TECHNICAL ABSTRACTS

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PROPELLERS AND PROPULSION

Results to Date of Comparative Cavitation Tests of Propellers. GAWN, R. W. L. *Society of Naval Architects and Marine Engineers, paper read at Summer Meeting, Washington,* 6-7 Sept. 1951.

The Fifth International Conference of Ship Tank Superintendents, 1948, approved comparative cavitation tests of propellers, and the owners of eight tunnels agreed to participate. Propeller models are to be circulated for test in each tunnel over a wide range of conditions. Two parent designs have been nominated, designated Series 1 and 2 respectively. Results of speed trials of ships fitted with propellers to these designs are available for comparison with the cavitation tests on completion. Proposals are being prepared for testing a third parent design, designated Series 3, which, as experience with Series 2 propellers indicates, may prove more susceptible to the effect of air in the water. The diameter of the models ranges from 8 to 18 in.

Results are given in this paper of tests of the 12-in. diameter model of Series 1 in four tunnels, and of the 9-in. model in three tunnels and in a ship tank. Series 2 results comprise the 12-in. model in one tunnel and the 8-in. model in four tunnels. Altogether five tunnels have been concerned in these tests. A fairly wide range of Reynolds number has been covered, namely about 1.2 to 3.5 million with Series 1 propellers and 1.2 to 2.7 million with Series 2. Results of precision measurements of the finish of some models are also included.

It would be premature to draw firm conclusions until the research has been completed. Undue emphasis on small differences can be misleading at this stage. So far, however, the tests do not indicate any consistent trend as regards effect of water speed or Reynolds number. Theoretical corrections for tunnel-wall interference slightly improve the agreement between results when there is no cavitation. No reliable correction for the cavitation condition has yet been established. The results of Series 2 propellers may be susceptible to the influence of air in the water to some extent. The 8-in. model, if not too small, would appear to approach the limiting small size for reliable records. These tentative views may have to be modified when the research is complete.

Torque measured on the smaller models in one tunnel appears to be consistently high, and in another tunnel both torque and thrust of the 12-in. and 9-in. models are comparatively low, although the efficiency is in fair accord. These results appear to be instructive from the point of view of equipment rather than the physical conditions of test.

References are given.

Propeller Coefficients and the Powering of Ships. LEWIS, F. M. *Society of Naval Architects and Marine Engineers, paper read at Annual Meeting,* 15-16 Nov. 1951.

Many forms of coefficients and chart arrangements have been used for presenting the results of tests of propeller series. The Author lists the main methods employed, and describes the properties that appear desirable in an ideal system. He proposes the use of the basic J, K_T, K_Q system with the addition of a constant $K_U = K_T/J^2$, and suggests a form of chart utilizing these constants which he hopes may find general acceptance. He shows that any type of non-cavitating propeller problem may be solved expeditiously by the use of these charts. The Author also suggests that the use of the constants "flow ratio" v_a/v and "resistance-thrust ratio" R_T/T would have advantages.

A limited amount of data on thrust and torque wakes obtained from model tests and trials is given. The Author then proposes a method of powering using the charts which utilizes two design points corresponding to the points of thrust and torque identity. This method is particularly suitable for single-screw ships. A set of type problems and solutions is given which are believed to cover all practical requirements.

More on the Controllable-Pitch Propeller. *Motorship*, **36** (1951), p. 31 (Oct.).

A Diesel engine, particularly a two-stroke engine, is primarily a constant-torque machine. When used for the propulsion of such craft as tugs or fishing vessels, in which the load varies between very wide limits, the combination of a fixed propeller and a Diesel engine will seldom be running at its highest efficiency. A suitable solution to this lies in the adoption of the controllable-pitch propeller. With this equipment the pitch of the propeller is adjusted, in most cases by hydraulic means. The control is affected by a single lever which can be placed in the wheel house. The propellers are controllable to the point of full reverse pitch, and since there is then no need to overcome the inertia effect of the rotating propeller and shaft this system provides the fastest means of reversing a screw-propelled vessel. By suitable adjustment, it is possible to hold the vessel dead in the water, or to move her at creeping speeds ahead or astern, while the engine and propeller are turning at full speed. When the cost of such an installation is being considered, it is not sufficient merely to compare the price of a controllable-pitch propeller with that of a fixed-blade propeller. For a true comparison, the cost of the controllable-pitch propeller with its control mechanism, the shafting, and the propulsion Diesel engine must be assessed against the fixed-blade propeller, reverse gear and controls, shafting, and Diesel engine in a geared-drive installation. It will be found that the controllable-pitch propeller drive will compare quite favourably with geared drive, and will have a considerably lower first cost than the Diesel-electric drive, which is the only other system offering comparable advantages.

The Author describes the Schelde controllable-pitch propeller, in which two pairs of blades are mounted in tandem on a hub of normal diameter.

Marine Propeller and Propulsion Miscellany. TELFER, E. V. *Transactions of the North East Coast Institution of Engineers and Shipbuilders, paper read* 17 Dec. 1951.

An account is given of the results of a number of miscellaneous investigations into marine propeller and propulsion problems. An attempt is first made to set up a satisfactory method of expressing the parabolic nature of the propeller-thrust curve and developing the Froude blade-factor concept. This leads to a further study of effective-pitch ratio and the factors that influence it. Next, the Brix-Baker expressions for experimental propeller efficiency are developed and applied to interpret standard-series results. Consideration of the classic treatment of relative rotational efficiency suggests that the interpretation is erroneous. A new interpretation is submitted, and it is shown that this leads to a better understanding of the trend of the scale effect on propulsion than is possible with the classic method.

The use of the apparent propulsive coefficient is discussed. Its application to correlation work is illustrated, and a method is developed which enables the correct rotational efficiency to be derived. A new method of analysing ship-trial data is outlined which enables with-weather results to be separated from against-weather results and tidal influence to be eliminated. Practical study is needed of the with-weather power curve to foster ship-model correlation, and of the against-weather power curve to encourage the shipbuilder to study the sensitivity of his ship to weather influence.

Finally, the current dilemma of correlating model-experiment results in the turbulent range with those of the welded ship is reviewed.

There is a bibliography.

A New Variable Pitch Propeller. *Shipbuilding and Shipping Record*, **79** (1952), p. 105 (24 Jan.).

At present the range of variable-pitch propellers developed by Slack & Parr (Marine) Ltd., Kegworth, Derby, extends from a two-bladed unit with a maximum power of 30 b.h.p. at 1,200 r.p.m. to a three-bladed unit capable of 200 b.h.p. at 300 r.p.m. These propellers are suitable for the smaller fishing and towing vessels.

The article gives details and illustrations of the 200 b.h.p. type, which has a 15-in. dia. hub and is supplied with reduction gear and clutch. It can be fitted with either manual or hydraulic control.

The propeller enables the boat to maintain any speed from zero to maximum, either ahead or astern.

WELDING AND OTHER METHODS OF CONSTRUCTION

Using Oxy-acetylene Processes for Fabricating Piping. AULER, E. P. *Heating, Piping and Air Conditioning*, **23** (1951), p. 102 (July).

The oxy-acetylene processes used in the fabrication of piping are described. The most important are the oxy-acetylene cutting torch, gouging torch, and the flame of a heating torch. The importance of an adequate source and distribution system of oxygen and acetylene gases is emphasized. Special applications of the process in pipe fabricating are mentioned, including torch cutting of the high chromium and chromium-nickel alloys, stack cutting, and low-temperature stress relieving of welds. Oxy-acetylene processes are adaptable to any shop or field conditions, but the operators must have a good working knowledge of the equipment to obtain the best results, and adequate safety precautions must be taken.

British Experience in the Argon-Arc Welding of Aluminium. BINSTEAD, W. V., and WEST, E. G. *International Welding Congress, Oxford*, July, 1951.

After a summary of the process and a brief description of the equipment available in this country, typical applications of the argon-arc welding of aluminium are given, together with data on welding conditions and procedure. These applications include containers and plant for the chemical and food industries, vehicle building, structural engineering and building, marine and aircraft assembly, and general purposes in fabricating works and factories.

Some of the problems requiring further investigation are discussed. The chief deterrent at present to the wider application of argon-arc welding is its comparatively high cost, due to the price of argon and the initial outlay for equipment. There are several disadvantages of the present equipment, and overhead welding cannot be recommended at present. The argon-arc process causes less serious difficulties from the point of view of material requirements than the oxy-acetylene or the metallic-arc welding methods. but the choice of material is still important. The principal material problems are porosity, hot tearing or cracking in welds made under constraint, and the effect of welding on mechanical and other properties. In most respects argon-arc welding imposes fewer limitations in design than other joining methods.

A list of references is given.

Stud Welding Comes Aboard. McARTHUR, W. E. *Marine Engineering and Shipping Review*, **56** (1951), p. 68 (Aug.).

Improved equipment and a wider variety of granular-flux-filled fasteners for use with the lightweight, semi-automatic hand gun have extended the uses of stud welding in shipbuilding. New fasteners have been developed for securing insulation materials, electrical equipment, cargo battens, and wood decking. Two new power units are described briefly, the Nelwelder Power Unit, which is equivalent in performance to two conventional 400-amp. generators in parallel ; and a battery-powered source, which makes it possible to stud-weld up to $\frac{1}{2}$-in. diameter studs at any location where power for welding generators is not available.

High-Temperature Welded Joints. ENGLISH, R. H. *Welding Journal*, **30** (1951), p. 907 (Oct.).

If it was not possible to join them by welding the use of high-alloy castings would be severely limited. The alloys that are used extensively in the temperature range 1,500° to 2,000° F. are three in number, namely those containing 25% Cr and 12% Ni, 25% Cr and 20% Ni, and 15% Cr and 35% Ni. The Author describes the properties of these alloys, and then considers methods of welding them. The method most usually adopted is the shielded-metal-arc process with D.C. reversed polarity. Lime and titania coatings are used, which must be kept dry. Less chromium is lost in the welding process when a lime coating is used, but the slag is more difficult to remove. Alloy additions are made to both types of coating to bring the analysis of the weld metal to the desired level. For high-temperature joints the slag must be removed from each weld pass, since these slags accelerate the oxidation of the metal when in intimate contact. Even where the metal sections are between $\frac{1}{4}$-in. and $\frac{5}{16}$-in. thick, $\frac{1}{4}$-in. diameter rods are used extensively, giving faster deposit rates. It is seldom necessary to use rods less than $\frac{5}{32}$-in. diameter.

Inert-gas-shielded metal-arc welding has been successfully used with these alloys, the high-temperature properties obtained being equivalent to those of the shielded-metal-arc process. There is practically no slag formation or loss of alloys, but the difficulty experienced in obtaining coils of wire of the desired analysis has retarded progress in this particular field.

Oxy-acetylene welding has also been used successfully, a carburising cone flame being employed with the higher-carbon alloy, and a neutral, or slightly reducing flame, for the other two. Fluxes are usually used, and are available in the form of dry powder. Gas welding is, however, slower than the arc process, and is used only on light-gauge material.

Weld strength can be tested at high temperatures by a simple cantilever-beam test which the Author describes. Finally the Author illustrates and describes a number of welded assemblies of these high-temperature alloys.

There are two references.

SHIPBUILDING (GENERAL)

Fuelling at Sea. BLACK, I. McD. *Transactions of the North East Coast Institution of Engineers and Shipbuilders, paper read* 11 Jan. 1952.

The Author describes the development and practice of fuelling at sea and the special tanker features required. A weight of cargo oil of 15,000 tons represents a suitable quantity at present for fuelling at sea. The length of a commercial tanker of this cargo-oil deadweight would be about 500 ft. with a loaded summer-freeboard draught of under 30 ft. The speed would be about 14 to 15 knots in the fully-loaded service condition, with a trial speed approximately a knot higher. An appreciable increase in steam capacity over the basic freighter is required, which is provided by a separate boiler-room forward of the engines. The cargo space has to be planned for three separate grades of cargo, namely aviation fuel, Diesel bunker fuel, and furnace oil, with the consequent arrangements of cofferdams and suction piping to avoid contamination by leakage. Three pump-rooms are required and the pumps are of the centrifugal type. In addition to the demands of the fuelling rigs, the replenishment features of the tanker also require more capacity for dry stores than the normal tanker hold and forecastle give, and an extended forecastle is very useful. Special precautions have to be taken to prevent berthing damage.

Existing R.F.A. and naval tankers are reviewed. Multiple fuellings, ship interaction and ship handling, fuelling between warships, and reception fittings in warships are discussed briefly.

MATERIALS : STRENGTH, TESTING AND USE

Chromium-Plated Aluminium. *Engineers' Digest*, **12** (1951), p. 356 (Nov.).

A new process for chromium-plating aluminium makes use of an abrasive material suspended in water for cleaning and finishing the metal surface by wet-blasting. The aluminium surface then retains a coating of the suspension thick enough to prevent oxidation for a sufficient length of time to permit the aluminium to be immersed in the plating bath. The coating then washes off, and the chromium is deposited directly on to the aluminium without an oxide coating between base and plating coating. The material used for the wet-blasting operation consists of crystals of silicon dioxide. The coatings have a hardness of between 75 and 82 Rockwell C. The costs are stated to be usually rather less than for standard methods of chromium-plating steel.

Sherardizing. WILLIAMS, A. E. *Iron and Steel*, **24** (1951) p. 529 (Dec.).

The sherardizing process of protecting iron and steel by coatings of zinc is inherently limited in its application to articles that can be packed into drums during the treatment, the drums being usually about 2 ft. in diameter and up to 20-ft. long. The process is particularly suitable for treating tubular and channel sections. Steel rods or bars which have been sherardized and are subsequently riveted into position do not suffer any deterioration of the protective alloy, since it flows with the metal during riveting. Sherardizing can be applied to welded and brazed surfaces, and can be applied before, but not after, soldering.

A sherardized surface is not resistant to acid (industrial) atmospheres and constant exposure to water, but is resistant to intermittent exposure to atmospheric moisture, because of the formation of a protective film of zinc carbonate. In a rural or marine atmosphere the life of a sherardized surface may be ten years or more. The main advantage of a sherardized surface over other zinc-coated surfaces is the greater uniformity of the coating. The dimensional increase due to sherardizing can be accurately controlled for any surface contour, which makes the process particularly suitable for the preparation of standard screw threads. This is illustrated with calculated examples.

Methods of sherardizing, surface preparation, and painting of sherardized surfaces are described. Mention is made of the "Sherablak" treatment, in which an oil-black finish is applied to sherardized surfaces.

Nimonic Alloys in a Lightweight Gas Turbine. *Wiggin Nickel Alloys.* No. 16, p. 3.

The Rover T.8 gas turbine, which was used to propel the 60-ft. motor yacht *Torquil* and the Rover Turbocar, is briefly described. This unit developed 100-120 b.h.p. for continuous running, while modifications made to later models permit up to 200 b.h.p. to be developed. The inner shell of the combustion chamber, or flame tube, operates at a very high temperature and is constantly scoured by a fast-moving gas stream. The material chosen for this component is Nimonic 75, a nickel-chromium alloy with high resistance to creep and fatigue at elevated temperatures and a low coefficient of expansion. The rotor of the compressor turbine is machined in one piece from a forged blank of Nimonic 90. The power turbine is a separate unit mounted immediately behind the gas producer; the rotor of this turbine is also machined from a solid blank, but, in view of the somewhat lower gas temperatures, the alloy employed is Nimonic 80. In the course of development work on heat exchanges, the Rover Company are experimenting with the use of Monel, a nickel-copper alloy with a high resistance to corrosion and favourable mechanical working properties.

Adhesives for Metals. MEAKIN, K. S. *Research,* **5** (1952), p. 126 (March).

Synthetic-resin adhesives have been greatly developed in recent years and show very promising results, especially in bonding dissimilar metals or metals to other materials. In general, the main advantages of glued joints are as follows:—There is no concentration of stress at certain focal points, such as is produced with riveting, bolting, or spot-welding; the materials to be joined are not first weakened by the drilling of holes; the area of contact is far greater than in other systems; the joints possess a far higher fatigue strength than riveted or spot-welded joints; and the joints can be made pressure-tight and external surfaces will be unmarked and aerodynamically smooth.

After intensive research, two basic requirements for an adhesive have been formulated, namely that it must wet the surface of the adherent, and that it must not set up stresses on solidification likely to disrupt the bond. In addition, adhesives for metals must have strength, durability, and resistance both to common solvents and extremes of temperature, and they must not corrode the metal.

Two synthetic-resin adhesives for metals, satisfying these conditions, have been evolved, called Redux and Araldite. Redux has been successfully used in aircraft-fuselage construction, in rubber-to-metal bonding, and for the attaching of brake and clutch linings. In pure tension, joints made with

Araldite and Redux have a failing load of about 5,000 lb/sq. in., and in pure shear, uniformly distributed, about 10,000 lb/sq. in.

Numerical data, photographs, and references are given.

See also Abstracts No. 2707, June, 1949, and 3012, October, 1949, and 4791, May, 1951.

Supersonic Flaw Detection in Marine Engineering. *Marine Engineering*, **75** (1952), p. 61 (Feb.).

Supersonic instruments, operating on similar principles to echo-sounders, are being increasingly used in shipyards and engine works for the non-destructive testing of light-alloy, ferrous, and certain non-metallic components. Porosity, hair-line cracks, slag inclusions, blow holes, laminations, fatigue cracks, and welding flaws can be detected by this method. A self-contained portable instrument has been developed that will withstand tropical conditions and corrosive atmospheres. A permanent record of any test can be obtained by means of a special camera. The method of operation is outlined. Advantages of the supersonic method are that it is only necessary to have access to one surface of the material under test, and that the equipment can be satisfactorily operated by untrained staff. The range of detection is from half an inch to approximately twelve ft. below the surface, but can be extended up to 25 ft. and over, if required.

Recent applications in marine engineering include the examination of a propeller shaft, the testing of welds, and the measurement of the thickness of metal when there is access to one side only.

BOILERS AND STEAM DISTRIBUTION

Trends in Application of De-Aerating Heaters for Treatment of Boiler Feedwater. CALISE, V. J., and STENARD, R. K. *American Society of Mechanical Engineers, Paper No.* 51-*F*-39, *read at Fall Meeting, Minneapolis*, Sept. 1951.

Corrosion and pitting of boilers and accessories is caused mainly by the presence of non-condensible gases such as oxygen and carbon dioxide, or by low pH in the feedwater. Although pretreatment can increase the pH of the feedwater, oxygen and free carbon dioxide must be completely removed in a properly designed feedwater de-aerating heater. The requirements of an effective de-aerating heater are laid down, and some of the heater designs now available for industrial power plants and central station plants are reviewed.

Automatic Combustion Controls for Marine Boilers. TAYLOR, B. *Transactions of the Institute of Marine Engineers*, **64** (1952), p. 1 (Jan.).

The two main objects of automatic combustion control are to vary the rate of combustion according to the steam demand so as to avoid appreciable pressure fluctuations, and to maintain the most efficient combustion at all firing rates within the range of operation. Automatic boiler controls can be divided into two groups, namely position-control and metered-control systems; most marine installations have been fitted with metered controls. In both the series and parallel type of metered control, a fluctuation in the steam pressure actuates the master controller, which delivers a signal to the regulators controlling the dampers, valves, etc. The settings of the fuel-flow and air-flow regulators are modified simultaneously in the parallel system, while in series control either the air or fuel regulator is directly controlled, the other being set by the fuel-air ratio controller.

The factors that affect the functioning of the controls are discussed, the most important being the range of output of the oil-fuel burners. Problems involved in the management and control of the fuel and air flow are considered. It is held that, where possible, the air flow should be controlled by fan-speed regulation and dampers for the best results. Although there are theoretical objections to the methods of air-flow measurement commonly adopted, such as that using the pressure drop through the furnace-front air directors, such methods have been found to be satisfactory in practice. Practical difficulties usually preclude the use of a venturi or an orifice plate, which give more accurate results. The oil-fuel supply can be regulated by control of the speed of the fuel pumps or by the adjustment of a valve in the oil-supply line, the latter being more commonly used.

There are a number of references, and the paper is followed by a discussion.

GAS TURBINES

Gas Turbines for Smaller Vessels. SLADE, F. H. *Ship and Boat Builder*, 5 (1951), p. 109 (Oct.).

Propulsion machinery for small and medium-sized craft should be light, occupy little space, develop full power from cold very rapidly, and be easy to control, operate, and maintain. Freedom from noise and vibration, and the ability to operate with the minimum of modifications under all climatic conditions are other desirable characteristics. All these requirements can now be met by gas turbines, which have been constructed with outputs of 200 to 300 b.h.p. and thermal efficiencies in excess of 20%.

The Author discusses the mode of operation of this type of prime mover with the aid of diagrammatic illustrations. An axial-flow compressor, while generally more efficient than the radial-flow type, is more costly to manufacture, and, being sensitive to accumulation of dirt on the blades, is less robust. Also, the radial compressor is more suitable for dealing with small quantities of gas. Problems arise in the design of small units due both to constructional and aerodynamic effects. The former include the difficulties of working to a sufficiently high accuracy in the manufacture of small complicated parts, and the accompanying problem of scaling-down running clearances in relation to the other dimensions of the engine. It is felt, however, that the difficulties due to limits and finishes are not likely to be serious, since tip-leakage loss constitutes only some 4% of the power of the turbine; thus, even if this loss is increased by 50%, the overall efficiency of the machine is only reduced by about 2%. Tests carried out on aircraft turbines with unpolished blades show that there is no detectable reduction in efficiency compared with turbines having polished blades, so that the importance of the finish of the blade surface appears to have been overrated. The Author gives brief details of a number of applications of gas turbines to marine propulsion, and gives a number of references.

Design Features of a 5,000-h.p. Gas Turbine. BUCKLAND, B. O., and BERKEY, D. C. *American Society of Mechanical Engineers, Paper No.* 51-*A*-113, *read at Annual Meeting, Atlantic City*, 25-30 Nov. 1951.

A new gas turbine of 5,000 h.p. rating is described. The plant is a one-compressor, two-turbine unit to be used with or without a regenerator, and designed to have a maximum of flexibility in its application. As a regenerative gas turbine the thermal efficiency at the output coupling will be 22.5% based on the higher heating value of natural gas fuel, or 25% based on the lower heating value. The combustion chambers and fuel nozzles are designed to burn natural gas, but by changing the fuel nozzles, adding a fuel pump and making a few other similar modifications liquid fuel can be used, either distillate or residual oil.

The axial-flow compressor has 14 stages and operates at a pressure ratio of 5.5. The turbine has two stages, the second of which produces the useful load and has a nozzle arranged so that its effective flow area can be varied during operation. The six combustion chambers are expected to operate at 800° F. preheat and at 650° F. rise. The cylindrically-shaped regenerator when used is mounted on end and outdoors. The lubricating-oil system is similar to that used for steam turbines. The plant can be supplied either with a motor-driven or a turbine-driven cranking assembly. The control means for starting and stopping the plant and for controlling the turbine speeds and temperatures during operation is described. The installation requirements such as weights, outline dimensions, and water requirements are given.

A bibliography is given.

Ceramics and Gas Turbines. DUCKWORTH, W. *Battelle Technical Review*, **1** (1952), p. 7 (Jan.).

The efficiency of a gas turbine depends on a high maximum cycle temperature; in modern practice, turbine-inlet temperatures of 1,300° F. to 1,600° F. are used. Higher temperatures, with the associated higher efficiencies, might be achieved by employing ceramic materials. Rapid advances have been made in the past few years in ceramic research relevant to gas turbines; nevertheless, there are a large number of raw materials and combinations of raw materials which have not as yet been investigated. Much remains to be learnt regarding the brittle fracture that is characteristic of ceramic materials, and also the mechanism of sintering in the glass-free ceramic materials. Glass has a poor resistance to thermal shock, and tends to soften and deform under stress at comparatively low temperature; hence the glass phase cannot be tolerated in structural parts for the hot zones of gas turbines.

Several of the available ceramic materials might serve advantageously for parts operating in the hot zones of gas turbines. For immediate use, coatings for metals are particularly attractive, but ceramic bodies may offer more outstanding benefits as a long-term policy. To extend the use of ceramic materials, close co-operation between gas-turbine engineers and ceramists is necessary; with this co-operation, gas turbines with higher operating temperatures, longer life, or both, and perhaps lower weight, seem likely to become available.

DIESEL AND OTHER I.C. ENGINES

Development of the Opposed-Piston Diesel Engine. MUELLER, G. A. *American Society of Mechanical Engineers, Paper No.* 51-*SA*-50, *read at Semi-Annual Meeting, Toronto*, 11-14 June 1951.

After outlining the history and developments of the opposed-piston Diesel engine, the Author summarises the advantages of such a design and describes various railway opposed-piston engines.

The opposed-piston Diesel engine approaches more closely than any other type the internal-combustion engine operating on the ideal Diesel cycle. Owing to the shape and construction of its combustion chamber, the opposed-piston engine offers the minimum area for heat dissipation for a given cylinder volume, and also avoids heat losses from the combustion chamber to the water-cooled cylinder head. The advantage of its uniflow scavenging is becoming more apparent with the constant trend towards higher piston speeds. The swirl control in the power cylinder is a further advantage. The swirl is produced by the tangential entry of the scavenging air through the specially proportioned intake ports. This helical motion given to the scavenging air not only assists in sweeping residual combustion products from the power cylinder, but, as the exhaust ports are closed and the volume of air is trapped in readiness for the compression portion of the cycle, the swirl persists throughout the compression stroke and is extremely effective in producing the efficient combustion characteristic of the opposed-piston engine. Further advantages are the good balance characteristics of the opposed-piston design caused by the opposite movement of equal masses, and the extreme mechanical simplicity and compactness of the design.

One reference is given.

Damage Prevention from Diesel Engine Crankcase Explosions. CAVILEER, A. C. *American Society of Mechanical Engineers, Paper No.* 51-*OGP*-3, *read at Oil and Gas Power Conference, Dallas, Texas,* 25-29 June 1951.

The results are given of investigations by the U.S. Naval Engineering Experiment Station on the problem of crankcase explosions. Several types of crankcase doors have been tested. The test set-up and method are described.

It was concluded that the relief area for crankcases should be approximately 1.5 sq. in. for each cubic foot of volume of the crankcase. Light-weight multiple relief valves are desirable along the length of the engine crankcase. All parts of a crankcase should be capable of withstanding an explosive pressure of 20 lb/sq. in. and relief valves should be capable of relieving pressures in excess of this. Good gasket-cementing techniques, with some type of flame protection, should be used to prevent loss or burning of gaskets as a result of an explosion.

An Opposed-Piston Auxiliary Diesel Engine. *Motor Ship*, **32** (1951), p. 241 (Sept.).

A brief description, illustrated by sectional drawings, is given of the M.V.D. auxiliary Diesel engine, built by the Moss Vaerft og Dokk, Norway. It is built in units of two, four, and six cylinders. In each cylinder are two opposed pistons, and there is a double-acting scavenging-air pump. The 12-hour rating of this engine is 150 b.h.p. at 425 r.p.m. or 132 b.h.p. at 375 r.p.m. The continuous ratings are 135 b.h.p. and 119 b.h.p. respectively. The cranks for the working cylinders are arranged at 180°, but the scavenge-pump crank angle is such that the top pistons uncover the exhaust ports before the bottom pistons allow scavenging air to enter. Similarly, the exhaust ports are closed before the scavenge ports.

POWER TRANSMISSION

The Design and Operation of Fluid Couplings. *Motor Ship,* **32** (1952), p. 499 (March).

Fluid couplings are now being frequently used in conjunction with geared-Diesel installations. Such couplings replace the main-engine flywheel, and prevent the transmission of torsional oscillations and severe shock loads from the engine to the propeller shaft or vice versa. The coupling described in this article is that recently fitted to the Icelandic motor trawler *Thorkell Mani,* the propelling machinery of which is a Ruston pressure-charged six-cylinder unit, developing a maximum of 1,610 b.h.p. when running at 455 r.p.m. This engine transmits through a Vulkan-Sinclair fluid coupling of the scoop-trimming type, interposed between the engine and the S.L.M. oil-operated reverse-reduction gearing. This coupling, constructed by the Fluidrive Engineering Co. is designed to transmit the maximum power with a slip not exceeding $2\frac{1}{2}$ per cent.

The drive is taken to the impeller, and is transmitted by the oil in the working circuit to the high-tensile aluminium-alloy runner mounted on the output shaft. A small electric pump is provided for filling and manœuvring conditions. When trawling, the engine runs at full speed to drive the winch generator at its forward end. Control of the propeller, which is then required to run at reduced speed, is achieved by rotating the handwheel that determines the position of the scoop tube, which in turn regulates the oil level in the coupling and thus varies the output speed of the shaft. Experience has shown that manœuvring is improved and simplified by control with the scoop in addition to operation of the engine throttle.

MACHINE PARTS

The Life of High-Speed Ball Bearings. Jones, A. B. *American Society of Mechanical Engineers, Paper No.* 51-*A*-69, *read at Annual Meeting, Atlantic City*, 25-30 Nov. 1951.

The requirements of modern jet engines have resulted in the use of large ball bearings for heavy loads at very high speeds. Conventional calculations of bearing life are based on the fatigue of the components due to the externally applied loads. At high speed, the centrifugal force on the balls increases the probability of failure of the outer race of radial-type ball bearings under radial load and hence reduces bearing life.

In angular-contact bearings operating under thrust loan, centrifugal loading of the balls tends to produce a higher contact angle for the inner race than the outer. The relative probabilities of failure of the outer and inner races are therefore different from those calculated from static loading, and bearing life is accordingly different. The theoretical conditions outlined in this paper have not yet been confirmed by life tests.

Plastics Versus Metals in Bearings. Warring, R. H. *Mechanical World*, **131** (1952), p. 27 (Jan.).

Plastic bearings may consist of a plain bearing block-machined from sheet, a bush machined from laminated plastic tubing, moulded bearings, or a strip bearing in which a number of strips of laminate are secured in a metal housing. Details are given of physical and mechanical data of various plastics suitable for use as bearings. These bearings will resist the action of suds, oils and petrol, grease, graphite, and most mild acids and alkalis.

The plastic bearing must be enclosed in a complete metal housing to prevent any plastic flow. In general, it should be set up with a minimum clearance of between 0.005 and 0.0075 in. Running clearances will then be considerably less. Adequate lubrication is important, both to prevent local overheating and to reduce friction, which is high in the dry state but compares favourably with that of a metal bearing when correctly lubricated.

LUBRICANTS AND LUBRICATION

The Use of Detergent Lubricants. Brown, F. T. *Motor Ship*, **32** (1952), p. 414 (Jan.).

The Author suggests that detergent lubricants could with advantage be used in heavy marine Diesel engines running on boiler oil. Where detergent oil has been used there have been fewer seized or fractured rings in the main and exhaust pistons, deposits in the exhaust and scavenge ports have been of a more pliable nature, and close inspection has shown an improved and more effectively oil-wetted surface finish, all achieved with a slightly reduced oil feed. A detergent oil should be used where it can be established that high sulphur is causing heavy wear or corrosion in marine Diesel-engine cylinders.

A brief history is given of the development of detergent lubricants.

Viscosity-Temperature-Pressure Relationships; their Correlation and Significance for Lubrication. BLOK, H. *Proceedings of the Third World Petroleum Congress, The Hague*, 1951.

The difficulty of expressing the viscosity–temperature–pressure relationships of lubricating oils by means of empirical formulæ is discussed, and it is suggested that the approach to the problem should be based on a study of similar groups of oils, i.e. those originating from a similar source and refined in a similar way. As an example, data are given on the variation of viscosity with pressure at different temperatures of Pennsylvania oils.

It is shown that in general the load-carriyng capacity of lubricated machine parts is not greatly increased by using oils whose viscosity increases very rapidly with pressure. As the viscosity of such oils would in general decrease rapidly with temperature, solidification might set in.

There is a bibliography and a brief discussion.

HEAT TRANSFER AND INSULATION

General Discussion on Heat Transfer. *Conference arranged by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers*, 11-13 Sept. 1951.

This Conference was divided into five sections. Among the papers presented were the following:—

Section I. Heat Transfer with Change of State

LINACRE, E. T. Heat Transfer by Spray Cooling.

BROWN, G. Heat transmission by Condensation of Steam on a Spray of Water Drops.

BROWN, J. Cyclical Heat Interchanges between Charge and Cylinder in a Refrigerating Compressor Operating on Freon 12.

SJENITZER, F. The Evaporation or Cooling of a Liquid Drop Braked by Air.

HAYWARD, R. W. Research into the Fundamentals of Boiler Circulation Theory.

RICHARDSON, E. G. Evaporation of a Liquid Drop into a Gas Stream.

KERR, W., SCOTT, A. W., and SOROUR, M. Determination of the Reversion Point in the Supersonic Supersaturated Expansion of Steam.

YODER, R. J., and DODGE, B. F. Heat Transfer Coefficients of Boiling Freon-12.

SHORT, B. E., and BROWN, H. E. Condensation of Vapours on Vertical Banks of Horizontal Tubes.

BOSANQUET, C. H. The Correlation of Heat and Matter Transfer with Pressure Drop.

THOMSON, A. S. T., SCOTT, A. W., LAIRD, A. MCK., and HOLDEN, H. S. Variation in Heat Transfer Rates Around Tubes in Cross Flow.

GHAI, M. L. Heat Transfer in Straight Fins.
CODEGONE, C. The Air Convection Coefficient in Pipes from 400° to 700° C.
SQUIRE, H. B. The Friction Temperature: A Useful Parameter in Heat Transfer Analysis.
SCHMIDT, T. E. Heat Transmission and Pressure Drop in Banks of Finned Tubes and in Laminated Coolers.
HINZE, J. O., and ZIJNEN, B. G. VAN DER HEGGE. Local Transfer of Heat in Anisotropic Turbulence.
MIZUSHINA, TOKURO. Analogy Between Fluid Friction and Heat Transfer in Annuli.
TAYLOR, SIR GEOFFREY, I. The Mechanism of Eddy Diffusivity.
CAMERON, A. Heat Transfer in Journal Bearings: A Preliminary Investigation.
PEREGRINE, E. P. Air Flow Insulation.
VERSCHOOR, H., and STEMERDING, S. Heat Transfer in Two-phase Flow.
TINKER, T. Shell Side Characteristics of Shell and Tube Heat Exchangers.
DRAKE, R. M. Heat Transfer Problems in High Speed Flows in Rarefield Gases.
SEBAN, R. A., and SHIMAZAKI, T. T. Temperature Distributions for Air Flowing Turbulently in a Smooth Heated Pipe.
KAYS, W. M., and LONDON, A. L. Remarks on the Behaviour and Application of Compact High-Performance Heat Transfer Surfaces.
SCHLINGER, W. G., BERRY, V. J., MASON, J. L., and SAGE, B. H. Prediction of Temperature Gradients in Turbulent Streams.
WEINER, J. H., GROSS, D., and PASCHKIS, V. An Experimental Determination of Local Boundary Conductances for an Unbaffled Circular Finned Cylinder.
SNYDER, R. W. The Cooling of a Freely Falling Water-Drop.
BONILLA, C. F., BROOKS, R. D., and WALKER, P. L. The Viscosity of Steam and of Nitrogen at Atmospheric Pressure and High Temperatures.

Section III. Conduction in Solids and Fluids.

ESHELBY, J. D. The Fundamental Physics of Head Conduction.
CETINKALE, T. N., and FISHENDEN, M. Thermal Conductance of Metal Surfaces in Contact.
PRICE, P. H., and SARJANT, R. J. Unsteady Heat Flow.
HUTCHINGS, E. E. Air Convection Losses from Horizontal Cylinders at Low Wind Speeds.
GRIFFITHS, E., and HICKMAN, M. J. The Thermal Conductivity of Some Non-metallic Materials.
KAYAN, C. F. Heat Exchanger Analysis by Electrical Analogy Studies.
ALLCUT, E. A. An Analysis of Heat Transfer Through Thermal Insulating Materials.
ANTHONY, M. L. Temperature Distributions in Slabs with a Linear Temperature Rise at One Surface.
THRING, M. W. Instruments for Measuring Heat Flux in Furnaces.
SPALDING, D. B. Heat and Mass Transfer in the Combustion of Liquid Fuels.
SCHMIDT, E. H. W. Heat Transmission by Natural Convection at High Centrifugal Acceleration in Water-cooled Gas-turbine Blades.
LINDEN, A. J. TER. Heat Transfer to Grate Bars.
BERNATH, L., POWELL, H. N., ROBISON, A. G., WELTY, F., and WOHL, K. The Determination of the Temperature of Non-Luminous Flames by Radiation in the Near Infra-red.

BAKER, H. DEAN, and LASERSON, G. L. An Investigation into the Importance of Chemiluminescent Radiation in Internal Combustion Engines.

Section V. Special Problems.

BROWN, T. W. F. The Effect of the Radiation Correction on Cooling Loss in High-temperature Cooled Gas Turbines.

DAVIES, S. J., and SINGHAM, J. R. Experiments on a Small Thermal Regenerator.

TREFETHEN, L. M. Liquid Metal Heat Transfer in Circular Tubes and Annuli.

ALCOCK, J. F. Heat Transfer in Internal-combustion Engines.

SAUNDERS, O. A., and SMOLENIEC, S. Heat Transfer in Regenerators.

STANIFORTH, R. Contribution to the Theory of Effusion Cooling of Gas-turbine Blades.

HRYNISZAK, W. The Turbo-regenerator as Applied to Gas Turbines.

TAYLOR, C. F. Heat Transmission in Internal-Combustion Engines.

ELLERBROCK, H. H. Some NACA Investigations of Heat-Transfer of Cooled Gas-Turbine Blades.

AUXILIARY EQUIPMENT AND MACHINERY

Fresh Water by Distillation of Sea-Water. BARBOUR, F. S. *Society of Naval Architects and Marine Engineers (New England Section), paper read* Jan. 1951.

An increasing number of ocean-going vessels are now providing their total fresh-water requirements by the distillation of sea-water in low-pressure, vacuum-type, distilling plants. The Author outlines the principles of the process and discusses some of its problems and their effect on the design of the plant.

Basically, there are two types of this equipment. In the vapour-compression or submerged-tube type, the vapour produced by the boiling sea-water is compressed to a higher pressure and temperature before condensation. In the flash-type distilling plant, the sea-water is heated, but not boiled, and allowed to flash into a chamber where the pressure and corresponding saturation temperature are below the temperature of the entering sea-water.

The problem of separating entrained brine from the vapour has been satisfactorily solved by the development of vapour separators, but that of scale deposition on heating surfaces is not yet completely solved. Experience has shown that scale deposition increases as the temperature and density of the brine are increased. Distilling plants have therefore been designed to keep the temperature and brine concentration at a minimum, and special design features are provided to allow for the deposition and removal of scale. Methods of treating the feed water to reduce scale formation have also been developed. Experience with merchant vessels has shown that scale deposition can be reduced to about the same extent either by pre-treatment of the sea-water or without pre-treatment but with careful control of operating conditions.

The overall design of a distilling plant is largely a matter of achieving a functional balance among all its components and arranging them in such a manner as to produce a unit which is both compact and easy to operate. The Author discusses in detail the principles of designing the components, i.e., the evaporator-tube bundles, distilling condenser, vapour feed heaters, air injector condenser, and condensate cooler, and their general arrangements.

He describes various existing distilling plants, distilling units of different capacities, and design allowances for heeling of the vessel up to 15°. He also outlines possible further developments.

As a result of research by the U.S. Public Health Service, the bacteriological purity of drinking-water obtained by low-pressure, vacuum-type distillation of sea-water has been found satisfactory, provided that the salinity of the distilled water does not exceed 0.25 grains per gallon. The salinity has therefore been adopted as the criterion for bacteriological purity.

Increased gain in economy has resulted from the use of higher vacua (down to 8 lb/sq. in. abs.), the use of quadruple-effect plants for large installations, and the use of multi-stage, flash-type distilling plants.

References are given.

CORROSION, FOULING, AND PREVENTION

Prevention of Corrosion and Metal Attack in the Steam Water Cycle of the Steam Power Plant. STRAUB, F. G., and ONGMAN, H. D. *Corrosion*, 7 (1951), p. 312 (Sept.).

In a closed-cycle steam power plant, the steam and water come into contact with copper, copper alloys, and steel. The results of studies conducted to determine the effect of pH in the cycle on the solubility of these metals are given, and the possible effects of their presence in the boiler are discussed. The pH of the steam and feed water can be increased by means of the controlled addition of ammonia to the cycle; and it is shown that by maintaining a pH of 9 in the feed water by this means the copper as well as the iron solubility is reduced to very low values. Methods of adding and controlling the ammonia in the cycle are given. A discussion is given of the action of reducing chemicals in the boiler beyond their normal action on free oxygen. This covers the potential action of these reducing chemicals in reducing the iron and copper entering the boiler, so that these metals shall not come in contact with the boiler metal until they have been reduced and thus eliminated as potential oxygen carriers.

One reference is given.

OPERATION AND MAINTENANCE

Cleaning Sludge from Oil Fuel Systems. *Syren and Shipping, Bunkering Supplement*, **221** (1951), p. 17 (14 Nov.).

The use of oil fuel has brought in its train many problems, since it contains many impurities peculiar to crude petroleum products, such as asphalt, bitumen, and tar. These tend to separate from the oil fuel, and, owing to their tacky nature, attach themselves to the walls and bottoms of tanks, pipes, etc., forming deposits commonly known as sludge. These deposits are frequently reinforced by sulphur, carbon and other impurities, by water condensing in the system, and by oxidation products. These sludges are firm, and hold solid matter, water, etc. in a state of dispersion from which they are not easily dissociated. Tanks therefore become congested and pipes, pumps, and feeding systems become clogged.

All oil fuels are potential sludge formers, and the problem is accentuated because, owing to increased demands, much of the present-day product is of lower quality than formerly. In most cases, it is impracticable to install cleaning and purifying plant to remove these impurities, and other methods have had to be devised. In many cases, these consist of adding " additives " to the fuel oil with the object of eliminating some of the defects inherent in most present-day fuel oils.

As the additive is introduced it mixes readily and completely with the oil. It comes into contact with sludge and deposit-forming materials, and reduces their adhesiveness and surface tension, allowing them to disperse in the bulk of the oil, and thus produces a uniform, free-flowing fuel. An addition to fuel as it is bunkered not only prevents the formation of sludge deposits in the oil fuel, but helps to remove existing deposits which have already accumulated in tanks, pipe systems, etc. A clean, sludge-free system is therefore ensured, and the costly task of cleaning oil-fuel systems is eliminated. The improved combustion ensures steadier and more efficient heating, and there is a consequent saving in fuel costs.

New System of Tank Cleaning. *Shipping World*, **125** (1951), p. 129 (22 Aug.).

The Groom system of tank and chamber cleaning has been evolved to provide a convenient and efficient method of removing dirty oil and asphaltic and other deposits from the internal surfaces of tanks, principally in ships. Basically the system consists of using an aqueous detergent solution which is heated, though only to about 150° F., and pumped through a flexible hose or fixed pipeline to the point of operation, where it is discharged from either a manually operated or a special form of automatic projector against the surfaces to be cleaned. The heated detergent solution acts on the deposit and removes it by a combination of dissolution, reduction of interfacial tension, and scouring. An essential feature of the equipment is that the detergent is used in a closed circuit, so that only a relatively small amount has to be heated, and hence only a small heat exchanger is required. The used mixture of oil, deposit, and detergent is pumped from the lowest part of the tank and separated, and the detergent is then reheated and again pumped to the point of projection. The separating and heating tank is of relatively small dimensions, 5 ft. long, 4 ft. wide, and 5 ft. high, with an additional small make-up tank; these are sufficient for an equipment capable of cleaning four oil tanks simultaneously. Two types of projector are available, either hand-operated or automatic. The hand-operated projector has two nozzles, one giving a long unbroken jet, and the other a flat stream from a fish-tail end. Where it is undesirable for the operator to enter the tank, the automatic projector, which operates on the same principle as the rotating garden sprayer and has four nozzles on a hollow shaft, may be used.

It has been reported that the time taken to clean a tanker of 12,000 tons deadweight, with seven 1,000 ton tanks and fourteen 50 ton tanks, was only 322 man hours with Groom equipment, as compared with 14,400 man hours using manual labour.