TECHNICAL ABSTRACTS

The following abstracts are reproduced from the " Journal of the British Shipbuilding Research Association," Vol. 6, No. 6, Vol. 6, No. 8, inclusive.

PROPELLERS AND PROPULSION

Results of Further Systematic Tests on Two- and Five-Bladed Propellers (Dutch). LAMMEREN, W. P. A. VAN. *Schip en Werf,* **18** (1951), p. 155 (13 April). *Publication No.* 94 *of the Dutch Shipbuilding Experiment Station.*

Tests were made of one series of two-bladed propellers with a disk-area ratio of 0.30 and two series of five-bladed propellers with disk-area ratios of 0.45 and 0.60, made to Wageningen B design. The diameter of the model propellers was 240 mm. (9.4 in.). The behaviour of the models was investigated at constant rotational speed over a slip range of 100%, which was covered by varying the speed from zero to that at which no propulsive force was obtained. The distance between propeller axis and the water surface was equal to the propeller diameter. The propulsive force was corrected for the static pressure on the propeller axis, and for the resistance of the propeller hub at the appropriate speed. The speed of rotation was selected so as to lie within the measuring range of the dynamometer, and so that the values of Reynolds numbers should conform with those obtained in previous tests.

The results show that in general the efficiency falls if the number of blades is increased. The two-bladed propellers had a considerably higher efficiency than the equivalent three-bladed propellers tested previously. If there is no danger of cavitation, and if the propeller size required can be accommodated, the use of these propellers should be considered. The optimum propeller diameter decreases if the number of blades increases ; if the propeller diameter is restricted it may therefore be advantageous to increase the number of blades. The optimum diameter of the two-bladed propellers was found to be considerably higher than that of the equivalent three-bladed propellers.

There is a list of references.

Stresses in Propellers and Propeller Shafting under Service Conditions. DOREY, S. F. *International Conference of Naval Architects and Marine Engineers, Newcastle, paper read* 5 July 1951.

In the past, marine engineers have had to rely for measurements mainly on mechanical devices or instruments, and if the use of these was precluded by physical limitations, then it was only possible to fall back on calculation or empirical estimates founded upon experience. The application of electronic methods has greatly increased the field over which stress measurements may be made.

Propeller-blade defects are mainly confined to the bending or fracturing of tips resulting from impact with external objects, with cavitation erosion a further cause for renewal and repair, particularly in cast-iron propellers. It is, however, comparatively rare for a propeller to throw a complete blade, and where this does occur it is desirable to investigate the incident closely, so that, if it is found to be caused by deficient design, defective material, or vibration fatigue, its recurrence may be avoided. An example of a vessel in which a propeller blade was thrown on a number of occasions recently is fully calculated in an Appendix. To carry out these calculations it is necessary to make numerous assumptions. To check these some method of direct measurement is required, and such a method, by which the measurement of stresses in full-size propeller blades in service is practicable, is now available. In this method, which is illustrated and described, wire resistance strain gauges are mounted on the propeller blades, and electrically connected through suitable slip-ring gear to the recording equipment. This arrangement has been tested and found satisfactory.

In considering the service stresses in propeller shafting, the Author concentrates on torsional and bending stresses. Two examples of shaft failure due to torsional stresses are given. A considerable number of war-built steam-driven vessels have experienced tailshaft failure. From a statistical table it appears that the geared-turbine " Victory " class has the highest percentage of tail-shaft renewals. In turbine installations, particularly of the double-reduction class, practically the whole of the propeller-torque variation due to pitching will be applied to the propeller shaft, whereas with reciprocating steam engines the propeller acts as an inertia shield, and only about 25% of the torque variation is transmitted to the tailshaft. For oil-engine installations, the proportion of propeller-torque variation transmitted to the tail shaft is some 66% to 80%.

Bending stresses may be divided into two types, those arising from changes in alignment of the bearings, and those caused by hydrodynamic and inertia forces acting on the propeller. To check the initial adjustment and maintenance of bearings in service a simple strain gauge of high sensitivity has been developed, which is applicable to any shaft line and gives a direct measure of the cyclical bending strains in the shafting.

There is a list of references.

The Thrust Deduction. WEINBLUM, G. P. *Journal, American Society of Naval Engineers*, **63** (1951), p. 363 (May).

The object of this article is to give a simple description of the theoretical methods used in investigations of thrust deduction and to sketch briefly the state of knowledge so far reached.

The main idea of modern investigations on the subject consists in describing the flow around the hull and the propeller by an appropriate choice of singularities (images). This forms the subject matter of Part I of the article.

Once these generating images (sources and sinks, doublets) are known, it is a matter of technique to compute the forces resulting from the mutual interaction between the hull and the propeller. This is done for uniform motions by Lagally's theorem. In Part II a short explanation is given of this theorem which proves to be a powerful tool in hydrodynamic research. Part III contains a brief survey of wake phenomena, Part IV the analysis of the interdependence between wake and thrust deduction, based on Dickman's method, and Part V presents a discussion of various practical problems connected with the subject. These include the influence of scale effect on the thrust deduction, especially the relation between the scale effect of the model and the ship ; the disagreement between measured " resistance augmentation " and the suction force computed from pressure measurements ; the effect of speed and load coefficients on thrust deduction ; the thrust deduction of single-screw ships ; the influence of the longitudinal position of the propeller on thrust deduction ; the Schoenherr and Aquino formulae for wake and thrust deduction ; the influence of changes in the forebody on thrust deduction ; and correlated problems, such as the pressure changes on a hull due to a working propeller, and the influence of the propeller field on the steering qualities of twin- and multiple-screw ships.

The state of scientific knowledge on thrust deduction may be summarised as follows :—The application of the source and sink concept to the combined ship and propeller leads to a satisfactory explanation of the phenomena of thrust deduction. Dickman has succeeded in elucidating the main features of the problem. Later contributions by other authors have not added essential ideas. The quantitative analysis of the forces involved, although in principle successful, still meets some difficulties, and there are some important gaps between results of theory and facts. One basic problem, the influence of the scale effect on the thrust deduction, especially the relation between the corresponding values for the model and the ship, cannot yet be rigorously solved ; theoretical considerations indicate, however, that the common assumption according to which the thrust-deduction coefficient is roughly the same for the model and the ship, may be a reasonable approximation, especially when the size of the model is large. So far no theoretical investigation exists dealing with the ship, propeller, and rudder combined.

References are given.

WELDING AND OTHER METHODS OF CONSTRUCTION

Welded Structures of High-Powered Engines. SCHMIDT, F. *International Congress on I.C. Engines, Paris, paper read* May 1951.

After a brief review of the application of welding before the war to large Diesel-engine parts, the Author explains the technical and economic reasons for their increased use after the war. The considerations that have led M.A.N. in the last few years to weld all bedplates of the larger engines are reviewed. Five different designs of large bedplates are described and illustrated. The manufacturing process, including dressing and stress-relieving, is outlined, and data for the calculation of prime costs compared with castings are given. Drawings and particulars are given of welded frames and scavenging-pump cylinders of high-powered Diesel engines being built by M.A.N.

The Effect of Local Stress Relieving in Welded Joints in Boiler Drums (German). *Zeitschrift des Vereines Deutscher Ingenieurs*, **93** (1951), p. 391 (11 May).

The efficiency of a welded joint may be improved if the component is annealed to relieve the residual stresses. Owing to the size and shape of the component it may not always be possible to anneal it as a whole. Tests have therefore been carried out in which longitudinal welded seams in a boiler drum were heated by a number of gas burners arranged along the length of the seam on the inside of the drum. The annealing temperature of 1,100° F. to 1,200° F. was reached after about 1½ hours, and maintained for 5 hours. The gas supply was then reduced in stages, and the seam gradually cooled. The temperatures were measured by thermocouples placed on the outside of the seam, which was insulated by asbestos sheets. The results show that, while the residual tensile stresses were not relieved to the same extent as when the heat treatment affects the entire component, they were reduced to some 6 to 9 tons/sq. in., which is adequate for practical purposes.

MATERIALS : STRENGTH, TESTING, AND USE

Modern Methods of Detecting Surface Flaws (French). LEIRIS, H. DE *Association Technique Maritime et Aéronautique, Paris, paper read* May 1951.

The method of detecting surface cracks and other flaws by dipping the component in oil, wiping it clean, and then applying a chalk-based solution to draw the oil from the crack by capillary action, and show the presence and extent of the crack by a stain has been in use for a considerable time. Recent developments in this technique permit the process to be speeded up considerably. In one method, the penetrating liquid is based on one of a number of solvents and is given a brilliant red colour. The component is cleaned with carbon tetrachloride or toluene, and the penetrating liquid then sprayed on to the surface. After some two minutes the excess fluid is wiped off, and a rag moistened with carbon tetrachloride passed over to ensure that no fluid remains. Talcum powder is then dusted over the surface. Compared with the old methods, the equipment required is small in bulk, and the time to carry out a test of this type is of the order of five minutes.

A more sensitive method, capable of detecting even finer cracks makes use of fluorescent powder. Here the penetrating fluid is saturated with a fluorescent salt, and is applied either by dipping the article or by brushing on the solution. The time of penetration is of the order of five minutes. The solution should then be carefully cleaned off the surface, care being taken to remove it from any irregularities or fillets, since these will give parasitic emissions. Very finely powdered silica or a detecting liquid consisting of a solution of colloidal silica in methanol is then applied, and the surface is viewed with ultra-violet light. Although the time taken for this method is in excess of that required for the first, the sensitivity is considerably higher ; definite figures are not available, but it appears that cracks narrower than 0.002 in. can be detected.

There is a bibliography.

The Chromising Process. GIBSON, T. *Sheet Metal Industries*, **28** (1951), p. 569 (June).

Chromising is a process which, by diffusing chromium into the surface of articles of ordinary iron and steel, provides valuable corrosion-resisting and heat-resisting surface properties on a relatively inexpensive base metal. The chromised surface layer is uniform over all parts of the surface, even when the surface is irregular or contains small holes or interstices.

The treatment is usually applied to completely fabricated articles ; it produces no appreciable change in the dimensions of the article, since it is based on a chemical reaction in which an iron atom is replaced by a chromium atom (which is of practically the same size). The coating becomes an integral part of the article and cannot be stripped off by purely mechanical means. From these aspects alone, it presents considerable advantages over electro-deposited coatings.

A description is given of the chromising process patented by Metal-Gas Co., Ltd., by which chromised coatings up to 0.012-in. thick can be obtained. The composition of the coating varies with the depth of diffusion of chromium, the highest chromium concentration (50%) being at the surface. The diffused zone containing about 12% Cr is considered to be the effective chromised coating, since transition from non-stainless to stainless steel takes place at this composition. A sharp boundary between the two zones can be detected under the microscope.

The properties of chromised coatings depend on the composition of the steel to which they are applied, in particular its carbon content. Generally, a high carbon content increases the hardness, but reduces the corrosion resistance of the coating, on account of the formation of chromium carbides. The formation of such carbides can be prevented, and increased corrosion resistance obtained, by adding titanium, columbium, manganese, molybdenum, vanadium, or zirconium to the steel. Chromised low-carbon titanium-bearing steel is widely used in the tensile-strength range of 22 to 26 tons per sq. in. Its coating is highly resistant to severe manipulating conditions (tube expanding, bending, pressing, drawing or rolling), and its corrosion resistance is comparable with that of 30% chromium ferritic stainless steel. It resists corrosion in industrial and marine atmospheres, wet steam, etc. Chromised mild steel resists oxidation at temperatures up to 1,600° F. This may be extended to temperatures of 1,900° F. by an additional treatment in which aluminium is diffused into the surface to form a complex iron–chromium–aluminium oxide film. Chromised steel containing up to 0.5% carbon combines excellent wear resistance with a considerable degree of corrosion resistance.

Chromised articles can be subjected to most heat treatments, including welding and brazing. Resistance welding is particularly convenient, but arc-welding is also suitable.

A few applications of chromised articles having scale-resisting and wear-resisting properties are mentioned. Many other properties and applications of the process are still being developed, and particular emphasis is laid on the growing requirements of gas turbines and high-temperature power plants. New steels are being developed, particularly of the low-alloy ferritic type which, when chromised, have outstanding high-temperature properties.

Laboratory Evaluation of Materials for Marine Propulsion Gears. GROSS, M. R. *Proceedings, American Society for Testing Materials, paper read at Annual Meeting*, 18–22 June 1951.

An account is given of a series of laboratory tests to determine the pitting resistance and root fatigue strength of materials for marine gear applications. By means of contact roller test machines, pitting limits have been determined for six steels and eight non-ferrous materials. The breakdown limits for five plastic base materials have also been determined. A new test called the " simulated gear tooth fatigue test " has been developed to evaluate the root fatigue strength of materials under reversed bending stresses. The effect of hardening treatments, root radii, and surface finish and treatments on the endurance limit of the root area has been determined for three steels.

Hardened copper–beryllium alloy had the highest resistance to pitting of any of the non-ferrous materials tested. Increasing the fillet radius was found to increase fatigue resistance of the gear tooth. The application of shot peening increased the fatigue resistance of the root area by 25%. The most effective tooth-strengthening treatments were carburizing and nitriding, both of which increased the root strength by 70%.

BOILERS AND STEAM DISTRIBUTION

A Steam Line Failure and an Investigation of Shafting Material. GATEWOOD, A. R. *Society of Naval Architects and Marine Engineers (Gulf Section), paper read at New Orleans*, 20 April 1951.

In the first part of this paper, the Author describes an investigation carried out on a section of main steam pipe which had been connected to a boiler superheater outlet. Cracks had developed in the line, and prompt action had been taken to prevent any more serious consequences. An examination of the arrangement of the piping on the ship showed that the design differed from usual practice in two respects, namely in the arrangement of the superheater escape pipe, and in the arrangement of the combustion-control installation. The superheater safety-valve connexion to the escape pipe had been made without provision for expansion. With regard to the combustion-control connexion, there was a long, unlagged, horizontal run of pipe, about 20 to 30 ft. long, at the same level as the main steam line before it dropped down to the combustion control board. It was thought probable that the condensate would fill up to the level of the horizontal lead so that periodically water might be carried over into the steam line by the rolling of the ship.

Evidence was found indicating that corrosion fatigue had played a part; and it was considered that the initiation of the cracks was caused by thermal shock, that is by repeated sudden and localized reductions of temperature due to condensate carry-over from the combustion-control connexion.

This corrosion-fatigue type of thermal cracking can be avoided if a thermal-sleeve connexion is used and if a generous, well lagged, vertical drop is provided at the combustion-control pressure connexion to the main superheated-steam line. In the case of flow-meter connexions, the thermal sleeves can also be used, but it is apparently not practicable to utilize the vertical drop because of the necessity for keeping the condensate in both legs balanced except when there is a change of flow. The principle of keeping the temperature of the horizontal source nipple high enough to evaporate any condensate carry-over, either by laying it up against the main steam line or keeping it hot by some other means, would seem to be one practicable solution.

In general, careful consideration must be given to the effect of the ship's motion when connecting any dead-end line to a superheated-steam line.

The second part of the paper deals with a project undertaken to determine whether the propeller-shaft material itself was responsible for the increase in propeller-shaft failures in recent years. Test results are given and discussed. No indication was given that better shaft performance would be obtained if the present requirement of 3 to 1 ingot reduction were changed to the former requirement of 5 to 1 reduction. The results did not show any correlation between impact properties and shaft performance. However, tests made on special forgings showed that for larger-diameter forgings a larger ingot size may off-set any increase in notch toughness produced by a higher ingot reduction. It is of interest to note that the best impact properties were obtained on the two shafts with approximately ½% nickel content.

Operation and Maintenance of Modern Marine Boilers. O'NEIL, J. R. *Society of Naval Architects and Marine Engineers (New York Metropolitan Section), and New York Society of Marine Port Engineers, paper read at Joint Meeting*, 22 March 1951.

Each vessel of the Moore-McCormack Lines is provided with the manufacturer's instruction book on the boilers fitted. In this paper, the Author draws attention to points of particular interest in boiler operation and maintenance. The steam ships are equipped with two boilers each, and deliver to the H.P. turbine steam at about 445 lb. per sq. in. and 740° F. The contract boiler-maintenance costs of each type of boiler for 1949 and 1950 are analysed.

The major portion of the crew's work consists in the maintenance and tightness of the boiler casings, refractory repairs, overhaul of soot blowers, and the cleaning of the fire-sides of the boilers. Methods of keeping fire-sides clean include hand cleaning, steam lancing, hot-water washing, and the so-called sweating method. The circulation of steam through the fire-sides by means of jets while the boiler is steaming minimizes soot and slag deposits on tubes. Few difficulties have been encountered with the water-sides of boilers. Lubricating oil in small quantities has entered the boilers in several instances, and the fault has invariably been traced to the main feed pump.

The maintenance of oil burners and air heaters and casualty-control safeguards are mentioned. Sectional header and " D " type boilers are compared from both maintenance and efficiency points of view. In general, the sectional-header type is preferred by the engineers. It is possible to obtain the same efficiency from either type of boiler.

STEAM ENGINES AND STEAM TURBINES

Unaflow Marine Engine. LINDSAY, G. L. *The Log*, **46** (1951), p. 62 (April).

These engines, built by the Skinner Engine Co., are vertical, double-acting, uniflow engines. All the cylinders are identical, steam being provided at full boiler pressure and temperature to each cylinder, and exhausted to the condenser. Except when starting or manoeuvring at slow speed, the speed and power of the engine is controlled entirely by cut-off, and this elimination of throttling contributes to the flat steam-rate curve obtained, with consequent good economy at low manoeuvring speeds as well as at cruising speeds.

By selecting the number of cylinders and the stroke it is possible to obtain powers between 500 and 7,000 i.h.p. and speeds between 90 and 300 r.p.m. Steam pressures used on these engines have varied between 150 lb/sq. in. gauge and 325 lb/sq. in. gauge with temperatures from 365° to 650° F. The wide ranges indicated by these figures are obtained from standard engines by using from two to eight cylinders in combination with one of seven different strokes.

Steam Reciprocator with Exhaust Turbine. BAUER, G. *World Shipbuilding*, **1** (1951), p. 39 (May).

In this invention, for which the Author has made application for a German patent, the output of the exhaust turbine is transmitted to the reciprocator crankshaft through a double-reduction gear. The reciprocator flywheel serves as the gear wheel of the second stage of the reduction gear. To utilize the greatest possible heat drop, it is necessary to maintain the best possible vacuum in the condenser, and for this purpose the connexion between turbine exhaust and condenser must be kept as short as possible. This is achieved by placing the double-flow exhaust turbine directly on top of the condenser which is fitted on the engine frame. A mechanical coupling makes it possible to disconnect the turbine from the engine shaft.

GAS TURBINES

Fuel Tests on a Naval Gas Turbine. *Shipbuilding and Shipping Record*, **78** (1951), p. 42 (12 July).

Bench tests on a Gatric gas turbine of the type installed in *MGB* 2009 were carried out in 1949 by the Metropolitan Vickers Electrical Company on Admiralty instructions. The results have just been published. In the first series of tests the turbine was started on gas oil and then run on various blends of boiler fuel containing between 20% to 100% fuel oil to Admiralty boiler-fuel specification. Each fuel was tested in a seven-hour cycle at various speeds. After each test, the engine was stripped and inspected, and any deposit from the products of combustion was removed before the next test was begun. No difficulty was experienced in running on the various blends, but it was found necessary to flush out the fuel system with gas oil immediately after shutting down to ensure a successful start in the next test. When running on 100% boiler fuel, the exhaust was nearly clean at the higher speeds, with some blue smoke present at idling speeds. When the engine was opened up for inspection after this trial, a moderate amount of carbon deposit was found in the combustion chamber. The test results indicated that the engine, as developed for gas oil, was capable of being run for a limited period on the heavy fuel used, although not well suited to this fuel.

Further tests were carried out with fuel of a high sulphur content. This fuel contained 2.8% sulphur, and was of a viscosity similar to gas oil. A number of trials were carried out, and it was found that, while a fair amount of smoke was emitted on starting, little was noticed during regular running. The exhaust had a distinct sulphurous smell. The performance was similar to that on gas oil. The inspection after test revealed only one serious defect —the eating away of the fuel-jet shields. These were made of a steel with a high nickel content, which appears to be specially liable to this type of attack when in a reducing atmosphere such as may exist in some parts of the primary chamber.

Free Piston Diesel as Gasifier for Turbine Installations. *Motorship*, **36** (1951), p. 22 (June).

The free piston gasifier and turbine compound plant has been chosen for development by the (U.S.) Navy because it combines the known high thermal efficiency of the Diesel cycle with the lightness and compactness of the gas turbine and an inherent lack of vibration. A description is given of a unit under test at the U.S. Naval Engineering Experiment Station, consisting of two gasifiers supplying hot gases for a single turbine. The turbine drives an alternator through a reduction gear. The output is controlled by a turbine speed governor. The power plant was developed for an output of 650 kW. at 90 lb/sq. in. gas pressure and 11,420 r.p.m. turbine speed.

A brief account of the development of the free-piston gas generator is given. It is considered that the combination of free-piston gas generator and gas turbine should be one of the most compact of all heat engines, having a specific volume ranging from about 0.08 to 0.15 cu. ft. per h.p. Specific weights of long-life units should be of the order of 7 to 10 lb. per h.p.

DIESEL AND OTHER I.C. ENGINES

Crankcase Explosions. HOARE, D. J., Engineer Rear-Admiral, and CONYBEARE, A. M. *International Congress on I.C. Engines, Paris, paper read* May 1951.

Although crankcase explosions are fortunately rare, the loss of man hours alone caused by one serious incident justifies research into the problem. After reviewing a number of case histories of crankcase explosions and summarizing previous experiments, the Authors describe an investigation carried out by B.I.C.E.R.A. The results showed that the atmosphere inside a crankcase is not explosive under normal conditions and is not immediately ignitable. Oil is present in the form of mist, and there is a negligible amount of vapour, since the vapour pressure at normal temperatures is very low. Under conditions of overheating, vapour may be produced in quantity and may form an explosive mixture with the air in the crankcase, which may be ignited by a hot-spot at a temperature of 1,200° F. or above. The atmosphere cannot, by increasing the quantity of oil-mist, be made too rich to ignite, as the inflammability depends on vapour rather than mist. The production of vapour may be too rapid to be adequately cleared by normal crankcase ventilation ; and crankcase sealing does not provide a solution, as the initial air is sufficient for several explosions. Pressure diagrams showed in general a rate of pressure rise too slow to result in detonation. Known cases of damage due to crankcase explosions can be accounted for by pressures of the order of one or two atmospheres.

Scavenging with carbon dioxide or other inert gas should be an effective means of preventing an explosion, if used in time ; but there are difficulties both in keeping the crankcase permanently filled with the gas and in holding it in readiness for an emergency. The use of exhaust gas from a fully-loaded auxiliary engine was tested and found to be capable of preventing explosions, but it is noted that prolonged presence of exhaust gas in a crankcase might possibly be attended by undesirable effects. Relief valves are an effective safeguard against dangerous pressures. They should preferably be of the re-closing type, and numerous and small rather than few and large.

There is a bibliography.

Research in Exhaust Manifolds. SCHWEITZER, P. H. *International Congress on I.C. Engines, Paris, paper read* May 1951.

The effect of the exhaust manifold on engine performance has largely been neglected until recently. An investigation, sponsored by the (U.S.) Office of Naval Research and described in this paper, was undertaken to study interference between cylinders and to develop exhaust manifolds of improved performance. The factors determining the relation between exhaust-pipe design and engine performance are discussed. In single-cylinder two-stroke engines the tuning of the exhaust pipe is of paramount importance. Tuning is much less important in multi-cylinder engines but the problem of interference must be considered.

The experimental equipment and methods are described. Model testing was found to be satisfactory and relatively inexpensive. Exhaust manifolds can be classified into three groups, back-pressure, aspirator, and neutral manifolds, and a number of designs from each group were tested. The most important factor in exhaust-manifold design is its geometric configuration. The importance of the proper size is demonstrated.

There is a list of references.

Design and Operation of Exhaust-Driven Turbo-Compressors for Diesel Engines. PENN, A. J. *International Congress on I.C. Engines, Paris, paper read* May 1951.

Supercharging by means of the exhaust-driven turbo-compressor gives increased power output without increase of engine capacity and at the same time improved overall thermal efficiency. The Author describes the design and operation of turbo-compressors for four-stroke Diesel engines, and discusses the problems associated with matching these units on the engines to obtain optimum performance.

Charge-cooling has recently been introduced to permit increased supercharging. By this means, increased outputs have been obtained without adverse effect on specific fuel consumption. For each basic type of turbo-compressor unit, a water-cooled charge cooler is available with an effectiveness of at least 70%, so designed that it can be installed between the turbo-compressor and the induction manifolding. The effect of prevailing atmospheric conditions on performance is considered, and correction curves are given.

It is believed that turbo-charged engines of power outputs twice those of normally aspirated engines of the same capacity will be introduced. In view of this, a new series of turbo-compressors has been developed for a maximum continuous rating of 2.0 : 1 pressure ratio and is now available to the industry together with suitable charge-coolers. A number of systems of supercharging two-stroke Diesel engines by means of turbo-compressors are under investigation.

POWER TRANSMISSION

Flexible Couplings. DEAN-AVERNS, R. *Torque*, **1** (1951), p. 10 (April).

Flexible rubber couplings have excellent damping qualities for vibrations, are completely reversible, and permit freedom of movement in more than one direction. The quality of the rubber can be accurately adjusted to suit particular applications. The Author quotes several examples of the use of such couplings in marine propulsion units. They are particularly well adapted to propeller-shaft systems of small water craft. Illustrations are given of the Silentbloc Cushioned Drive Coupling, in which the rubber bushes absorb shock loads, torque fluctuations, torsional vibrations, and some degree of misalignment ; the Silentbloc Marine Coupling, in which the rubber bushes are disposed radially to take axial thrust ; and an improved construction in which spigots are provided in the inner sleeves of the coupling unit to relieve part of the load on the driving pins.

A coupling unit with variable rates of stiffness is provided by the Andre Shear Compression Bush. This has been developed for cases in which the normal input torque is multiplied many times and temporarily reaches peak overload conditions. Vibrations at normal load are damped by the flexibility of the coupling, while an increase in the load causes progressive stiffening of the coupling, through the introduction of two moulded slots running through the length of the annular sleeve of Andre rubber which is the flexing medium in the bush.

The Strength of the Tooth Flank in Straight-Toothed Steel Gear Wheels (German). NIEMANN, G., and GLAUBITZ, H. *Zeitschrift des Vereines Deutscher Ingenieure*, **93** (1951), p. 121 (21 Feb.).

The strength of the tooth flank considered is its resistance to pitting, or rolling strength, as opposed to the resistance to wear, or sliding strength.

The loading of gear wheels is often limited by this pitting effect, particularly when the flanks are not hardened. Experiments have been carried out on pairs of gear wheels to determine this flank strength, and the results are given for a number of wheels, together with the tensile and fatigue strengths for the material and the hardness. The effect of oil viscosity was also investigated, and it was found that the rolling strength increased with the use of thicker oils. Further experiments to be carried out on this subject are outlined.

The Direct or Indirect Drive of Ships by Diesel Engines (German). STEIGER, J. *Schweizerische Bauzeitung*, **69** (1951), p. 275 (19 May).

Whereas until recently the most usual method of using a Diesel engine for ship propulsion has been by driving the propeller shaft directly by a slow-running long-stroke engine, which has a low fuel consumption and, owing to its robust construction, a high reliability and long life, there is a tendency nowadays for fast-running geared engines to be employed, although more difficulty is experienced in running these on heavy fuels.

The most important factor with this type of installation is the coupling between engine and gearing. Gear manufacturers are loath to supply gears to transmit more than a certain power, owing to the irregular engine turning moment and the danger of increasing the tooth stresses by torsional vibration. In one particular case, a Bibby coupling was installed in a motor vessel fitted with an engine developing 6,700 h.p., and a hydrostatic vibration damper was installed at the other end of the crankshaft ; this arrangement has proved satisfactory during 17 years of service.

A further improvement is the hydrostatic-damping coupling, in which the primary part consists of a gear wheel with which the pinions of a number of oil pumps engage. These pinions transmit the power to the secondary portion, on which the oil pumps are mounted. Under normal conditions, oil flow is prevented by pressure-operated valves, and the pinions turn only very slowly to an extent governed by leakage losses. If the turning moment exceeds a certain pre-determined value, the pressure-operated valves open, and the slip increases so that the coupling is protected from overloads. The slip at normal loads is about 1%. In the hydrodynamic coupling, on the other hand, the motor and shaft are, from a vibration point of view, almost completely separated and possess the advantage that motors can be coupled in and out during operation. The disadvantage of this system lies in the slip, which is of the order of 2% to 2.5%. Electro-magnetic couplings reduce the slip to some 1% to 1.25%. In this case, oil tanks, oil cooler, and pumps are not required, and manoeuvring is more rapid and can be effected from the bridge.

The floor area occupied by a geared engine is about the same as that for a directly coupled engine, but the height required is less, which may be of importance. The saving of weight effected by using geared engines is some 8% ; both this factor and the space occupied could be further reduced by supercharging the engines, but the difficulties this brings in its wake, particularly when running on heavy fuels, has prevented the widespread use of this technique. The fuel consumption referred to shaft horsepower is some 10% higher for geared engines, but this is to some extent offset by the possibility of having the propeller operating at its best speed.

MACHINE PARTS

A New Stern Gland (German). BLEICKEN, B. *Hansa*, **88** (1951), p. 608 (28 April).

In the past it has been customary either to let the propeller shaft run in a lignum-vitae bearing or in an oil-filled bearing. In the former, it is found that the wood wears down comparatively rapidly, so that the shaft is seldom lined up absolutely correctly ; moreover, since the shaft is running in salt water, it must be given a protective bronze coating, and there is also difficulty in keeping the gland at the inboard end of the bearing tight. At the latter type of bearing difficulty is experienced in maintaining the gland at the outer end of the bearing tight, and so it is necessary to use an expensive saponifying oil.

The Author describes the " Simplex " glands for oil-filled bearings, which have been developed by the Deutsche Werft. The actual stern gland consists of two washers made of an artificial rubber, resistant to sea-water and oil. The outer edge of each washer, which is concave in section, is secured to the stern tube ; the inner edge rubs on a chrome-steel bush secured to the shaft, and is kept in contact with the bush partly by the pressure of a spiral spring surrounding the shaft, and partly by the pressure of the water in the case of the outer washer, or the oil in the case of the inner. To ensure that the washers are concentric with the shaft and are lubricated, their central ridges are secured to a steel ring lying between them, which is a clearance fit on the shaft, and is lubricated with oil. This device ensures that, even should the shaft move slightly with respect to the outer casing of the gland, the position of the contact surface of the washers relative to the shaft remains unchanged. The area of the contact surface is very small, so that it is easy to keep tight, and the washers exert very little frictional resistance. It has been found that in practice the wear of the rings is very small, and in fact that, were it not for the chrome-steel bush, wear would occur on the shaft. The gland at the inner end of the oil bearing is of similar construction. In each case, an auxiliary washer is included on the side of the gland remote from the bearing to prevent dirt from entering.

These glands have proved very successful in practice, some 80 sets having been delivered up to the present.

LAYOUT AND INSTALLATION

Joints for High-Pressure High-Temperature Piping. CARLSON, I. H., and BLACK, W. S. *Transactions, American Society of Mechanical Engineers*, **73** (1951), p. 237 (April).

The problem of obtaining leak-proof joints for high-pressure high-temperature piping is complicated by the fact that differences in temperature, rigidity, and coefficients of expansion and of heat conductivity result in relative movements of sealing surfaces. An account is given of tests carried out on three special joints intended to permit relative movement of parts differing in thermal expansion, namely the pressure-seal joint, the bellows type, and a spiral-wound, metal, asbestos-filled gasket joint designed for 1,900 lb/sq. in. 1,050° F. steam service.

The pressure-seal joint remained tight throughout 25 cycles of heating to 1,050° F. and quenching with saturated steam at approximately 575° F. The bellows-type joint leaked 11 times out of a total of 23 quench tests. The amount of leakage was extremely slight, and the length of time of leakage varied from 15 secs to 8 min. The joint sealed itself in every case. The asbestos-filled gasket joint was unsatisfactory. During the first quench the gasket leaked moderately for 15 min., after which time the joint sealed itself. During the second quench the joint leaked severely.

The paper was followed by a short discussion, in which it was suggested that the tests were abnormally severe, and that the relative simplicity of the spiral-wound gasket and its flange warranted further development to improve its shock characteristics. The company with which one contributor was associated had experienced completely satisfactory service with spiral-wound asbestos-filled gaskets in flanged joints at 500 lb/sq. in. pressure and 1,050° F.

Steam Piping for High Pressures and High Temperatures. BAILEY, R. W. *Proceedings, Institution of Mechanical Engineers, paper read at General Meeting,* 13 April 1951.

Steam piping has hardly kept pace in scientific design, and in the consequent economic use of materials, with turbine development for high temperatures and pressures. Consequently, piping systems have commonly been more costly and heavier than has been necessary. The Author discusses design principles by which economy in design can be achieved where temperatures and pressures are high, and by which advantages can also be obtained under less exacting conditions.

The question of allowable creep strain and its place of application is considered first. If the material would fail by intergranular cracking with low ductility, the selection of a limiting creep strain would be made for the position where creep strain is a maximum, namely at the bore. If, however, the ductility of the material would be high, selection could rationally be determined by permissible change in dimensions, and be applied to the outside diameter of the pipe where the creep strain would be least. It is shown that the British Standards formula leads to a pipe thickness from one-third to one-half greater than is really needed to withstand the pressure in a straight pipe. Differences in behaviour between austenitic and ferritic steels are reviewed briefly.

Consideration is given to the problem of determining the addition to be made to the rated temperature to provide for specific variations in pressure and temperature for the creep strain not to exceed a predetermined amount. Bending and torsion of a pipe line caused by loading resulting from thermal expansion, and its mitigation by a closing gap when cold, is well known. It is pointed out, however, that control by a closing gap must eventually be ineffective in pipe lines operating at high temperatures where creep dominates behaviour and design.

The principles affecting bolted joints in high-temperature steam piping are discussed. A design of terminal joint is described, which provides a measure of flexibility between the flange ring and the joint face to accommodate differential thermal-expansion effects. It is recommended that as far as possible, piping should consist of straight lengths joined by butt welding to standard elbows of principally 90° but also of 30°, 60°, and 180°. There appears to be a good case for cast elbows. The problem of making a joint between ferritic and austenitic steel piping and components is under investigation.

Tests carried out on the corrosion in steam of a range of steels lead to the conclusion that low-alloy ferritic steel would be satisfactory for steam piping and also for the turbine for rated steam temperatures as high as 1,100° F., and that 1,050° F. is a conservative temperature.

The Author shows that the principles discussed in this paper can also be applied with advantage to piping for less advanced conditions.

A list of references is given.

HEAT TRANSFER AND INSULATION

Planning Thermal Insulation. *Ship and Boat Builder,* **4** (1951), p. 338 (March).

The properties of the various materials available for thermal insulation are discussed. Practically all thermal insulating materials make use of the properties of still air as a non-conductor of heat, and, by eliminating convection currents, prevent the transfer of heat due to movements of the molecules of air. Magnesium–asbestos and asbestos insulations have an exceedingly low thermal conductivity because of the minute air cells formed by the interlocking crystals, while cork also has a structure consisting of sealed air cells, and therefore a low thermal conductivity of 0.27 in British units. A material with comparable insulating properties is Isoflex, a light-weight multi-layer plastic made of cellulose acetate film, and having a thermal conductivity of 0.32. This insulant is non-porous and non-absorbent and can be cut to shape with an ordinary knife.

Another thermal insulant that is achieving prominence for ship interiors is glass fibre, which is available in several different forms, including a ½-in. thick blanket of which 40 sq. ft. weigh only 1 lb. These blankets and mats have a high degree of thermal and acoustic insulation, are strong and durable, and resist moisture, heat, fumes, fungi, and vermin. Another use for glass-fibre cloth is in the production of sandwich insulants, in which a layer of expanded rubber or plastic is protected by external layers of glass cloth. These constructions combine strength and stiffness with exceptionally low density, while the heat insulation is outstanding, ranging from 0.12 to 0.35 according to the density of the core.

The Regenerative Heat Exchanger for Gas-Turbine Power-Plant. COX, M., and STEVENS, R. K. P. *Proceedings, Institution of Mechanical Engineers,* **163** (1950), p. 193 (W.E.P. No. 60).

The desirability of using a heat exchanger to improve the efficiency of gas-turbine plant of moderate gas temperatures and pressure ratios has often to be considered in relation to the large space requirement and cost involved in the installation of a unit of the normal tubular type. The Author shows that the possibilities of reducing the bulk of the heat exchanger lie mainly in the use of passages of small diameter and length. He examines the potentialities of the regenerative type of heat exchanger and the essential requirements of a practical unit working on this principle. The most practical form of regenerator appears to be one employing a rotating heat-exchanging element, and a stationary seal system to prevent the loss of high-pressure air ; the relative merits of units of this type are discussed. The main problem to be overcome is that of developing an efficient and reliable sealing system. Work at the National Gas Turbine Establishment on a rotary-disk regenerator to study the sealing and general mechanical problems is described, together with the results of tests made on a smaller unit built to determine the heat-transfer properties of heat-exchanging elements of the flame-trap type.

There is a list of references.

AUXILIARY EQUIPMENT AND MACHINERY

A Method for Checking the Injection System on the Test Bed and on Board Ships. GRAVESTEYN, B. J. J. *International Congress on I.C. Engines, Paris, paper read* May 1951.