudders fitted with instantaneous recording gear, and the effects of such variants have been obtained. Several check measurements on ships have been made. The last of these was on the "Beacon Grange" in 1938. This was the first time that an attempt had been made to account for the complete motion of a ship under helm, from data obtained from model experiments. The tests showed good general agreement, and brought out several factors, such as the fact that small yaws had no effect on resistance provided they were met with small helm. Several points remain unexplained, such as the momentary large loss of efficiency if the rudder is moved *quickly* to large angles. These tests really require repeating as it is not wise to form conclusions from one set of results. The data mentioned above covers most types of ship, but requires extending for quadruple-screw ships and really high-speed vessels such as express liners, destroyers and skimming motor boats.

Vibration.

Some three years ago the Advisory Committee agreed to the vibration of hulls being taken up as a research, and shortly afterwards this was extended to cover propellers as well. A general theory of hull vibration is extant, and the first thing that seemed desirable was to check this by tests and calculations for several ships. This has been done in a few cases with fairly good agreement between calculated and actual frequencies. The main difficulty in such work is in the determination of the extent to which superstructures act as part of the main elastic structure, and the damping effect of entrained water. Some work on the inertia value of bars when immersed in water has been done, but this requires some material elaboration before the results can be applied with certainty to a ship. Also more data is required for that class of ship having continuous superstructures amidships for varying portions of the length. From such data the correct method of dealing with these structures could be obtained, and hull vibration frequencies would then be calculable as accurately as anyone requires. This question of vibration is really an offshoot of the much larger one of structural strength and bending. In passenger ships there is a great deal of guessing as to the part played by various members of the complicated structure in the longitudinal and transverse bending of the ship, a most interesting research but somewhat outside our recognised ambit.

After the war is over there will inevitably be raised the question of whether this or that research work pays. The shipping industry is in a peculiar position in this respect. Mr. Cleminson, in his address to the Royal Empire Society two years ago, quoted an American writer as stating that merchant shipping is "desirable for America but vital for Great Britain". But the maintenance of a fleet of ships of all sizes and variety in the free and open market of world competition demands amongst other things that the shipbuilding and marine industry of the country must be just that little more efficient on all technical matters than any other. This can only be secured where organised research of various kinds constitutes a background of the industry. Industry flourishes where research is a living reality. Research in hydrodynamics has amply repaid the country in the past. During the last ten or fifteen years no single foreign government or body has been able to build ships of greater efficiency in propulsion than our own. The future should contain an expansion of research not only on this subject, but on all matters appertaining to naval architecture. Establishments of this kind now exist in Germany, America and Sweden, and we should not be behind.

APPENDIX.

EXPERIMENTAL WORK IN CONNECTION WITH SHIPS MADE AT THE WILLIAM FROUDE LABORATORY SINCE ITS INAUGURATION IN 1911.

This work is divided into seven groups: 1, Resistance; 2, Propulsion; 3, Waves; 4, Steering; 5, Stability; 6, Backing; 7, Vibration.

ABBREVIATIONS.

T.I.N.A.—Transactions of the Institution of Naval Architects.
T.E.S.S.—Transactions of the Institution of Engineers and Shipbuilders in Scotland.
T.N.E.C.—Transactions of the North East Coast Institution of Engineers and Shipbuilders.
T.I.M.E.—Transactions of the Institute of Marine Engineers.
T.I.C.E.—Transactions of the Institution of Civil Engineers.
T.L.E.S.—Transactions of the Liverpool Engineering Society.
B.A.—British Association, Cambridge.
H.M.S.O.—His Majesty's Stationery Office.

P.R.S.—Proceedings of the Royal Society.
C.I.I.N.—Congrès International des Ingénieurs Navals, Liège.

No.*	Particulars.
	1, Resistance. (Hull, Skin friction, Calculated, Wind and Wake).
(4)	Methodical Experiments with Mercantile Ship Forms. By G. S. Baker. T.I.N.A. 1913.
(5)	Effect of Form and Size on the Resistance of Ships. By G. S. Baker and J. L. Kent. T.I.N.A. 1913.
(6)	Model Experiments on the Resistance of Mercantile Ship Forms. By G. S. Baker. T.I.N.A. 1914.
(8)	Further Model Experiments on the Resistance of Mercantile Ship Forms. By J. L. Kent. T.I.N.A. 1915.
(9)	Notes on Model Experiments. By G. S. Baker. T.N.E.C. 1915.
(14)	Model Experiments on the Effect of Beam on the Resistance of Mercantile Ship Forms. By J. L. Kent. T.I.N.A. 1920.
(26)	Form Effects and Form Resistance of Ships. By W. G. A. Perring. T.I.N.A. 1925.
(41)	Experiment on the Resistance and Form of Towed Barges. By G. S. Baker and E. M. Keary. T.I.N.A. 1930.
(49)	Further Model Experiments on the Resistance of Mercantile Ship Forms—Coaster Vessels. By F. H. Todd. T.I.N.A. 1931.
(60)	Abstract of Results published on a Methodical Series of Resistance Experiments on Ship Models and their use in Design. By A. W. Riddle. H.M.S.O. 1934.
(85)	The Effect of Shape of Bow on Ship Resistance. Part I. By A. Emerson. T.I.N.A. 1937.
(96)	Further Resistance and Propeller Experiments with Models of Coasters. By F. H. Todd and J. Weedon. T.I.N.A. 1938.
(101)	Effect of Shape of Bow on Ship Resistance. By A. Emerson. T.I.N.A. 1939.
(10)	Skin Friction Resistance. By G. S. Baker. T.I.N.A. 1916.
(30)	Some Experiments upon the Skin Friction of Smooth Surfaces. By W. G. A. Perring and the Tank Staff. T.I.N.A. 1926.
(29)	Ship Wave Resistance. A Comparison of Mathematical Theory with Experimental Results. Part I. By W. C. S. Wigley. T.I.N.A. 1926.
(33)	Ship Wave Resistance. Part II. By W. C. S. Wigley. T.I.N.A. 1927.
(42)	Ship Wave Resistance. Some further Comparisons of Mathematical Theory and Experimental Result. By W. C. S. Wigley. T.I.N.A. 1930.
(46)	Ship Wave Resistance. An Examination and Comparison of the Speeds of Maximum and Minimum Resistance in Practice and in Theory. By W. C. S. Wigley. T.N.E.C. 1931.
(64)	A Comparison of Experiment and Calculated Wave-Profiles and Wave-Resistances for a Form having Parabolic Waterlines. By W. C. S. Wigley. P.R.S. 1934.
(78)	The Theory of the Bulbous Bow and its Practical Application. By W. C. S. Wigley. T.N.E.C. 1935.
(91)	Effects of Viscosity on the Wave-making of Ships. By W. C. S. Wigley. T.E.S.S. 1937.
(103)	The Wave Resistance of Ships: A Comparison between Calculation and Measurement for a Series of Forms. By W. C. S. Wigley. C.I.I.N. 1939.
(105)	The Analysis of Ship Wave Resistance into Components depending on Features of the Form. By W. C. S. Wigley. T.L.E.S. 1939.
(43)	Model Experiments on the Wind Resistance of Ships. By G. Hughes. T.I.N.A. 1930.
(52)	The Air Resistance of Ship Hulls with Various Types and Distribution of Superstructures and the Effect on Design and Performance. By G. Hughes. T.E.S.S. 1932.
(57)	The Effect of Wind on Ship Performance. By G. Hughes. T.I.N.A. 1933.
(40)	Ship Wake and the Frictional Belt. By G. S. Baker. T.N.E.C. 1929.
(72)	Wake. By G. S. Baker. T.N.E.C. 1935.

* Tank reference number.

No.	Particulars.
	2. Propulsion. (Single, twin and open).
(19)†	Model Screw Propeller Experiments with Mercantile Ship Forms. By G. S. Baker and W. C. S. Wigley. T.I.N.A. 1923.
(35)†	The Analysis of Screw Propeller Efficiency with Particular Reference to Froude's Method. By G. S. Baker, T.I.N.A. 1927.
(38)†	Experiments on the Propulsion of a Single Screw Ship Model. By G. S. Baker and J. L. Kent. T.I.N.A. 1928.
(39)†	An Experimental Comparison of the Performance of Model Propellers Working in Air and in Water. By W. Sprague and the Staff of the William Froude National Tank. T.I.N.A. 1928.
(47)†	The Design of the Stern of a Single Screw Ship. By G. S. Baker. T.L.E.S. 1931.
(48)†	The Efficiency and Steering Effect of Inward and Outward Turning Screws. By G. S. Baker. T.I.M.E. 1931.
(51)†	The Effect of Immersion on Propellers. By E. L. Smith-Keary and the Staff of the William Froude Laboratory. T.N.E.C. 1931.
(53)	Screw Propellers of Varying Blade Section in Open Water. By G. S. Baker and A. W. Riddle. T.I.N.A. 1932.
(58)	Screw Propeller Experiments with Models of Coasters. By F. H. Todd. T.I.N.A. 1933.
(61)	Screw Propellers of Varying Blade Section in Open Water. Part II. By G. S. Baker and A. W. Riddle. T.I.N.A. 1934.
(63)	Screw Propeller Experiments with Models of Coasters. The Effect of a Cruiser Stern on Propulsive Efficiency. By F. H. Todd. T.N.E.C. 1934.
(69)	The Effect of a Fin upon the Efficiency of Ship Propulsion. By F. H. Todd. T.L.E.S. 1934.
(80)	Model Experiments on Twin Screw Propulsion. By G. Hughes. T.I.N.A. 1936.
(82)	The Propulsion of Single Screw Vessels. The Effect of Varying Revolutions and Diameter of Propellers. By G. S. Baker. T.E.S.S. 1936.
(87)	Experiment Results for a Series of Three-bladed Model Propellers in Open Water. By G. Hughes. T.L.E.S. 1937.
(93)	The Qualities of a Propeller Alone and Behind a Ship. By G. S. Baker. T.N.E.C. 1938.
(98)	Steam Drifters. Tank and Sea Tests. By F. H. Todd (and J. Edward of the Coal Utilisation Council). T.E.S.S. 1938.
(102)	Model Experiments on Twin Screw Propulsion. Part II. By G. Hughes. T.I.N.A. 1939.
(106)	Effect of Changes in Propeller Shape and Dimensions upon the Propulsion of a Single Screw Cargo Vessel. By J. L. Kent and R. S. Cutland. T.E.S.S. 1939.
(107)	Resistance and Propeller Experiments with Models of Coasters. By F. H. Todd and J. Weedon. T.I.M.E. 1940.
	3. Waves.
(18)†	Experiments on Mercantile Ship Models in Waves. By J. L. Kent. T.I.N.A. 1922.
(22)†	Effect of Wind and Waves on the Propulsion of Ships. By J. L. Kent. T.I.N.A. 1924.
(28)†	Experiments on Mercantile Ship Models in Waves (2nd Series). By J. L. Kent. T.I.N.A. 1926.
(34)†	Propulsion of Ships under Different Weather Conditions. By J. L. Kent. T.I.N.A. 1927.
(36)†	Average Sea Speeds under Winter Weather Conditions. By J. L. Kent. T.I.N.A. 1927.
(50)†	The Effect of Rough Water on the Propulsion of Single Screw Ships. By J. L. Kent. T.I.N.A. 1931.
(56)	Propulsive Efficiency and Seaworthiness of a Ship in Smooth and Rough Water. By J. L. Kent. T.E.S.S. 1933.
(62)	Appropriate Ship Lengths for Minimum Pitching and Maximum Seaworthiness. By J. L. Kent. T.I.N.A. 1934.

† These publications have been collected together in Vol. XXIII, 1932, of the Collected Researches of the National Physical Laboratory. Published by H.M.S.O.

No.	Particulars.
(73)	Resistance Experiments in Smooth and Rough Water made with Models of High Speed Ships. By J. L. Kent and R. S. Cutland. T.I.N.A. 1935.
(79)	Self-propelled Experiments in Smooth and Rough Water made with Models of High Speed Ships. By J. L. Kent and R. S. Cutland. T.I.N.A. 1936.
(95)	Further Experiments in Smooth and Rough Water with a Model of a High-speed Ship. By J. L. Kent and R. S. Cutland. T.I.N.A. 1938.
	4. STEERING.
(17)†	Manœuvring of Ships. Part I. By G. S. Baker and G. H. Bottomley. T.E.S.S. 1922.
(24)†	Manœuvring of Ships. Part II. By G. H. Bottomley. T.E.S.S. 1924.
(23)†	The Steering of Ships in Shallow Water and Canals. By G. S. Baker. T.I.N.A. 1924.
(25)†	Manœuvring of Ships, Model Experiments of Rudder Forces under Service Conditions. By Miss E. M. Keary. T.L.E.S. 1925.
(32)†	Manœuvring of Ships. Part III. By G. H. Bottomley. T.E.S.S. 1927.
(45)†	Manœuvring of Ships. Part IV. By G. H. Bottomley. T.E.S.S. 1930.
(55)	Manœuvring of Ships. Semi-balanced Rudders of Twin Screw Ships. By G. H. Bottomley. T.N.E.C. 1932.
(67)	Full Scale Steering Experiments on Three Ships and Comparison with Model Tests. By E. M. L. Smith-Keary, F. H. Todd and Staff of the William Froude Laboratory. T.I.M.E. 1934.
(75)	Manœuvring of Single Screw Ships. Effect of Rudder Proportions on Manœuvring and Propulsive Efficiency. By G. H. Bottomley. T.I.C.E. 1935.
(100)	Special Trials of the "Beacon Grange". By A. Emerson. T.N.E.C. 1939.
	5. STABILITY.
(3)	The Effect of Bilge Keels on the Rolling of Lightships. Part I. By G. Idle. Part II. By G. S. Baker. T.I.N.A. 1912.
(12)	The Effect of the Longitudinal Motion of a Ship on its Statical Transverse Stability. By G. S. Baker and E. M. Keary. T.I.N.A. 1918.
(104)	Rolling Experiments. By G. S. Baker. T.N.E.C. 1939.
	6. BACKING.
(68)	The Backing of Propellers. By J. F. C. Conn. T.E.S.S. 1934.
	7. VIBRATION. (Ships and Propeller Blades).
(97)	Vibration in Ships. By F. H. Todd. B.A. 1938.
(99)	Marine Propeller Vibration. By J. F. C. Conn. T.E.S.S. 1939.
(108)	Vibration Patterns of Propeller Blades. By G. S. Baker. T.N.E.C. 1940.

† *Loc. cit.*

*A Mercury Propelled Cargo Ship.

By W. L. R. EMMET.

While the Emmet mercury vapour process has not been applied to the propulsion of a ship, and while the conditions of ship propulsion are quite different from those to which this process has been successfully applied, it may be said in the beginning that there is no feature of the designs here shown which has not been demonstrated to be practicable and dependable in long service on shore, and no condition of these designs which could possibly be interfered with by a ship's motion or other condition incident to ship service.

The reason why this process has not been applied to a ship is that, until the past three years, no type of mercury boiler has existed which was adaptable to this purpose.

Several years ago, a marine mercury installation was planned by the Sun Shipbuilding & Dry Dock Co. in co-operation with the General Electric Co., the Sun Oil Co., an allied concern, having at that time and ever since, used mercury boilers in applying temperature-controlled heat to the process of oil distillation. The first of these boilers used by the Sun Oil Co. were of the writer's design, and their experience with such boilers led to their proposal to apply the process to a ship.

This first proposal for a ship installation was given up because a considerable amount of experimentation and study had failed to provide a boiler design which was considered certain of success, the mercury boiler being the one problem which has limited the wide use of this process.

Since the time of this first installation, the writer, although retired, has devoted such money and facilities as were available to the development of a type of mercury boiler suitable to ships, and it was not until about three years ago that results were obtained in an installation at Pittsfield which seemed to give promise of unqualified success.

Since the writer's retirement, the engineers of the General Electric Co. have devoted attention mostly to the development of large mercury boilers for use in power stations on shore and in types in no way suited to ship use, but there has been much in their studies which has contributed greatly to the scope of the mercury process in general, and our knowledge of its possibilites for any purpose.

It should be said in the beginning of this discussion of a mercury ship that, a suitable mercury boiler being available, the process has peculiar fitness for ship use. This fitness lies largely in the extreme simplicity of the making of steam by the condensation of mercury vapour.

Steam will do approximately half the work in a mercury-driven ship, and in the steam-making mercury condenser much of the complication and expense of the

* This paper was presented at the Annual Meeting of the Society of Naval Architects and Marine Engineers, New York, Nov. 14th-15th, 1940, and is reproduced by kind permission of the Council of the Society.

marine steam boiler are eliminated. The mercury turbine, being of much lower speed, is inherently a more efficient device than a steam turbine of equivalent capacity and complication.

Outside of the mercury boiler, there are no features or details involved in such an installation of which the practicability has not become fully demonstrated by nine years of service in the mercury installation of the Hartford Electric Light Co., where a 10,000-kilowatt mercury-turbine-driven generating unit, with valve mechanisms and accessories more complicated than those required in a gear-driven ship, has been in use without any kind of trouble, and with only such interruptions of continuous service as were made necessary by occasional cleanings and overhaulings of the mercury boiler.

In at least eight of these years of service, there has been no loss of mercury through leaks and escape of mercury fumes which could cause sickness of the operating force.

The parts of the apparatus at Hartford which carry mercury at pressures above that of the atmosphere are contained by an enclosed structure which is held at a pressure slightly below atmosphere by connection with the suction of the stack. Similar arrangements of enclosures will be desirable in ship installations and will preclude any possibility of danger through mercury escape.

Type of Ship.

The case considered for this first marine installation is a 9,000-horse-power cargo vessel of a type adopted by the United States Maritime Commission and of which several have been built, or are building, to be driven by steam of various pressures, and by Diesel engines. The case is therefore a particularly desirable one, since it will be directly comparable with identical ships driven by such other methods as are now in standardized use.

The normal power specified for this ship is 8,700 shaft horse-power, and the maximum demanded is 9,350 shaft horse-power. The speed of the single propeller is 85 revolutions per minute.

Propelling Turbines.

Power will be delivered to the propeller by two turbines, one driven by mercury vapour and the other by steam. Both deliver their power by double reduction through the same large gear on the propeller shaft. The mercury turbine will operate at about 1,200 revolutions per minute, and the steam turbine at about 4,000 revolutions per minute.

Since the steam for all auxiliary and ship service purposes is normally made from heat delivered by the condensation of the mercury turbine exhaust, the division of work between turbines will depend upon the quantity of such other purpose steam. With such steam use as is frequently required for heating, lighting and power purposes in ships, the work delivered to the propeller by the two driving turbines will be not far from equal.

Reversing.

In the low-pressure end of the steam turbine, reversing elements will be provided exactly as they would be in connection with the low-pressure part of a geared-turbine

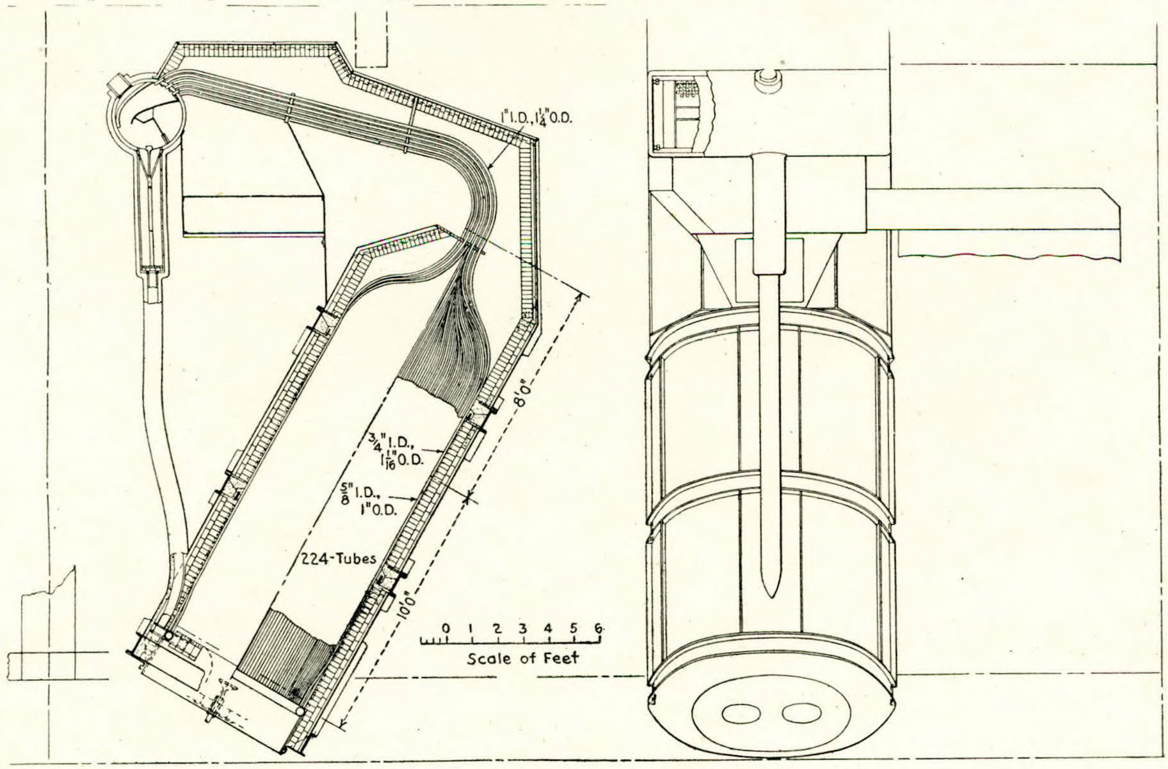


FIG. 1*.—*Mercury boiler.*
**Blocks kindly loaned by "Shipbuilding, and Shipping Record".*

steamer. The same action, which closes the valve which admits mercury vapour to the mercury turbine, opens a safety by-pass valve by which the vapour from the mercury is carried directly to the steam-making mercury condenser so that the production of steam is not interrupted and the conditions for reversing are just what they would be in an ordinary turbine-driven steamer.

While the quantity of steam normally produced by the condensation of the mercury vapour in operation is less than that given by the boilers of a steamer, there will be ample for reversing since the mercury production will then be at low pressure and the firing of the mercury boilers can be greatly increased if desirable for prolonged high power backing. For ordinary reversals the heat storage of mercury and water will make any increase of firing unnecessary.

Mercury Boilers.

These designs propose two mercury boilers each having 224 tubes arranged as shown in Fig. 1. This number of tubes gives a very conservative rating of the boilers, the quantity of vapour per tube being considerably less than that which has been found successful in a boiler of similar type in service at Pittsfield.

This low rating in a first installation is desirable for several reasons. The boilers will be fitted with hand-operated valves by which either can be disconnected and, if desirable, emptied while the other is running the ship. This will make possible examinations and development of full knowledge of the overload capacity of this type of boiler. For such conditions as would be met in applications to warships, knowledge of overload possibilities in actual service is very desirable.

In such boilers the upper parts of the tubes are empty at no load, but are filled with a mercury spray after vapour production has begun. In the lower part of the boiler the heat is delivered to tubes mainly by radiation, and in the upper part it is delivered by contact with the hot gases which impinge upon the tubes with suitable velocity.

The interior arrangements of the mercury boiler drums are designed to separate the vapour from the liquid completely so that no liquid will pass over to the turbine from the mercury boiler. These interior structures are made conveniently removable so that a man can get into the drum and put a cleaner through every tube. Experience to date, with the one boiler of this type, has indicated that under normal conditions such cleaning would never be required.

Mercury Condenser.

This condenser is proportioned to give ample surface

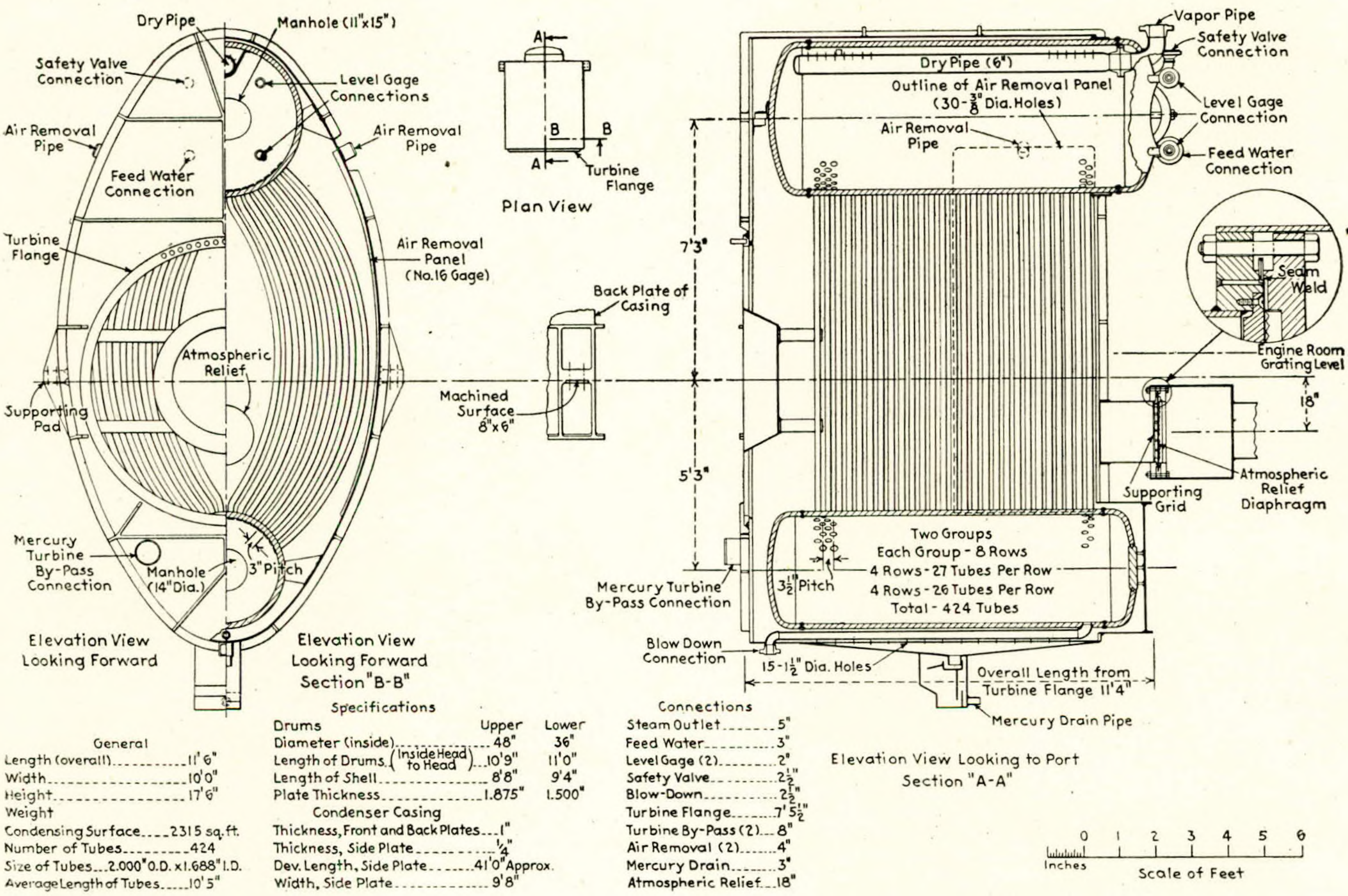


FIG. 2.—*Mercury condenser.*

and is designed for accessibility for cleaning and freedom from expansion stresses which could cause vacuum leaks. The tubes are 2 inches in diameter and free from sharp bends.

The condenser shell and turbine structure are supported from the centreline level by outside legs so that expansions cannot change its level with respect to the turbine shaft. Since the shaft packings are of the self-centring type, small relative movements are not objectionable.

The condenser shell is protected from internal pressure by a steel blow-out diaphragm perfectly vacuum tight, and arranged to blow out with light internal pressure.

The exhaust from the turbine passes into the condenser in such a way that there can be no cutting by thrown liquid mercury, and when the admission valves are closed a mercury vapour by-pass enters the condenser through two pipes at the bottom where its flow cannot impinge upon the tubes. This by-pass comes from automatic safety valves which prevent an undue rise of pressure in the mercury boilers.

Since the temperature in the condenser with the vacuum used is only about 470° F., there is no possibility of overheating any part as in steam boilers.

The air pump connection is made to perforated chambers of considerable area on the outer walls, an arrangement which should give very perfect removal of non-condensables, a matter of importance in mercury condensers.

Superheater and Air Preheater.

It is economical to produce a high superheat with such an equipment since it gives improved economy of the steam part with very small expense, either in first cost or maintenance. It is also desirable to impart as much heat as possible to the incoming air with due regard to the cost, weight and space required.

A counterflow superheater of ordinary type is proposed as indicated in the illustration, and an air preheater of the Ljungstrom type. This preheater is indestructible and easy to clean and consequently well suited to such a purpose.

Efficiency.

The following calculations show the basis upon which the fuel consumption of this ship has been estimated. These involve turbine efficiencies directly comparable with the similarly designed mercury turbine at Hartford and with many well-known steam turbines on ships and on shore.

The assumptions concerning boiler and combustion losses are very conservative. Similar mercury boilers have been run successfully with only 10 per cent. excess air while here we have assumed 20 per cent. The assumption of 6·15 per cent. loss on account of hydrogen in the fuel is also conservative.

These assumed losses give a boiler efficiency of 84 per cent. and in many modern marine steam boilers working under comparable conditions, much higher efficiencies are generally claimed.

Fuel Rate.

These calculations show a fuel rate for all purposes of 0·443lb. of oil per shaft horse-power hour. This fuel rate for the reasons stated would presumably be materially less.

Other Kinds of Fuel.

Studies and comparisons indicate that such boilers as here proposed might be used with powdered coal or other forms of coal firing, but this has not been tried. The temperatures and cleaning possibilities seem favourable. As in a steamer, any kind of oil fuel can be used, a fact which should be remembered when the economy of this method is compared with that of ships propelled by Diesel engines which need more expensive fuel.

Of lubricating oil there would be no more required than in a geared-turbine steamer.

Cost Comparisons.

While cost estimates have been made on the boilers, condensers, mercury and steam turbines, superheaters, air heaters, etc., for the case here shown, the best comparative idea of costs can be had by comparing weights, there being no reason for any wide variation in cost per pound of the comparable parts used in this ship and in a steamer with geared steam turbines.

The weights of the principal parts in these two cases

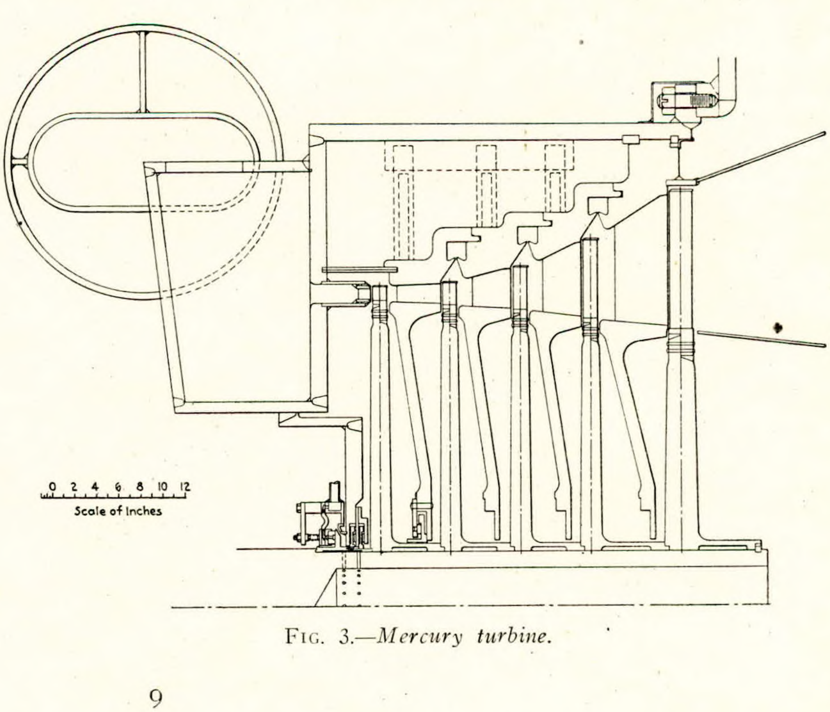


Fig. 3.—*Mercury turbine.*

are approximately as follows:

Mercury Equipment.	Pounds.	*Steam Turbine Equipment.*	Pounds.
2 mercury boilers ...	100,000	2 steam boilers ...	240,000
1 mercury condenser...	45,000	high and low-pressure turbines and gears	248,000
Mercury and steam turbines with gearing	290,000		14,500
1 Ljunstrom air heater	14,500		
2 superheaters... ...	28,500		
2 mercury feed pumps	6,000		
	484,000		502,000

I am informed by a shipbuilder who has built C-3 steamers that the difference of cost to them incident to the smaller steam condensers and engine rooms, auxiliaries plus the reduction in stack and fuel-handling facilities would amount to $56,000. This would much more than pay for the mercury needed which at normal prices would cost about $30,000.

The facts and figures here given, if carefully investigated by an unprejudiced engineer, will be seen to give not only very good fuel economy but also low cost and economy of space.

Parts Preferably Made by Turbine Manufacturer.

Mercury turbine with admission and by-pass valves, Fig. 3.

Steam turbine with reversing wheels, Fig. 4.

Helical gearing connecting both turbines to the propeller shaft and also carrying the main thrust bearing, Fig. 5.

Motor-driven centrifugal mercury feed pumps, one being a spare duplicate.

Two duplicate motor-driven vacuum pumps for mercury condenser, and two small pumps for circulating water in turbine packing.

Mercury level gauges and pressure gauges.

Parts which Might be Made in the Shipyard or Obtained from Outside Sources.

Two mercury boilers as per Fig. 1.

One steam-making mercury condenser, Fig. 2.

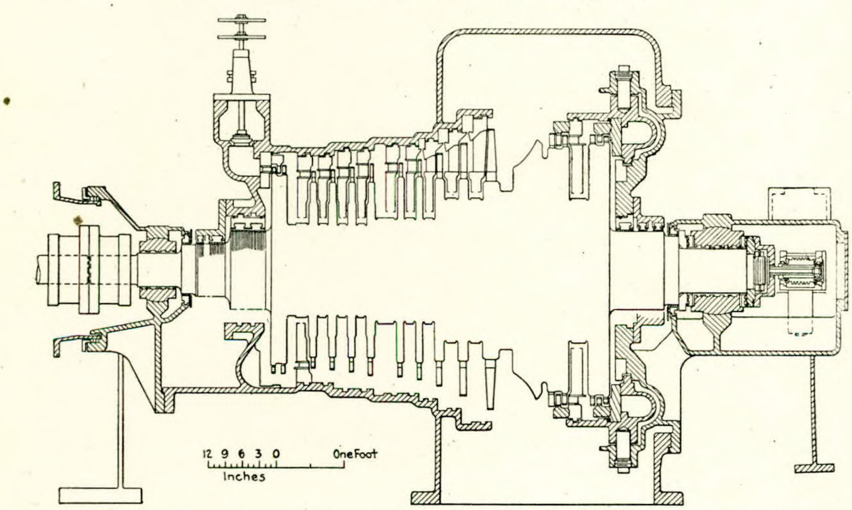


FIG. 4.—*Steam turbine.*

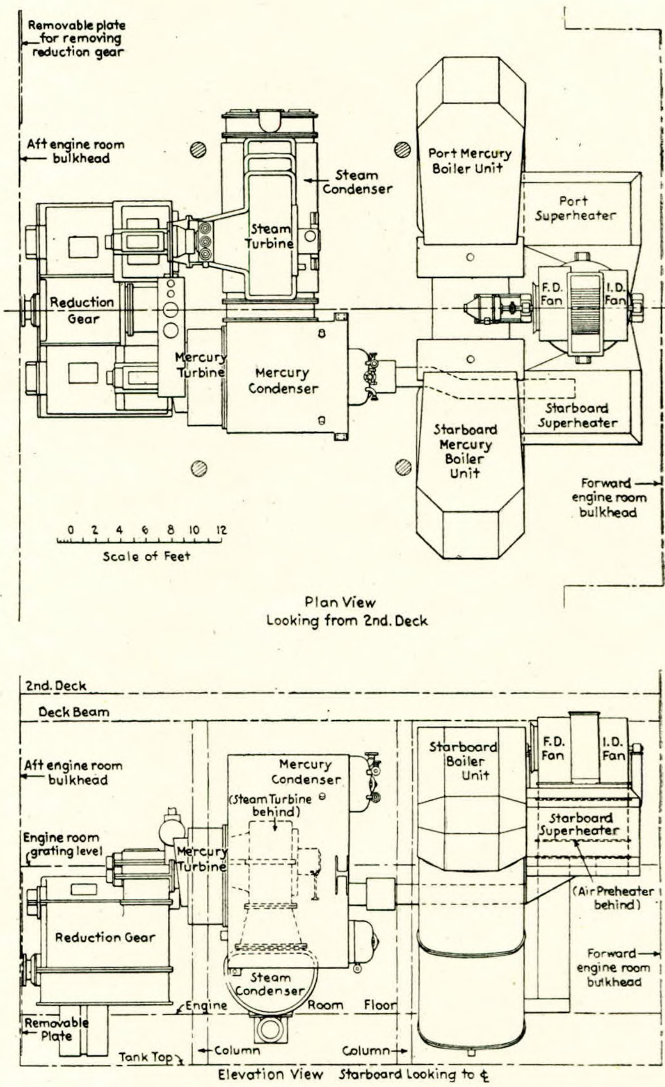


FIG. 5.—*Machinery arrangement of mercury propelled cargo ship.*

Steam condenser and auxiliaries as for a 5,000-horse-power steamer.

Two superheaters each of about 1,650 square feet.

One Ljungstrom air preheater, Type CGZX12.

About 30,000 pounds of mercury.

Fuel storage and handling facilities and stack connections as for a 6,000 horse-power steamer.

All piping for steam and mercury and a sheet metal enclosing structure for parts carrying mercury under pressure.

Instructions concerning making and arrangements of all such parts can be given by the writer or his assistants.

CALCULATED DATA FOR MERCURY-DRIVEN C-3 CARGO SHIP.

Prepared by B. P. Coulson, Jr.

Normal shaft horse-power	8,700
Maximum shaft horse-power	9,350
Reduction gear efficiency, per cent.	97
Load at mercury turbine shaft, h.p.	4,750
Load at steam turbine shaft, h.p.	4,900
Live steam (saturated) for heating, etc., lb. per hr. ...	2,500
Auxiliary steam superheated to 800° F. (sea load 350 kW.), lb. per hr.	5,040
Total auxiliary steam, lb. per hr.	7,540

Plant Conditions.

Mercury System.

Initial pressure at turbine bowl, lb. per sq. in. abs.	100
Initial temperature at turbine bowl, deg. F.	907
Final pressure in condenser-boiler, lb. per sq. in. abs. ...	1·12
Final temperature in condenser-boiler, deg. F.	466
Fuel oil	Bunker "C"
Calorific value of fuel, B.t.u. per lb.	18,500
Mercury pressure at boiler outlet, lb. per sq. in. abs. ...	110
Temperature of air to burners, deg. F.	500

Auxiliary power, two 350-kilowatt turbine generator condensing units

100lb. per sq. in. abs.—907° F.—152·85 B.t.u. per lb.—0·1242 entropy

1·12lb. per sq. in. abs.—466° F.—109·85 B.t.u. per lb.

Available energy, B.t.u. per lb.	43,000
Mercury vapour flow, lb. per hr.	397,600

Heat absorbed by mercury in boilers =

$397{,}600 \times (152{\cdot}85 - 14{\cdot}2) = 55{\cdot}05 \times 10^6$ B.t.u. per hr.

For one boiler unit $= 27{\cdot}525 \times 10^6$ B.t.u. per hr.

Steam System.

Temperature of steam in condenser-boiler, deg. F.	436
Pressure at condenser-boiler outlet, lb. per sq. in. abs. ...	365
Pressure at turbine throttle, lb. per sq. in. abs.	350
Temperature at turbine throttle, deg. F.	800
Pressure in steam condenser, in. abs.	1½
Feedwater temperature to condenser-boiler, deg. F. ...	300

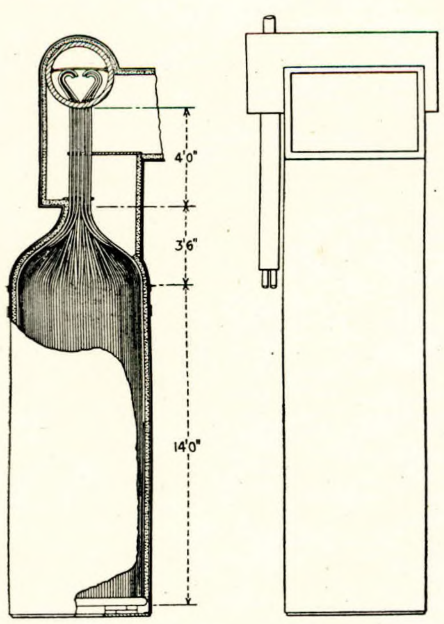


Fig. 6.—*New type mercury boiler installed at Pittsfield, Mass.*

	Pressure, lb. per sq. in. abs.	Temperature, deg. F.	Heat, B.t.u. per lb.
Condenser-boiler outlet ...	365	436	1204·1
Turbine throttle	350	800	1419
Turbine exhaust	1½in. abs.	91·7	...
Feedwater		300	269·6

Amount of steam produced in condenser-boiler, lb. per hr. 45,800

Total steam produced, lb. per hr. 45,800

Heat added in steam superheaters =

$(45{,}800 - 2{,}500) \times 215 = 9{\cdot}31 \times 10^6$ B.t.u. per hr.

Amount of fuel required

Total amount of fuel required, lb. per hr. 4,146

Overall s.h.p. fuel rate $= \dfrac{4{,}146}{9{,}350} = 0{\cdot}443$lb. per hr.

Overall thermal efficiency $= \dfrac{3{,}412}{10{,}980} = 31{\cdot}1$ per cent.

Design of Boiler.

Type of boiler—Emmet's Pittsfield type.

Assume the carbon dioxide in the flue gas equals 12·65 per cent. when burning oil. This requires 20 per cent. excess air and the weight of the products of combustion is 18lb. per lb. of fuel.

Flow of gas—4,146 × 18—74,500lb. per hr.
Fuel = 4,146lb. per hr.
Flow of air = 70,354lb. per hr.

Assume 100 per cent. or 70,354lb. per hr. of air goes through the air preheater.

Temperature of air preheater, deg. F.	500
Temperature of air to air preheater, deg. F.	80
Rise in temperature through air preheater, deg. F. ...	420

Heat in fuel $= 18{,}500 \times 4{,}146 = 76{\cdot}7 \times 10^6$ B.t.u. per hr.

Heat in air from preheater =
$70{,}354 \times 420 \times 0{\cdot}2438 = 7{\cdot}2 \times 10^6$ B.t.u. per hr.

Total amount of heat in furnaces $= 83{\cdot}9 \times 10^6$ B.t.u. per hr.

Total amount of heat in one furnace $= 41{\cdot}95 \times 10^6$ B.t.u. per hr.

Description of Boiler.

In this boiler the combustion chamber is formed as shown in Fig. 1, the walls consisting of longitudinal tubes connected to a ring header at the bottom and discharging into the drum placed on one side of the top; the upper portions of these tubes forming the convection surface are in a horizontal position sloping slightly downward into the drum. These horizontal tubes are above the cold liquid level. The lower ring header is fed from a down pipe connected to the bottom of the drum. Two oil burners in each boiler will fire upward from the lower end. The flue gases pass through the convection surface in four passes and then out to the steam superheaters and air preheater.

Projected area receiving heat by radiation—438 sq. ft. for one boiler.

Combustion chamber volume one boiler = 726 cu. ft.

Air Preheater.

Ljungstrom Type CGZX12

Heat transferred from gas to air	$7{\cdot}2 \times 10^6$ B.t.u. per hr.
Air leaving preheater	70,354lb. per hr.
Gas entering preheater	74,500lb. per hr.
Temperature air entering preheater...	80° F.
Temperature air leaving preheater ...	500° F.
Temperature gas entering preheater	765° F.
Temperature gas leaving preheater...	400° F.

Steam Superheaters.

Heat added in steam superheaters...	$9{\cdot}31 \times 10^6$ B.t.u. per hr.
Steam flow through superheaters ...	43,300lb. per hr.
Gas entering superheaters	74,500lb. per hr.
Temperature steam entering superheaters	436° F.
Temperature steam leaving superheaters	800° F.

Temperature gas entering superheaters	1,217° F.
Temperature gas leaving superheaters	765° F.
Superheater surface	3,300 sq. ft.

HEAT BALANCE.

Useful Heat.	B.t.u. per hr.	Per cent.
Heat in fuel for one mercury boiler ...	38,350,000	100·0
Heat absorbed by mercury radiation tubes	20,880,000	54·50
Heat absorbed by mercury convection tubes	6,645,000	17·35
Total heat to mercury for one boiler ...	27,525,000	71·85
Heat added by one steam superheater ...	4,655,000	12·15
Total useful heat for one boiler unit ...	32,180,000	84·00

	B.t.u. per hr.	Per cent.
Net useful heat and boiler efficiency ...	32,180,000	84·00
Losses—One Boiler.		
Hydrogen based on 11·5 per cent. by weight in fuel	2,360,000	6·15
Moisture in air	116,000	0·30
Radiation loss	383,000	1·00
Total combustion loss for one boiler unit	2,859,000	7·45
Stack loss for half of gas	3,276,000	8·54
Total boiler loss	6,135,000	16·00
Heat to Air.		
Heat to half of air in air preheater ...	3,600,000	
Heat in furnace for one mercury boiler	41,950,000	

Correspondence: "Marine Oil Burning."

Mr. F. Turnbull (Associate), referring to the Paper on "Marine Oil Burning" in the December, 1940 TRANSACTIONS (Vol. LII, No. 11, pp. 205-215), suggested in a written communication that the author, Mr. J. T. Tomlinson, had not stressed the use of an observation drain tank for the oil fuel heating coils. Granting that on page 208 Mr. Tomlinson mentioned that "an observation separator drain tank allows the heater discharge . . .", nevertheless this would give the impression that the tank is a refinement, whereas Clause 14, Section 35 of Lloyd's Rules reads: "Where steam is used for heating the oil fuel, either in the bunkers, tanks or heaters, the exhaust drains are to discharge the water of condensation into an observation tank, where it can be seen whether or not it is free from oil".

Mr. J. T. Tomlinson, in reply, stated that the point made by Mr. Turnbull in connection with the observation drain tank was a good one because it showed that the importance of ensuring that the boiler feed water was free from oil contamination was appreciated. Although an observation drain tank was an essential fitting and a requirement of Lloyd's, this only allowed of visual examination by means of a loose cover or illuminated sight glasses; it did not prevent, or even minimize, the possibility of oil, if present in the condensate, passing through to the hotwell. The point which Mr. Turnbull had apparently overlooked was that the writer referred to an observation ***separator*** drain tank which not only allowed of examination of the contents but was of such construction that any contaminated water was automatically purified before being discharged to the hotwell.

ELECTION OF MEMBERS.

List of those elected by the Council during the period 3rd December, 1940 to 24th January, 1941.

Members.

Roderick Glen Boomer.
William Hugh Currie.
John Edward Shields.
Robert Alexander Stevenson.
Ivor D. Jenkins.

Associates.

James Edward Butler.
Harry Lane.
Henry Leeper.
Glyn Lewys-Jones.
Ronald Edwin Wootten.
Leonard Henry Waller Wright.

Student.

Roger Graham Knibb.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

The Journal of Commerce Annual Review. Charles Birchall & Sons, Ltd., 252 pp., copiously illus., 2s. 6d. net.

The 1941 edition of "The Journal of Commerce Annual Review", dealing with the progress of shipping, shipbuilding, marine engineering and allied industries during 1940, unlike most publications, appears to have suffered no noticeable war-time attenuation. It continues to be the large, fat publication, representing astonishing value for its price, to which we have become accustomed.

Nor does the interest and value of its contents appear in any way to have diminished, as the following list of articles indicates, viz.: "British Shipping: The Past and the Future", by Haldin; "The Liner Requisition Scheme", by Roberts; "Future of British Shipping", by Holt; "The War at Sea", by the "Journal of Commerce" Naval Correspondent; "Protection of Commerce at Sea", by Bowen; "Merchant Navy Officers and the War", by Coombs; "War-time Safety Measures at Sea"; "Designers of the King's Ships"; "Shipbuilding in War-time", by Hancock; "Metallurgical Developments Affecting Shipbuilding"; "Shipbuilding in the United States", by Gerrish Smith; "Largest Merchant Ship Built in United States"; "Marine Steam Engineering in War Conditions", by Hamilton Gibson; "Marine Electricity"; "Submarines—Engines—Aircraft", by Hardy; "Security of Marine Insurance Market", by King-Page; and "Chartering Business Considerably Curtailed".

British Standard Specification No. 939-1940 for Engineers' Squares. The British Standards Institution, 2s. per copy, 2s. 3d. post free.

This specification has been prepared with the co-operation of the manufacturers and close collaboration with the National Physical Laboratory. The Squares are divided into three grades of accuracy, viz., Reference, Inspection and Workshop. Squares in the first grade are for reference purposes, where the highest degree of accuracy is essential. Those in the second grade are intended for inspection purposes or for use in tool rooms and workshops, where a good grade of accuracy is necessary. Those in the last grade are for general workshop use. For the last two grades the specification includes sizes up to 24in. length of blade. For reference grade up to 12in. The difference in the existing practice of manufacturers makes it impracticable to attempt at a close standardisation of the dimensions of Squares.

Hiduminium Technical Data. High Duty Alloys, Ltd., Slough, 45 pp., no published price.

This is an entirely new publication and replaces the present data sheets, presents the fullest details, including chemical composition, physical properties, mechanical properties, properties at elevated temperatures, etc., of the complete range of Hiduminium alloys. This comprises the well-known R.R. series and also the more recent Anticorodal series such as Hiduminium 15, 23, 33, 35, 40, 42 and 45 which were introduced to meet the ever increasing demand for alloys which combine high corrosion resistance with good mechanical properties. There is also included an Index to Specifications, both D.T.D. and B.S.I.

The primary aim of this book, and one which was kept constantly in mind during preparation, is to give to the designer and draughtsman fullest details concerning Hiduminium aluminium alloys, in the clearest possible form. To ensure a flat opening book, a spiral binding of an improved type is employed. This incorporates the use of a spine—which is of obvious value when the volume is standing in a bookshelf. Additional sheets will be issued from time to time and provision is made for their inclusion at the back of the book. Copies of this publication may be obtained on application to the publishers, who also point out that copies of "Aluminium Alloys" from the book by Professor Zeerleder—one of the world's leading authorities on aluminium and its alloys—are also available. Applicants for this volume should state in which industry they are engaged or, if students, which profession they are studying.

Diesel Engines and Diesel-Electric Power. Sir Isaac Pitman & Sons, 304 pp., copiously illus., 10s. 6d. net.

As the publishers state in the introduction, this book is not intended for designers, though there are a few hints which some of them might keep in view.

The book is certainly all the publishers claim for it, and should prove a very useful work to those for whom it is specially written. Furthermore, it could be very useful as an *aide memoire* to those who have had Diesel engine experience in the past, but have forgotten a few essential features of their operation and maintenance.

Although it mainly covers engines for land service, much of the information is equally applicable to engines aboard ship—especially generating sets. Chapter 8, which covers the electrical end of the plant, gives very useful information for junior watch-keeping engineers who may not have made a special study of electricity. This part is particularly clear in its presentation.

A few criticisms might be made on some points. For instance, as far as can be seen, no mention is made of British or Continental oil engines of proved good service and outstanding design. The exhaust temperatures given on page 155 are somewhat high limits for continuous running on steady load, though they may be all right for variable loads as in road vehicles. No mention is made of supercharging of four-cycle engines. The method of testing compression and firing pressures by an Okill or similar indicator might have been mentioned in the section on Diesel engine maintenance, page 221; this is essential after even a small overhaul, specially in a multi-cylinder engine of large or medium size. Dealing with automatic voltage regulators on page 280, this is a very clear and simple explanation, though there are one or two errors in the lettering of the diagrams.

Altogether, it is an excellent book for those in charge of Diesel engines and generators.

Manual of Electric Arc Welding. By E. H. Hubert. Philips Lamps, Ltd., 102 pp., 108 illus., 3s. 6d. net.

This is a useful, readable and well indexed manual on electric arc welding. Some of the points touched on are debatable, such as the theory of overhead welding and the welder's glass shield to protect the eyes; in the latter case the essential points have been laid down by the British Standards Institution. The same sort of remarks can, however, be made about any technical manual and this publication gives fully the principal matters to be considered by the welding engineer and it is all to the good if it prompts him to inquire further. The training course outlined for operators is interesting.

The Design of High Pressure Plant and the Properties of Fluids at High Pressures. By D. M. Newitt, M.C., D.Sc., Ph.D. Oxford University Press, 401 pp., 165 illus., 35s. net.

This book is well written and illustrated. It reveals that fundamental and wide view which is so characteristic of the chemical engineer and at the same time includes those details of construction of high pressure vessels and apparatus which appeal to the mechanical engineer and are so essential for successful operation.

The first third of the book deals with the design of high pressure vessels and plant and the materials used in their construction, special attention being given to very high pressure joints.

In the remaining two-thirds Professor Newitt deals with the properties of fluids at high pressure. While the molecules in a gas move at random in complete disorder, those of a liquid present something of the space lattice arrangement characteristic of crystalline solids. It can be regarded that there are two opposing forces acting between the molecules of a fluid: firstly, the force which repels the molecules from each other and compels a gas to fill its container, no matter how large that vessel may be, and secondly a force of attraction between the molecules. This attractive force becomes more and more important as the pressure and density of a gas increase and accounts for cohesion and surface tension in a liquid. Each of these two forces will obey a different law connecting the distance between adjacent molecules and the resultant force between them. The algebraic sum of the repellant and attractive forces on all the molecules determines the relation between the volume and the pressure exerted by a gas. This relation is of the utmost importance, since it gives us the key to the internal forces within a gas.

Professor Newitt first considers the relation between pressure, volume and temperature in an "ideal" gas that obeys Charles's and Boyle's laws implicitly and explains these relationships by the kinetic theory. Comparison is then made between these results and those experimentally obtained for real gases and the results are expressed in various alternative forms as "equations of state".

These equations of state at first appear very formidable, but they are really only methods of expressing the value of pV as a series function of the pressure, or the density of the gas, there being one such equation for each isotherm.

At the critical point increase in density, whether this is due to an increase in pressure or reduction in temperature, results in the gas becoming liquid and thus the crucial test of the validity of an equation of state is the way in which it reproduces the critical isotherm; here the equation has to take into account the gradual introduction of molecular order as the gas is converted into the liquid phase.

Once an accurate mathematical expression has been obtained to portray the relation between pressure, volume and temperature for a given gas, theory indicates that it is only necessary to determine one of its thermal properties as a function of temperature and all other thermodynamic properties can be mathematically deduced. The coefficient of expansion, the specific heats at constant volume and constant pressure, the fugacity or tendency to escape, the Joule-Thomson cooling effect on expansion, the liquefaction, solubility, viscosity, dielectric strength and optical refractive indices of gases are considered and the theory compared with experimental results.

Finally a chapter is included on the pressume-volume-temperature relationships of liquids.

The author draws upon his own and other research work and at the end of each chapter is given a list of references which practically forms a complete bibliography of subject matter of the chapter.

Chemical Thermodynamics. By J. R. Partington, M.B.E., D.Sc. Constable & Co., Ltd., 230 pp., 42 illus., 14s. net.

This book was first published in 1913 as a pioneer work, nothing of its scope and character being then available in English. The present (third) edition is described as a modern introduction to general thermodynamics and its application to chemistry. The nine chapters of the book deal with specific and latent heats, the first law of thermodynamics, the second law of thermodynamics, simple systems and physical changes, ideal solutions, chemical equilibrium in gases and ideal solutions, non-ideal solutions and electrolytes, the Nernst heat theorem, and statistical methods. A considerable number of examples, complete with answers, are included in the book. The book is of a highly theoretical nature demanding a mathematical knowledge of a high order.

The Motor Ship Reference Book, 1941. Temple Press, Ltd., 324 pp., 107 illus., 7s. 6d. net, 8s. post free.

The 1941 edition of "The Motor Ship Reference Book" has just been published. It is a completely revised volume and presents a review of motor ship progress, with many statistics to show the remarkable growth of this development. All the large oil-engined vessels in service are tabulated.

The book contains many illustrations and the reproductions from photographs of big and small oil engines for installation in ships are in themselves a means of reference that is most useful to those who study the development of our Mercantile Marine. The methods by which ships' machinery has reached the highest known degree of efficiency and the diverse character of the auxiliary plant which is part of the modern vessel's engine room are clearly described. The contents of the volume, which has been published annually for many years, are compiled by the staff of "The Motor Ship".

Flight Handbook—A Guide to Aeronautics. By W. O. Manning, F.R.Ae.A. Iliffe & Sons, Ltd., 2nd edn., 184 pp., 115 illus., 4s. net, 4s. 5d. post free.

The second edition of this book has been thoroughly revised. Interest in aircraft and flying has become so general and widespread that an understanding of the principles which make flying possible and govern progress in aircraft development is eagerly sought. The magnificent exploits of the R.A.F. and, in particular, the introduction of the new Air Force training scheme for boys has quickened interest in the subject.

No specialised knowledge is required by the reader of this practical handbook issued by the publishers of the journal "Flight". It claims to contain all the information necessary to obtain a grasp of the theory of aeronautics, and shows in simple language how such theory is applied in the various designs and methods of construction employed in aircraft manufacture.

The function of every part of the machine is clearly explained. A section of the book describes the instruments on which the pilot relies for controlling and navigating the aeroplane and chapters are devoted to gliding, sailplanes, airships and balloons.

Munro's Engineer's Annual, 1941. James Munro & Co., Ltd., 143 pp., illus., 3s. net.

This useful publication continues to make its appearance annually and the 1941 edition has been completely revised. In addition to the usual tables the book is replete with valuable technical articles on a variety of subjects. Intended specially for marine engineers, the book represents particularly good value in these days of general increase in the cost of production of books.

JUNIOR SECTION.

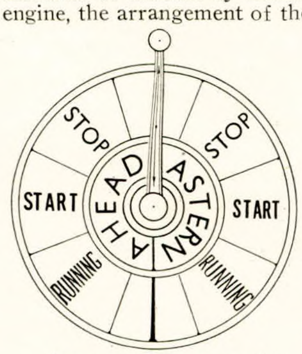
Naval Architecture and Ship Construction.

The publication of Chapter VIII is unavoidably deferred until the next issue of the TRANSACTIONS.

Abstracts of the Technical Press

New Deutz Two-stroke Marine Engine.

A new Deutz two-stroke engine for outputs up to 500 b.h.p. has recently been developed to supplement the four-stroke range of Deutz engines for small craft. The manufacturers have adopted the same cylinder diameter and piston stroke—240mm. and 360mm., respectively—for the two-stroke engine as are used in one of their standard four-stroke designs. The output of a six-cylinder unit is 300 b.h.p. at 300 r.p.m. and 500 b.h.p. at 500 r.p.m. By adopting the standard bore and stroke, it has been found possible to standardise several of the parts with those of the original four-stroke type. The spur-gear drive to the scavenge blower at the after end of the shaft and is taken to the three-lobe rotor of the blower through a flexible coupling. Reversal is effected by means of a lever at the after end of the engine, the arrangement of the controls being shown in the accompanying diagram. If the engine is running ahead and it is desired to go astern, the lever is moved from the "running" (ahead) position to "stop" and thence to the astern "stop" position. This causes (*a*) the rotary valve of the blower to be turned so that the suction space becomes the pressure chamber, and *vice versa;* and (*b*) the starting cams to be set in the position for astern running. The lever is then further moved to the "starting" (astern) position, when air is admitted and the engine starts. On swinging the lever to the "running" position, the compressed air is shut off and the fuel pumps come into operation. The necessary interlocks are provided to ensure that when moving from the "running" to the "stop" position and passing through the "starting" position, starting air cannot enter the cylinders, whilst, when the lever is moved to the "running" position, fuel cannot be admitted unless the engine is turning in the direction indicated. The time taken to reverse from full speed ahead to full speed astern is 10 to 12 seconds. The speed of the engine is controlled by a small handwheel at the front and it is claimed that satisfactory slow running down to 65 r.p.m. is available, the engine running on the governor throughout its entire speed range. Cylinder lubrication is automatically reduced or increased according to the load on the engine. Scavenging air at a pressure of $2\frac{1}{4}$-3lb./in.^{2} is admitted through ports at the bottom of the cylinder, the exhaust ports being opposite the scavenging ports, and the amount of scavenging air 1·4 times the stroke volume. The rating of the new six-cylinder engine is 400 b.h.p. at 410 r.p.m. and the fuel consumption at full load about 0·35lb./b.h.p.-hr. The full load corresponds to an m.e.p. of 64lb./in.^{2} but the engine is claimed to be capable of maintaining a 20 per cent. overload. The lubricating oil consumption is about $1\frac{1}{4}$ pints per hr. An 8·8-cu. ft. starting air reservoir with the air charged to 350lb./in.^{2} has been found to suffice for 22 manœuvres, the air pressure falling to 50lb./in.^{2}. The new engine is made in three-, four- and six-cylinder units, but a smaller model with two or three cylinders of 170mm. diameter and 250mm. piston stroke, is also manufactured. The output per cylinder in this case is 25 b.h.p. at 570 r.p.m. and $32\frac{1}{2}$ b.h.p. at 750 r.p.m.—*"The Motor Ship", Vol. XXI, No. 250, November, 1940, pp. 256-257.*



Arrangement of engine controls.

The World's Largest Car Ferry.

The 6,000-ton twin-screw steamer "City of Midland 41", which is due to be put into service early next year on the Manitowoc-Ludington (Lake Michigan) run for the carriage of railway trucks, motor vehicles and passengers, is claimed to be the largest railway ferry steamer in the world. The ship's propelling machinery comprises two sets of 5-cylinder simple expansion Skinner uniflow engines, having cylinders 25in. in diameter and a piston stroke of 30in. All the cylinders are identical, take steam direct from the throttle and exhaust direct to the condenser. The normal output of each engine is 3,000 s.h.p. at 120 r.p.m., with an average m.e.p. of 73lb./in.^{2}, but the maximum power developed is 3,500 s.h.p. at 125 r.p.m., with an average m.e.p. of 84lb./in.^{2}. Each engine has its own condenser and condenser auxiliaries. The main bedplate and main frame are single-piece castings entirely enclosing the crankcase, and forced-feed lubrication is fitted throughout. The inlet and exhaust valves are cam-operated and the engine controls, located at the inboard side forward, consist of three levers—one for the throttle, one for cut-off ahead and one for cut-off astern. An oil-valve control is also provided which automatically opens the cylinder drains when warming through. The normal vacuum in the main condensers is 26in. Steam at a pressure of 325lb./in.^{2} and total temperature of 640° F. is supplied by four Foster Wheeler D-type boilers, equipped with waterwalls, convection superheaters and economisers, coal-fired by Hoffman mechanical stokers and fitted with automatic combustion control of the electrically-operated type. Both forced and induced draught fans are installed, as well as fly-ash recovery equipment. Each of the four boilers is provided with two Hoffman "Firite" coal-stoking units operating independently of each other. The capacity of each unit is sufficient to operate its boiler at more than its rated capacity and automatic throw-out clutches are fitted to guard against any possibility of a breakdown of both stoker units of any boiler. The stoking equipment is designed to deal with a wide range of fuels of varying sizes up to two inches. In the event of a total failure of the mechanical stokers, the boilers can be hand-fired through special furnace doors provided for the purpose. There are no moving parts in the furnaces and all the mechanism subjected to radiant heat is water-cooled. The boiler furnaces are equipped with Hoffman patented tube tuyère grates designed to admit combustion air uniformly and in a turbulent state. The design of the tuyères incorporates steel reinforcing members, disposed in such a manner as to prevent tuyère failure due to the cracking of a cast-iron surface. The entire firing equipment, which is operated by steam pressure, is claimed to be extremely sensitive to changes of load and to give a high degree of manœuvrability with a minimum of attention from the boiler-room attendants.—*"The Nautical Gazette", Vol. 130, No. 10, October, 1940, pp. 12 and 27.*

Sixtieth Anniversary of Electric Lighting in Ships.

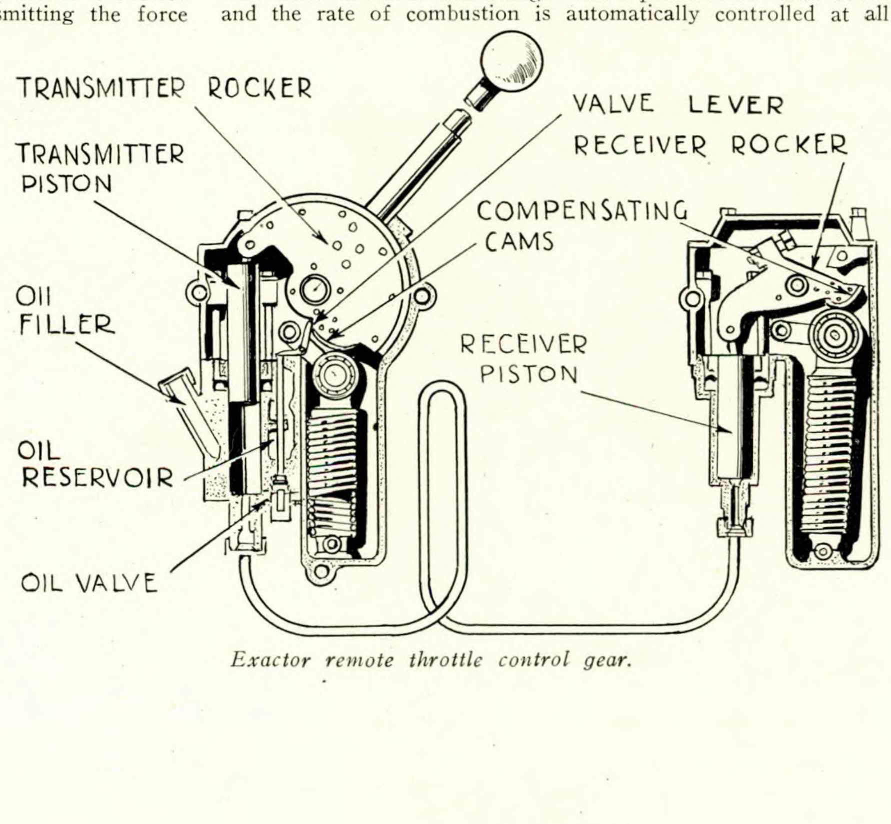
The year 1940 marks the 60th anniversary of the lighting of steamships by electricity. The first historic electric lighting installation for ships was designed, built and installed by Thos. A. Edison, in 1880, on board the Oregon Railway and Navigation Company's steamer "Columbia". It consisted of three 100-volt constant-potential dynamos, constructed at the Thos. A. Edison Laboratory in Menlo Park, N.J. Each dynamo was capable of supplying sixty 16-candle-power lamps, and a fourth dynamo, used to excite the others, was run at half speed. The original lampholders were of wood, suspended by the supply wires to avoid shocks which might break the fragile glass bulbs. The paraffin-cotton-covered wires were insulated by rubber tubing. Lights in staterooms were controlled by the stewards from outside and all the fixtures were so arranged that oil lamps could be quickly substituted in the event of a failure of the electric lighting system. The original installation remained in constant service for over 15 years with only minor changes and repairs.—*"The Nautical Gazette", Vol. 130, No. 10, October, 1940, p. 30.*

The Manufacture of Large Drums for Water-tube Boilers.

The paper gives a brief description of the so-called "Chesterfield" process for the production of hollow forgings as used for the drums of water-tube boilers. The drums can either be supplied in the condition as hot-drawn or they may be machined internally and externally. They may be produced with one end solid or with the solid end cut off to form an open-ended drum. The various stages in the manufacture of the drums, including heating, hot punching and drawing, cooling, annealing, normalising and stress relieving are briefly described with the aid of diagrams and sketches. A short account is given of the thorough examination of the material of a drum forged in the above manner, and a print is reproduced showing the result of the macro-examination to which it was subjected. The drum in question was of mild steel, but the author states that similar forgings have been produced in various grades of carbon and alloy steels.—*Paper by P. W. McGuire, "Transactions of the Institute of Marine Engineers", Vol. LII, No. 10, November, 1940, pp. 195-200.*

Accuracy in Remote Control.

A hydraulic throttle control system for high-speed engines of motor torpedo boats and similar light craft, known as the Exactor Hydraulic Engine Control, has been put on the market by a Middlesex engineering firm, who claim that the device is positive in action and free from lost motion, in addition to which it will "stay put" in any position. The Exactor Control is not mechanically assisted in any way and consists of a transmitter unit and a receiver unit, which are similar in construction and connected by a small-bore pipe line filled with thin oil. Movement of the hand lever of the transmitter unit imparts motion to a piston, to which it is connected by a crank arm and rod, and this motion is accurately reproduced by the piston of the receiver unit, similar mechanism converting the longitudinal movement of this piston into rotary movement of the throttle shaft. The arrangement is shown in the accompanying sectional drawing. The fluid in the system is kept under pressure at all times by opposing springs acting on the two pistons. This pressure causes a certain amount of friction in the packings, thus preventing the setting of the throttle being upset through vibration or by the movement of the vessel. The pressure applied to the fluid by the springs is exactly balanced in all positions, so that no movement of the pistons can take place after the control handle has been released. This balancing of pressure is effected by the arrangement of the mechanism transmitting the force of the springs. In each unit there are two concentric helical springs mounted on a guide which is pivoted at its lower end and carries at its upper end a roller which is also attached to a rocking lever. The crank arm connected to the piston is extended backward to form a cam of varying radius which works in a groove on the surface of the roller and is so designed that the spring pressure acts through a short radius when the spring is compressed and through a long radius when the spring is extended, the turning moment being the same in all positions. Automatic compensation for changes in the volume of the hydraulic medium due to variations of temperature and slight leakage, is provided by a connection from the lower end of the transmitter cylinder to a small oil reservoir embodied in it, through a spring-loaded valve. Normally, this valve is closed, but when the operating lever is moved to the end of its travel, the final four degrees of movement operate the valve mechanism through a bell-crank lever and shaft and open the valve against its spring. The system is then open to the reservoir; the pressure is released and any variation in volume is thus rectified, any deficiency being made up from the reservoir or any excess being forced out by the receiver piston, which when the pressure is released, is forced to the bottom of its stroke. The initial backward movement of the transmitter lever allows the valve to close and any further movement is exactly reproduced by the mechanism of the receiver unit. The operation of the system is unaffected for all normal purposes by the distance between the transmitting and receiving units. Several variations of this system are available, *e.g.*, there may be two transmitting units to enable the control to be operated from different places in the vessel, or there may be one transmitter and two receivers. For some purposes it may be desirable to have a spring return so that the control returns to a predetermined position when the handle is released, and this requirement is met by arranging for the spring pressure of the receiver to be greater than that of the transmitter; or, in certain cases, the springs may be entirely omitted from the transmitter unit. The standard control unit is capable of transmitting a torque of 130in.-lb. on the suction stroke, with, of course, considerably greater loads on the pressure stroke. The operating lever is set at an angle of 60°. The component parts of the units comprise anodised light-alloy castings, and the combined weight of the transmitter and receiver is only 4¾lb. The Exactor Control is, at the present time, not made in a form suitable for reverse-gear operation.—*"The Motor Boat", Vol. LXXIII, No. 1,877, November, 1940, pp. 157-158.*



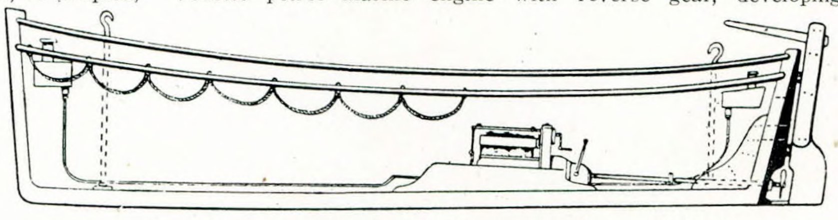
Exactor remote throttle control gear.

Engineering Features of the Maritime Commission's Programme.

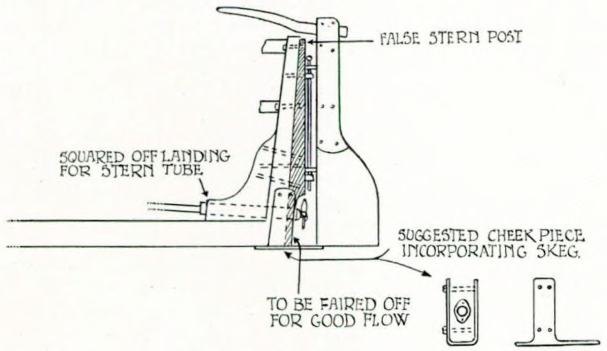
When the U.S. Maritime Commission embarked on its present shipbuilding programme, it made an engineering study of every aspect of the matter before deciding on the specifications of the C-2 class of cargo ships. These vessels are now in service and their record to date gives evidence of achievement. The Commission's aim to evolve the most economical design consistent with low first cost, available materials, light weight and manufacturing facilities, led to the adoption of two fundamental designs, *viz.*, a steam installation employing cross-compound geared turbines, and a Diesel installation, comprising in one case direct-drive Sun-Doxford engines and, in the other, geared Diesels. The steamships of the Commission's C-1, C-2 and C-3 classes are fundamentally the same, except as regards horsepower, and have each two water-tube boilers of either the sectional-header or two-drum type, employing air preheaters or economisers, or in some cases both preheaters and economisers, with water-cooled furnaces to give an overall boiler efficiency of 88 per cent. at normal load with a feed temperature of 318° F. One motor-driven forced-draught fan is provided for each boiler and the rate of combustion is automatically controlled at all times. Wide-range burners are fitted in all the latest steamships. The boilers work at a steam pressure of 450lb./in.^{2} and 750° F. total temperature at the superheater outlet and are equipped with internal desuperheaters to supply steam for heating purposes. The main feed pumps are either of the motor-driven reciprocating or the turbine-driven centrifugal types. The main turbines are of the conventional cross-compound, D.R. geared type, bleeding steam non-automatically for three stages of feed heating and exhausting to a main condenser located directly under the turbine exhaust. The astern turbine is incorporated in the exhaust end of the L.P. turbine and consists of one Curtis wheel to give 80 per cent. of the normal torque at 50 per cent. of the normal ahead revolutions with 100 per cent. normal ahead steam flow. The ahead turbines are either of the impulse or the combined impulse-reaction types. The segmental-type main thrust bearing is in the gear housing. The tooth loading on the main gear is limited to 60lb./in.^{2} face per inch pinion pitch-circle diameter. The main turbines and gears are lubricated by a common gravity system, the sump tank being under the gear case. Two closed and one direct-contact de-aerating-type feed heaters give a feed-water temperature of 318° F. with zero oxygen by the Winkler method. The main condenser is of welded construction with C.I. water boxes of either the two-pass or single-pass design, with a maximum water velocity of 7ft./sec. It is designed to maintain a vacuum of 28½in. with circulating water at 75° F. and 85 per cent. clean tubes. Motor-driven centrifugal pumps are employed as far as possible, with duplex steam pumps for standby purposes in some cases. This eliminates a great amount of steam piping and fittings and also many inefficient small turbines and steam-driven duplex units. Electric current at 240/120 volts d.c. is supplied on the 3-wire system with 25 per cent. unbalance by two geared turbo-generators, one acting as a standby. The turbines operate on the same steam conditions as the main engines and exhaust into their own condensers at a vacuum of 28½in. Twin two-stage air ejectors mounted on inter and after condensers are used for removing air from both the main and auxiliary condensers, one element acting as a standby. The turbo-generators are arranged to exhaust to the atmosphere in an emergency and to facilitate dead ship starting. In the C-1 ships all the motor controls in the engine room are grouped in a cubicle from which any motor can be started. Additional push buttons, however, are provided at the motor for stopping and starting locally, if desired. Steam at 50lb./in.^{2} is generated in a contaminated steam evaporator for use in the oil-fuel heating system. Make-up feed is supplied by an evaporator taking steam from the main turbines, with the evaporator supplying heating steam to the first-stage heater and draining into the de-aerating heater. All piping is insulated as necessary to limit the surface temperature to 125° F. and motor-driven ventilating fans with adequate air ducts ensure complete and proper ventilation of the machinery spaces. The main propeller is of the aerofoil-section, variable-pitch type. The C-2 class s.s. "Challenge", the first vessel of the Maritime Commission's design to go into service, has established what is believed to be a new world record for a ship of her type and class, with a fuel consumption for all purposes of 0·575lb./s.h.p.-hr. under trial conditions. This constitutes a striking contrast to the performance of the oil-burning vessels built for the U.S. Shipping Board during the last war, when an 8,000-ton d.w. ship could only do 10½ knots with a fuel consumption of 1·1lb./s.h.p.-hr., whereas the new C-2 class ships, having a d.w. of 9,758 tons, can steam at 15½ knots. The machinery installation of the direct-drive motorships consists of one 4-cylr. 2-stroke directly reversible engine with cylinders 32-in. in diameter, a combined piston stroke of 95in. and a piston speed of 728ft./min. The pistons and cylinders are cooled with fresh water. Electric current is supplied by 275-kW. Diesel-driven generators. Both the main and auxiliary engines operate on high-grade "bunker C" fuel which is heated to about 180° F. to assist atomisation. Chromium-plated liners are also being tried in order to reduce liner wear. As these engines operate with a jacket-water temperature of 170° F., arrangements are being made for thermal control. This has been found desirable when running light in order to maintain a clear exhaust and to ensure smooth running with the heavy fuel. A water softener is provided for the fresh-water cooling system of the main engines, the cooling water passing through a sea-water-cooled heat exchanger. All the auxiliaries are motor driven and the pumps are of the centrifugal type, where possible. Heating steam is generated in a waste-heat boiler, supplemented by an oil-fired section. The first vessel of this type to carry out trials proved to have a fuel consumption for all purposes of 0·42lb./s.h.p.-hr. Initial trouble with scavenging blowers was overcome by the employment of motor-driven centrifugal blowers, which are now giving excellent service. The other design of motorship developed by the Commission consists of either four or two main engines driving the propeller through reduction gearing and utilising either hydraulic or electro-magnetic slip couplings. The main engines are of the 2-cycle type and run at about 240 r.p.m., with a piston speed of not more than 1,110ft./min. and a brake m.e.p. of 60lb./in.^{2} at normal load. The deck machinery in all the Commission's vessels is almost entirely motor driven and the steering gear is of the electro-hydraulic type with duplicate follow-up control and dual ram gears, which has eliminated the need for relieving tackle. The old system of cargo refrigeration, using brine with its complications, frosting problems and heavy weight, has, in the Commission's vessels been replaced by direct-expansion units in each cold-storage compartment. A separate compressor is in most cases provided for each compartment and any temperature down to 0° F. can be maintained. Frosting problems have practically been eliminated, as the suction pressure in the compressor is now more nearly equivalent to the temperature desired. By far the most outstanding engineering achievement so far is the Commission's P-4-P design for a Pacific liner, which is now in specification form. This ship is to be 760ft. long, with a beam of 98ft. and a draught of 31ft. 9in. on a displacement of 41,000 tons. The propelling machinery will consist of two sets of triple-cylinder turbines driving twin propellers through D.R. gears, with a total output of 58,000 s.h.p. at normal load and a maximum power of 88,000 s.h.p. The working pressure of the boilers will be 1,200lb./in.^{2} at 750° F. total temperature and the steam will exhaust from the H.P. turbines at about 300lb./in.^{2} and return to the reheater section of the main boilers to be reheated to 750° F. before passing to the I.P. turbines. The boiler feed water will be heated to 400° F. by means of three closed heaters and one de-aerating heater. Electric current will be supplied by four 440-volt,, 3-phase, 60-cycle, 1,000-kW. generators driven by turbines taking steam at 1,200lb./in.^{2} and 750° F. at the throttle. The adoption of the reheat cycle instead of the Rankine cycle for the main and auxiliary turbines will reduce the fuel consumption by some 15 per cent. and provide control over the moisture content in the exhaust, thereby giving a flatter fuel per s.h.p. curve, *i.e.*, the same economy will be obtained at half power, normal power and full power. The Commission is also constructing an experimental cargo vessel with machinery of 8,000 s.h.p. of the same basic design as that of the P-4-P ship, and using reheat.—*Paper by J. E. Schmeltzer, presented at the annual meeting of the Society of Naval Architects and Marine Engineers, on the 14th and 15th November, 1940.*

Motor Lifeboats for Ships.

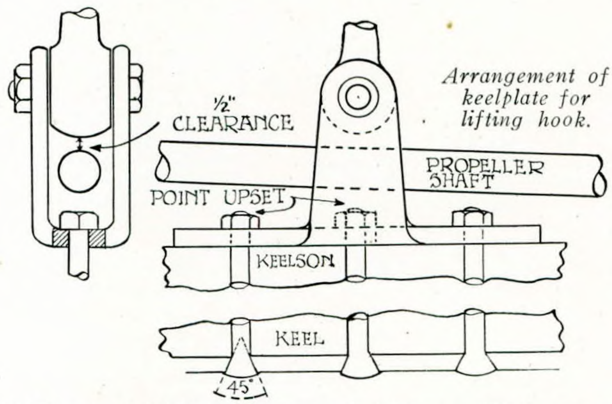
With reference to the strong recommendation made by the Ministry of Shipping to all owners of merchant ships of over 2,000 tons gross concerning the provision of at least one power-driven lifeboat in each such vessel, a number of modifications in Paragraphs 99, 103, 107, 108, 109, 110 and 112 of the *Instructions as to the Survey of Lifesaving Appliances* issued by the Ministry have now been made to facilitate the emergency fitting of an engine in an existing lifeboat. Certain additional unofficial recommendations may prove helpful to those who are responsible for installing the engine. For efficient starting, a suitable bung should be provided with a chain attached to it to fit not too tightly in the exhaust-pipe outlet. With a following wind at sea, much salt-laden atmosphere can be driven up the exhaust pipe, and this deposits rust on the valve-stem seatings, and even in cylinder bores and on sparking-plug points. Bulkheads fore and aft of the engine are unnecessary, but the engine bearers should be closely joggled over the frames and the ends closed up to form a partial bulkhead. In order to prevent oil from penetrating into the bilges, a suitable tray, as deep as possible, should dispense with the need for the partial bulkhead. Two tanks might be installed instead of one, as shown in the accompanying illustration. The regulations concerning the provision of fire extinguishers may be met by providing one of the liquid type or a 1-gallon froth type. A centre-line installation, if adopted, may require the addition of a false sternpost through-fastened to the existing sternpost, as illustrated. If the outside diameter of the stern tube is such that little material is left on each side of the sternpost, this may be reinforced by galvanized-metal cheek pieces. The line of the shaft should be kept as low as practicable and the angle should not exceed 10°. The problem of keeping the boat's lifting arrangements clear of the propeller shaft can be solved in the manner shown in the sketch, allowing the shaft to pass through with at least ½-in. clearance all round. An off-the-centre-line installation obviates this, and should this method be considered, the rotation of the propeller should be remembered, as this affects the turning of the boat in one direction. An engine casing of light metal should be used, but failing this a wooden casing, suitably fire-proofed inside, will be accepted. The exhaust pipe should be fitted so that it is impossible for sea water to enter the engine if it is stopped alongside a ship or when the boat is being launched from the davits. A dry exhaust, with a water-cooled syphon bend, is the best arrangement. The type of engine installed should, generally speaking, give an indication of the arrangement of exhaust pipe to be adopted. The circulating-water inlet should be as low as possible, with a weed trap of the type that enables it to be cleared while the boat is under way. Suitable drain cocks should be fitted for draining the cylinder jackets and pump.—*"The Motor Boat", Vol. LXXIII, No. 1,877, November, 1940, pp. 138-139.*



Suggested method of putting an engine in an existing lifeboat.



Details of stern modification.



Arrangement of keelplate for lifting hook.

Steel Motor Lifeboats for Merchant Ships.

To meet the need for a motor lifeboat for merchant vessels of over 2,000 tons, a Glasgow firm is producing steel boats to fulfil the requirements laid down by the Ministry of Shipping. It was found that the design of the ordinary rowing lifeboat carried on board ship did not lend itself readily to the installation of an engine, so it was decided to design a boat built on the lines of a ship's motor lifeboat. By increasing the beam and depth slightly over the figures for the standard rowing boat, seating accommodation for the same number of persons as carried by the rowing boat was obtained, and provision made for the extra buoyancy required to float the engine. The hull is built on the firm's patent seamless pressed-steel principle, which incorporates stiffening ribs integral with the shell plating, these ribs being formed by flanging the plate edges and welding them together by the electric arc process. A flush outside surface is thus ensured. The steel engine seating is of riveted construction efficiently secured to the hull, the forward end of the seat stopping against an oiltight door and thus dividing the boat into two separate compartments. A bilge suction is fitted in each of these compartments, together with a screwed plug for clearing the boat of water while at the davits. Small decks are fitted fore and aft, the fuel tank being supported by a vertical bulkhead well above the level of the carburettor, to ensure gravity feed. The engine selected for installation in the boat is the Morris Vedette petrol marine engine with reverse gear, developing 6/12 h.p. at 1,000/2,000 r.p.m. and driving a 12½-in. propeller. This unit is claimed to be eminently suitable for the purpose on account of its reliability, compactness, easy starting and simplicity of operation. During a trial of the boat in the loaded condition carried out under Ministry of Shipping survey, a speed of 5·84 knots was recorded, which was considered very satisfactory.—*"Shipbuilding and Shipping Record", Vol. LVI, No. 20, 14th November, 1940, p. 481.*

Swedish Plant for Cleaning Cotton Waste.

Old used cotton waste is generally regarded as having no value, and most of it is burned or thrown away. At the present time, however, it has proved to be a valuable product, which can be used again, in addition to which it yields valuable oil. Reports from Sweden describe a new plant used in that country for the cleaning of cotton waste on an industrial scale. This plant purifies a considerable quantity of waste obtained from various Swedish industries, traffic undertakings, etc. All oil and moisture are removed by centrifuging in a special apparatus, the oil quantities recovered generally constituting about 30-35 per cent. of the weight of the waste. This oil is then purified by means of chemical and mechanical methods, after which it is used for a variety of purposes. The waste is washed and carded and is declared to be just as good as new after treatment.—*"The Engineer", Vol. CLXX, No. 4,427, 15th November, 1940, p. 320.*

Vibration Patterns of Propeller Blades.

The author describes a series of experiments carried out on a number of cast-iron two-bladed propellers. The two blades had flat faces in one plane perpendicular to the boss and were supported on a central spindle with a solid metal base. The blades were vibrated over a large frequency range, under electric control, and the resulting patterns and frequencies for the various types of resonance obtained were recorded. These are given in the paper, together with the effects of blade outline, curving the thickness line, and type of blade section. The general question of the application of such results to a propeller and twisted blades is discussed, and approximate formulæ are given for primary flexural and torsional resonance, these formulæ being for blades without twist and in air. The text of the paper is illustrated by 27 diagrams and plates.—*Paper by G. S. Baker, O.B.E., D.Sc., read at a general meeting of the N.E. Coast Institution of Engineers and Shipbuilders, on the 15th November, 1940.*

Fabricated Machine Tools.

The principle involved in the term "fabricated structure" implies building up by the use of smaller parts, *i.e.*, the use of plates and sections welded together to form a structure which, hitherto, could only be obtained by using a more or less complicated casting. In marine work, the gear cases of turbines and the crankshaft casings of Diesel engines are now fabricated instead of being cast, and fabricated construction has likewise been adopted for the frames of electric generators and motors. This method of manufacture is also being employed at the present time by a number of British firms engaged in the construction of machine-tool frames. In one instance the frame of a 350-ton hydraulic press was made in this manner as was also the frame of a plate-bending rolls capable of handling plates 1½-in. thick by 20ft. wide.—*"Shipbuilding and Shipping Record", Vol. LVI, No. 20, 14th November, 1940, p. 471.*

A New Type of Power-torque Meter.

The paper deals with the tests recently carried out at the U.S. Naval Research Laboratory with an experimental power-torque meter which is claimed to possess certain notable advantages over the usual type of torsion meter employed afloat. With the new instrument the scale may be expanded for either torque or power measurements by a factor of 20 to 1 for low-scale measurements. Both ahead and astern readings of either torque or power may be taken and instantaneous values of torque and power are obtained, which, because of the inertia of the moving system of the current meter, are averaged out over several revolutions of the shaft. Furthermore, the author maintains that a considerable advantage in the reading of any power meter is derived from a relative steadiness of the meter indications, since, for a given throttle opening, the power output remains approximately constant, even though the speed and torque vary in opposite directions.—*Paper by W. C. Hall, presented at the annual meeting of the Society of Naval Architects and Marine Engineers, on the 14th and 15th November, 1940.*

De-aeration of Boiler Feed Water.

De-aeration may be effected by either chemical or physical means. The general principle of all chemical de-aerators is the same, *i.e.*, the feed water is brought into contact with a readily oxidised substance capable of taking up the oxygen. The main disadvantages of chemical de-aeration are the increase in the total solids in the water, the need for continual replenishment of the chemical used, and the cost of operation. De-aeration by physical means is the method commonly used in practically all modern machinery installations. In the open type of feed system a de-aerator is necessary to remove the gases entering the system with the make-up and absorbed from the atmosphere above the open feed tank, etc., whereas in the closed feed system de-aeration is effected in the main condenser, and the water is maintained free from any contact with the atmosphere throughout its circuit, so that no oxygen can be absorbed. There are three main types of physical de-aerator at present in general use. The first type comprises a direct-contact form of heater, in which the water to be treated is sprayed through jets or fine nozzles into a vessel which can be maintained either under vacuum or under a pressure lower than that corresponding to the feed temperature; the water, after being finely divided by spraying and losing a part of its oxygen, comes into contact with exhaust or bled steam and is thereby heated to boiling point. Owing to the fact that the boiling takes place under reduced pressure, the remaining oxygen in the water is driven off. The ebullition is much more violent and effective in freeing any gases in solution than is simple heating, which is insufficient to produce adequate de-aeration within a short space of time. In the second general type of de-aerator the untreated water is first broken up and exposed in thin films by being allowed to flow over a series of trays contained within a vessel in which a vacuum can be maintained. The partially de-aerated water then falls over a series of horizontal tubes forming the elements of a surface heater, receiving bled or exhaust steam. The water, in coming into contact with the hot tube surfaces, is "flashed" into steam, this rapid boiling under reduced pressure effectively liberating the remaining air in solution. The third type of de-aerator also employs the flashing method, but in this arrangement the raw feed is first heated, and then sprayed or injected into a chamber in which the pressure is somewhat lower than that corresponding to the water temperature. The sudden reduction of pressure results in a portion of the water flashing into steam, energy is liberated, and a violent breaking up of the water spray occurs, accompanied by liberation of the air. Various arrangements of trays, spray jets, heater units and de-aerator vessels are employed, but in every case the basic principle depends on the fact that when water is heated to boiling point for any given pressure the partial air pressure or the pressure of gas in and upon the surface of the water becomes nil and no gas can be retained in solution. Rapid and violent ebullition, combined with the breaking up of the water into fine particles or thin layers—thus exposing a large surface area—are employed to reduce the time taken for thorough de-aeration. The first type of heater referred to is exemplified in the Weir direct-contact de-aerating feed-water heater which has long enjoyed great popularity for marine work (Fig. 4). In this the untreated feed is sprayed into

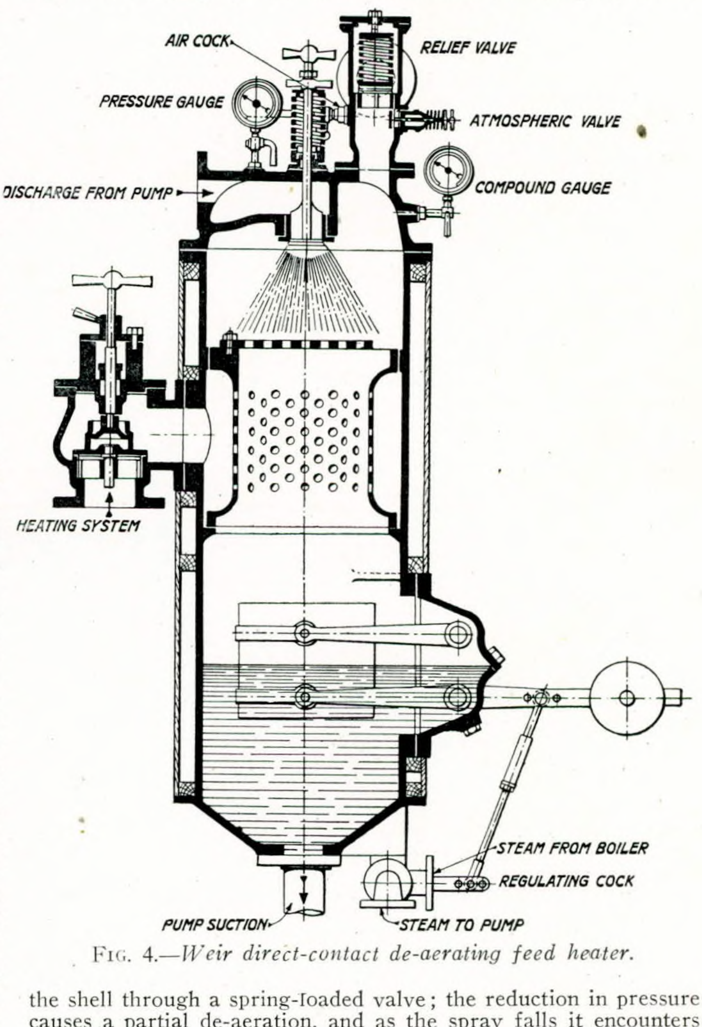
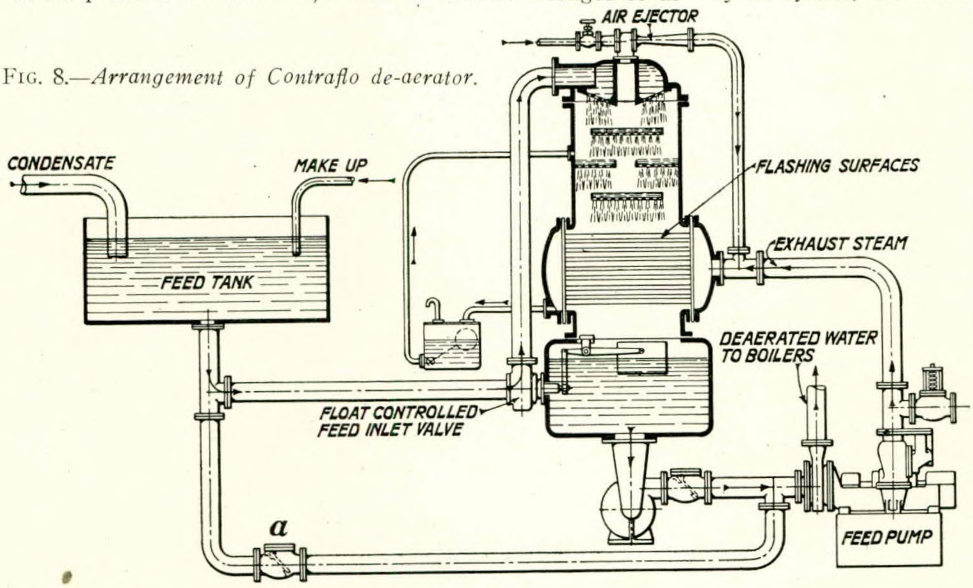


FIG. 4.—*Weir direct-contact de-aerating feed heater.*

the shell through a spring-loaded valve; the reduction in pressure causes a partial de-aeration, and as the spray falls it encounters heating steam rising from a perforated belt, becoming heated and further de-aerated as it goes. The treated water falls to the base of the vessel, from which it is drawn off, while the liberated air passes up through the sprays, becoming devaporised and cooled, and is withdrawn by means of a connection to the main condenser or an ejector. Since the water at the base of the heater is at approximately the boiling temperature corresponding to the pressure in the heater, the latter must be arranged so as

FIG. 8.—*Arrangement of Contraflo de-aerator.*



to give sufficient static head over the extraction pump which draws from it to prevent vaporisation in the pump suction. A typical example of a de-aerator operating on the second principle mentioned, is the Contraflo type, embodying trays and flash tubes. The water to be treated is led from the feed tank to the inlet at the top of the de-aerator, and then falls over a series of trays in the upper part of the chamber. The water is thus broken up into drops and at the same time heated by vapour rising from the lower part of the de-aerator chamber which contains a bank of steam-heated tubes, the partly heated water dripping from the trays on to the hot tubes and being flashed into vapour. The de-aerator is maintained under vacuum either by a steam-jet ejector or by a vent connection to the main condenser. Preliminary de-aeration takes place in the upper portion of the de-aerator, as the feed "rain" is heated by the rising vapour under reduced pressure. The remainder of the air is liberated as the water drips down over the hot tubes, with violent ebullition or "flashing". The treated water falls to the base of the shell and is withdrawn by an extraction pump; the de-aerator base contains a float gear, controlling the inlet of untreated water to give a constant water level in the de-aerator. The air released rises through the "rain" and leaves by the ejector or vent, the vacuum maintained corresponding to the temperature of the water leaving the de-aerator. Fig. 8 shows a typical installation of this type in diagrammatic form. A by-pass containing a non-return valve *a* is provided so that when the de-aerator is not in operation the feed may be taken from the feed tank direct to the feed-pump suction. The de-aerator is heated by the turbo feed-pump exhaust, together with the steam from the de-aerator air ejector, but bled steam could, of course, be used if required. An example of the third type of plant mentioned is the Mirrlees Watson de-aerator shown in Fig. 9. In this the de-aeration process is divided into two distinct stages. The feed water to be treated is first delivered under pressure to the tubes of the vapour condenser, where it is partly preheated, and is then led to the spraying valve at the top of the upper, or heater chamber of the de-aerator, where it is broken up into a fine spray. Heating steam enters the heater chamber below the spray, which is thus raised some 30° F. in temperature as it falls. The combined heating and mechanical breaking-up of the water cause a certain amount of air and gases to be liberated at this stage, and these pass out through a vent pipe. The sprayed water, together with the condensed heating steam, drops to the base of the upper chamber, from which it is withdrawn, under the control of a float-operated valve, to the lower chamber through a second sprayer. In the lower or de-aerating chamber the necessary vacuum for efficient de-aeration is maintained by the surface vapour condenser and by an ejector, the latter discharging the air and gases to the atmosphere. The injection of the hot spray into the chamber under a vacuum results in a portion of the water being flashed into steam, and the air and gases in solution are thus liberated. The steam generated due to the sudden pressure drop rises and is condensed by the surface condenser, giving up its heat to the untreated feed in the tubes. The condensate, together with the spray, drains to the base of the de-aerating chamber, from which it is finally withdrawn by an extraction pump, under the control of a second float-operated valve. The steam supply to the direct-contact heater may be regulated by means of a thermostatic valve, arranged either to keep the final feed-water temperature constant within limits, or to use the minimum amount of steam necessary for de-aeration, according to the fluctuation of the load. The makers state that the minimum temperature difference due to the reduction in pressure in the de-aerator should be

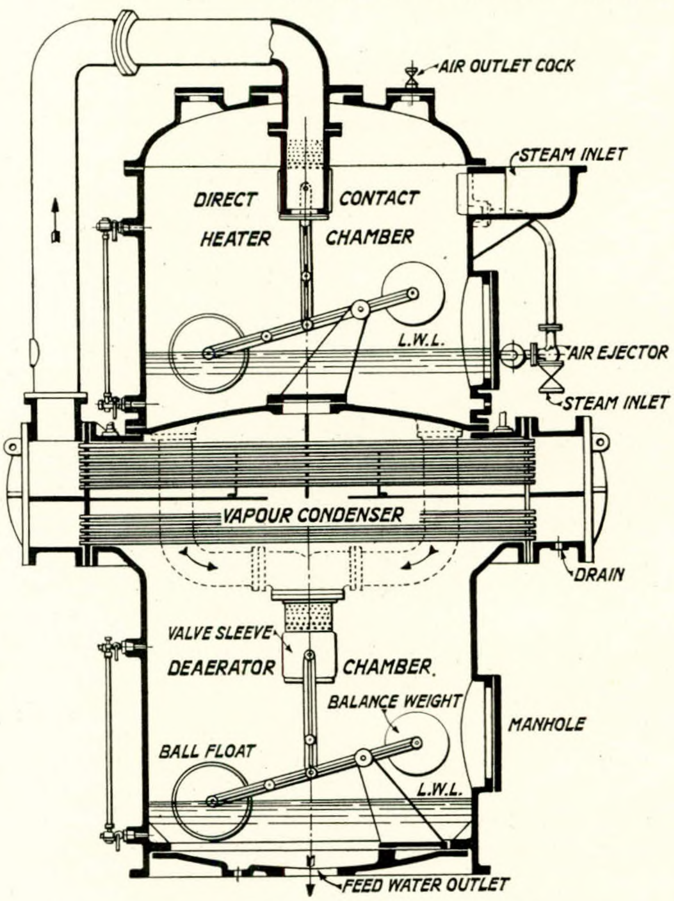


FIG. 9.—*The Mirrlees Watson de-aerator.*

25° F. and that the final feed temperature should be at least 160° F. The temperature of the water entering the de-aerator chamber is then 185° F., while that of the water entering the heater chamber is about 150° F. The heating steam must therefore be sufficient to heat the water from 150° to 185° F. The feed inlet temperature will be about 125° F. Should the feed-water temperature be lower than this, more heating steam may be admitted to bring the temperature at the de-aerating chamber inlet up to 185° F., but this should not be exceeded greatly, or the heater will have to work at above atmospheric pressure and the plant arranged accordingly. A minimum head of 20ft. is required at the water inlet of the de-aerator with the heater under atmospheric pressure, to overcome the friction through the vapour condenser and to provide sufficient pressure for the sprays. The treated water is withdrawn by means of an extraction pump. Another type of de-aerator, falling under the third classification but differing in several essential features, is the Hick, Hargreaves atomising spray de-aerator shown in Fig. 11.

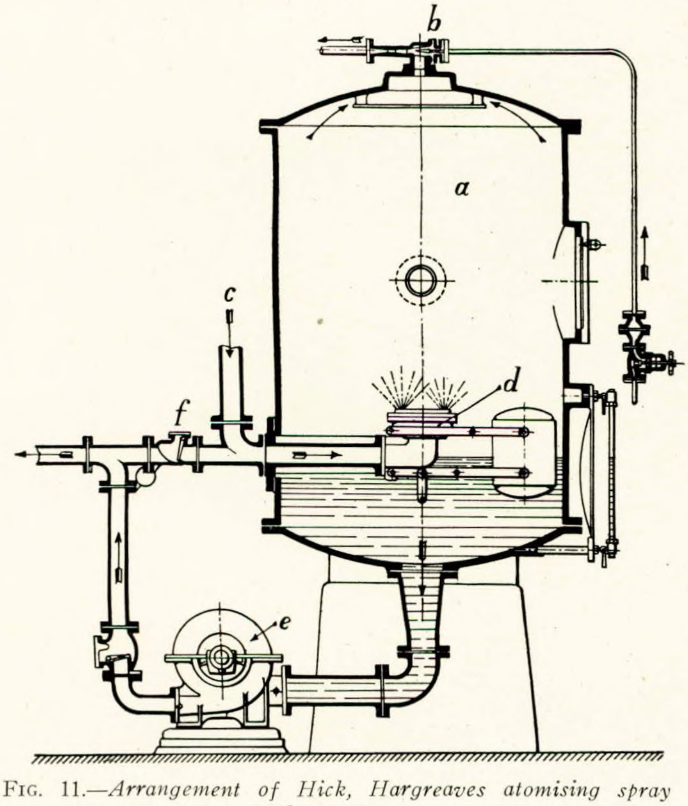


FIG. 11.—*Arrangement of Hick, Hargreaves atomising spray de-aerator.*

It consists of a single vessel *a*, which is evacuated by means of a steam-jet ejector *b*. Hot feedwater enters through the inlet pipe *c* and is sprayed into the de-aerating chamber through the spray-nozzle valve *d*, the supply of water to which is regulated by float gear. The breaking up of the water into a very fine spray under the vacuum is claimed to give thorough de-aeration. The treated water is withdrawn from the base of the plant by the extraction pump *e*, discharging to the boiler feed-pump suction, and a loaded non-return valve *f*, a by-pass being fitted to provide direct feeding in the event of a stoppage of the extraction pump. No additional feed heating is necessary provided the temperature at the feed inlet is not less than 130° F. De-aeration is claimed to be entirely effective due to the atomised spray, a full spraying effect being obtained by means of a special patented method of control which opens up groups of nozzles in sequence, according to the load on the plant. When the feed temperature is below 130° F. a separate exhaust-steam feed heater may be fitted to the feed inlet, or a nozzle heater may be fitted in the feed tank to give the required temperature.—*"The Power and Works Engineer", Vol. XXXV, Nos. 413 and 414, November and December, 1940, pp. 267-270, 274 and 291-294.*

Moisture in Coal.

Whenever coal is purchased by weight, the amount of moisture present will obviously affect the heat value expressed in terms of cost per British thermal unit. Moisture in coal is present in two distinct forms, the first being the inherent moisture of the coal itself and the second the free moisture due either to moisture in the mine, to the possible washing of the coal at the colliery, or to the transit and storage of the coal in wet weather. According to an article appearing in the house journal of a well-known British firm of combustion engineers, the total moisture due to the combination of all these sources may be as much as 15 per cent., so that if the gross calorific value of the coal is 14,000 B.Th.U./lb., taking 85 per cent. of this, the calorific value of the fuel as received is only 11,900 B.Th.U.'s/lb. The water has, of course, no heating value but rather the reverse, since it requires heat to convert it into steam and to superheat the latter to the temperature of the flue gases. On the other hand, it is suggested that as the steam is formed, it causes the fuel to swell and to become more porous, thus permitting air to pass more freely through it and thereby promoting more efficient combustion.—*"Shipbuilding and Shipping Record", Vol. LVI, No. 20, 14th November, 1940, p. 471.*

Condenser Scoop Design.

The paper describes a series of experiments carried out with the object of measuring the heads regained by various designs of inlet and outlet scoops in water, together with model condensers and piping. The measurement of resistance of models to movement through the water did not come within the scope of these experiments. The apparatus and models used for the experiments are briefly described and the nature of the laboratory tests involved is explained. The results of the tests are given in the form of performance curves for various designs of inlet and outlet scoops. Photographs of flow patterns in model scoops made at condenser flows of about 50 gallons (U.S.) per minute were obtained by allowing the water to drag a mixture of lamp black and oil along the surfaces of the models and of sheet metal plates fitted to the scoops at their centre-line plane. Twelve such photographs are reproduced in the paper. A substantial amount of data for designing full-size scoops was compiled from the results of the experiments with the models and is tabulated by the authors, who point out, however, that the results of the tests cannot be regarded as a final answer to the problem concerning the design of the most efficient form of scoop obtainable. Much remains to be done in developing practical designs of scoops which will combine maximum head recovery with minimum ship resistance, but the authors express the hope that their paper will lead to a better understanding of flow conditions in scoops and that it will serve to assist designers where model tests or past practice are not available.—*Paper by E. F. Hewins and J. R. Reilly, presented at the annual meeting of the Society of Naval Architects and Marine Engineers, on the 14th and 15th November, 1940.*

A Marine Reverse-reduction Gear.

A new form of reversing gear for geared Diesel-engined ships with non-reversing engines driving through Vulcan-Sinclair fluid couplings and reduction gearing has lately been developed by a Middlesex engineering firm. It is known as the S.S.S. reverse-reduction gear and the usual arrangement is to have a pair of engines geared to the propeller shaft, although four engines may be used on one shaft in certain cases. The fluid coupling serves to isolate the engines from the gearing as regards torsional vibration. This arrangement is particularly suitable for tugs and coasters, in which individual engines of up to 500 h.p. may be employed, but it is also applicable to larger units of 1,000 h.p. or more, running at speeds up to 750 r.p.m., so that a twin-screw or single-screw ship could be constructed on this system. The scoop-controlled type of fluid coupling would be used, since it enables either engine to be cut in or out of service as required, in addition to providing infinitely-variable-speed regulation for manœuvring below the minimum speed of the engine. The quantity of liquid in the working circuit is regulated by simply moving the scoop-tube lever, and no pumps, tanks or other auxiliaries are required. The gear is of conventional design, having an input shaft with two pinions, one of them meshing with a gear wheel which is clutched to the output shaft to give ahead drive; the other drives through an idler wheel to a gear wheel which is clutched to the output shaft to turn the propeller astern. A special feature of the design is the employment of synchronized dog clutches for engaging the forward or the reverse gear wheel, this engagement taking place only when the shafts are stopped and rocked slightly backwards by the application of a rocking brake on the input shaft. This rocking brake is a standard device used in connection with fluid couplings for driving Diesel-engined winches, capstans, etc., where it is necessary to rock the shaft slightly backwards to facilitate the disengagement of a dog clutch or sliding pinion, which may be subjected to the drag torque of the fluid coupling.—*"The Motor Ship", Vol. XXI, No. 250, November, 1940, pp. 246-248.*

Sirron Engines with Oil-cooled Pistons.

Whereas Sirron two-stroke oil engines have hitherto been constructed with uncooled pistons, the makers have now developed a design for a high-powered engine with an oil-cooling system for the pistons and employing a dry sump, the lubricating oil being drawn continuously from the crank chamber and delivered to a storage tank in the engine room. Other modifications of the earlier design include the provision of concave piston heads and direct fuel injection into the cylinders instead of the former arrangement of convex piston heads and separate combustion chambers. The adoption of oil-cooled pistons and a moderate supercharge of scavenging air (2-3lb./in.^{2}) makes it possible to obtain a substantially greater power output with cylinders 320mm. in diameter and a piston stroke of 426mm. which, in the uncooled piston design of engine, are rated at 100 b.h.p. at 300 r.p.m. In the new engine the cylinder heads are made in two parts, the inner covers being of a depth which is practically equivalent to the thickened part of the cylinder liners in the neighbourhood of the top flanges. The general construction of the new engine is similar to that of the makers' standard models, the special features of which include the provision of water-cooled exhaust port bars in the cylinder liners, a chain-driven camshaft and through-bolts to relieve the framework from stresses due to combustion.—*"The Motor Ship", Vol. XXI, No. 250, November, 1940, p. 261.*

New Mirrlees' Marine Engine.

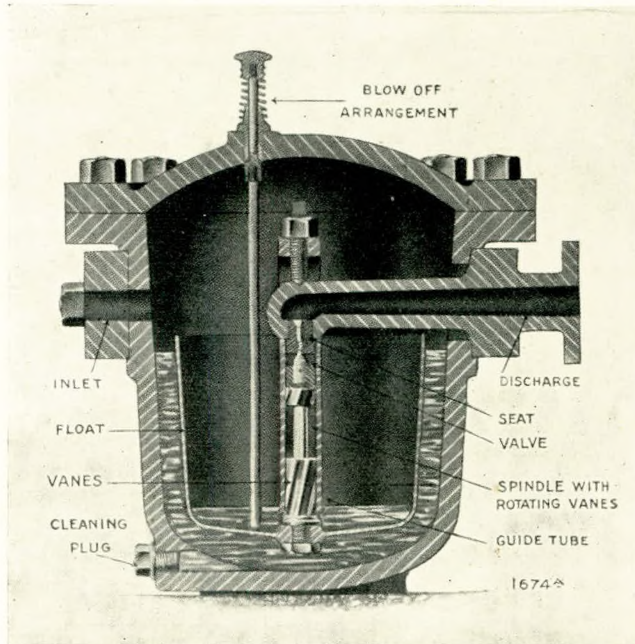
A new four-stroke marine Diesel engine has been developed by Mirrlees, Bickerton & Day, Ltd., and is now undergoing tests. It has six cylinders of 13⅝in. dia., with a piston stroke of 21in., the output of the engine being 540 b.h.p. at 300 r.p.m. Reversing is effected by double cams on the camshaft, ahead and astern cams being brought into operation according to the direction of rotation required, by means of swinging links. Whilst the engine is generally similar to an existing Mirrlees stationary type, apart from being modified to render it directly reversible, it drives its own circulating water and bilge pumps and compressor, and operates with forced circulation on the dry sump system. The engine is totally enclosed and a Michell thrust block is bolted to horns forming an extension of the engine bed.—*"The Motor Ship", Vol. XXI, No. 250 November, 1940, p. 271.*

Proposed Method of Standardising Marine Diesel Engines.

In a letter to the editor the writer explains the reasons which, in his opinion, should make the standardisation of marine Diesel engines of moderate power—say, below 1,200 b.h.p.—of benefit to British shipbuilders, shipowners, and exporters. After referring to the success achieved by German makers of such marine Diesel engines in the world market, he expresses the view that the two factors which contributed most to this success were low engine speed and direct drive to the propeller. The writer then goes on to suggest that for main-propulsion engines the rates of revolutions should be from 400 to 500 r.p.m. up to 200 b.h.p.; 300 to 375 r.p.m. for 250-400 b.h.p.; 250 to 300 r.p.m. for 450-750 b.h.p.; and 225 to 275 r.p.m. for 800-1,200 b.h.p. With such engine speeds he considers that the drive can be taken direct through to the propeller without any reduction gearing. The engines should preferably be directly reversible, although for some fishing craft a reverse gear might be desirable for powers below 250 b.h.p. Reverse gears, however, generally increase the cost of the complete installation and are often a source of additional trouble.—*Marcel Porn, "The Motor Ship", Vol. XXI, No. 250, November, 1940, p. 261.*

"Sentinel" Steam Traps.

The engineer's steam trap is to all seeming a very simple piece of apparatus, but it is a fact that out of countless patents very few designs have survived the test of continuous use. They



A "Sentinel" steam trap with hand blow-off.

fall in general under two heads; the expansion trap and the gravity trap. The "Sentinel" is of the latter type. The main features of the current design are shown in the illustration. They include the self-regrinding discharge valve and, in this case, a hand-operated device for testing the action of the trap at any time by causing it to blow off. The points to which attention may most profitably be given, however, are: first, the impossibility of the bottom of the guide tube becoming unsealed by the condensate; and secondly, that when the float sinks it must sink quickly. The first condition makes it impossible for the trap to discharge steam, and the second prevents a state of balance arising in which the discharge of water could become a valve-scoring dribble. The "Sentinel" trap is either full open for the discharge of water only or it is tight shut to both water and steam.—*"The Syren", Vol. CLXXVII, No. 2,310, 4th December, 1940, p. 297.*

Engineers for Norwegian Motor Ships.

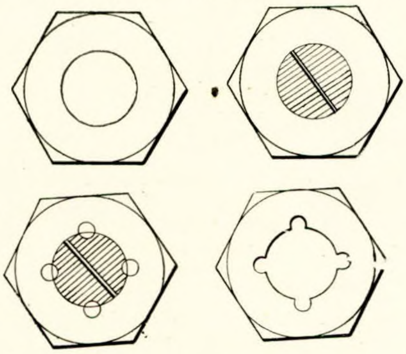
There is some difficulty in obtaining a sufficient number of trained Norwegian engineers for the mercantile tonnage now operating under the control of the Norwegian Trade and Shipping Mission. This has resulted in engineers of other nationalities being accepted for service, including Czechs, Poles and Frenchmen, to the number of about 60.—*"The Motor Ship", Vol. XXI, No. 250, November, 1940, p. 264.*

Ship Repairs by Electric Welding.

The following descriptions of two major ship repairs will serve to demonstrate the value of electric welding for such purposes: The s.s. "Manuchu" sustained serious damage to her rudder whilst passing through a series of locks. A new gudgeon was forged and machined and then welded into position at the top of the stern frame, the volume of the weld being about 84 cu. in. Electric welding was also employed to repair rivets, the "A" plate seam in the way of the propeller aperture and streamline plating. The work was carried out by a London firm of ship repairers. The s.s. "Rokos Vergottis" went aground after leaving port, the stern frame being badly distorted and fractured in the way of one of the original fireweld scarves. The frame weighed 14 tons and was 12in.×7¾in., with a back post measuring 36ft. 9in. and a heel of 17ft. 5½in. A very successful welding repair with mild-steel electrodes was carried out by a Newport engineering firm.—*"The Motor Ship", Vol. XXI, No. 250, November, 1940, pp. 272-273.*

Home-made Die-nut.

The threads of studs or bolts are sometimes badly bruised and the position of the studs, etc., is such that the dies cannot be run down them in place. To meet such a case a "die-nut"



Details of the home-made die-nut.

can be made from a nut of corresponding size by plugging it and drilling four small holes round the edge of the plug, as shown in the accompanying sketches. The size of the small holes must depend on that of the nut. The plug is then removed and the nut case-hardened, after which it is ready for use with a box spanner or an ordinary spanner. The cutting edges of the four vertical holes will remove the bruises quite effectively.—*A. Hamer, "Pratical Engineering", Vol. 2, No. 46, 7th December, 1940, p. 615.*

Smaller Bolt Heads and Nuts.

To secure economy in steel, the British Standards Institution is co-operating with the Ministry of Supply by preparing "War Emergency" Standards. One now issued for black bolts and nuts is No. 916, and is additional to the B.S. 28 for black bolts and nuts of "Whitworth" dimensions, and provides for black bolts having heads and nuts, smaller than the full Whitworth sizes. It is estimated that manufacture to this new standard will effect a saving of some 60,000 tons of steel per year. The dimensions of the heads and nuts are those of the next smaller nominal size in the "Whitworth" series, and permit the use of existing spanners. The dimensions are, therefore, in effect, those which have been long recognised for bright B.S.F. bolts and "Auto-Whit" bright bolts as laid down in B.S. 191 and B.S. 193. The specification makes provision for both the B.S. Whitworth and B.S. fine thread.—*"Industrial Power", Vol. XVI, No. 182, November, 1940, p. 204.*

Long-angle Lathe Files.

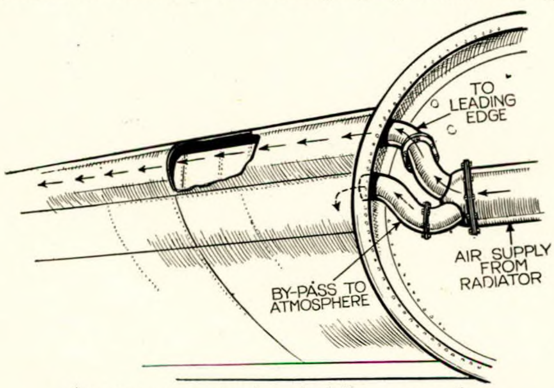
A Canadian manufacturing firm has recently introduced a special form of file intended for use with a lathe. As everyone with turning experience knows, the ordinary file has a tendency to clog fairly quickly when used on a lathe, while under certain conditions it is difficult to avoid chatter and drag when filing work in a lathe. The new file, which has been specially designed for this duty, has its teeth cut at an angle of approximately 45° to the horizontal, as against about half this angle in the ordinary file. The tip of the file at the top left-hand end is uncut so as to provide a convenient grip for the operator. Made in a variety of lengths up to 16in., the file is claimed to have none of the drawbacks of the ordinary type for lathe work.—*"The Marine Engineer", Vol. 64, No. 760, November, 1940, p. 260.*

New Lubricating Oil Purifier.

A continuous-type oil purifier for marine work, known as the Hilco, has been developed in the U.S.A. The purifying medium is a filter bed of a material known as Hilite and fuller's earth, with canvas and filter paper. The appliance is self-contained and includes a heater to raise the temperature of the oil before filtering and a cooler to reduce it to the required engine temperature.—*"The Motor Ship", Vol. XXI, No. 250, November, 1940, p. 262.*

Wing De-icing Equipment in German Aircraft.

Most people are familiar with the pulsating rubber shoe method of de-icing the leading edges of aeroplane wings. Another method consists of allowing a chemical preparation to seep slowly through small holes in a rubber covering on the leading edge of the wing, while a third method is the smearing-on of an anti-freezing paste. However, in the course of an examination by R.A.F. officers of a captured German Ju.88 bomber, it was ascertained that the de-icing system employed on the latter is one which has for a long time seemed so simple, but which it has not yet been found possible to adopt on British aircraft for reasons which are not altogether apparent. In the Ju.88, air taken in behind the engine radiator is heated by contact with the exhaust stubs and then flows along piping to the leading edge of the wing. Here it enters a D-shaped duct formed by the curve of the leading edge and a vertical strip of sheet metal riveted to the upper and lower wing surfaces. In its passage along this duct to the wing tip it heats the leading edge and is then discharged at the wing tip into the interior of the wing, thereby slightly raising the temperature within it so that control hinges and pulleys do not freeze at high altitude. A valve is provided to by-pass the flow of air when not required. The arrangement is shown in the accompanying sketch and appears



Arrangement of wing de-icing connections.

to be so simple that it may well be wondered why it has not been adopted before, as it fulfills the three requirements of reliability, simplicity and low weight. If this equipment is *really* effective against the worst icing conditions likely to be encountered, then there is little doubt that it is the best de-icing system hitherto devised. De-icing of the tailplane in the Ju.88 is accomplished by the pulsating rubber shoe method in order to avoid piping hot air right down the fuselage to the tail. Air for cabin heating is also taken in behind the radiator and passes through a small water boiler which is heated by the stub exhaust pipes.—*"Flight", Vol. XXXVIII, No. 1,667, 5th December, 1940, pp. d and e.*

generator has a special starting winding so that it may be started from the ship's battery. Although the main Diesel engines are fresh-

Plan of engine room of "Edmond J. Moran".

New Electric Winches.

New types of electric winches have been produced by the American Hoist & Davit Company for the 79 new ships built

ing 5,400 s.h.p. at 3,600 r.p.m., driving a single propeller at 84 r.p.m. through D.R. gearing and giving the ships a service speed of 14 knots. The boiler installation of each vessel com-

which 43,000 cu.ft. is refrigerated cargo space. The cargo-handling equipment comprises fourteen 5-ton derricks and one 30-ton derrick, operated by electric winches. The passenger accommodation, arranged amidships, includes staterooms for 97 first-class passengers, every stateroom having its own bathroom or shower. The principal public rooms include a hall, library, bar and dining saloon, and there is also a swimming pool. The ship is manned by 124 officers and men.—*"The Nautical Gazette", Vol. 130, No. 11, November, 1940, pp. 12-19.*

U.S. Coastguard Light Tender "Juniper".

The twin-screw Diesel-electric machinery of this vessel marks the first application in any ship of variable-speed a.c. drive. The installation comprises two Cooper-Bessemer type GN 6-cylr. Diesel engines of 10½-in. bore and 13½-in. stroke, each rated at 550 h.p. at 730 r.p.m. They are stationary type units with alloy pistons, and each engine drives a 370-kW. Westinghouse generator and its direct-connected 20-kW. exciter. The generators furnish current to two 450-h.p. Westinghouse propulsion motors. The engines are electrically started by using the generators as starting motors, with a 54-cell storage battery supplying starting current and emergency lights and power. Auxiliary current is supplied by two Diesel-driven generators of 20kW. and 30kW. capacity, respectively. The principal dimensions of the "Juniper" are 177×32×13ft., with a gross tonnage of about 400 tons and a displacement of some 800 tons.—*"Marine Engineering and Shipping Review", Vol. XLV, No. 11, November, 1940, pp. 114-120.*

American Train Ferry "Seatrain Texas".

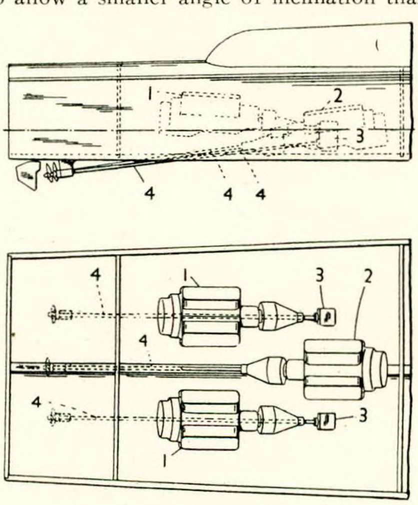
The "Seatrain Texas" is the third of four similar vessels to be built for Seatrain Lines, Inc., by the Sun Shipbuilding and Dry Dock Company. The approximate dimensions of the ship are 465ft.×63⅓ft., with a draught of 24½ft. on a displacement of 15,267 tons. The hull is constructed on the Isherwood system of longitudinal framing, the propelling machinery being aft. The general layout of the latter is similar to that adopted in the steamships of the U.S. Maritime Commission, there being a set of D.R. geared cross-compound turbines developing 8,800 s.h.p. when driving the propeller at 105 r.p.m., and two oil-fired Babcock and Wilcox boilers, generating steam at 450lb./in.² and 738° F. at the superheater outlet. Electric current is supplied by two 250-kW. geared turbo-alternators. The superstructure deck of the ship is divided into two sections by a loading hatch 57ft. long for the full width of the ship, the railway trucks being embarked and unloaded through this hatch by means of cranes at each terminal port. There are four cradles at each deck and tank top and one on the superstructure deck, for handling the cars. These cradles are situated in the loading hatch or cradle space, and when the ship is fully loaded, a car is on each cradle except the one on the superstructure deck, which is used as a gangway. All decks and the tank top are laid with steel rails for carrying freight cars, as well as jack rails for centering and securing the latter. Hauling rails are fitted at the centre of the main rails for moving the cars into position by special steel cables led to two steam winches on the superstructure deck and controlled by vertical driving shafts to the 'tween decks and lower hold. All the rails are welded to the deck and tank top. The winches have two-cylinder engines of the reverse-valve type and are placed at the centre of the superstructure deck, one forward of and one abaft the main hatch. The power from these winches is transmitted by cross shafts and bevel gears to vertical shafts, one port and one starboard, extending the full depth of the cargo space midway between the centre and wing tracks. These shafts rotate continuously with the engine. A wire-rope drum is installed at each deck level, which may be engaged or disengaged by separate foot-operated clutches. Each drum serves one centre and one wing track for hauling cars back or forward in the ship by means of an endless wire rope having three wraps on the drum and passing over sheaves to the centre of one track, back to the bulkhead, across the other track and back to the hatch sheave and across to the drum again. At the centre of each track is a small steel rail upon which is mounted a cast-steel carriage with a pendant chain for attachment to the freight-car couplings. These carriages are secured to the endless wire cable and are always at opposite ends of their respective tracks. The total carrying capacity of the train ferry is 100 freight cars.—*"Marine Engineering and Shipping Review", Vol. XLV, No. 11, November, 1940, pp. 110 and 120.*

Mechanical Gearing for Large Power Transmissions.

The author of this paper reviews past developments and possible future improvements. He traces the history of the modern high-speed gear, which is oil-film lubricated, since its introduction into commercial use in 1910, and deals with some interesting phases of its development. For fully satisfactory operation of large-power gears, perfection must be aimed at in design, construction, assembly, materials, accuracy of tooth form and pitch, smoothness of tooth surface, lubrication and balancing; the author surveys present-day achievements in respect of each of these items. As gear-testing apparatus is briefly described, and from data obtained by tests with this apparatus, an estimate of the frictional losses of disengaging teeth is made. The author shows that the character of the rules originally adopted for limiting the values of the loading rates was justifiable, and he foreshadows probable future adjustments of the existing rules. The main scope for further development in load-carrying capacity, etc., lies in improvement in the surface finish or smoothness of the tooth flanks and in the quality of the materials employed. Higher fatigue limits are desirable but must not be obtained at the expense of ductility; an increase in hardness is inadmissible without a corresponding improvement in the quality of the surface finish of the tooth flanks. The text of the paper is illustrated by eight diagrams.—*Paper by L. M. Douglas, read at a general meeting of the N.E. Coast Institution of Engineers and Shipbuilders on the 29th November, 1940.*

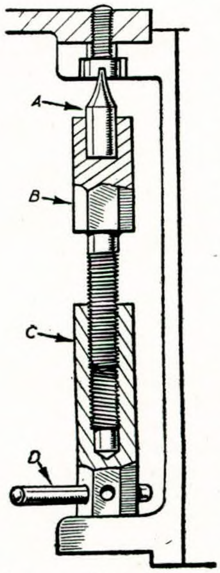
Arrangement of Engines in High-speed Boats.

Triple-screw and quadruple-screw engine arrangements for high-speed craft have been patented by Mr. Scott-Paine, and diagrams showing the former layout are reproduced. It is pointed out that formerly a triple-screw boat would have the port and starboard engines forward of the central unit, which drives the propeller through a return shaft. With the new arrangement, however, the wing engines (1) are aft of the central unit (2) and are provided with return drives (3). The propeller shafts (4) of the wing engine pass below the crankcases, and it is possible to allow a smaller angle of inclination than if a direct



Engine layout for Scott-Paine triple-screw high-speed motor boat.

drive were adopted. On the other hand, the central engine is forward of the wing units, and is placed lower in the boat. Thus all the shafts are enabled to be fitted at angles which are not excessively remote from the horizontal, and the propulsive efficiency is correspondingly improved. The invention is preferably applied to motor boats of the hard-chine type, whether three or four engines are employed.—*"The Motor Boat", Vol. LXXIII, No. 1,878, December, 1940, p. 173.*



A screwdriver for removing tight screws.

Screwdriver for Removing Tight Screws.

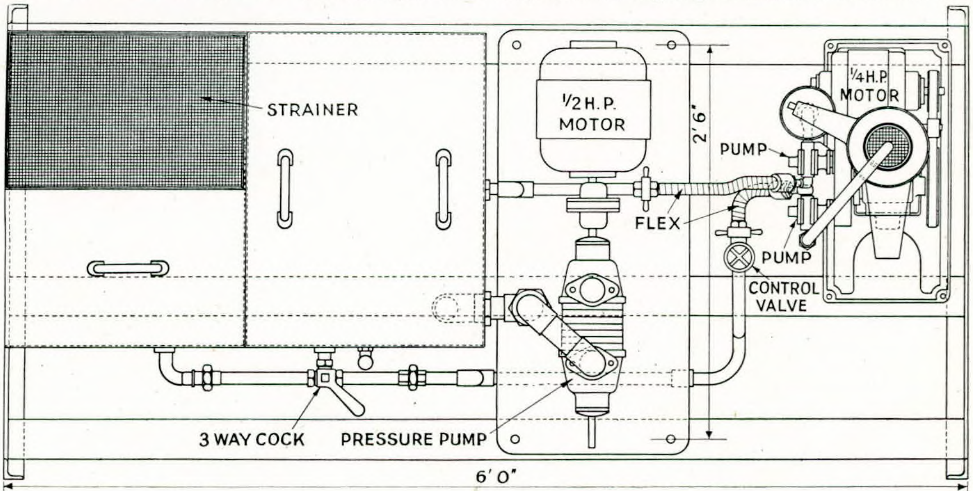
A is a square bit of tool steel, one end of which is ground as a screwdriver, and the other end of which fits into a square hole in shank *B*. The screwed end of *B* fits into a female thread in body *C*, and both *B* and *C* are of hexagon bar. To use, adjust until bit *A* is well bottomed in the screwdriver slot, and body *C* butts firmly against some other part of the machine. *C* is prevented from rotating by means of a spanner or tommy pin *D*, and turn shank *B* with a spanner. As the screw comes out, shank *B* enters further into body *C*, and a slight movement of *C* will compensate for any difference in the pitch of thread of the screw being removed, and that of the tool itself. This driver was originally devised for removing badly rusted-in screws, and has never yet failed. Bit *A* can be changed if worn or broken, or to suit a different size of screwdriver slot.—*E. P. Wilson. "Practical Engineering", Vol. 2, No. 48, 21st December, 1940, p. 673.*

New Type of Miners' Flame Safety Lamp.

A new type of miners' flame safety lamp has recently obtained official approval of the Mines Department. The lamp has been designed with the following objects:—(*a*) The highest possible candle-power compatible with cool burning; (*b*) ease of manipulation; and (*c*) ease of maintenance in the lamp room. The new lamp, which burns mineral colza, has been approved as a Schedule A lamp for use with the colza substitute fuels now available; it is of the combustion-tube type, with double gauzes, giving the following candle-powers, as specified on the Mines Department's approval certificate, for a full nine hours:—Mean spherical candle-power, 1·45; mean candle-power over horizontal angle, 2·60. In designing the lamp, particular attention has been paid to obtaining (*a*) clear vision of the testing flame when examining for gas; (*b*) ease of cleaning and general maintenance; and (*c*) stability of the flame in wind. The oil vessel is locked either by a lead-rivet or a magnetic lock; the latter is opened by a small but powerful, permanent magnet instead of the cumbersome electro-magnet previously used.—*"Iron and Coal Trades Review", Vol. CXLI, No. 3,797, 6th December, 1940, p. 579.*

Cleaning Machine Parts by Paraffin Spray.

In order to facilitate the cleaning of machinery components of oil engines and similar plant by means of paraffin, a special type of equipment has been developed by the De Laval organization. The parts to be cleaned are arranged on a perforated plate and paraffin is sprayed on to them by a pistol spray gun having a trigger-operated valve. The layout of the unit—which is self-contained and transportable—is shown in the accompanying plan view. The paraffin sprayed over the machinery parts, drains down through the perforated plate into a hopper and thence, through a strainer, into the left-hand compartment of the paraffin supply tank. The fluid is partially settled in this compartment and flows over a weir into the right-hand section of the tank, whence the paraffin is pumped continuously to a De Laval centrifugal purifier, in which it is purified and returned to the tank. It is then delivered again to the spray gun through a high-pressure centrifugal pump, which has a relief valve fitted on its discharge side. If the spray gun is shut off, no excess pressure is built up, and the paraffin is returned to the tank. As the cleansing through the centrifuge proceeds continuously, impurities cannot accumulate in the paraffin and there is no risk of any contaminated fluid coming into contact with the parts being cleaned. The apparatus is known as the Parawash unit.—*"The Oil Engine", Vol. VIII, No. 92, December, 1940, p. 218.*



Diesel Fuel Characteristics.

Distillate. The requirement that the fuel be straight distillate is frequently specified. This means that the fuel must be produced by the distilling of a certain cut of oil and that it is not a blend or mixture of several oils nor a cracked residual. A straight distillate will tend to be a uniform oil, whereas blends or mixtures may settle out and not give a uniform product. Non-distillate fuels may have a tendency to leave a residue which may cause sticky rings or other troubles, but some engines run on mixed fuels with apparent success.

Ignition quality and Cetane number. Ignition quality refers to the facility with which the fuel will ignite and give proper combustion. The Cetane number is a measure of the ignition quality or burnability of the fuel. The Cetane number of Diesel fuels ranges from about 30 to 70. For small high-speed engines a Cetane number of about 50 is considered desirable, while large slow-running engines will usually operate satisfactorily with a Cetane number as low as 30. The use of fuel with too low a Cetane number for any particular engine may lead to difficult starting, rough running, high maximum combustion pressures and probably excessive combustion temperatures. These conditions may result in distorted and stuck injector spray nozzles, pitting of exhaust valve seats and slugging of lubricating oil.

Conradson carbon. This is a test for carbon residue. The residue is that portion of fuel remaining in the cup after the fuel has been evaporated at a temperature of 527° F. for 120 hours, *i.e.*, it is an indication of unevaporated carbon. This carbon residue may cause combustion difficulties, particularly in small high-speed engines. Some makers of large engines do not recommend a Conradson of over 2 per cent., while in other cases such engines run satisfactorily with as much as 5 per cent. Small high-speed engines usually require from 0·2 to 0·5 per cent. There is some difference in opinion among engine builders as to the full significance of the Conradson carbon test, but high Conradson has generally been found troublesome.—*"Marine Engineering and Shipping Review", Vol. XLV, No. 11, November, 1940, p. 122.*

Fuel Injection Equipment for Operation on Boiler Oil.

The utilisation in Diesel engines of heavier grades of residual oil than have hitherto been employed may represent one of the more important fields of development in the near future. Considerable interest has been aroused by the requirements of the United States Maritime Commission in this connection. In all of the 42 motor cargo ships and cargo liners built and building under the Commission's programme it is specified that the main and auxiliary Diesel engines must be capable of operating satisfactorily on a heavy residual fuel. Among the motor ships already in service in which the machinery is running on the heavier oil are some C3 passenger and cargo liners, in each of which are installed four 2,250 b.h.p. Busch-Sulzer two-stroke single-acting engines running at a speed of about 225 r.p.m. The injector which is illustrated in Fig. 1 is water-cooled. The injector body (1), which is a steel forging, has a diameter of $1\frac{3}{4}$in. (the engine cylinder diameter is $20\frac{1}{2}$in.) and it is drilled for the delivery of the fuel to the needle guide. At the lower end of the injector body where it joins the needle guide (3B, Fig. 1), it is hardened, ground and lapped, forming a pressure-tight joint with the corresponding surface of the needle guide. The needle guide, of special steel of corrosion-resisting quality, is hardened to the maximum possible extent and it is also ground and lapped at the bottom to prevent leakage where it fits against the injector tip (17). In this guide is a drilled passage delivering the fuel just above the needle seat. The needle (3A), which is spherical at its upper end where it contacts the intermediate rod (4), is hardened and lapped to a close fit in the needle guide. For several reasons the injector tip, which is the only portion of the valve that projects into the combustion chamber, is separate. This permits of maximum hardness of the seat in the guide and allows of the use of identical injectors in various sizes of engines, whilst the tips may be changed when experimenting with new engines or combustion chambers. The tip is entirely surrounded by water below the needle valve guide and seat and this is an essential feature for satisfactory operation on heavy residual oil. The needle and guide assembly are surrounded by the water-cooled portion of the cylinder head. Leakage of fuel past the needle lubricates the needle. The leaking oil accumulates above the needle, collects in the injector body between the intermediate rod and its bore and drains off through the drain tube (22, Fig. 1). The operation of the injector follows the normal principle. When the fuel pressure rises above the spring load on the needle, the needle is lifted off its seat and the fuel flows through the drilled passage and orifices in the injector tip, into the engine cylinder, until the pressure of the fuel is relieved at the pump. The needle is then forced in to its seat by the spring. In the injector used in the Busch-Sulzer engines in the C3 class ships, the length of the valve from the top of the cap to the bottom of the tip holder is about 18in. The injectors are manufactured in sizes from 21mm. to 45mm. in diameter of injector body, the largest size mentioned being that for the Busch-Sulzer engine. Separate pumps are provided for each cylinder and they are actuated by cams and adjustable tappets between the cam and pump plunger. The pump is of the constant-stroke type employing a spill valve to control the quantity of fuel injected into the cylinder at each stroke. The body of the pump (2, Fig. 3) bolts on to the upper flange of the pump housing (1) and the whole unit is attached to the engine by the lower flange of the pump housing. The fuel flows from the suction reservoir through the suction valve (50) to the pump chamber below. This valve is spring-loaded and automatic. The suction valve assembly, consisting of the valve (50), the valve cage (51) and the valve spring (52), is attached to the pump body by a nut. The plunger (41) and barrel (47) form an independent assembly screwed into the pump body, the bore of the barrel being lapped and the plunger lapped to this bore. The discharge valve assembly consists of the discharge valve (6), its guide (7), spring (5), automatic release cock (4), and a nipple (3). The spill valve is actuated from the control shaft (35) through the rocker arm (36) and the tappet (28). The rocker's fulcrum point is on the control shaft and is provided with a screw adjustment for setting the clearance between the top of the ball-link guide and the stem of the spill valve. In the pump housing is the plunger spring (43) and the spring cup which serves as a tappet for preventing any side thrust being transmitted to the plunger. Assembled in the pump housing is the fuel control mechanism comprising the rocker, the control shaft, the ball link, and the ball-link guide. The control shaft (35), a single throw hardened and ground crankshaft, is carried in needle bearings and connected to the engine governor mechanism by the lever (71) and link. In operation fuel is supplied from the fuel storage tank to the pump reservoir and as the plunger travels downward, oil is drawn into the pump chamber through the suction valve. On the upward stroke of the plunger (41) the fuel is delivered through the drilled passage to the discharge valve. This is lifted off its seat under the pressure of the fuel which flows through the injection tubing to the engine fuel injector. Delivery to the fuel injector continues until the spill valve opens. From that moment the fuel displaced by the plunger is returned to the intake reservoir and once the spill valve is opened the plunger is unable to create any more pressure. In the illustration the pump plunger is at its lowest position at the beginning of the plunger lift on the cam. The control shaft is in the "stop" position. At that point the clearance between the ball-link guide and the stem of the spill valve is about one-thousandth or two-thousandths of an inch. As soon as the plunger commences to lift, due to the rotation of the cam, this clearance is taken up and the spill valve opens. All the fuel therefore pumped by the plunger will be returned to the suction reservoir. When the control shaft is in the full-load position, the clearance between the stem of the spill valve and the ball-link guide will become

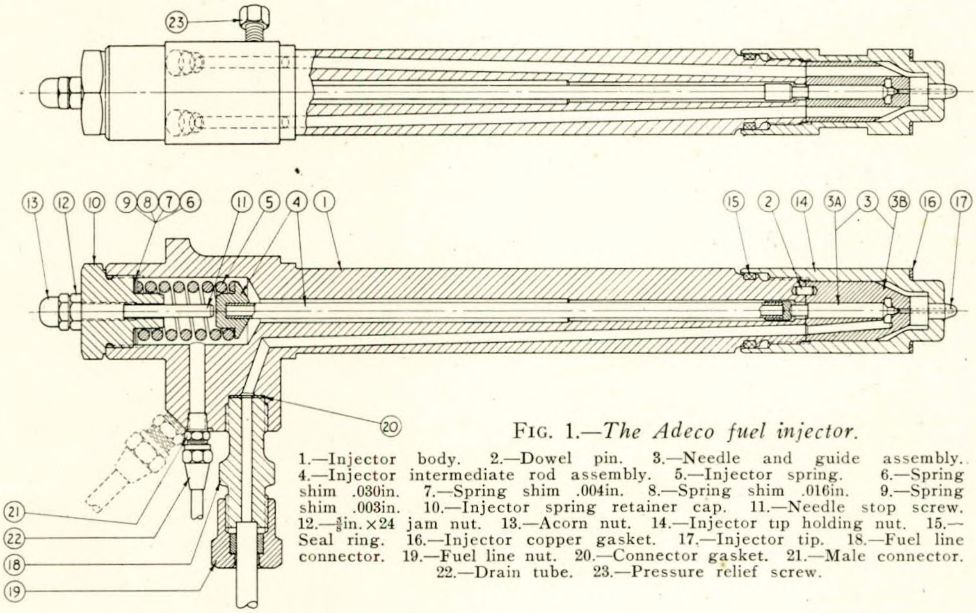


FIG. 1.—*The Adeco fuel injector.*

1.—Injector body. 2.—Dowel pin. 3.—Needle and guide assembly. 4.—Injector intermediate rod assembly. 5.—Injector spring. 6.—Spring shim .030in. 7.—Spring shim .004in. 8.—Spring shim .016in. 9.—Spring shim .003in. 10.—Injector spring retainer cap. 11.—Needle stop screw. 12.—$\frac{3}{8}$in.×24 jam nut. 13.—Acorn nut. 14.—Injector tip holding nut. 15.—Seal ring. 16.—Injector copper gasket. 17.—Injector tip. 18.—Fuel line connector. 19.—Fuel line nut. 20.—Connector gasket. 21.—Male connector. 22.—Drain tube. 23.—Pressure relief screw.

larger, and the plunger will be permitted to displace fuel through the discharge valve until this clearance is taken up and the spill valve lifted. The control shaft can be placed at any position between "stop" and "full load" so that the fuel quantity discharged can be varied at will, the regulation being effected through the engine throttle, which operates the control shaft. The pump is designed so that the suction valve assembly, plunger and barrel assembly and discharge valve assembly may be removed without disturbing the calibration of the pump. Before delivery to the fuel pumps the oil is centrifuged and heated to a temperature of 180° F.—*"The Motor Ship", Vol. XXI, No. 251, December, 1940, pp. 294-295.*

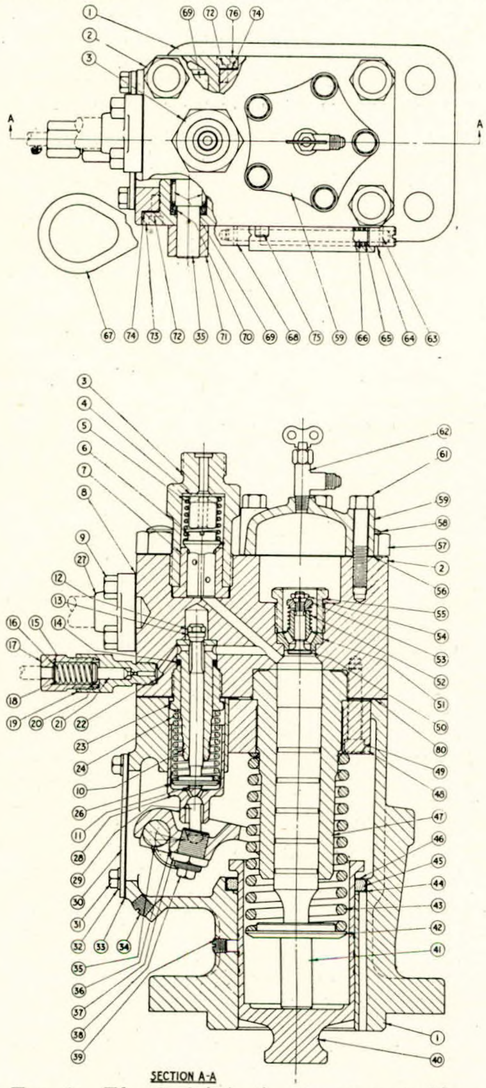


FIG. 3.—*The fuel injection pump assembly.*

1.—Pump housing. 2.—Pump body. 3.—Discharge valve nipple. 4.—Auto-relief valve stop. 5.—Discharge valve spring. 6.—Discharge valve. 7.—Discharge valve guide. 8.—Inlet tube flange gasket. 9.—Cap screw. 10.—Spill valve barrel. 11.—Spill valve stem. 12.—Spill valve nut. 13.—Spill valve head. 14.—Spill valve barrel gasket. 15.—Spring shim .020in. 16.—Spring shim .003in. 17.—Relief valve spring cap. 18.—Safety relief valve spring. 19.—Safety relief valve body. 20.—Safety valve spring seat. 21.—Safety relief valve. 22.—Copper gasket. 23.—Spill valve barrel nut. 24.—Spill valve spring. 26.—Spill valve spring collar. 27.—Inlet tube flange. 28.—Spill valve tappet. 29.—Spill valve tappet ball link. 30.—Pump housing cover. 31.—Cap screw. 32.—Standard light lockwasher. 33.—Pump housing cover gasket. 34.—¼in. standard pipe plug. 35.—Spill control shaft. 36.—Spill valve rocker arm. 37.—Spill valve adjusting screw nut. 38.—Spill valve adjusting screw. 39.—⅛in. standard pipe plug. 40.—Plunger spring cup. 41.—Plunger. 42.—Plunger spring collar. 43.—Plunger spring. 44.—Plunger cup oil seal washer. 45.—Plunger cup oil seal. 46.—Plunger cup oil seal retainer. 47.—Plunger barrel. 48.—Plunger barrel retaining ring. 49.—⅜in.-16×2in. LG socket HD cap screw. 50.—Suction valve. 51.—Suction valve cage. 52.—Suction valve spring. 53.—Valve spring collar. 54.—Suction valve lock nut. 55.—Suction cage nut. 56.—Suction valve cover gasket. 57.—Pump body stud nut. 58.—Pump body stud. 59.—Suction valve cover. 61.—⅜in-16 NC×2¼in. LG Hex. HD cap screw. 62.—Air vent cock. 63.—Groove-pin. 64.—Cut-out rod end. 65.—Cut-out spring. 66.—Cut-out rod. 67.—Cut-out latch. 68.—Groove-pin. 69.—Needle bearing. 70.—Oil seal washer. 71.—Control lever. 72.—Socket HD cap screw. 73.—Control shaft bearing cage. 74.—Control bearing cage gasket. 75.—Control lever stop pin. 76.—Control shaft bearing cage.

American Dredger "William L. Guthrie".

The suction dredger "William L. Guthrie", recently completed for the U.S. War Department, is a self-propelled vessel with Diesel-electric machinery. A 16-in. centrifugal dredging pump discharges through the stern, and the cutter head is carried on a steel ladder mounted in a well at the bow and supported by a structural gallows and A-frame. Two top-haul steel spuds are fitted in gate wells on the stern and are supported and operated from structural spud frames with built-in head sheaves. The shell and deck plating of the vessel are supported by longitudinal framing except in way of the engine and pump pits and propeller tunnels, where transverse framing is employed. The hull is divided into W.T. compartments by four longitudinal and 13 transverse bulkheads, four of the latter extending right across the hull. Four balanced rudders are fitted, two aft of the propellers for steering ahead and two forward and outboard of the propellers for use when going astern. The deck machinery includes a steering engine and three capstans, while the main power plant consists of a 1,200-h.p. Diesel generating set which supplies the current for the propulsion motors and dredging motors. There is also a 20-kW. auxiliary Diesel generating set. The main generator is of the three-wire type, rated at 650kW., 240/120 volts d.c., compound-wound. Overhung on the shaft of the main generator is a 65-kW. generator for supplying power to the hauling-winch motor by variable-voltage control. The two propulsion motors are each rated at 350 h.p. at 350 r.p.m., their speed being varied by field control over a range of from 250 to 350 r.p.m. The dredging pump motor is of the open type, compound-wound, 230 volts, d.c., capable of developing 500 h.p. at any speed between 225 and 300 r.p.m. The hauling and hoisting winch at the forward end of the dredger is of D.R. gear 5-drum type, the centre drum being for ladder hoisting, the outboard drums for spud hoisting, and the intermediate drums for hauling. The winch motor, of the reversible type, is of 75 h.p. at 250 volts, 450/900 r.p.m. The motor is started and controlled by increasing the voltage on the 65-kW. generator and varying the motor field current. The cutter motor, compound-wound for operation at 200 volts, d.c., has a capacity of 150 h.p. at any speed between 300 and 600 r.p.m.—*"Marine Engineering and Shipping Review", Vol. XLV, No. 11, November, 1940, pp. 111 and 120.*

C-3 Cargo Steamer "Exchequer".

This all-welded C-3 cargo steamer, built for the U.S. Maritime Commission by the Ingalls Shipbuilding Corporation, has now been taken over by the U.S. Navy Department and renamed "Pocomoke". She is the first all-welded ship to be completed under the Commission's building programme and is about 600 tons lighter than other C-3 vessels of this type. The entire structure of the hull was divided into assemblies or weldments of large size and practically the whole of the structural material, except certain curved platforms and frames, was assembled into such weldments. The inner-bottom weldments, including the inner-bottom plating, vertical keel, floors and intercostals, were assembled upside down for downhand welding. The bulkheads, side shell plating and decks were assembled with the stiffener, bean and frame side up. All the finish welding of the seams and butts of the flat surfaces was carried out by the Unionmelt process. On the ways the flat keel and bottom shell were first laid, regulated and welded, after which the inner-bottom weldments were erected. A substantial structure of shores and ribbands extending up to the third deck, was erected on the inner bottom, and on this the deck assemblies were placed after the transverse and longitudinal bulkheads had been placed in position. At the ends of the ship where the inner-bottom structure narrows down and the side framing and deck flare out, the outward line of shoring was carried clear of the inner bottom down to the concrete ways. The shoring and erection of materials for the extreme ends of the ship involved special treatment. Although the service speed of the ship is 10½ knots, she did just over 20 knots (in a light condition) on her official trials, the oil fuel consumption being 0·57/lb./s.h.p.-hr. for all purposes.—*"Marine Engineering and Shiping Review", Vol. XLV, No. 11, November, 1943, pp. 112-113.*

The Shortage of Sea-going Marine Engineers.

The reference to the above question made by Mr. Wm. Hinchcliffe in his Presidential Address to the Liverpool Engineering Society (*see abstract on p. 114* TRANSACTIONS, *Vol. LII, No. 6, 1940*), has been followed by a written discussion of the causes of this shortage and of possible remedies. Among the suggestions made by contributors to this discussion are some which emanate from lecturers in marine engineering at a famous technical college in this country and from a superintendent engineer of a well-known shipping company. One such contributor states that marine engineers are largely recruited from shipbuilding and ship repairing yards and that in his experience marine engineering firms are willing to do less for their apprentices in regard to technical education than any other type of engineering employer. A partial solution of the difficulty might, therefore, be a committee made up of representatives of shipping, shipbuilding and ship repairing firms, the Marine Engineers' Association and technical education establishments, to draw up a suitable scheme of recruitment, and practical and theoretical training for marine engineering apprentices. This contributor remarks that a complete solution will, however, not be obtained until the conditions of employment for marine engineers have been improved sufficiently to be comparable with similar posts ashore. Another contributor suggests that boys from the best of our schools should be advised and encouraged after matriculating to enter an engineering works and, while learning to use their hands, undergo a course of technical study, either by means of night classes or the "sandwiching" system; then, when they are 21, they should apply to a good shipowning company—no matter whether tramp or liner—by whom they would almost certainly be taken on, spend some years at sea and obtain their certificates, and afterwards either rise to the top of the profession as chief engineers, or take up executive or even administrative positions ashore. It could be argued that this might in turn cause a shortage of senior sea-going engineers, but the mesh guarding the higher posts ashore is fairly fine, in addition to which many engineers find life at sea more congenial than the undertaking of further responsibilities ashore. Such men would be the real engineer officers of the British Merchant Service—of a quality that will command conditions and remuneration commensurate with the benefits that will accrue to the shipowner. Another contributor adds the following practical suggestions for making the life of a sea-going marine engineer more attractive. (1) Let every effort be made to give the engineers "time off" in ports—especially in home ports. This may mean an increase in the shore staffs, but will do much to remove the sense of injustice often occasioned by "surveys while going round the land", and other strenuous overhauling in home waters. (2) Let "field days" on winches and other auxiliary machinery be regarded as emergency measures only, and not, as is still too often the present case, as things which have to be done for the good of the soul and the filling-up of the "work book". Shipowners may not regard them in this light, but a more ready employment of shore labour, or of day workers at sea, would do much to remove the necessity for them, and to remove some of the sea-going die-hard ideas about them. In this connection, the upkeep of the increasing amount of electrical equipment aboard ship should be revised. Not every junior engineer considers it a privilege to have lights, fuses, wiring, fans, etc., under his care—to be attended to in his "off watch" periods at sea. (3) Let there be a steady improvement in accommodation and feeding. The test must not be that it is "very good for a ship" or that it is much better than in ships of 50 years ago, but that it compares well with shore standards. (4) Abolish the usual custom of necessarily paying the master more than the chief engineer. After all, it is mainly upon the latter that the economical running of the ship depends, and it is his advice which is sought in case of accident to hull or machinery.—*"Bulletin of the Liverpool Engineering Society", Vol. XIV, No. 4, November, 1940, pp. 6-19.*

Purolator Oil Filters.

In the Purolator filters for Diesel and lubricating oil an ingenious method of construction is employed for the formation of the filtering surface. A metallic ribbon of bronze, monel metal or stainless steel is coiled edgwise on a perforated frame. This ribbon has a flat front edge and tapers in cross section. At definite intervals it is provided with projections of uniform height which support the front edge of the ribbon parallel to the frame on which it is wound. The degree of filtration is determined by the height of these projections, which can be made as small as 0·0005in. or less. It is claimed that the element not only ensures very fine filtration, but forms an "edge" filter of improved design, with the ability to shear particles of solid material from the filtrate even when the particle is smaller than the width of the opening between the edges of the ribbon. The filtrate is forced through the narrow slots formed by the metallic ribbon, particles of foreign matter being left behind on the outside surface of the element. The particles thus removed build up the front edges of the ribbon and the tapered cross-section of the ribbon renders it impossible for wedging to take place behind the front edges and so cause choking of the filtering spaces. The projections on the ribbon ensure that the filtering spaces are maintained without variation so that the designed degree of filtration is always provided. The metallic ribbon is wound tightly upon the element body and is held permanently in place by means of end caps. The element may be washed in paraffin or other suitable fluid and is of robust construction with a long life. Where an external method of cleaning is necessary, a separate cleaning mechanism in the form of a scraper may be provided. It consists of a spring knife blade supported in a frame which carries the element assembly. The outlet end of the element engages through a cross piece with a short drive shaft, which is connected to an external handle at the top of the filter. By turning the handle the element is caused to revolve against the knife blade, which cuts underneath the solid material adhering to the filtering surface and lifts it away, so that it falls to the bottom of the sump and may be removed from the filter by draining periodically. Purolator filters are usually furnished with element spacings between 0·003in. and 0·005in. for general lubricating oil applications and for light Diesel oil from 0·001in. to 0·002in. They may be applied in both pressure and suction lines. The filters are manufactured in sizes having a range of capacity from a few pints up to many thousands of gallons per hr. and pressures up to thousands of lb. per sq. in. The complete filter with body can be supplied for installation in a pipe line, or the element only can be furnished for immersion in a tank, or for building as part of the engine. Certain advantages are claimed for the design. In the first place the width of the filtering spaces is accurately maintained over the whole of the element surface. Secondly, owing to the tapered cross-section of the ribbon the pressure drop is reduced to a minimum and there is no possibility of dirt wedging in the filtering passages. Thirdly, the largest capacity per unit area of filtering surface is made possible by the fact that the spacing projections are kept to the smallest width, and the size of the filter for a given capacity is consequently reduced. Finally, element spacings between 0·020in. and 0·0005in. or even smaller, can be used.—*"The Oil Engine", Vol. VIII, No. 91, November, 1940, p. 190.*