TECHNICAL ABSTRACTS

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PROPELLERS AND PROPULSION

Cavitation Tests with Model Propellers in Natural Sea Water with regard to the Gas Content of the Water and its Effect upon Cavitation Point and Propeller Characteristics. EDSTRAND, H. *Publication of the Swedish State Shipbuilding Experimental Tank No.* 15, 1950.

This paper is complementary to publication No. 6 of 1946 describing cavitation experiments on two model propellers made in tap water. The present paper deals with some similar experiments with the same model propellers in natural sea water and includes some further work on the results from the previous tests.

The solution of atmospheric gases in distilled and sea water, its importance in testing technique in cavitation tunnels, and methods of measurement of the gas content are discussed. The results of the present cavitation experiments are set out in graphs and sketches. As with tap water, the quantity of gas dissolved in the sea water may have an appreciable effect, and the same distinct differences between bubble cavitation and sheet cavitation concerning their dependence upon gas content are noticeable.

Characteristics at high advance coefficients are considerably influenced by sheet cavitation on the face of the blades, but this effect is independent of the quantity of gas dissolved in the water. At lower advance coefficients, within the peak efficiency range and below, the characteristics fall rapidly with increasing gas content. Gas separation and bubble formation are facilitated in sea water and have a tendency to increase as gas content decreases, owing to a reserve of chemically fixed carbon dioxide. It is not certain that the differences between propeller characteristics in sea and tap water are solely attributable to dissociation of carbon dioxide. Small solid particles in the water may be a contributory factor. The salt content is shown to have no appreciable effect upon the characteristics in the sheet-cavitation range. Torque and thrust coefficient curves for the atmospheric tests in sea water lie below the corresponding tap-water curves.

Comparison is made with Numachi's experiments and with circulation theories.

Variation of Efficiency with Pitch Ratio. LERBS, H. *Admiralty Experiment Works Report No.* 29/49 (1949).

Methodical series propeller results cover a range of pitch ratio of about 0.4 to 2.0, and indicate that the peak efficiency increases with pitch ratio, although the increment is small as the pitch ratio approaches 2.0. This report is a theoretical analysis to guide extrapolation to higher pitch ratios. The parent propeller is of three blades and 0.35 blade-area ratio. It is found that the peak efficiency increases from 0.78 at unit pitch ratio to a maximum of 0.85 at 2.4 pitch ratio, and then decreases to 0.68 at 10.0 pitch ratio. The advance coefficient for peak efficiency increases more or less progressively from 0.928 at unit pitch ratio to 8.0 at 10.0 pitch ratio. The theoretical curve shows reasonable agreement with test results over the comparable range of pitch ratio from 1.0 to 2.0. To work at the maximum peak efficiency of 0.85, the propeller r.p.m. would be small, *e.g.*, 130 for a propeller of 10-ft diameter and 24-ft face pitch advancing at 30 knots.

Application of Theodorsen's Theory to Propeller Design. CRIGLER, J. L. *National Advisory Committee for Aeronautics. Report* 924, 1949.

A theoretical analysis is given for using Theodorsen's propeller theory to obtain the load distribution along a propeller radius to give the optimum propeller efficiency for any design condition. The efficiencies realized by designing for the optimum load distribution are given in graphs, and the optimum efficiency for any design condition may be read directly from the graph without any laborious calculations. Examples are included to illustrate the method of obtaining the optimum load distributions.

A list of references is given.

Note on the Slip of a Propeller Working Under Varying Conditions (French). DINECHIN, G. DE. *Association Technique Maritime et Aéronautique, paper read* June 1950.

A given propeller sometimes has to work under widely different conditions of slip, as for example the propeller of a submarine when submerged or surfaced. The present memorandum develops a simple formula which may be helpful in problems of this kind.

The Development of Cavitation on the Propellers of a Running Torpedo. ANDREWS, D. G. *Torpedo Experimental Establishment, Greenock. ACSIL/ ADM*/49/515. *S.T.R. No.* 548, Dec. 1948.

A comparison has been obtained of the cavitation on three types of propeller, namely, standard four-bladed propellers, six-bladed, cast-steel propellers having blades each of the same chord and pitch grading as the standard type, and Japanese propellers having four blades of increased chord. Runs were made with Mark 8 torpedoes at 45 knots—12 feet and 50 knots—20 feet, and a qualitative assessment was obtained by the use of paint which is removed by the shock. The cavitation patterns obtained are examined in the report and it is shown that four-bladed propellers of increased chord and pitch appear to be least prone to tip-vortex cavitation. With standard propellers, the after propeller is shown to be overloaded, and with the six-bladed propellers of standard shape and pitch the results are disappointing, perhaps because of the effective over-pitching of the tips.

Research on the Possibility of Improving the Efficiency of the Screws of Warships by Employing the Effect of Cavitation on the Thrust (Dutch). GROOT, D. DE. *Schip en Werf*, **17** (1950), p. 251 (9 June), and p. 288 (23 June). *Publication No.* 89 *of the Dutch Shipbuilding Experimental Station, Wageningen.*

The effect is investigated of thrust- and torque-breakdown through cavitation on the optimum efficiency of the three-bladed propellers of warships. The Author uses the results obtained with full-scale and model screws under cavitation. His references are listed in a bibliography, and they include the papers by R. W. L. Gawn and by F. M. Lewis.

Boundary lines are constructed for different degrees of thrust- and torque-breakdown. With the aid of these diagrams and those of Gawn, a method is devised for the calculation of screws that work in the cavitation zone and employ the effect of thrust- and torque-breakdown. The results obtained with this method for the propeller of a destroyer are compared with corresponding trial results. The difference in the revolutions of the screw was $\pm$ 1%, and that in the s.h.p. between 3% and 6%. The efficiencies of model screws tested in the Dutch tank are found to be about 2½% higher than the figures obtained from Gawn's diagrams.

Finally, a number of calculations are made for the propeller of a destroyer running at different speeds from 325 r.p.m. to 475 r.p.m. and constant ship speed (37.5 knots). The calculations are carried out for two different conditions ; one, where the propeller works at the onset of thrust-breakdown, and the other within the breakdown range. The efficiency of the resultant optimum screw is computed for the cruising speed of 18 knots.

The analysis of the results of the calculations shows that the acceptance of a thrust-breakdown offers advantages only for propeller speeds above 325 r.p.m. At a ship speed of 37.5 knots and 475 r.p.m. the efficiency of the screw is about 6% higher than that of a propeller designed for no thrust-breakdown. This corresponds to an increase of the ship speed by 0.8 knots. At the cruising speed, the propeller efficiency for breakdown conditions would be 10.2% higher than for a normal propeller.

The Schnitger Propeller. *Motor Ship*, **31** (1950), p. 142 (July).

A description is given of the Schnitger propeller. In this propeller a light conical circular shroud is either welded at half propeller radius, in separate segments, between the propeller blades, or is made in one casting with the propeller when the propeller is being built. The shroud rotates with the propeller and has the effect of preventing the swirling of the water in front of the propeller and within the propeller itself. The shroud reduces the tendency of the water to flow radially on to the pressure side of the blade tips.

The hydrodynamic action within the shroud has not yet been fully explained. Full-scale service measurements have confirmed test data from tank experiments. Results of trials are given on the Norwegian twin-screw 14,000-ton motor tanker *Ringfjell* and the whaler *Krutt* ; they show that for the same speed (12 and 13½ m.p.h. respectively) the brake horse-power is reduced by 8.1 and 10.5% respectively. The large Norwegian 12,000-h.p. twin-screw motor ship *Skaugum* has Schnitger propellers weighing 12 tons each.

WELDING AND OTHER METHODS OF CONSTRUCTION

New Applications for Welding. *Shipping World*, **122** (1950), p. 391 (April).

The writer discusses the advantages and applications of welding in maintenance and repair work in ships. The process is flexible and trustworthy, but should be undertaken by skilled operators.

Welding has proved particularly useful for boiler reconditioning where fractures are awkwardly situated, and also for rudder repairs. It has been successfully applied to the distorted and fractured stern-frame of a ship damaged by grounding. The frame was 12 in by $7\frac{3}{4}$ in with a back post measuring 36 ft 9 in and keel extending 17 ft $5\frac{1}{2}$ in ; the time saved by welding was substantial.

Important welding repairs are carried out on diesel engines ; in one recent case three cylinder covers weighing 2 tons, with extensively cracked water jackets, were reconditioned.

Notable lines of recent progress are the technique of handling very thick metal, the control of heat flow, and the welding together of dissimilar metals. Welding can also be used to repair damage due to wear or corrosion.

The possibility of welding light alloys to steel is receiving increasing attention in ship design.

Practical Butt Weld Inspection using Ultrasonic Flaw Detection. RANKIN, A. C. *Welding*, **18** (1950), p. 199 (May), and p. 243 (June).

An account is given of the essential principles and theory of weld testing by the ultrasonic technique, and of various methods of using it in practice.

With regard to the relationship between radiography and ultrasonic flaw detection, it is claimed that economy, portability, and simplicity are favourable towards the latter. Where the two methods are both suitable, radiography gives the shadowgraph representation of flaws, which makes flaw differentiation relatively simple, and where this is desirable is more successful. Ultrasonic flaw detection, however, is generally more convenient for the measurement of flaw depth, and is also more sensitive in finding cracks which are difficult to detect radiographically, and which it may be imperative to locate. As a result the combined use of radiography and ultrasonic flaw detection can be most effective in increasing the general efficiency of weld testing.

Apart from this, ultrasonic flaw detection, using the transverse wave technique, is applicable to sections from about $\frac{1}{8}$-in thick upwards and thus finds applications beyond the present scope of radiography. It is also readily applied to pipe welds, flash-butt welds and similar cases where radiography has serious limitations.

There are numerous diagrams and photographs.

The Inspector's Approach to Arc Welding. EPHITHITE, C. W. *Welding*, **18** (1950), p. 218 (May), and p. 255 (June).

The Author discusses the various duties of an inspector or supervisor responsible for maintaining satisfactory standards of welded work. The inspector's programme is outlined and reference made to the various types of joint and the kind of faults likely to be encountered.

The Author refers at length to fillet welds, deep penetration welds, square butt welds and briefly to automatic welding. He indicates common defects and the points to be watched.

Shrinkage Distortion in Welding. SPRARAGEN, W., and ETTINGER, W. G. *Welding Journal*, **29** (1950), p. 292-s (June), and p. 323-s (July).

The Authors present the information available in the literature on the subject of shrinkage distortion in the form of charts and formulae with suitable correction factors. In view of the fact that more than 20 variables are involved, arbitrary assumptions have been made throughout which are

believed to represent average conditions. Formulae are evolved for transverse shrinkage of butt and fillet welds, and the effects of plate width, length of joint, degree of applied restraint, joint design, positions of welding, peening, thermal factors, and welding method are discussed. Methods of calculating angular distortion and longitudinal shrinkage are also given, and recommendations are made for the control of distortion due to welding.

There is a bibliography.

SHIPBUILDING (GENERAL)

The Timber Problem for Ships' Decking. *Shipbuilding and Shipping Record*, **75** (1950), p. 672 (June).

The experimental work being done by the Timber Development Association to find a satisfactory timber to replace teak on ships' decks has reached a stage where preliminary conclusions have been drawn. These are presented in Selected Report No. 11a.

The stability and surface qualities of experimental areas of decking have been compared with those of teak. Ipe with margins of white peroba was laid on the *Haparangi*. The ipe gave fairly satisfactory results and the timber appears to stand up to deck conditions very well, but the white peroba though closer in weight to teak is lowered in value by checking and splitting.

Similar tests carried out on the *Sussex* with agba and ayan show that the agba should wear well if carefully selected.

The ayan, although hard wearing, has a tendency to split. Kokrodua laid at the head of a companion way on the *Himakura* proved very satisfactory except as regards colour, but the blackening effect observed may possibly have been due to some preliminary treatment. Further observation of this wood should prove of great interest.

It is observed that when the political situation in Burma is stabilized, teak may again be available in sufficient bulk ; nevertheless, if satisfactory alternative timbers can be found it will be of advantage to shipbuilders.

Development of Graphic Aids to Preliminary Design. RIDGELY-NEVITT, C. *Journal of the American Society of Naval Engineers*, **62** (1950), p. 303 (May).

The Author presents in graphical form a number of approximations for use in preliminary design, particularly in the early stages before drawings have been made and more exact computations can be undertaken. To do this, data taken from existing ships or recently completed designs have been plotted, and the resulting charts reflect, as nearly as possible, recent American practice. The charts cover displacement, length, transverse and longitudinal metacentres, form characteristics at various draughts, depth, and power and revolutions.

There is a bibliography.

MATERIALS: STRENGTH, TESTING, AND USE

Influence of Temperature on Young's Modulus of Alloys for Jet Engines (French). VIDAL, G., and LESCOP, P. *Revue Générale de Mécanique*, **34** (1950), p. 170 (May).

Young's modulus was determined by an acoustic method over a range of temperature, from ambient to above the temperature of utilization in a jet engine, for light alloys, ferritic steels, and refractory steels and alloys. Curves of E plotted against temperature were linear for the light alloys tested, the value of E decreasing with increase of temperature. The ferritic steels did

not follow a linear law, the slope of the curve increasing with temperature ; the shape of the curves and the values of E were very little affected by chemical composition. Two of the refractory austenitic steels, a straight 18/8 steel, and an 18/8 steel alloyed with 10% tungsten and cobalt followed a linear law up to 1,800°F ; an 18/8 steel alloyed with 4% tungsten and Nimonic 80 were linear up to the temperature of utilization—between 1,100°F and 1,350°F, the discontinuity in the curves corresponding with anomalies in their expansion curves, probably caused by a physico-chemical transformation. A large range of refractory alloys of widely varying chemical composition was also tested. It is concluded that the relative decrease in E between the ambient temperature and the utilization temperature was of the order of 10% for light alloys, 12% for ferritic steels, and up to 30% for refractory austenitic alloys.

Heat Treatment of Steel Forgings for Gas Turbines. KIRKBY, H. W. *Metallurgia*, **41** (1950), p. 317 (April).

The Author discusses the problems that arise when dealing with large forgings in the more complex austenitic steels, due to the high solution temperatures employed. The steels being used or under consideration for the long-life gas turbine come under two groups ; ferritic steels and austenitic steels. In general, the production and heat treatment of the ferritic steels follow normal low-alloy practice. Special ferritic steels with improved creep resistance, however, require heat treatments above this general range.

When dealing with the complex austenitic steels, it is almost impossible to carry out bulk heat treatment satisfactorily, because of the difficulties of temperature control and uniformity in the range 2,200°F–2,400°F ; and individual heat treatment is preferable whenever it is practicable. Creep resistance is directly related to the solution temperature, and correct heat treatment is extremely important. The handling problems involved in the heat treatment of the larger forgings are considered, and ageing treatments and the final tests carried out on the finished article are mentioned.

Vinyl Plastic Facings in Naval Construction (French). *Journal de la Marine Marchande*, **32** (1950), p. 1021 (11 May).

Vinyl plastic facings such as Durofilm can be applied cold, are non-ageing, flexible, resistant to corrosive agents, and easy to service and repair. They are particularly suitable as a lining for containers and pipelines for wine, oil, soft drinks, etc. ; for filters, heat-exchangers, and pipes in the bottom of the hold ; and promise to have applications for protecting structural elements against corrosion and for petrol tanks and piping. To get the most durable results, the surface on to which the Durofilm is to be sprayed must first be carefully polished to give a completely smooth finish.

Residual Stresses in Metals. BALDWIN, W. M., JR. *Proceedings, American Society for Testing Materials*, **49** (1949), p. 539.

The Author reviews the progress made in the understanding and treatment of residual stresses in metals during recent years. Methods of determining residual stresses are described, and it is emphasized that these methods are in most cases approximations. A representative group of the residual stress patterns that exist in metals is discussed, including residual stress patterns arising from thermal effects in flat plates and cylinders, and those arising from mechanical effects, in strip rolling, drawn wire, sunk and drawn tube.

Residual stresses may be reduced by heating, usually known as relief annealing, or the residual stress pattern may be altered by subjecting the

metal to plastic deformation. Not all forms of cold work reduce originally existent residual stress patterns, but, in general, it can be stated that any of the surface-working processes can be employed as residual stress relief measures since they tend to induce compressive residual stresses at the metallic surface. Repeated bending can be similarly employed.

A residually stressed metal can warp or distort when machined or cut, and residual stresses are an important contributing factor in the fracturing of metals and other substances, either in the presence of corroding media, on heating, or by brittle fracture.

A list of references is given.

The Cold-Working Capacity of Cr–Mo–Si Alloy-Steel Superheater Tubes (German). *Zeitschrift des Vereines Deutscher Ingenieure*, **92** (1950), p. 344 (11 May).

Several cases have arisen in which superheater tubes of Cr–Mo–Si alloy steel have developed longitudinal cracks during boiler operation or even during construction. The cracks always started from the bends in the tubing, and were mostly along the neutral zone in the plane of flexure. There was often a further fissure at the opposite tube wall. The cracks in the neutral zone were at the inner tube wall, and those in the external bend always started from the outer tube wall.

Transverse stresses were held responsible for the longitudinal cracks, and since such cracks occurred after cold working and before the tubing was operated in the boiler, the cause was thought to be the spring-back of the material after bending in one direction. Various tests of sample tubes from one steel batch showed clearly the effect of the first deformation, and therefore of the dimensions of the tube-bending roller. The crystalline structure was also found to have an important effect on the tendency of the tubing to crack. Specimens with a low capacity to resume their original shape all had a pronounced structure of irregularly arranged grains and a de-carburized marginal zone, and those with a high capacity of returning to the original shape had a fibrous structure and no pronounced marginal zone. Coarse marginal structures invariably produced cracking during boiler operation. It is recommended that bent tubing should be annealed, and that radial compression stresses should be avoided.

There is one reference.

The Stresses in the Tube-Plates of Boilers (French). BALLET, M., and MALLET, G. *Ass. Tech. Marit., paper read* June 1950.

The paper, which is a continuation of an earlier one read to the same Association by Legendre in 1938, deals with the determination of the stresses in boiler-tube plates with staggered holes in diamond arrangement by the photo-elastic method.

In the first part, the Authors set out briefly the main principles of the photo-elastic technique as adapted to the solution of their problem.

The second part discusses the results of many tests on models of tube-plates with different arrangements of holes. The stress patterns are shown in six charts, which give the stresses at the extremities of diameters of the holes parallel to the directions of the external load and the maximum stresses at the edges of the holes.

BOILERS AND STEAM DISTRIBUTION

The Priming of Boilers (German). *Z.V.D.I.*, **92** (1950), p. 290 (21 April).

The short article reviews some German literature and research on the priming and operation of boilers. The main causes of priming are surface tension, formation of colloidal particles, and electrostatic forces. Low surface tension is in itself insufficient to produce the trouble. Clean water, which is free from salts, will not prime. Some experiments, though not wholly conclusive because they did not properly reproduce operational conditions, showed that alkaline salts promote priming much more than neutral salts, and that the salt concentration at the surfaces of the steam bubbles is the criterion for the degree of priming.

Salts do not themselves form the colloids which are responsible for priming, the presence of hardening agents being necessary. Precipitated hardening agents can be redissolved by alkalis. Hence, the difficulties experienced with feed-water of slight hardness to which alkalis are added for neutralization. Colloidal salts in boiler water generally have negative polarity and can therefore be caused to coagulate by adding other colloids which are electro-negative.

Boiler design is also an important factor in the avoidance of priming. The steam space in the drums should be as great as possible. The installation of baffles does not help very much. It is preferable to fit separator drums and traps, and to have the correct location of the risers with regard to the steam drum. Steam receivers are mostly ineffective. Fitting cyclone-type separators is to be recommended. There are some special boiler designs, like the Schmidt-Hartmann boiler, in which priming has been appreciably reduced.

Investigation of Water-Tube Boiler Characteristics. *Engineering and Boiler House Review*, **65** (1950), p. 40 (Feb.), p. 74 (March), and p. 119 (April).

A survey is given of extensive research carried out in Russia on a number of problems connected with water-tube boilers. Experimental and analytical investigations of hydraulic-flow characteristics of steam-water mixtures in steam boilers are described ; and a number of recommended design graphs are given, which are based on the data obtained and cover the very considerable range of operating conditions normally encountered in boiler plant.

Various methods of securing minimum steam contamination by appropriate design of the boiler circuit are discussed, and a proposed new system of steam purification involving double washing of the boiler steam is described in detail. It is claimed that this scheme has better self-regulating characteristics than conventional systems, and that the operational control should be more simple.

The importance of correctly designed steam-temperature control equipment for satisfactory superheater operation is emphasized, and an account is given of an investigation into the operating characteristics of a steam cooler of the condensing type. In order to ensure a uniform distribution of moisture to superheater elements, it is recommended that generally all tube inlets at the superheater inlet header should be arranged in a single row. The installation of a de-superheater between superheater stages in the intermediate header in a Russian boiler of 400,000 lb/hr. evaporative capacity is described. Long-term operating records of a boiler equipped with a de-superheater of this type showed that no superheater damage was caused by uneven steam-temperature distribution. There was, however, some leakage of the superheater element joints on the header due to thermal expansion effects. A design that will overcome this defect has now been developed.

Boiler Feed-Water Regulation (French). LIVOIS, M. DE. *Chaleur et Industrie*, **31** (1950), p. 120 (May).

The problem of feed-water regulation must be studied in relation to the particular installation. It depends on the boiler pressure, the characteristics of the boiler, the importance of the " ebullition effect " (see below), properties of the water, type and pressure characteristics of the pumps, etc., number of boilers fed from a common reservoir, type of furnace and quality of fuel.

In regulating the water level in the boiler, there is no self-stabilizing effect and consequently, in the event of malfunctioning of the automatic regulator it is essential to have a warning device and also to have a rigorous daily check on the correct working of the regulators.

After discussing in detail the causes and characteristics of the " ebullition effect," wherein the boiler water is permeated by steam bubbles and hence has a lower density and rises to a higher level, for the same mass, the advantages of single and multi-element regulators are discussed. If a constant level is called for in the boilers, the phenomenon of ebullition, which follows rapidly on variations of the régime, imposes a heavy load on the regulating mechanism and on the pumps ; it may therefore be an advantage for the regulator not to respond too quickly to changes in level.

Single-element regulators, in which the action of the valve regulating the water-supply is controlled solely by the water level, are simple and generally satisfactory when well constructed. They are, however, very sensitive to the ebullition effect. Two-element regulators respond to variations in the steam output as well as variations in the water-level ; the response of these mechanisms can be very rapid. They have two advantages over the single-element regulator—the possibility of a rising regulator-characteristic curve (water level plotted against steam output), and their response to changes in water level is automatically slowed up in the presence of expansion. Three-element regulators respond also to variations in the water supply ; this eliminates the disadvantages of a bad valve profile and of variations in pump pressure. Regulators must be sensitive, of quick response, and stable in operation ; the three-element regulator is superior from the point of view of stability and absence of hunting.

Developments in Water-Tube Boiler Design. SIMONSON, W. F. *Fourth World Power Conference, London*, 1950.

The Author reviews the trend of design of water-tube boilers against the background of conditions arising during and in consequence of the second World War, with particular reference to load and fuel characteristics and availability requirements in Great Britain. Present trends in unit capacity and operating pressure are given in graphical form in two figures. Current practice in methods of firing, circulating systems, and general features of design, is outlined, with a more detailed description of the design characteristics of the stoker-fired and pulverized-fuel fired boiler. The advent of the spreader type stoker and its future possibilities are noted.

The trend towards large boiler unit capacities operating on high-temperature, high-pressure steam cycles is shown to postulate the adoption of pulverized-fuel firing, and developments in design to meet such requirements are indicated. The paper is illustrated by nine reproductions of drawings typical of current and projected water-tube boiler designs exhibiting the features described.

Reference is made to current practice in regard to the maintenance of steam purity and to water-treatment procedure. Methods of superheat control and the trend in regard to auxiliary control systems in general are briefly outlined,

and developments in constructional methods are described, in particular the extended use of welding for pressure parts and other plant items. The paper concludes with an indication of possible future trends of development in the use of heat cycles, and the relation of the water-tube boiler thereto.

Oil-Fired Marine Boilers. GREGSON, W., CAPTAIN (E), R.N.R. *Fourth World Power Conference, London*, 1950.

The paper deals with the present state of the art of development of marine oil-fired boilers for the British Merchant Service and for ships built in British shipyards during the post-war years. The change-over from coal to oil as fuel has greatly influenced the basic designs of such boilers ; their conception starts with a furnace design appropriate to liquid-fuel burning, after which consideration is given to the surfaces absorbing radiant heat and also to the bulk of the convection surface beyond the superheater zone. Secondary heating-surface, provided by air pre-heaters or economizers, or a combination of both, is discussed. Examples are given of typical boiler installations in cross-channel ships, large liners, intermediate and cargo liners, cargo ships, and tankers. For the high-powered units pressures from 540 to 650 lb/sq. in. superheated up to 850°F, have been used ; but for lower powers the steam conditions most generally adopted are 450 lb/sq. in. and 750°F. One instance of four ships running at 850 lb/sq. in. and 850°F, with reheat (turbo-electric machinery) is cited. The trends towards wide-range oil burners, automatic combustion control, and automatic-sequence soot-blowing are noted.

STEAM ENGINES AND STEAM TURBINES

Diesel Engine Design Considerations applied to Marine Steam Engines (German). OPPITZ, A. *Schiff und Hafen*, **2** (1950), p. 57 (March).

This paper was read in November 1949. The Author considers certain improvements made to diesel engine design and their application to marine steam engines. They are :—(1) Utilization of the cylinder losses owing to incomplete expansion and insufficient vacuum. This is possible by fitting an exhaust-steam turbine. (2) A closer, more compact design of the engine.

After an exhaustive study of these two main points for four-cycle diesels, the Author makes proposals for a new design of marine steam engine.

In existing arrangements, the power supplied by an exhaust steam turbine is either fed into the main shaft (Bauer-Wach, Brown-Boveri), or it is used for compressing the exhaust steam from the H.P. cylinder in a steam compressor before passing it into the following stage (Götaverken). The former system is studied in greater detail. It is seen that there is a close connection between the revolutions of the turbine and those of the steam engine. This relationship is more complicated than would follow from the theoretical engine diagram. Indicator diagrams, which the Author analyses, reveal three pressure waves during every cylinder cycle, and he shows that the greater part of the useful exhaust energy is delivered during the exhaust lead period.

The Author's theoretical analysis shows that desirable features are a high velocity of exhaust opening during the exhaust lead (*i.e.*, ports, not valves), as many pressure impulses per revolution as possible (several cylinders), a small volume of the steam pipe lines, and a simple arrangement of the piping. This means a multi-cylinder, single-expansion engine, and steam engine and turbine in one compact unit. The resultant gain in power may then be 40% or more.

Engine and turbine can conveniently be built together in a compact block either by grouping the cylinders around two parallel shafts (Christiansen and Meyer), or by employing the V-type cylinder arrangement of diesels. The

Author studies the effects of design modifications to such a V-type single-expansion engine with four double-acting cylinders. The variables he discusses are selection of angle of inclination of the cylinders ; offset or in-line of cylinders, the former being preferable ; valve gear and regulation ; selection and arrangement of cross-head guides, guides with concave cross-section being preferred. The result of these considerations is the Author's design project.

Operation of Turbines and Gears. BROWN, R. J. *Marine Engineering and Shipping Review*, **55** (1950), p. 65 (May).

The Author discusses the operation of the modern marine steam turbine and gears in relation to general design factors. Operation factors of the turbine affecting steam rate performance are considered under two headings, direct and indirect. The former are of effect, and include such things as inlet steam pressure and temperature, exhaust steam pressure, r.p.m., valve control, extraction demands, steam seal regulation, lubricating-oil temperature, and sudden vibration. The indirect factors are of consequence generally after a period of time, and include bucket or blade clearances, packing clearances, cleanliness of steam, moisture separation, leaky inlet and extraction valves, proper drainage after shutdown, and sustained vibrations.

Turbine operation factors that affect mechanical performance are, in general, fairly well recognized. The object should be to keep the rotor clearances to the close tolerances allowable, to keep the parts and casings under pressure in a tight condition, and to keep the control and safety devices functioning freely. The most important objective in gear performance is to provide an ample supply of clean oil to the gear mesh and bearings. Periodic examination of the tooth surfaces for signs of misalignment and resultant overloading is necessary. Good operation of propulsion gears requires that the r.p.m. should be considered as well as the power output in order to avoid overloading.

GAS TURBINES

The Combustion of Residual Fuels in Marine Gas Turbines. *Admiralty Bulletin No.* 29 ; see also *Engr.*, **189** (1950), p. 511 (28 April).

It is recognized that, if gas turbines are used at sea, it will be virtually essential to run them on residual grades of fuel. For this reason, an extensive study of the heavy fuel problem is being undertaken by the Admiralty in close collaboration with the National Gas Turbine Establishment. The investigations cover fuel characteristics, atomization, combustion, heat transfer, blade and heat-exchanger fouling, and materials.

The equipment at present in use at the Admiralty Engineering Laboratory consists of a Metropolitan-Vickers " Gatric " engine, coupled to a " Dynamatic " brake, a pressurized combustion-chamber testing rig and apparatus for the gravimetric chemical analysis of combustion gases. Additional equipment is on order. Facilities are being provided for brake-testing small turbines of up to 200 s.h.p. at speeds between 15,000 and 40,000 r.p.m. The Gatric engine had been run for some 120 hours up to the end of 1949, using Pool gas oil, and a number of tests were carried out. The combustion rig has been operated principally on kerosene, initially to develop satisfactory operating technique and instrumentation and latterly to provide data regarding the rate of oxidation of various blade materials in the combustion products of kerosene.

The ultimate objective of work on the combustion rig, Gatric engine, and blade test turbines is to secure satisfactory operation of gas turbines on boiler fuels falling within the Admiralty specification.

Rotary Gas Turbine Compressors. JACKSON, I. E. *J. Am. Soc. Nav. E.*, **61** (1949), p. 829 (Nov.).

The principal characteristics of existing types of compressor are discussed. Requirements for marine uses are considered to be :—

(*a*) Maximum reliability of operation (10,000–100,000 hrs.).
(*b*) High efficiency at full load and part load (20% full power).
(*c*) Broad stability range.
(*d*) High pressure rise per stage.
(*e*) Minimum weight and space requirements.
(*f*) Minimum operating noise level.
(*g*) Minimum sensitivity to surface deposits.
(*h*) Minimum sensitivity to vibration and shock.

Marine gas-turbine engineers have exercised more freedom than aircraft designers in the selection of compressor types. Axial-flow, mixed-flow, positive-displacement, and centrifugal-flow compressors have all been utilized in the U.S. Navy programme. The characteristics and relative advantages of these types are discussed.

Standardization of methods of representing the results of compressor tests is not yet universal. A graphical method accepted in the United States is described, and a chart is given suggesting a rough basis for rating the various types of compressor.

DIESEL AND OTHER I.C. ENGINES

Chromium Plated Engine Cylinders (Swedish). HORST, J. VAN DER. *Teknisk Tidskrift*, **80** (1950), p. 359 (22 April).

The paper, which was read in November 1949, is an introduction to the technique of chromium-plating Diesel and petrol-engine cylinders, and discusses its effect on engine performance. Coating cast iron and light-metal cylinders electrolytically with chromium brings about a better contact between base metal and the layer ; and modern methods produce a porous chromium surface which is better capable of retaining the lubricant than a solid surface. At the same time, the resistance of the plated cylinder liners to wear is considerably increased.

The Author describes a number of micrographic tests on chromium-plated flat specimens and discusses etchings of the samples. He reports also on comparative experiments with plated cylinders on the test bed which showed clearly their superiority over normal components. They include tests with plated light-metal liners in a " Comet II " engine in Holland.

The written discussion was devoted to extensive tests with the chromium-plated cylinder liners of four-cycle and two-cycle marine engines in U.S.A., the results of which were taken from American publications.

Summary of Current Developments in Large Diesel and Gas Engines. BOYER, R. L. *Fourth World Power Conference, London*, 1950.

This paper summarizes the present status of Diesel and gas engines in America. It does not include automotive sizes, covering only engines of 8-in bore and larger. America has not kept pace with Europe in the application of the Diesel engine to the marine field, but there is evidence that this situation is undergoing a change. One American builder of large marine engines uses the Doxford type of design. Geared drives appear to be increasing in favour, and, with the development of electric couplings of the eddy-current type, and the electric drive, or a combination of the two, the trend indicates more cylinders at higher r.p.m. to gain both space and weight. An outline is given

of progress in ratings, speeds, weight reduction, and efficiency. The standing of two-stroke versus four-stroke engines, and means of scavenging and supercharging are discussed.

The important position of the gas engine in America is emphasized, including the gas-Diesel or dual-fuel type of engine. Design considerations such as the tendency towards V-engines, and current practice with regard to frames, shafts, bearings, pistons, and fuel injection are considered briefly. Cooling systems, allowable cooling temperatures, piston-cooling progress, and maintenance considerations are also discussed.

Modern Trends in Oil Engine Designs. WANS, I. *Fourth World Power Conference, London*, 1950.

The first part of this review deals with present-day practice with regard to design and performance of the four-cycle compression-ignition vertical oil engine of powers up to about 300 b.h.p. per cylinder when pressure-charged.

In the second part the Author discusses trends in design and performance. The outstanding requirements are reliability, low costs of operation and maintenance, with the lowest possible outlay. It is thought that these requirements can be achieved only by a better understanding of the behaviour of materials under working conditions, the adoption of reasonable engine ratings, and more knowledge of combustion conditions within the cylinders, coupled with higher mechanical efficiencies. The development of greater power from a given cylinder size by increased crankshaft speeds is considered, and some system of pressure-charging, whereby a greater weight of fuel can be economically burnt with permissible maximum pressures and temperatures, is suggested.

Fuels for High-Speed Diesel Engines. DERRY, L. D., EVANS, E. B., and WINDEBANK, C. S. *Fourth World Power Conference, London*, 1950.

A comparison of the minimum standards for quality set by the B.S.I. and A.S.T.M. fuel specifications with currently marketed grades of Diesel fuel showed that all the fuels inspected came within the range of the B.S.I. specification, with one exception which was sold in the U.S.A. and complied with the requirements of the A.S.T.M. specification. An account is given of investigations of the effect of fuel characteristics on engine cold-starting performance, fuel economy, maximum power, noise, exhaust smoking, and engine fouling, and the results are discussed in relation to the related properties of Diesel fuels.

For any particular engine it is possible to construct a chart from which can be predicted the interrelated changes in engine performance that a fuel will produce. It is shown that it is impossible to improve any one of the engine-performance characteristics without affecting, usually adversely, one or more of the others. The Authors suggest that the use of starting aids and detergent lubricating oils may offer the most economical solution to the problem of supplying adequate quantities of automotive Diesel fuel.

German Marine Diesel Engines in 1950 (German). EHMSEN, E. *Hansa*, **87** (1950), p. 539 (29 April).

The trend of development of marine Diesel engines in Germany is mainly in the following directions :—

1. New types by increasing the cylinder volume of the smaller engines.
2. Supercharging four-cycle engines, mostly by exhaust-gas turbines.
3. Construction of high-speed, two-cycle trunk-piston engines instead of four-cycle engines.
4. Construction of two-cycle engines with additional charge.

5. Use of geared drive, which permits the use of large, high-speed, high-powered engines.

6. Use of double-acting two-cycle engines as slow Diesels for direct drive and as high-speed geared engines.

The Author predicts for the future a decrease in the use of Doxford engines and an increase in that of single- and double-acting two-stroke Diesels. Since the end of the war, a noticeable, if gradual, replacement of four-cycle by two-cycle engines has occurred. Manufacturers of large Diesels like M.A.N. and Krupp limit the cylinder diameters of their types as follows :—

Four-cycle, trunk-piston engine	23.6 in.
Two-cycle, trunk-piston engine	20.5 in.
Two-cycle, crosshead, single-and double-acting engines	28.3 in.

A table is given of the maximum cylinder h.p. of prominent German four-cycle and two-cycle Diesels.

Most firms building four-cycle engines supercharge them. M.W.M., for instance, have an exhaust turbine fitted to all six- and eight-cylinder Diesels from 5.9 in diameter onwards. Other makes considered in this respect are Wumag-Krupp (formerly Krupp Germaniawerft), Deutz, M.A.N., Maschinenbau A.G. Kiel (M.A.K., formerly D.K.W.). Two-cycle trunk-piston Diesels are built by the Hanseatische Motoren-Gesellschaft up to 240 h.p. and by M.A.N. up to 400 h.p. Owing to the high r.p.m. such engines are scavenged by Roots or centrifugal blowers.

Two-cycle Diesels with piston-operated port openings normally lose a percentage of the charge because the exhaust ports remain open during a small crank angle after the completion of scavenging. This naturally means a power loss. M.A.N. avoid these losses by fitting rotary slide valves which close the exhaust ports at the end of scavenging, so that no further fresh air can leave the cylinder.

German shipbuilders tend to give preference to the geared drive over Diesel-electric sets, since gear transmissions and couplings have been developed to high perfection in Germany. The main object of couplings is to damp out torque fluctuations, and this problem has been solved adequately by employing the Vulcan drive, which is built by the A.G. Weser. Such couplings have a slip, and therefore power loss, of 3% to 5%. There are also other couplings (*e.g.*, gear-type, elastic band, etc.) on the market with very low losses.

POWER TRANSMISSION

Magnetic Fluid Clutch. *Engineers' Digest*, **11** (1950), p. 160 (May).

A brief description is given of an improved magnetic fluid clutch, 6 in long and 6 in in diameter, which is capable of transmitting more than 60 h.p. The clutch contains two coupling elements in the shape of metal cylinders separated by the magnetic fluid. A novel feature is the provision of rectangular teeth on the clutch faces, which is said to increase the grip between the magnetic fluid and the coupling elements. Magnetic fluid clutches made in Great Britain are now on test by the Defence Establishments with a view to applying them to servo-mechanisms.

The Beam Strength of Gears with Profile Correction. Choice of the Material in Relation to Cylinder Pressure and Life (German). ROHLAND, G. *Die Technik*, **5** (1950), p. 102 (March).

The Author's aim is to assist gear designers in assessing beam strength and

surface endurance of the teeth. He uses orthodox theory, but simplifies it by providing nomograms and diagrams which avoid much of the cumbersome numerical procedure.

The bending stress in a tooth is not calculated by Lewis' formula, generally adopted in Britain and U.S.A., but by Wissmann's relation, as a function of load, face width, module (reciprocal of diametral pitch), and a tooth-form factor. Where a correction of the tooth profile is required, the form factor must be corrected in proportion to the ratio of the squares of the widths at the root of the uncorrected and corrected tooth. The Author presents a nomogram which gives the relationship between number of teeth, radial profile correction (positive or negative), and tooth width at the root. A boundary line has been entered to indicate where further correction would result in too sharp teeth. The form factor of the uncorrected tooth can then easily be converted to that of the corrected one after reading the tooth width of the corrected tooth from the nomogram. The corrected form factor in its turn will give the actual bending stress in the corrected tooth. The nomogram is constructed for a pressure angle of 20°, tooth numbers from 10 to 100, and module 1 ; it can, however, be adapted to other modules.

The Author shows in a numerical example how the nomogram is used. Whereas the uncorrected pinion of the particular spur gear train would have to be made of special alloy steel to take up the bending stress, a positive correction of the pinion would reduce the stress so much that normal steel would do. Alternatively, if the more expensive material is to be retained, the diameters of pinion and gear could be reduced by correction, so that the complete gear train would be lighter.

The surface pressure and wear of teeth is assessed either by Hertz's equation for the maximum surface pressure, or by the relation for the cylinder pressure. In both cases, the value of the pressure depends on the gear specifications. Hertz's formula has the disadvantage of introducing a mean value of Young's modulus for pinion and gear. The value calculated by either formula has to be within a permissible value of the surface pressure, whose determination requires that of other quantities which are themselves without interest to the designer, who is merely concerned with number of revolutions, Brinell hardness, and life of the gear.

By modifying the conventional formulæ, the Author succeeds in developing simplified relations for the Hertz and the cylinder pressure, and in constructing for each of them a nomogram in which the permissible value of the pressure is plotted against Brinell hardness and the number of revolutions for 5,000 hours of operation. The Hertz pressure is given for steel, cast steel, and cast iron, and the cylinder pressure for steel and cast steel only. If gears of dissimilar materials are to mesh with each other, a simple conversion of the figures found from the nomogram is required. A table is provided for this purpose.

Where the gears are to be designed for a life different from 5,000 hours, the surface pressure found from one of the two diagrams has to be corrected ; a further diagram gives the correction factor. Finally, the Author presents a graph which correlates Hertz pressure to cylinder pressure.

The Author illustrates the determination of the surface pressure with a complete numerical example, and tabulates the results obtained for different conditions and by different methods. There are six references.

MARINE POWER INSTALLATIONS (GENERAL)

Problems in the Development of Marine Engineering (German). BAUER, G. *Hansa*, **87** (1950), p. 531 (29 April).

The Author discusses a few problems on ship propulsion machinery and

auxiliaries. The controversy on steam versus Diesel drive for modern trans-atlantic liners has been decided in favour of the former. Equally conservative has been the shipowners' opinion on whether to use geared turbines or turbo-electric drive. The high first and operational costs of turbo-electric units led to the adoption of geared turbines for new projects. The steam is usually generated in oil-fired boilers. Steam temperature and pressure were both increased, but builders and operators have been rather reluctant in driving them to the limit of what is acceptable for modern constructional materials. The conditions in the latest designs are 440 lb/sq. in. to 630 lb/sq. in. above atm. and 750°F to 850°F.

For smaller cargo-ships, triple-expansion steam engines will still be favoured for a long time to come, and they are preferably run on highly superheated steam up to 660°F. In addition, the four-crank double-compound engine is favoured because of good mass balance. The introduction of poppet valves (*e.g.*, Lentz) or cam-operated slide valves (*e.g.*, Andrews & Cameron) is to be recommended. Smaller reciprocating plant will frequently be of the so-called steam-motor type, *i.e.*, a set of equally dimensioned cylinders with poppet valves, high revolutions (up to 1,000 r.p.m.), and reversing-reduction gearing.

One of the modern requirements for transmission gears is to reduce noise to a minimum. This requires high accuracy of the components. Relatively new are mechanical reversing gears, which may have a great future in gas-turbine drive and possibly also Diesel drive. Variable-pitch propellers offer advantages in certain cases, *e.g.*, operation in shallow water.

Oil-fired water-tube boilers are adopted as a matter of course in large units. Medium-size and smaller ships, however, are still preferably equipped with Scotch boilers. But it is doubtful whether in the long run shipowners will put up with their high weight. Similar factors affect the fuel problem, *i.e.*, whether to burn coal or oil in a water-tube boiler. Coal-fired water-tube boilers are nowadays reasonable only if suitable mechanical stokers are available, and this forms a further problem awaiting solution. Combined cylindrical water-tube boilers (Capus, Howden-Johnson) may offer some advantages, but are not the final answer to the question. Automatic control devices have a high importance for water-tube boiler operation.

High-powered Diesel ships employ mostly double-acting, two-cycle or opposed-piston (Doxford) engines, both with pressure injection. Smaller units often have high-speed four-cycle Diesels, again with pressure injection. Although the direct Diesel drive requires a comparatively large space, it has yet sufficient scope in combination with suitable space-saving mechanical transmission, for instance, hydraulic gear. It is doubtful whether the gas turbine will be a serious competitor of the steam turbine in the near future.

The auxiliaries of large ships are nowadays mostly electrically driven. The necessary reduction in personnel and increase of safety of passengers and crew have called for an improvement and simplification of the fire-fighting equipment. Progress made in welding has led to all-welded ship hulls and largely welded engine components and therefore to an appreciable weight reduction and increase in safety.

The Problem of Reducing Weight and Space of Marine Power Installations (Dutch). KATZINGER, O. A. *Polytechnisch Tijdschrift*, **5** (1950), p. 259a (18 April), p. 294a (2 May), p. 335a (16 May), and p. 365a (30 May).

The Author considers the theory and design of the Brown-Boveri Velox boiler, its use for marine purposes, and the saving in weight, space, and fuel consumption which it makes possible in comparison with other water-tube boilers.

It is shown by the theory of heat transfer from the boiler combustion gas to the water-tube heating surfaces that, by increasing the gas pressure, the boiler space is reduced by 49%, and the boiler weight by 34%. If simultaneously the gas velocities are increased by compressing the combustion air in a gas- and steam-turbine driven compressor, the diameter of such a boiler is reduced by 20% and its length by 39%. The thermal efficiency of a boiler with this installation is a little lower than that of a normal boiler, but if it is considered that the exhaust gases are expanded in the gas turbine which drives the compressor, the figure would rise beyond the efficiency of a normal boiler. The Author demonstrates this with the example of a small, oil-fired locomotive boiler.

The last sections of the paper contain a discussion of a diagrammatic sketch of a Velox boiler, of some marine designs, and of the Author's personal experience with Velox marine plants. Under normal conditions, a Velox boiler requires very little attention and can be started within 8 to 10 min. It therefore requires less personnel than a normal boiler. The thermal efficiency of a Velox boiler is moreover practically constant down to $\frac{1}{3}$ load. A table is shown in which space and weight are compared of Scotch, normal water-tube, and of a Velox boiler. The figures are the lowest for the Velox.

MACHINE PARTS

Rotary and Sliding Seals (French). ROGER, V. *Technique Moderne*, **17** (1950), p. 149 (May).

The Author has gathered information on mechanical and hydraulic seals for rotary and sliding shafts from current literature listed in a bibliography. Nearly all the various types of seals, of which sketches and photographs are shown, produce absolute tightness, except those which, like labyrinth packings, are without direct contact with the shaft, or carbon packing rings for steam turbines, etc., where a certain amount of fluid is bound to escape. A number of the joints can be used on both rotating and sliding shafts.

The performance and scope of each type are described, and the Author specifies the service conditions for each of them—range of fluids, temperatures, pressures, etc.

LUBRICANTS AND LUBRICATION

Wear in Relation to Dry Friction and the Three Types of Fluid Friction (French). MARCELIN, A. *Revue Générale de Mécanique*, **34** (1950), p. 67 (Feb.), and p. 139 (April).

The Author gives a further account of his research on coefficient of friction and wear for the different types of friction of pairs of mating surfaces. His earlier publications are quoted. The introductory section of the present paper defines the four basic types of lubrication, *viz.*, dry friction ; stratofilm lubrication (by interposition of one or several mono-molecular layers of the lubricant between the rubbing surfaces) ; boundary lubrication (thickness of the fluid layer generally 1μ to 2μ, where $\mu = 4 \times 10^{-5}$ in) ; and the hydrodynamic régime. The experimental work dealt exclusively with the two first types.

Whereas boundary lubrication is characterized by the interposition of a thin film of the lubricant between the two rubbing surfaces, which reacts like a rubber pad to transverse loads, stratofilm lubrication is related to dry friction. But the coefficient of friction of stratofilm lubrication is far lower than that of dry friction. In stratofilm lubrication the lubricant has very much the same effect as sleet has on an uneven road.

The experimental devices used for the Author's tests were of the reciprocating

type. One of the mating surfaces was caused to oscillate, dragging the other with it ; the movement of the secondary surface, which depended on the type of friction and other quantities, was recorded by a stylus on a strip of film. The apparatus is described, and there are several diagrams and photographs of it.

The Author worked with various materials (alloys and pure metals) as surface materials, different oils and water as lubricants, different loads, temperatures, and surface conditions (rough and fine-machined, ground, different grades of electrolytic polishing). Starting friction received special attention. He arrives at the following principal conclusions :—

The coefficient of friction for both types of friction, even for one particular pair of surfaces, cannot be clearly predicted, since it depends on several factors, in particular on rubbing (wear-in) time and on the surface conditions. The coefficient of starting friction both for dry friction and stratofilm lubrication is independent of the load ; and for stratofilm lubrication is about half of what it is for dry friction. Under prolonged operation, the coefficient of dry friction ceases to be independent of load, whereas that of stratofilm lubrication finally resumes its relationship to the load conditions, but is about one-third of the corresponding coefficient of starting friction. The bearing surface in dry friction increases with time and is a function of load. It increases rapidly during the starting time (running-in wear). That in stratofilm lubrication is low and hardly affected by the load. With improved surface conditions, the coefficient of friction and the running-in time are reduced.

Lubricated alloys and pure metals do not differ much in their frictional and wear properties ; they differ only in the dry condition, *i.e.*, when the lubrication fails. The frictional performance of zinc and copper is bad when they are dry, although coefficient of friction and wear are low when they are lubricated. Silver and copper–antimony–tin alloys are excellent bearing metals, irrespective of whether they are dry or lubricated.

THERMODYNAMICS

Some Thermodynamic Aspects of Power Production (French). SEIPPEL, C. *Fourth World Power Conference, London*, 1950.

An illustrated description is given of a steam turbine of 110,000 kW at 3,000 r.p.m., representative of Swiss design practice. A number of questions pertaining to the low-pressure elements of turbines are examined in order to complete the numerous publications dealing with high pressures and high temperatures. The exhaust ducts recuperate a part of the kinetic energy of the steam (or the gas) in spite of an adverse effect due to the compressibility of the fluid. The law of velocity of distribution may be irrotational (free vortex) or not. It is useful to introduce the idea of " degree of rotation," which is a complement to the well-known degree of reaction. A theory of the losses caused by rotational flow is developed, and drainage of moisture and regenerative heating are considered. The advantages of re-superheating are discussed. In conclusion, some suggestions are made as to the future of the steam turbine, gas turbine, and a combination of the two.

There is an English summary.

Comparative Efficiencies of the Main Types of Internal Combustion Engines (French). SERRUYS, M. *Fourth World Power Conference, London*, 1950.

A detailed comparative study is given of the thermal efficiencies attained in the principal types of internal combustion engines, and recent endeavours to improve these figures are discussed. The Author estimates the influence

exerted by the essential features of the different types, not only on the overall thermal efficiency, but also on the various contributing elements, namely, the theoretical thermodynamic efficiency, the relation between thermodynamic efficiencies implied by the theoretical and the actual indicator diagrams, the combustion efficiency, the mechanical efficiency, and a fuel correction factor which takes account of the fuel used.

A statement and appreciation of the values of thermal efficiency obtained in a number of different cases is followed by consideration of the possibilities of achieving an indicator diagram connoting greater practical efficiency. Two new forms of diagrams are suggested, one for an ordinary reciprocating motor and one for such a motor in conjunction with a back-pressure turbine operated by the burnt gases and possibly with a forced-feed compressor.

There is an English summary.

Load Capacity Rating of Lubricants. BRIX, V. H. *Journal, Institute of Petroleum*, **36** (1950), p. 295 (May).

It has always been difficult to rate lubricants in terms of their ability to lubricate. This property is usually expressed as the load capacity, film strength, etc., as determined on some arbitrary test machine. Such results do not always reproduce properly or correlate with service conditions.

Some success, however, has been achieved in recent years with the development of the I.A.E. (now the M.I.R.A.) $3\frac{1}{4}$-in oil-testing machine. This method possesses, nevertheless, certain drawbacks which limit its more widespread use. For instance, it is necessary to use accurately fabricated and ground test gears.

A machine is described which employs simple test-pieces which can be re-used indefinitely, and which is easy and rapid in operation. The results have a similar trend to those obtained on the I.A.E.-type gear machine, and have shown useful correlation with service conditions.

AUXILIARY EQUIPMENT AND MACHINERY

A Review of Auxiliary Equipment. *Marine Engineer*, **73** (1950), p. 137 (April).

In this review of recent developments in auxiliary equipment, particular notice is given to the increased use of pressure-charged auxiliary Diesel generating sets. A new design, the Mirrlees J-type four-valve engine, is mentioned. Examples are in service in many British and foreign motorships. The engine can be either naturally aspirated or turbo-charged at either low or high pressure. A sectional view is given of a new Götaverken three-, four-, or six-cylinder auxiliary oil engine, and several two-stroke engines for generator drive are described. Turbo-generators of comparatively high output have been fitted in a number of ships, including the *Himalaya*, the *Empire Fowey*, *Presidente Peron*, and *Eva Peron*.

A.C. auxiliaries are becoming more popular in this country, and an A.C. winch is operating satisfactorily on board the motor liner *Oranje*. The Clarke-Chapman enclosed steam winch has been installed in a number of vessels. The motorship *Melrose* is the first ship to be fitted with the Mactaggart Scott hydraulic system for driving the deck auxiliaries. Electric deck cranes have been fitted in a number of ships lately, including the *Port Brisbane*, the *Doric*, the *Delphic* and the *El Halal*.

Several systems for easier unloading are mentioned. The refrigerated cargo liner *Duquesa* is equipped with a novel arrangement of derrick-boom topping

hoists to replace the customary chain and triangle plate method of securing the topping lift. The turbo-electric tanker *San Silvestre* is the first British vessel to be fitted with centrifugal pumps capable of handling substantial quantities of cargo. A variable-output rotary piston pump has been installed in a molasses-carrying tanker for handling the cargo.

The increasing interest in the burning of high viscosity fuels in Diesel engines is noted. A new marine fan-controller for series-wound motors below 1-h.p. is illustrated ; and the Hayward-Tyler circulating pump designed specifically for forced-circulation boiler installations is described briefly. Compact heating units for the heating and ventilation system of a large tanker are also shown.

Polyphase Current Systems on Board Ship (Spanish). GONZALEZ-LLANOS Y CARUNCHO, J. M. *Ingeniería Naval*, **18** (1950), p. 250 (June).

The discussion chiefly concerns three-phase systems, which are compared with direct current and single-phase alternating current systems. Three-phase current power plants are quite normal for the propulsion of ships, and the Author considers three-phase systems for the drive of engine-room and deck auxiliaries, lighting and other services (refrigeration, cooking, etc.). Advantages and disadvantages of the three different types of current are detailed, and it is shown in how far three-phase current is preferable.

The Author discusses for this type of current the characteristics, types, design of and improvement in generators, switchboards, distribution systems, motors, and applications to the running of various machines and plant. He then illustrates his general considerations with the practical example of the three-phase plant, in a type " F " ship of the Empresa Nacional Elcano (Spanish National Shipyard) of 16,000 tons and 20,000 s.h.p. at a speed of 21 knots. There are complete lists of the electric drives of each of the auxiliaries in this ship with particulars of the motors and circuiting.

INSTRUMENTS AND CONTROL DEVICES

A New Diesel Engine Indicator. *Motor Ship*, **31** (1950), p. 69 (May).

An illustrated description is given of a new instrument for measuring the maximum compression pressures of Diesel engines. The indicator is fitted with a connection enabling it to be secured to any normal indicator cock or valve, and will show immediately whether there is any unequal loading of the cylinders through leaky piston rings and valves, or through unequal fuel metering or choked atomizers. There are no pistons or valves and the friction of the instrument is negligible. Cleaning is effected by washing with a solvent at infrequent intervals.

VIBRATION AND SOUND-PROOFING

Torsional Vibration in Geared Turbine Marine Propulsion Plants—An Introduction to the Subject. ANDRIOLA, A. D. *Society of Naval Architects and Marine Engineers, paper read* 17 Feb. 1950.

The Author describes methods by which the designer may determine the frequencies of torsional vibration and the probable amplitudes of displacements and torques which will occur at these frequencies. Methods by which relatively vibration-free systems can be achieved are also discussed.

It is emphasized that the undesirable effects of torsional vibration generally can be avoided by proper analysis in the early stages of design. The frequency analyses presented are based on the assumption that the rotating system can be replaced by an equivalent system consisting entirely of discrete masses

connected by elastic elements which have no mass in themselves. The agreement between calculated and measured vibratory displacements and torques has not been as good as that for the critical speed. The reasons for this are suggested, and it is pointed out that the recommended values for torque excitation and damping are on the conservative side and can be used with assurance.

The first critical speed has a single node which occurs in the line shaft for installations of the geared-turbine type. In vessels of normal design with the machinery located amidships, this critical generally occurs at very low speed and power and may safely be ignored. For vessels with machinery located aft, the first critical speed may occur close to designed full power. When calculations indicate that the corresponding vibratory torque may be considerable, the position of the critical may be shifted by changing the number of propeller blades, or it may be raised above the operating speed by increasing the line shaft diameter. When single-reduction or nested-type double-reduction gears are used, no critical speeds above the first occur in the operating range, as a rule. With double-reduction gears of the articulated type, the second and usually the third critical speeds may also fall within the operating range. On most ships the second critical is eliminated entirely by tuning, and this method is recommended whenever it may be accomplished without compromising other features of the design.

A bibliography is given.

Vibration and Noise Measurement. *Torque*, **1** (1950), p. 18 (April).

By the application of electronic techniques, measurements can be made with a very small amount of equipment of the frequency of a vibration, the displacement of the moving part, and its velocity and acceleration. A vibration meter and an A.F. analyser suitable for this type of measurement are described. Both are self-contained and portable. The frequency spectrum of a sound or noise can be determined by the use of the A.F. analyser in conjunction with a sound-level meter, which is also a self-contained portable instrument and gives a direct measurement of sound level over the full audible range.

AIR CONDITIONING, VENTILATION, AND REFRIGERATION

Jets and Inlets in Ventilation. BECHER, P. *Journal, Institute of Heating and Ventilation Engineers*, **18** (1950), p. 107 (May).

To design an effective ventilation plant it is desirable to know the laws of the spread of jets. This paper gives formulæ and diagrams for the calculation of the velocity and the throw of air jets.

Prediction of Thermal Conditions in H.M. Ships in Tropical Waters. GRAY, J. A. B., and SMITH, F. E. *Medical Research Council, Royal Naval Personnel Research Committee, ACSIL/ADM/49/596.*

The high air temperatures and humidities in H.M. ships during the past war showed the need for defining the upper limits of the thermal environment.

The difference between the total heat content of the air within a compartment and that of the external air (heat gain) is shown to be independent of the climate provided the ventilation is unchanged.

Compartment wet-bulb temperature can be predicted by adding heat gain to a given external total heat content and converting the answer to wet-bulb temperature.

For mess-decks a technique is used for converting the predicted wet-bulb

temperature into effective temperature for air speeds between 20 and 300 feet per minute.

A nomogram is presented for easy prediction of effective temperature on mess-decks. It also indicates the rate of change of effective temperature in respect to the total heat content of the air and the speed of air movement.

CORROSION, FOULING, AND PREVENTION

Performance of Anti-Corrosive Compositions in Sea Water: Effect of Surface Preparation of Steel. HUDSON, J. C. *Journal, Iron and Steel Institute*, **165** (1950), p. 314 (July).

The paper presents and discusses the results of the Marine Corrosion Sub-Committee's researches which show that different methods of surface preparation have a marked effect on the performance of anti-corrosive compositions in sea water.

Paint gives poor protection against exposure to sea water if applied over millscale. Since, however, some paints fail to adhere to a completely descaled, freshly prepared, and unrusted steel surface, it is recommended that the descaled steel surface be allowed to rust slightly or be treated with phosphoric acid wash before the application of the priming coat of anti-corrosive composition. In the case of ships' hulls, weathering the steel plates until they have shed their millscale completely should therefore yield good results. In practice it is difficult to ensure complete descaling of all the component plates of a ship's bottom, and descaling of the plates by grit-blasting or by pickling, followed by a short weathering period or treatment with a surface wash, is recommended.

Rates of pitting up to 0.16 in/yr. have been observed at " holidays " (bare areas in a paint film) on an immersed steel plate. The presence of intact millscale beneath the paint may also promote pitting, but if about 90% of this is removed by weathering, pitting will probably be no more severe than when the millscale is removed by pickling. The procedure of launching a ship with the bottom unpainted is not recommended because, owing to the slower removal of millscale, pitting may result ; it is also difficult to clean the surface before painting.

With a few exceptions, the relative behaviour of a given set of bottom-painting schemes is the same whether applied to new specimens of unpainted steel or to specimens which have previously been painted and exposed to an immersion test. This applies in the main to both the protective and anti-fouling properties of the painting schemes.

Formulated anti-corrosion compositions developed by the Marine Corrosion Sub-Committee give good results as priming paints under a bottom-painting scheme. A mixed red-lead and white-lead paint in linseed oil is less satisfactory, although much better than a red iron-oxide paint in linseed oil.

Zinc or aluminium coatings on steel improve the performance of bottom painting schemes applied over them ; lead, however, promotes pitting.

Results of a raft test and those of a patch-painting trial are in good agreement.

Corrosion-Erosion of Boiler Feed Pumps. *Engineering and Boiler House Review*, **65** (1950), p. 151 (May).

A series of tests have been conducted by the Detroit Edison Company to obtain corrosion-erosion data applicable to present-day conditions of high feed-water temperatures. The work comprised measurements of the resistance to the corrosion-erosion type of attack of Navy M bronze, three chromium

steels, a chromium–molybdenum steel, a molybdenum steel, a 0.24% carbon steel, leaded bronze, and chromium-plated surfaces. In addition, the influence of *p*H within the range 7.3 to 8.3 upon the resistance of cast carbon steel was observed.

Specimens were exposed to the action of feed-water under high-velocity and turbulent conditions similar to those encountered in boiler feed pumps and regulating valves. The method of testing is described.

Carbon steel was found to be more resistant to corrosion-erosion attack at high than at low temperatures. A reduction in the rate of attack at higher temperatures is possibly due to the formation of a more tenacious oxide coating. Magnetic iron oxide formed at 320°F and 385°F, while at 250°F ferric oxide was formed.

The corrosion-erosion resistance of the chromium bearing steels was greater than that of the carbon steel, being proportional to the chromium content at 250°F, but relatively reduced at the higher temperatures.

Navy M bronze is satisfactory up to 320°F ; the rate of attack is too high at 385°F, being 10 times that obtained at 250°F. Chromium plating is an unsuitable protection.

It is indicated that increases in the *p*H value of feed-water should be made with caution.

Corrosion Fatigue—The Influence of Disarrayed Metal. WHITWHAM, D., and EVANS, U. R. *Journal, Iron and Steel Institute*, **165** (1950), p. 72 (May).

The Authors describe investigations undertaken to determine whether a preliminary period of dry fatigue should lengthen the normal corrosion-fatigue life by strain-hardening, or shorten it by producing disarrayed metal which may be particularly susceptible to corrosion. Two-stage tests were carried out on wire specimens. On one set of specimens a period of dry fatigue was followed by corrosion fatigue up to failure ; for comparison, a second set was submitted to corrosion fatigue without previous dry fatigue. With both cold-drawn and annealed wires, little or no change in corrosion-fatigue life was brought about by preliminary dry fatigue under the conditions tested.

A metallographic study was also made of changes during air-fatigue and corrosion-fatigue processes. In air fatigue, the repeated application of a stress greater than the fatigue limit results in the plastic deformation of many grains, as a preliminary to the development of micro-cracks and failure. Simultaneously, heat is generated in the specimen and a superficial oxidation of the surface follows.

In corrosion fatigue at a stress below the air-fatigue limit, a localized attack leads to stress intensification and hence to corrosion along slip bands. Attack spreads around the circumference of the wire, with subsequent weakening. The major damage, estimated by loss in tensile strength, occurs towards the end of the process, both in air fatigue and corrosion fatigue. Cracking is mainly transcrystalline, but may occasionally be intercrystalline for distances of a few grain diameters.

A list of references is given.

OPERATION AND MAINTENANCE

The Fuel Consumption in Merchant Ships (French). GUILLERM. *Annales Techniques de la Marine Marchande*, **3** (1950), p. 339 (No. 30).

The Author has constructed a nomogram which gives the relationship

between s.h.p. and fuel consumption in tons/24 hrs. for the main classes of ship propulsion plants (steam engines, geared turbines, turbo-electric drives, direct Diesel drives, geared Diesels, Diesel-electric drives, and gas turbines). The three fuels considered in the diagram are coal, fuel oil, and Diesel oil. Special provision is made in the nomogram for using i.h.p. instead of s.h.p., standard values being chosen for the relationship between both. The lines in the diagram have been based on the following efficiencies :—

Steam engines	0.78
Diesel engines	0.81
High-efficiency Diesels	0.85

The diagram is valid only for some main types of ships and for propulsion plants with proper maintenance and burning good quality fuel.

The nomogram is mainly intended for ship layout purposes, *e.g.*, when the power is given and the fuel capacity is to be determined, etc. The Author explains its application with many examples. Some of them deal with special problems, *e.g.*, the correction of figures obtained from the nomogram for special classes of vessels (liners, refrigerated ships, factory ships), for low quality fuels, and for engines in bad condition. The nomogram is, of course, intended only for rough estimates ; but, if the readings are carefully made, its accuracy is as high as 95% for the fuel consumption under normal conditions.

MISCELLANEOUS

A Mercury Shaft Seal. SAWYER, J. W., and CRAWFORD, L. *Journal, American Society of Naval Engineers*, **62** (1950), p. 349 (May).

A detailed account is given of the development of a centrifugal mercury seal, supplemented by a rubbing seal which is to function only at low speeds. A test model and experimental work are described, and possible fields of application are discussed. The seal consists of four main elements, namely, the annular channels, expandable elements, static element, and the sealing medium, which is mercury. The shells bounding the annular channel are secured to the rotating shaft through suitable means. Expandable elements are attached to and form a part of the channel. The static element is fixed to the housing. The sealing medium is retained in the annular channel. Operation is automatic, the various elements operate over the desired speed range and are actuated by the centrifugal forces developed by rotation. Advantages include the low manufacturing tolerances required, elimination of contact between solid elements at high rubbing speeds, sealing under radial and axial misalignment, and low friction losses.

Tests conducted on the model seal indicated that a system of forced lubrication is needed between the flexible element and the static ring when hydrostatic pressure is applied. The low speed and static components appear extremely reliable for all pressures. Improved functional performance with power economy, and greater overall reliability due to its great flexibility are two claims made for this design.

Suggested applications are for main shafting on ships, sealing of line shafting at points of bulkhead penetration, sealing a shaft at the point of entry to a gear case, and for centrifugal pumps.

Several design recommendations for the full-size unit are made, and the importance of the proper selection of material is emphasized. The design of the seal should be such that the mercury filling may be withdrawn and replaced with a minimum amount of difficulty.