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Italian Tanker

The tankers now building in Italian shipyards under the provisions of the Cappa Law include a series of large steam-driven vessels of some 32,250 tons deadweight. The first of these vessels to complete is the *Mirella d'Amico,* one of a group of three sister ships building for Soc. di Navigazione d'Amico by Cantieri Riuniti dell'Adriatico at their Monfalcone yard. These ships have a service speed of 16 knots with 13,000 s.h.p., but the *Mirella d'Amico* achieved a speed of 17·32 knots on trials at full load and over 18 knots at half load. The principal particulars of the ship are as follows: —

Length o.a.	659 feet
Length b.p.	621 feet
Breadth moulded...	86·2 feet
Depth moulded	45·7 feet
Draught at full load	34·2 feet
Deadweight	32,250 tons
Full load displacement	41,500 tons
Cargo tank capacity	1,520,000 cu. ft.

The ship complies with the requirements of the Registro Italiano Navale, Lloyd's Register of Shipping and the American Bureau of Shipping for the highest class of bulk oil carriers on long routes, and also with the requirements of the Safety of Life at Sea Convention. There are two longitudinal bulkheads in the cargo tanks, dividing the 10 tanks into 30 compartments. From forward to aft, transverse bulkheads divide the ship into forepeak, water ballast tanks, forward fuel oil deep tanks with forward pump room at centre, forward cofferdam, the cargo tanks, after cofferdam, after deep fuel oil tanks and pump room, boiler room, engine room and after peak. The main propelling machinery consists of a three-stage arrangement of CRDA-Parsons steam turbines, developing 13,000 s.h.p. in service at 100 r.p.m. to give the service speed of 16 knots. Steam is supplied at 595lb. per sq. in. by two Foster Wheeler boilers. Of the deck auxiliary machinery, mention has already been made of the steam winches. The windlass and two warping capstans, the latter being located aft, are also steam driven, while the steering gear is of Hastie electro-hydraulic type.—*The Shipping World, 3rd March 1954; Vol. 130, pp. 260-261.*

Electronic Instruments for Marine Turbine Research

Instruments for noise and vibration analysis developed by the electronics department of Pametrada are described. Details of several new methods which are being investigated for the measurement of temperatures in marine engineering components are given. The development of a method for the measurement of temperatures up to about 450 deg. F. based on an electrical resistance material which has a very high negative temperature coefficient is described. A method of measuring turbine rotor out-of-balance forces is being developed with the ultimate aim of carrying out the measurement with the turbine mounted in its own bearings on board ship. The instrument proposed shown in Fig. 7 would enable balancing to be carried out at a rotor speed as low as 500 r.p.m. and would indicate the phase-angle of the force with respect to a known fixed point, and also the amplitude of the force. As is common to other vibration measuring apparatus the instrument would have two principal parts: the pick-up and the instrument. The vibration pick-up will take the form of a mass-spring system whose frequency would be tuned to 8·3 c/s (500 r.p.m.) and this operating into a velocity type of electro-mechanical pick-up would be mounted on one of the turbine bearing pedestals. This arrangement has several desirable features; being tuned to the balancing speed, vibration frequencies due to oil criticals existing on the pedestal are not transmitted to the instrument, and the sensitivity of the pick-up is increased by the Q of the

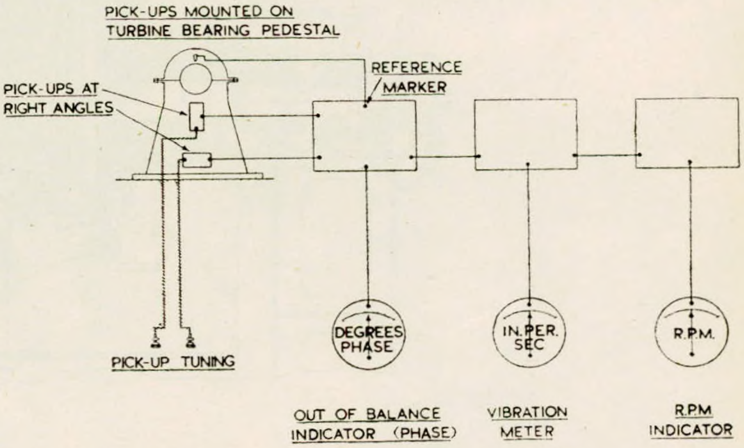

FIG. 7—*Proposed out-of-balance indicator*

system. In some systems of balancing it is usual to use the mass of the electrical pick-up as part of the mass-spring tuned system. Such a method, however, produces large errors of phase-angle which are not desirable in this application. The voltage generated by the electrical pick-up will be applied to an electronic phasemeter which will indicate the angle on a cathode-ray tube. Perhaps the easiest interpreted display is one of a circular trace in which the beam is deflected by the voltage from the pick-up, that is, producing on the circumference of the trace a distinctive mark corresponding to the angle of out-of-balance. Since the pick-up produces a voltage proportional to vibration velocity, a very simple amplifier can supply an indicating meter suitably scaled in velocity units. The instrument is very much in a state of development, and it may be some time before it can be tried out on a turbine installation.—*Paper by J. Hare and R. B. Conn, read at a Meeting of The Institution of Engineers and Shipbuilders in Scotland, 9th February 1954.*

Gas Turbine Progress

Marine auxiliary and industrial gas turbines ranging in power from 140 to 900 kW are being developed at Bedford by W. H. Allen, Sons and Co., Ltd. Of the four basic designs involved, the smallest is an all-radial-flow single-shaft unit with a rating of 200 b.h.p. (140 kW) at an air inlet temperature of 60 deg. F. (15 deg. C.); the prototype is now undergoing extensive testing and development. Designed originally at the request of the Admiralty, this small engine is intended for any duty where low fuel consumption is of less importance than such advantages as light weight, compactness, quick starting, rapid acceptance of load, and absence of cooling water. An ingenious feature is the use of a one-piece turbo-compressor rotor, with the centrifugal impeller vanes machined from one face of a forged steel disc and the centripetal turbine vanes from the other. By thus taking the familiar back-to-back arrangement of radial-flow components to its logical conclusion, the opportunity is presented of cooling the turbine by direct heat transfer across the rotor disc. The Allen designers have applied this principle so successfully that the ferritic steel disc of the prototype engine shows every sign of lasting for many thousands of running hours despite the use of inlet gas temperatures up to 800 deg. C. (1,470 deg. F.). A larger gas turbine of familiar type to the 200-b.h.p. unit has been designed, and manufacture will commence shortly. Six d.c. generator-driving versions of it have been ordered by the Alfred Holt shipping concern for auxiliary use aboard Blue Funnel liners, the rating being 350 kW at an air inlet temperature of 85 deg. F. (30 deg. C.). These sets are too large to make efficient use of a radial-flow turbine, so the single-stage centrifugal impeller is driven in each case by a two-stage axial turbine. On behalf of the Admiralty, the company is designing and constructing two interesting gas-turbo-alternators rated at 500 kW in tropical conditions. No details have yet been released for publication.—*The Oil Engine and Gas Turbine, March 1954; Vol. 21, p. 436.*

Centripetal Turbine for High Specific Outputs

In 1939 the U.S. Navy Department requested bids on two 2,500-h.p. propulsion turbines for the Navy submarine chaser PC-452. The author's Company was awarded the contract on the basis of the evaluation made by the U.S. Navy Department, which took into consideration the weight of the turbines, their overall dimensions, and their efficiency. The Company's design study resulted in the choice of a compound turbine arrangement—this is, a high-pressure and a separate low-pressure turbine for each of the two propelling units. It also indicated that it was necessary to operate these turbines at no less than 15,000 r.p.m. if the design target (with regard to bulk, weight, and efficiency) was to be met. This high speed ruled out the axial-flow wheel for the last stage of the low-pressure turbine, because this type is incapable of passing the large volume flows at such high r.p.m., without prohibitively low efficiency. The high-specific-speed centripetal turbine came to the rescue, and was used not only in the last stage but also in the next-to-last stage of the low-pressure turbine, a sectional view of which is shown in Fig. 10. This particular application of the high-specific-speed centripetal turbine made possible the attainment of a specific weight, for the complete unit, of only slightly over 3lb.-per-shaft horsepower, including the double reduction gear, turning gear, and other accessories. This specific weight is by far the lowest that has ever been achieved for a marine propelling steam turbine. The units fully met the efficiency guarantees, and their small dimensions

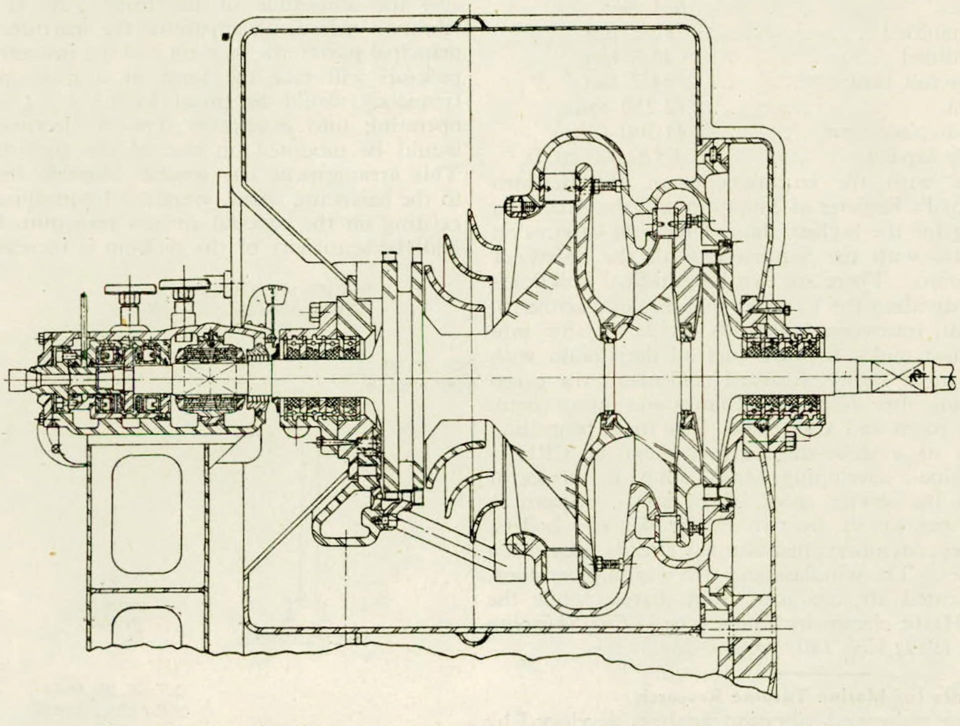

FIG. 10—*Longitudinal section through low-pressure sub-chaser turbine*

made it possible to accommodate them easily in the confined space of the slender hull. Several different sizes of turbo-superchargers for Diesel engines have been constructed in the past four years by the author's Company. In the course of the development of these units it has been clearly demonstrated that the high-specific-speed centripetal turbine wheel is the ideal answer for this application for the following reasons: 1. This turbine is capable of an r.p.m. sufficiently high to bring the compressor driven by it into a specific speed range where maximum compressor efficiency can be obtained. An axial-flow turbine designed for the same flow and stress conditions would have to operate at lower r.p.m., which would result in a correspondingly lower specific speed of the compressor, thus preventing the attainment of maximum possible compressor efficiency. 2. Under the particular flow and operating conditions encountered in the service of exhaust turbines for Diesel engines, distinctly higher turbine efficiency can be obtained with the centripetal turbine than is possible with the axial-flow type. 3. The efficiency of the centripetal turbine, which in itself is high, can be further increased by the recovery of kinetic energy in the turbine exhaust through the use of an exhaust diffuser in the form of a simple conical duct. 4. The centripetal turbine, owing to its low number of husky blades, is far less delicate than the axial-flow wheel and better able to cope with the severe service of Diesel-engine exhaust gas operation. In addition thereto, it is cheaper to manufacture. 5. The turbine blades and turbine rotor hub can be cooled in a simple manner, similar to the one described for the aircraft exhaust gas turbines. This reduces the metal temperatures even under the extreme conditions of Diesel-engine preturbine temperature encountered during engine overload conditions, to values which permit designing for virtually unlimited time to rupture. 6. The inertia of the centripetal wheel is lower than that of an equivalent axial-flow wheel, which results in a more rapid change of turbo-supercharger speed with a change in engine load. 7. The stationary turbine nozzles, directing the flow into the centripetal wheel, can be arranged between parallel radial walls, which makes it practicable to provide for pivoting the guide vanes to adjust the nozzle areas and angles for matching the turbo-supercharger to the engine.—*R. Birmann, Transactions of the A.S.M.E., February 1954; Vol. 76, pp. 173-187.*

Pipe Flanges Research Committee Report

The Third Report of the Pipe Flanges Research Committee is concerned, with the exception of elastic resistance straingauge measurement of stresses of two standard flange rings, with the results of a programme of investigation, projected by the Committee in being when the Second Report was made, into the elastic and plastic (creep relaxation) behaviour of flanges, drilled and undrilled, by means of model flanges, and of certain bolt materials. Execution and completion of the programme and attention to its results was interrupted and delayed by the 1939-45 war. Subsequently examination of the creep relaxation data showed that the phenomenon, and the interpretation of the results, involved difficulties unknown at the time the tests were made, and the need for further investigation became evident. The results, however, have important bearing upon the behaviour of flanged joints and also as a contribution to the subject providing a base for further advances.—*Paper by A. E. Johnson, read at a General Meeting of The Institution of Mechanical Engineers, 12th February 1954.*

Application of Marine Water-tube Boilers

During the past half century diligent research by naval architect, shipowner, and machinery supplier has resulted in decreased fuel rates per shaft horsepower. This operational economically justifiable first cost has paralleled the shipowners' continued desire to increase the vessels' deadweight while also increasing the trips per year. Consequently the space and weight allotted per pound of steam evaporated has continually decreased, resulting in smaller boilers and attendant high boiler ratings. Further, to increase the number of voyages per year, the shipowners have specified more speed, and have attained it by improving hull design and installing more efficient machinery. The machinery thermal efficiency has been improved by raising the operating steam pressures and temperatures, and economic studies of steam cycles have shown that to justify the higher thermal conditions the steam generator efficiency must be improved by operating with gas temperatures leaving the boiler unit which are lower than the temperature corresponding to the saturation temperature at the operating pressure. Consequently, terminal heat exchanges have been employed and both air heaters and economizers have enjoyed considerable favour in the industry. Small boiler units designed for high steam pressures and temperatures are not synonymous with high boiler efficiency and low maintenance and, in this paper, it is intended to delineate the development of the water-tube boiler and to discuss this apparent incompatibility as well as some of the design criteria considered important for a rational consideration of functional boiler design. Although structural developments have, of necessity, kept pace with the functional developments, it is not intended to discuss them in this paper. Some of the information which affects the boiler design and should be made available in the early stages of the proposal is delineated below: *A.* The space limitations should be specified and consideration be given to the amount of weight allotted to the boiler equipment. *B.* To set the functional performance of the unit it is important that the following information be provided at the normal and maximum continuous ratings. 1. Total steam flow per boiler per hour. 2. The percentage of steam flow which is to be superheated. 3. The superheater outlet conditions including pressure and temperature. These values should be at the superheater outlet after allowances have been made for the pressure and temperature drop in the lines to the turbine. 4. Feedwater temperature to the boiler unit and the type of make-up. 5. The efficiency required with due consideration given to the uptake temperature necessary to produce the efficiency specified and to the minimum practical uptake temperature. 6. The total draught loss permitted. Since this figure will set the gas velocities through the unit and influence the number of oil burners required, it is quite important that some indication of the acceptable values be given. 7. An indication of the type of boiler preferred and what accessories will be required including type of soot blowers, combustion controls, feed-water regulators, and oil burners.—*Paper by D. C. Bowersock, abstracted in Bulletin, The Society of Naval Architects and Marine Engineers (New York), February 1954; Vol. 9, pp. 31-32.*

Steam Generators with Pressurized Furnaces

An article by N. Ermoshkin and A. Zamotaiev in Morskoy y Rechmoy Flot (U.S.S.R.) describes some breakdowns and other failures experienced during operation of a type of marine boiler with pressurized furnace. The boiler, of which a brief description and sketch are given, is essentially a Velox boiler with one main point of difference, namely, that the axial compressor is driven not only by a gas turbine as in the Velox boiler but also by a steam turbine operated on exhaust steam. Both turbines are of single-stage design and are placed at the opposite ends of the axial compressor. The failures occurred mainly in the turbo-compressor unit and to a lesser degree in the combustion chamber which incorporates the steam-generating and superheating units. The automatic regulation was sometimes not working satisfactorily, and this resulted in considerable fluctuations in compressor speed, gas-turbine inlet temperature, and steam-turbine pressure. Excessive inlet-gas temperature caused distortion of the turbine casing in one case. In another case, a number of compressor blades developed cracks and a broken blade sheared off all the blades in one stage of the compressor. In some cases, bulging of the steam-generating elements was observed, and on inspection an oily deposit was found on the walls. This was attributed to the contamination of feed-water, because washing of steam-generating elements was not undertaken for a number of years. Compressor thrust bearings and ball bearings in feed-water pumps showed excessive wear due to contamination of lubricating oil with water, for which no separators were provided. Operating experience showed that the designed performance of the generator was not fully attained in practice. Steam output was only 60 to 65 per cent of the designed output and the efficiency of the axial compressor was 20 to 22 per cent below the designed value. Originally, these boilers were operated on Diesel oil, but since February 1952 they have been working on boiler oil which is preheated to about 250 deg. F. It has been noted that this oil causes rapid wear of nozzles in burners and also requires special ignition equipment. In conclusion, it is stated that the use of these generators in steam-turbine ships has proved to be justified and that fully-automatic regulation of such installations is possible.—*Journal, The British Shipbuilding Research Association, February 1954; Vol. 9, Abstract No. 8,581.*

Refrigeration from the Operator's Viewpoint

Modern ships built for universal refrigerated cargo trades will all have air cooling of spaces rather than side and ceiling coils. Besides the loss of cubic in the use of coils they are subject to damage when carrying general cargo. The only problem presented by the exclusive use of air cooling is that of defrosting the coils. With the intermediate system there is no problem since hot liquid may be passed through the coil. However, direct expansion presents quite a different problem. There are three systems to choose for defrosting, i.e. hot gas, hot water and indirect hot gas. The ordinary manually operated hot gas defrosting systems have not, as a rule, proved either efficient or effective. The process is slow and allows too great a temperature rise during the operation. It further requires more skill and patience to operate than other systems. Hot salt water is probably the most common method employed and has been applied in several ways. A manually operated hose is rapid and effective but as a rule very messy. Personnel do not like this method as an engineer is required to spend some time in a subfreezing fan room splashed by water from the hose. This also results in an excessive amount of drainage to the bilge which is undesirable. The third method, which is believed to be most satisfactory, involves the use of a heat exchanger containing liquid whose purpose is to retain heat which is received through exchange from the hot gas on the high side. An automatic timing device is set so as to perform a cycle at designated intervals in which the condensed liquid from the evaporator passes back through the heat exchanger where it is again evaporated before returning to the compressor, superheated gas being supplied to the evaporator for defrosting. Whether completely automatic or partially manual it is believed that this system is superior to the others.—*Paper by G. R. Aitken, abstracted in Bulletin, The Society of Naval Architects and Marine Engineers (New York), February 1954; Vol. 9, p. 35.*

Large Nine-cylinder Diesel Engine

A nine-cylinder engine designed to develop 11,200 b.h.p. at 115 r.p.m. under normal conditions at sea has recently been completed by Burmeister and Wain. It has cylinders 740 mm. in diameter with a piston stroke of 1,600 mm., and is to be installed in a tanker under construction at the Nakskov Skibsvaerft for A.P. Möller, Copenhagen. It is the highest-powered marine engine constructed by Burmeister and Wain. The new engine is equipped with three turbochargers of the Brown-Boveri VTR-630 type, these blowers being similar to those employed in the main engines of A. P. Möller's M.S. *Dorthe Maersk* and the *Songkhla, Samoa* and *Sibonga* of the East Asiatic Co. The output of the 11,200 b.h.p. engine is slightly higher than that of a corresponding 12-cylinder non-turbo-charged unit, which is about 10 feet 10 inches longer and 35 per cent heavier than the nine-cylinder turbo-charged engine. Ten nine-cylinder engines of this type are being built by Burmeister and Wain and one with 10 cylinders, for a cargo ship, at Eriksbergs Mek. Verk. developing 12,500 b.h.p. In Japan an engine has been installed in the recently completed *Harunasan Maru,* a cargo ship of 10,200 tons with a service speed of 17¼ knots. The fuel consumption of these engines, based upon the results of similar but smaller units installed in ships now in service is expected to be 0·334lb. per b.h.p. hr., the mechanical efficiency being about 88 per cent. In normal service the mean indicated pressure is approximately 102lb. per sq. in.—*The Motor Ship, March 1954; Vol. 34, p. 518.*

Oil Burner with Steam Atomizer

A contribution by H. Bock to the Jahrbuch d. Schiffbautechn. Ges. (1952) discusses combustion in boilers with special reference to atomizers. A steam atomizer known as a Y-burner, from the form of the paths taken by the oil, the steam and the oil-steam mixture, can be used with all types of fuel oils, even oils with bituminous characteristics, and can work satisfactorily over a wide range of pressures. The atomizer is being manufactured in seven sizes, the range being given as between 330lb. and 4,000lb. oil delivery; the output of a burner of this type can be varied over a range of 6:1, or, if the furnace is not cooled, over a range of 10:1. The pressure of the atomizing steam should be about 30lb. per sq. in. above the oil pressure, and the combustion air must have a pressure of about 2½in. water-gauge; a reduction in the air pressure reduces the amount of oil delivered. The steam consumption of this atomizer is about 1 per cent of the steam produced in the boiler. The atomizer can also be used with compressed air, provided that the pressure is the same as with steam.—*Journal, The British Shipbuilding Research Association, February 1954; Vol. 9, Abstract No. 8600.*

Non-destructive Inspection of Welded Joints

The Ship Structure Committee is undertaking an investigation with the object of developing effective and economical non-destructive test methods for the detection of flaws in welded joints in ships' hulls. This report surveys the flaw-detection methods at present available or under development, and discusses radiography, magnetic-particle inspection, ultrasonic testing and the use of fluid penetrants. Radiography, either with X or gamma rays, is the method at present most widely employed for flaw detection in ship structures. While it is the most reliable of the methods available, it will not, in general, detect microscopic cracks. Magnetic-particle inspection is used extensively, especially where both sides of a welded joint are inaccessible to radiography. The ultrasonic method appears to offer potential advantages, but it requires further development and has not yet been applied to weld inspection. Fluid penetrants, although limited to the detection of surface defects, are quick and simple to apply. The authors make recommendations regarding the improvement in existing radiographic methods and filmless techniques, and the development of the magnetic-particle and ultrasonic methods.—*U.S. National Research Council, Ship Structure Committee, Report No. SSC-72. Journal, The British Shipbuilding Research Association, February 1954; Vol. 9, Abstract No. 8552.*

Behaviour of Welded Structures

These two reports form part of the research programme, sponsored by the U.S. Ship Structure Committee, the object of which was the study of the zone of brittleness which appears adjacent to welds in ship-plate steels. The aim of the investigators in this phase of the programme was to obtain an insight into the basic mechanism responsible for the brittle zone found in the subcritically heated region of the welded joint, to determine the maximum embrittlement possible in the base plate by subcritical heat treatment, and to suggest possible methods of decreasing this embrittlement. A low-carbon ship-plate steel (designated "Steel C" by the Ship Structure Committee) was used as the basis of the study, which included impact and hardness tests on specimens heat-treated at subcritical temperature, quenched and aged. The work described in the two reports led to the following conclusions:—The quench-ageing mechanism was responsible for the loss in ductility and the increase in hardness. The severity of the embrittlement increased with increasing initial temperature in the range 650 deg. to 1,300 deg. F., no embrittlement occurred when the initial temperature was less than 650 deg. F. Characteristic ageing curves, based on impact transition temperature and hardness changes, indicated that the peak transition temperature and hardness, and the time to attain these peaks, decreased with increasing ageing temperature. Metallographic examination revealed a two-stage precipitation reaction. A low-temperature post-heat at about 650 deg. F. would do much to eliminate, by overageing, the zone of minimum ductility previously found in the subcritically heated region of welds of this and similar grades of steel. Higher post-heat temperatures involve the risk of introducing another ageing cycle if fast cooling is used. The Fourth Report also contains a supplement on the embrittlement of "C" steel with nitrogen. Steel specimens were subcritically heated in a nitrate salt and then cooled at various rates. The embrittlement was found to increase with subcritical temperature, the time during which the specimen was held at this temperature, and the cooling rate. The embrittlement due to nitrogen pick-up is superimposed on that resulting from subcritical heat treatment carried out in air. Both reports contain references.—*U.S. National Research Council, Ship Structure Committee, Serial No. SSC-60 and SSC-61. Journal The British Shipbuilding Research Association, February 1954; Vol. 9, Abstract No. 8550.*

Toroidal-shell Expansion Joints

The problem considered in this paper is shown in Fig. 1; a thin toroidal shell of centre-line radius *a* and torus mid-surface radius *b* is slit at its inner edge and welded to relatively stiff cylindrical pipe sections to form an expansion joint. Stresses and axial deformation under the axial load P are computed.—*N. C. Dahl, Journal of Applied Mechanics, December 1953; Vol. 20, pp. 497-503.*

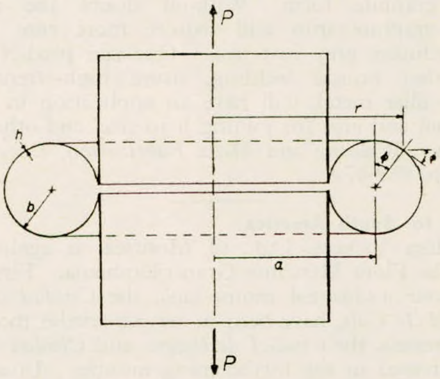

FIG. 1—*Geometry of toroidal shell*

Full Scale versus Model Tests

The report by H. F. Nordstrom, published as Report No. 27 of the Swedish State Shipbuilding Exp. Tank, gives an account of full-scale towing tests carried out on the twin-screw destroyer *Wrangel*. The results are compared with values predicted from model tests. The principal particulars of the ship were as follows:

Length on C.W.L.	228·3ft.
Breadth on C.W.L.	21·6ft.
Draught	6·1ft.
Displacement (with rudder), naked hull with appendages	14,054 cu. ft.
Block coefficient	0·471

The shell plating was riveted. The butts below the waterline were flush riveted with butt-straps on the inboard side. Before trials, the plating was scaled, the existing recesses were filled with composition, and finally two coats of paint were applied. Attempts were made to measure the roughness of the hull but no reliable results were obtained. The first series of tests was carried out with all normal hull appendages in position, except that the propellers were replaced by dummy bosses. In the second series, all the appendages were removed, with the exception of the rudder. Towing speeds up to approximately 20 knots were used. The resistance results show satisfactory agreement with those predicted from model tests. Local friction was measured at three points on the bottom of the ship by means of friction plates let in to the surface, and the results were compared on the basis of the "sand roughness" theory. Local friction coefficients were also calculated from measurements of the velocity distribution in the boundary layer made by means of pitot tubes. Both methods gave reasonable results for the local friction. The wake was also measured, but the results did not give reliable coefficients. The wave profiles on ship and model were recorded and certain differences in wave formation were apparent. Numerical data and details of test arrangements are given.—*Journal, The British Shipbuilding Research Association, February 1954; Vol. 9, Abstract No. 8542.*

Corrosion Studies on Model Rotary Air-preheater

Tests have been carried out on a model rotary air heater in an attempt to study, on a laboratory scale, corrosion phenomena under conditions similar to those experienced in industrial practice. The acid dew-point of the combustion gases used varied from 240 to 320 deg. F. and maximum corrosion occurred at surface temperatures within the range 215-240 deg. F. The results confirm previous conclusions as to the influence of the acid dew-point and of the sulphur trioxide content of the gases on corrosion.—*Paper by G. G. Thurlow, submitted to The Institution of Mechanical Engineers for written discussion, 1954.*

Post-war Development of Metal-arc Welding

Development of electrodes in the post-war period has been generally to improve the detachability of the slag, to increase the amount of metal recovery, to increase the depth of penetration, and to produce better welding characteristics in electrodes for positional welding. Special developments have been electrodes to give austenitic weld deposits that meet the exacting requirements of Inspection Authorities for fabrications subject to severe service conditions. It is rather surprising that there has been a tendency to return to types of coverings having a basis similar to those tried in the very early days but, of course, with the added metallurgical knowledge and experience gained during the past twenty years. The increased metal recovery claimed for the contact type of electrode is due to an expansion of the use of iron powder and a development of the procedure of touch welding which was a feature of Strohmenger's patented system of welding. The increased type of penetration obtainable with certain "deep-penetration" electrodes is due to an expansion of the use of cellulosic materials. Many of the electrodes used for producing welds to meet stringent radiographic examination have an iron-oxide-silicate base, although the electrodes of that type made twenty years ago gave very porous welds with low mechanical properties. The low-hydrogen electrodes now advocated for the welding of high-tensile steels and other steels of poor welding quality have a covering consisting largely of calcium carbonate and fluoride. The recognition of the need to control the hydrogen content of the covering together with the improvement of the welding characteristics has produced an electrode far superior to the early limestone-fluorspar type. A revised British Standard 639 for covered electrodes for welding mild steel and medium high-tensile steels and a new British Standard 1719 for the classification of these electrodes have been issued recently. Side by side with the development of electrodes in the past decade, there has been improvement in the design of welding plants, which has given increased efficiency and a more pleasing external appearance in line with modern conceptions. Idling devices to reduce the off-load consumption of fuel in engine-driven plants, and remote-control units to enable the welder to adjust the current without moving from his welding position, are now available. High-frequency units, which superimpose upon the normal 50-cycle output of A.C. welding plants a high-frequency stabilizing current at about 3 megacycles per second, have made possible the successful use of stainless-steel, non-ferrous and other electrodes on A.C. which previously could only be used on D.C. The welding of sheet metal is made considerably easier by the use of this unit, since it is possible to establish the arc without touching the electrode on the material to be welded, thus eliminating the bugbear of "sticking". The more efficient use of multiple electrodes for suitable applications has been made possible by the introduction of a modified Scott-connected transformer, which takes a balanced load from the mains and delivers a two-phase output to twin-cored electrodes.—*E. Flintham, British Welding Journal, January 1954; Vol. 1, pp. 3-10.*

Locked-up Stresses

In 1948 a study was made at the Engineering Department, Cambridge, of stresses in butt welded mild steel plates, especially when welded under severe restraint. This showed that high locked-up stresses generally reaching the yield point occurred in the immediate vicinity of the weld even where no reaction stress, i.e. restraint, was present. It was demonstrated, moreover, that the magnitude and distribution of residual stresses could be greatly changed by small departures from established procedures, thus throwing doubt on the generally accepted belief that residual and reaction stresses could be controlled, provided correct welding procedures and sequences were followed. It emerged that cracking was due to lack of ductility in the weld metal on cooling and it was therefore necessary to follow well-established practices in order to limit the amount of plastic deformation required of the weld metal. Other theoretical and experimental work led to the conclusion that residual stresses could have no influence on the static carrying capacity of a structure provided the material behaved in a plastic manner, and provided that residual stresses would not result in elastic instability. Under certain conditions the presence of residual stresses must be considered to reduce the load factor for elastic instability. It would seem, therefore, that residual stresses cannot be ignored in material which is notch brittle. Their potential danger can best be eliminated by ensuring a sufficient degree of notch toughness at service temperatures. The Admiralty Ship Welding Committee has recently amplified its earlier findings on locked-up stresses in the following terms:—(*a*) Regardless of the procedure, sequence of welding, or restraint, every welded structure (unless stress-relieved) contains locked-up stresses which locally reach the yield point of the material. (*b*) Continued researches have so far not revealed evidence that these locked-up stresses have adverse effects on the strength or reliability of welded ships' structures, provided that the material, including the weld, is in a notch tough condition at the prevailing temperature. (*c*) It is important, however, to appreciate that undue restraint during fabrication may lead to cracking during or shortly after welding and unless such cracks are found and dealt with they may lead to serious failures in service.—*R. B. Shepheard, Welding and Metal Fabrication, January 1954; Vol. 22, pp. 28-32.*

Welding of Ductile Cast Iron

Ductile cast iron is a grey cast iron—yet has properties quite detached from ordinary castings which form the main text of this article. For instance, ultimate tensile strengths of 40 tons per sq. in. with 4 per cent elongation are common in the "cast" state, against under 20 tons with no elongation for orthodox grey iron. Short-term annealing enhances the properties of the new material still further and provides around 15 per cent elongation with a strength no less than 35 tons per sq. in. Such revolutionary figures for "cast iron" have been brought about by adding quite small amounts of cerium or magnesium to the foundry mixture, which causes the graphite to exist in the form of nodules or spheroids, rather than as embrittling flakes. Most of the advantages of grey cast iron have been retained while its main disadvantage—brittleness, has been eliminated. As regards weldability of ductile cast iron, no high temperature welding process will retain full ductility in the heat-affected zone, since the matrix is unstable above about 750 deg. C. and will therefore change from ferritic to one which is substantially pearlitic with some increase in hardness and a corresponding decrease in ductility. As far as the usefulness of gas and arc-welding methods is concerned, the position is more or less reversed since to date no completely satisfactory gas-fusion welding rod seems to have been marketed, although some useful research work has been carried out. In the spheroidal-graphite cast-iron welding rods tried out by the author the tendency has been for them to deposit metal of decidedly flaky-graphite type, whereas joints made with ordinary super-silicon rod show strengths in the order of 13 tons per sq. in. or less, with some pronounced tendency towards cracking in the weld. Gas welds are machinable, however, with a normal transition zone from weld to parent metal, that is to say, the graphite structure of the parent metal remains basically unchanged with little or no free carbide present. Any future promise for gas welding, however, rests upon the ability of producing a *stable* grey iron rod of spheroidal-graphite type. In practice, the same "compromise" weld metals must be used for arc welding ductile iron as for common grey iron, and although the natural ductility of the new iron must undoubtedly render joints less susceptible to fissures and cracks, the hardening tendency will remain about the same. Thus, welds made with ferrous electrodes will introduce massive carbides in the parent metal, whereas the use of non-ferrous rods of the nickel-alloy type must produce softer and correspondingly less rigid joints. As to whether welds made in this material will be porous depends more or less upon the changes which occur in the welding zone—particularly as regards graphite structure. For instance, if much free carbide is precipitated then porosity will very probably follow, and the same may apply with any major change from the spheroidal to flaky graphite form. Without doubt the welding of spheroidal-graphite iron will require more care than when welding ordinary grey cast iron. One can predict with some accuracy that bronze welding, using high-strength nickel-containing filler metal, will have an application in joining the new material and also for joining it to steel and other metals.—*T. J. Palmer, Welding and Metal Fabrication, December 1953; Vol. 21, pp. 469-474.*

Motorships for South America

Canadian Vickers, Ltd., of Montreal is again delivering ships to The Flota Mercante Grancolombiana. First two of a series of four additional motorships, the *Ciudad de Valencia* and *Ciudad de Cali,* have been in service several months. The other two vessels, the *Ciudad de Ibague* and *Ciudad de Cumana* will be delivered in the forthcoming months. In accord with their building programme, Flota Mercante Grancolombiana, S.A., placed orders with Canadian Vickers, Ltd. for the construction of these four new vessels to augment their very fast cargo carrying service between the major ports of Venezuela, Colombia, Ecuador, New Orleans, New York and Montreal. Each ship is propelled by a single Nordberg six-cylinder Diesel engine, rated 4,275 b.h.p. at 160 r.p.m., direct connected to the propeller shaft. The engine has a 29in. bore by a 40in. stroke and is of the two-cycle, single-acting type with port scavenging and port exhaust. The propulsion Diesel is independently scavenged by two motor-driven blowers each of 200 h.p. rating, taking air from the engine room through a Maxim silencer and each discharging 10,000 cfm. at about 2·4lb. per sq. in. discharge pressure to a common intake manifold. This method of obtaining scavenge air results in a shorter engine, and in case of failure of one of the blowers, the engine is still capable of maintaining 70 per cent ship speed with the remaining blower. The main engine control platform is at the after end of the engine on the port side and the log desk, engine telegraph, instrument panel, alarm panel, telephone booth are all disposed conveniently around the operator and are actuated by automatic controls. They have an actual air delivery of 68 cfm. at 870 r.p.m. and are of the two-stage type, water cooled and fitted with inter and after cooler. Auxiliary power on each of the vessels is supplied by three Nordberg four-cycle, eight-cylinder inter-cooled-supercharged Diesel engines. These engines are of the single-acting, trunk piston, mechanical injection type with cylinders of 9in. bore and 11½in. stroke rated 580 h.p. at 600 r.p.m. Each drives a 400 kW. 120/240 volt, 3 phase Westinghouse generator arranged for parallel operation and capable of carrying a 25 per cent out of balance current.—*D. Shearing, Diesel Progress, December 1953; Vol. 19, pp. 42-43.*

Diesel-electric Tanker

The accompanying illustration shows one of the two Diesel-electric propelling motors of 1,750 h.p. at 128 r.p.m. in the 9,300-tons Soviet tanker *General Asi Aslanow*. The motors are supplied with direct current at 700 volts from four 700 kW. D.C. generators, each driven by a supercharged six-cylinder four-stroke cycle Diesel engine at 900 b.h.p. at 720 r.p.m. Cylinder diameter is 308 mm. and stroke is 330 mm. The pistons are of light alloy and are not liquid cooled.—*S. Antonow, Schiffbautechnik, December 1953; Vol. 3, pp. 359-362.*

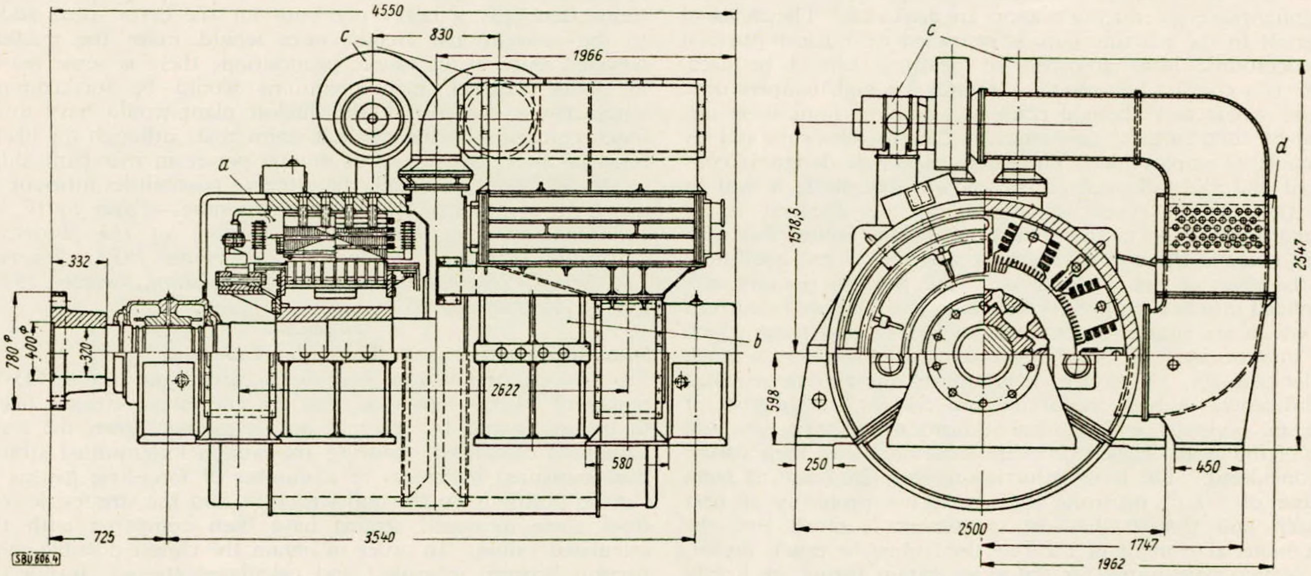

FIG. 4

Development of Industrial and Marine Gas Turbines

While the advantages of the gas turbine are already decisively in its favour for Naval applications the case for its adoption for Merchant Marine propulsion rests upon potential advantages regarding which there is only limited operating experience. In merchant vessels, competition is with Diesel engine and steam turbine propelling machinery, both of which are firmly established prime movers whose operating characteristics are clearly defined, and either of these prime movers can operate on furnace oil containing an appreciable percentage of ash. While development work towards this end is actively in progress in the gas turbine field, formidable difficulties have arisen in the use of boiler oil as a gas turbine fuel. Basically, the problem is not one of combustion, but lies in the fact that certain constituents of the ash formed from practically all grades of residual fuel have a melting point in the neighbourhood of the maximum gas temperature required for the operation of a gas turbine. The offending ash constituents are primarily vanadium pentoxide and sodium compounds, which combine to form complex vanadates which "flux" on to the surfaces of the first few rows of stationary and rotating blades. In extreme cases, the rate of deposition has been very rapid and the blade passages have been blocked to such an extent that it has been impossible to continue running the turbine. In addition to causing deposits, the molten ash constituents have a strong "fluxing" action when in contact with the material of the turbine blades, and tend to dissolve away the protective oxide skin which normally forms on both the steels and nickel chromium alloys which are used for operation at high temperatures. Once this protective oxide is removed, a very rapid attack on the base metal sometimes takes place, which may corrode the blade at an altogether unacceptable rate. In view of the importance of overcoming vanadium attack at high temperatures, a considerable research effort has been expended by Government establishments, oil companies and engine builders in finding solutions. Initial laboratory work confirmed the extreme corrosive nature of vanadium compounds, and showed that it was improbable that metallurgical solution to corrosive attack would be found in the near future. Even such normally resistant materials as silica, gold and platinum were seriously attacked by vanadium pentoxide at gas turbine operating temperatures. The alternative approach of adding compounds to the fuel which would produce an innocuous ash has, however, yielded more promising results, and actual engine tests carried out by the author's Company and elsewhere on zinc and magnesium additives have shown that the characteristics of the deposit can be markedly altered by the use of quite small quantities of such additives. In this case, the objective is to form a complex zinc- or magnesium-vanadate which has a melting point above the operating range of the turbine, and as a result will blow through the gas passages as a very fine powder, causing no damage to any part of the installation. In practice, a certain amount of ash usually collects on the convex surfaces of the blading, but with zinc or magnesium additives, the deposit is of a very friable nature, and measurements taken of the effective "size" of a turbine while running indicate that this soon stabilizes at a value slightly smaller than its original size when perfectly clean. The inference is that deposits build up to a certain equilibrium thickness, after which they tend to flake off, giving an approximately constant "size" of the turbine under steady running conditions. While it is still too early to claim that the problem of corrosion from the ashes of residual oil fuels has been entirely solved, the promising results which have been achieved by a number of workers suggest that real progress has already been made towards this end. When a full solution is available, the gas turbine will be a most attractive form of propelling machinery for all types of shipping. In the first place, it has the inherent characteristics of simplicity, low maintenance and freedom from vibration which are possessed by the steam turbine, but it lacks the complication and ancillary problems of a boiler. In the second place, it has the ready availability of the Diesel engine, and if designed suitably, can repeatedly be called upon to deliver full power a few minutes after being started up. The advantages of this characteristic during manœuvring, and in certain special types of service such as ferries, are self-evident. —*G. B. R. Feilden, Bulletin of Liverpool Engineering Society, 1953/54; Vol. 27, No. 5, pp. 7-41.*

Nuclear Reactors and Power Production

The lecturer deals with the design and construction of nuclear reactors, particularly of types suitable for the generation of power. A detailed description is given of the British Experimental Pile (BEPO) installed at Harwell, which is a typical "thermal" reactor on a small scale, using natural uranium as fuel and graphite as moderator. It is air-cooled and the shielding and control arrangements illustrate general practice. There follows an account of some of the engineering and construction problems met in the erection of the Windscale piles, and the solutions achieved. The problems involved in designing power-producing reactors are discussed. The choice of materials in the reacting core is restricted by nuclear physical considerations; large absorbers of neutrons cannot be used. There is a conflict between the demand for high temperatures, to give satisfactory thermal efficiency, and the limitations imposed by metallurgical properties of the fuel elements and by the coolants employable. The safety aspect of design is considered and the influence of the coolant described; it will be seen that certain types of reactor can be designed to be inherently safe even in the event of a coolant failure, but with others there is the risk of reaching a super-critical condition, and the effect of this is discussed. The possible reactors may be divided into two groups; those which use "thermal" neutrons and which are similar in principle to BEPO, and those which use "intermediate" or "fast" neutrons and which have a much smaller core-size. Within each group are alternatives provided by differences in fuel, moderator and coolant. A number of these are reviewed with general indications of their size and some of the more detailed problems associated with their design are considered. The large reduction in core size resulting from the use of "fast" neutrons leads to acute problems of heat transfer, and though the fuel investment is much less, the fissile-material content of the fuel used must be much higher. One or two possibilities for the more distant future are briefly mentioned. Prospects for the large-scale development of nuclear power are discussed and it is argued that the replacement of coal-fired boilers by nuclear reactors as the heat source at power stations should be economically sound before many years have passed.—*James Clayton Lecture delivered by Sir Christopher Hinton at the Institution of Mechanical Engineers, 26th February 1954.*

High Speed Journal Bearings

The hydrodynamic theory of bearings has been used to derive equations for the mean oil-film temperature, the frictional losses, and the oil consumption of journal bearings. In addition, a large number of tests have been made, in a specially-designed bearing-testing machine, of a variety of journal bearings of different sizes under a variety of operating conditions. The agreement between theory and experiment is satisfactory. The displacement of the axis of the shaft has been obtained from measurements of the temperature distribution round the shaft. It is shown that play in the bearing affects the temperature, in addition to the other variables which were already known to do so. The effect of changes in the viscosity of the lubricating oil on the conditions in the bearing can be expressed by an "oil coefficient". Formulæ have been deduced for practical use, from which it is possible to determine the mean temperature, the frictional losses, and the oil consumption of journal bearings of different sizes and proportions and under a variety of operating conditions. The degree of play that is desirable in a bearing depends on the operating conditions, and appears to be somewhat smaller than has hitherto been thought necessary.—*H. Stephen, VDI-Forschungsheft No. 439 (1953). Journal, The British Shipbuilding Research Association, January 1954; Vol. 9, Abstract No. 8483.*

Oil and the Atom

The author reviews in general terms the applications in the petroleum industry of gamma-ray bombardment and radioactive tracer techniques, and then considers the possible fields of competition between nuclear energy and the energy derived from the combustion of mineral oils. In this connexion the use of atomic energy for merchant-ship propulsion is briefly examined. The conclusions are quoted of an investigation carried out by a group of Harvard Business School students, on the feasibility of nuclear propulsion for the dry-cargo North Atlantic trade. The study was, essentially, a comparison of a 20-knot C-4 "Mariner"-class vessel with a hypothetical nuclear-powered craft of equivalent cargo capacity and a service speed of 35 knots, and an attempt was made to determine on economic grounds whether the benefits resulting from the higher speed would outweigh the higher initial cost of the atomic ship. The conclusions are unfavourable to nuclear propulsion, and it seems that only a heavy premium for the extra speed added to the conventional freight rates would make the nuclear-powered ships an economic proposition; there is some reason to doubt whether such premiums would be forthcoming. Alternatively, the cost of the nuclear plant would have to be much reduced. On the whole it seems that, although the likelihood of an extensive use of atomic power in merchant ships in the near future is small, the ultimate possibilities inherent in this form of propulsion offer much promise.—*Paper by W. L. Davidson, read at the Annual Meeting of the American Petroleum Institute, Chicago, 9th November 1953. Journal, The British Shipbuilding Research Association, January 1954; Vol. 9, Abstract No. 8539.*

Stress Investigation on Tanker during Launching

Launch calculations have been carried out for a 445-ft. tanker of 11,000 tons d.w. and the theoretical stresses likely to be experienced by the hull on its passage down the ways have been calculated. During the launch longitudinal strains were measured by means of a number of long-base gauges at various positions on the hull structure, and the stresses derived from these measured strains have been compared with the calculated values. In order to obtain the closest possible comparison between measured and calculated stresses during the launch, a static bending test was carried out on the ship afloat during which strains were measured under the application of accurately known bending moments. By these means it was possible to obtain a stress-bending moment relationship for use in calculating the launching stresses, on the assumption that the dynamic effects were negligible. The investigation was carried out by the British Shipbuilding Research Association.—*Paper by A. J. Johnson and M. Meek, read at a Meeting of the North-East Coast Institution of Engineers and Shipbuilders, 29th January 1954.*

Synthetic Rubber for Propeller Shaft Protection

Since 1939, and all throughout the war years, vulcanized-rubber covering, plus antifouling paint, usually the hot-plastic type, was the accepted method of protection of stern-tube shafts for all combatant Naval ships. As a result of the natural-rubber shortage it became imperative in 1941 to use synthetic rubber in lieu of natural rubber for this and many other purposes. Satisfactory synthetic rubber was applied as early as 1943. During the latter phases of the last war and the years subsequent to it, it became apparent that shaft cracks and complete shaft failures were becoming quite pronounced. Such failures were analyzed to result from the severe stresses developed close to the ends of the shafts or under the bronze sleeves shrunk on to the steel shafts in way of the water-lubricated bearings. Such shaft failures usually were observed at the strut bearings, both the intermediate and main struts. These failures were more pronounced on the high-speed ships, particularly destroyers, where enormous power transmission is required. It was considered that the waster rings, consisting of mild steel, which were applied at both ends of the bronze journal, were not performing the functions expected of them in that the cracks in the shafts usually were found beneath the waster ring or within a few inches of the ends of the bronze journals. Accelerated corrosion which was supposed to be taken up by these waster rings did not limit itself thereto. In addition, fretting corrosion was observed under the rings. Frequently, steel waster pieces and zincs inadvertently get painted and then their function is further impaired or lost entirely. Conventional underwater painting systems were recognized to be unsatisfactory and rubber covering of these exposed shafting sections was adopted by the Bureau of Ships as a dependable means of protection. After the waster rings are removed, the shafts are magnafluxed to detect internal defects and repairs are made to the shafts as required. It is emphasized that performance and material specifications have been developed since 1940, which have overcome previous procurement difficulties, and which ensure satisfactory materials as well as competent technique of application. The soundness of the decision to use vulcanized-rubber shaft coatings was further confirmed after an examination of the rubber-covered exposed shafting on the U.S.S. *Brooklyn.* The rubber covering was in excellent shape 16 years after its application. Dry-dock shaft covering involves certain compromises in the types and techniques of rubber covering which can be applied without delaying the ship's docking periods excessively, or running costs up too high. It is recognized that vulcanized sheet rubber undoubtedly constitutes the best covering. Such covering is applied in two ways, depending on whether the shaft is hollow or solid cross section. Hollow shafts are covered by the application of semi-hard rubber with a soft-rubber top covering all vulcanized in place through the application of steam through the bore of the shaft. In the unvulcanized state, these materials are semi-plastic in nature, much like bread dough which has been rolled into a sheet. They are tacky and require no cement except in respect to the metal surfaces. Pressure normally is required during the vulcanization process and is obtained by wrapping wet cloth tape around the outer surfaces. The tape shrinks when the water evaporates as heat is applied to the bore. Induction coils may provide vulcanizing heat for short sections. The overall thickness of the rubber shaft covering is normally about $\frac{3}{16}$ inch. The rubber is anchored mechanically on to the bronze journals through a series of dovetailed grooves cut into the journals. In the case of solid shafts, the hard-rubber underlay is dispensed with, since curing such material requires more heat than normally can be applied from the outer surfaces of the shaft covering during vulcanization. The same technique of applying wet tape, which subsequently is removed, is used to develop the pressure to compact the rubber and avoid lamination.—*E. A. Bukzin, Mechanical Engineering, January 1954; Vol. 76, pp. 17-20, 28.*

Gas Turbined Coaster

The first merchant vessel to be equipped with propelling machinery consisting of gas turbines fed by free-piston gas generators has recently completed her sea trials. This coaster, the *Cantenac,* is one of two vessels of the same type ordered by the French Ministry of Merchant Marine on behalf of Worms & Cie., from the Chantiers et Ateliers Augustin Normand at Le Havre, as war loss replacement. The *Cantenac* is a vessel of 850 tons with three holds and has her propelling machinery arranged aft. She is 185 feet in length b.p., 30 feet 6 inches moulded breadth, 14 feet 5 inches moulded depth to main deck, and has a mean draught of 13 feet 6 inches. The propelling machinery consists of two Pescara-SIGMA type GS-34 free-piston gas generators; two gas turbines connected to a reduction gear, each fed by one gas generator; and a double reduction gear connecting the turbines to a single shaft and reducing the number of revolutions to 220 r.p.m. The complete design of this vessel, both hull and engines, has been carried out by the shipbuilders. *Saving in Weight.* The free-piston gas generator operates on the two-stroke cycle and consists of a horizontal cylinder with two opposed pistons, each of which is directly connected to a compressor piston. The outer part of the compressor cylinder constitutes a compensating cushion. The mixture of exhaust gas and scavenge air forms the gas which is used to drive the turbine. A comparison of the weight of a gas generator installation compared with that of a corresponding Diesel installation is in favour of the former scheme. A typical four-stroke Diesel engine, developing 1,800 h.p. at 220 r.p.m., and with 40 per cent supercharge, weighs about 126lb. per h.p., whereas a gas generator installation consisting of two GS-34 generators, one turbine and reduction gear of the same power and speed, is about 89lb. per h.p. The saving in weight and bulk is only one advantage. There is also flexibility of operation, avoidance of vibration, ease of maintenance and low starting air consumption. It is claimed that in all probability the free-piston gas generator unit will become the engine with the highest thermal efficiency, with a specific fuel consumption referred to the turbine shaft of less than 0·33lb. per s.h.p. per hr. At the moment it is in the region of 0·39lb. per s.h.p. per hr., a figure not far different from the consumption of 0·33lb. per b.h.p. per hr. obtained from a supercharged two-stroke Diesel engine. Trials were run on 19th January on fuel No. 1, which corresponds to a Redwood viscosity of about 950 secs. at 100 deg. F. The unit is designed to run on both distillator and light residual fuel. The engine was run with two gas generators developing 1,200 h.p. on one trial and with one only developing 700 h.p. on another. It is understood that the tests were highly satisfactory and it was found possible to establish, in particular, the ease and speed of manœuvrability of the propelling machinery, as well as the ease with which one fuel was substituted for another.—*The Shipping World, 17th February 1954; Vol. 130, p. 213.*

The Transatlantic Passenger Liner

It is essential to realize that a mammoth trans-Atlantic liner today, with all that would be required in the way of auxiliary equipment and complete air conditioning, would cost so vast a sum that no individual shipowning organization is likely to have the temerity to undertake it, particularly in view of the uncertainty which the future holds at the hands of the rival system of transport. In this connexion a recent report may be noted that available figures for air and sea traffic of all North Atlantic companies prove that, as had been anticipated, "the liner is continuing to hold its own". That phrase surely in itself is not only important, but it is almost defeatist. Had it been "continues to find growing but not serious competition from the air" then all might be well; but even the most anti-airminded man cannot but think on reading those words. What is the post-war position? With the exception of the *United States,* built under conditions where money literally did not matter, no major trans-Atlantic ships have been built. From the international aspect all the principal contestants for trans-Atlantic honours are back on the North Atlantic again, even Germany, which has recently returned by courtesy of the Swedish-American Line with the 29-year-old twin-screw British-built motor passenger liner *Gripsholm,* to be renamed *Berlin.* Great Britain still has the biggest and best trans-Atlantic liners, though the problem with which the Cunard White Star Line must be faced at the present moment regarding the replacement or otherwise of the *Queen Mary* is certainly not one which can be approached in a lighthearted manner. In her speed of 21 knots the *Olympia* points the way to what may be acceptable in the future. In all the new designs for the more modest type of trans-Atlantic travel, we find a growing tendency to eliminate cargo space—an interesting pointer to the ever growing specialization of modern sea-going tonnage. The elimination of cargo space, for other than motor cars and a small amount of deep freeze or reefer cargo, simplifies the interior design of the ship, because there is no need for trunk hatches; the ideal everywhere being long clear deck spaces. An additional complication, on the other hand, which has to be accepted, is the need for air conditioning throughout. —*A. C. Hardy, World Shipbuilding, February 1954; Vol. 4, pp. 5-6.*

Free Piston Gas Generators

The Baldwin-Lima-Hamilton free piston generator development was conducted under a (U.S.) Navy Department contract to obtain a unit suitable for naval-combatant requirements. Consequently, it was designed with a view toward high specific output, reasonably low weight, and compactness, and to provide high thermal efficiency and reliability. In other words, to fulfil its purpose, it had to compete favourably with the thermal efficiency of modern Diesel engines and give the added advantages of simplicity, low initial cost, and smooth vibrationless operation. The power plant constructed was a twin unit with two gas generators supplying gas to a single turbine and reduction gear. It is outward-compression with both direct-bounce and reverse-bounce cylinders for control. The two gas generators are synchronized to reduce pulsations of the gas to the turbine and they can be operated together or singly, as the load requirements necessitate. The principal specifications are given as follows:—

TABLE 2.—B-L-H MODEL B GAS GENERATOR SPECIFICATIONS

Power-cylinder bore, inches	8¼
Compressor-cylinder bore, inches ...	23
Direct-bounce-cylinder bore, inches ...	8¼
Reverse-bounce-cylinder bore, inches...	23
Piston stroke (full load), inches ...	11
Cyclic frequency (maximum), cycles per min.	1,035
Exhaust pressure to turbine, lb. per sq. in. gauge	90
Exhaust temperature to turbine, deg. F.	1,295
Gas horsepower (maximum)	885

The complete power plant, after completion of its acceptance trials at the builders' plant, was sent to the U.S. Naval Engineering Experiment Station at Annapolis, Md., in 1950, for further test and evaluation. The principal data obtained during 700 hours of test operation are presented. Fig. 11 shows the gas-generator output, based on adiabatic expansion of the gas. The output pressure to the turbine was carried to 90lb. per sq. in. gauge as contrasted with 50lb. per sq. in. gauge for the French SIGMA Model GS-34. Of course, the relation of horsepower output to exhaust pressure is mainly a function of the size and characteristics of the turbine used in these tests. The curve shows outputs up to 1,770 gas-horsepower with the 90lb. per sq. in. gauge maximum pressure to the turbine. On later accelerated tests to determine piston-ring and cylinder-liner suitability, where more severe operating conditions were imposed without a turbine, the same output was reached with only 70lb. per sq. in. gauge exhaust pressure and the same exhaust temperature. This was a result of increasing the effective orifice area because the turbine used has a smaller equivalent orifice. The gas-horsepower curve in Fig. 11 shows that the output is increasing without any decrease in rate up to the limiting exhaust temperature and pressure set by this particular design. The shaft-horsepower curve in Fig. 11 is based on the desired 85 per cent efficiency for turbine and reduction gear, as it was in the SIGMA data. That efficiency was not reached with the turbine used on the actual tests. However, turbines are available with peak efficiency of 85 per cent or higher. The shaft-horsepower curve is corrected for the power requirement of the auxiliary equipment which cannot be driven directly from the turbine. Thus about 1,420 s.h.p. is available from an installation with a weight and space no greater than that of current Diesel installations and less than that of other types of power plants having comparable thermal efficiency. The model now under development at B-L-H is much smaller and lighter. Fig. 12 shows the measured fuel consumption on a gas-horsepower basis and those calculated for a possible turbine efficiency of 85 per cent. The maximum thermal efficiency of 40·3 per cent at the gasifier discharge is very satisfactory and compares favourably with the SIGMA maximum of 38·2 per cent. This increase in thermal efficiency is to be expected in view of higher operating conditions. The correction to a shaft-horsepower basis shows a greater reduction than was made for the SIGMA design because exact information was available on the B-L-H power plant and deduction was made for all losses, including supply of auxiliary control air, cooling-water pumping, and similar power expenditures. The only deduction made for the SIGMA unit was based on turbine efficiency of 85 per cent. It is not known if the previously published data include corrections for power to auxiliary equipment. After making these corrections to a minimum shaft-horsepower basis, the thermal efficiency is still 32·3 per cent. The turbine was rated at a maximum inlet temperature of 1,350 deg. F. However, the peak pressure of 90lb. per sq. in. gauge was reached with less than 1,300 deg. F. As stated before, without the turbine and with a variation in the gas pressure-to-orifice relationship, the same temperature gave as much load with only 70lb. per sq. in. gauge exhaust-gas pressure.—*J. J. McMullen and W. G. Payne, Transactions of the A.S.M.E., January 1954; Vol. 76, pp. 1-14.*

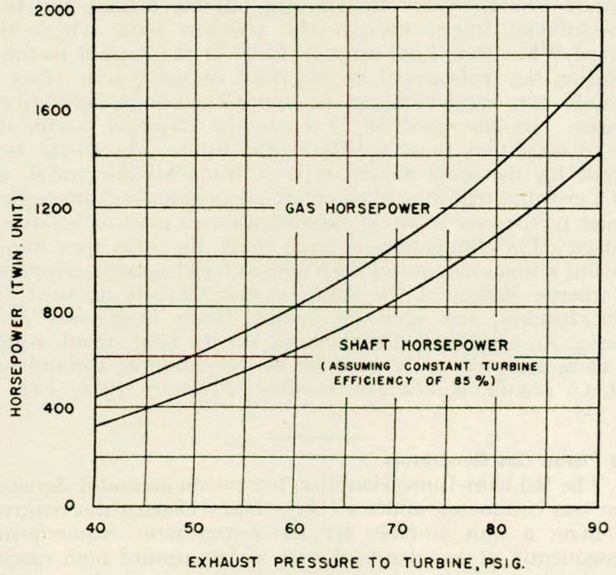

FIG. 11—*Variation of horsepower with gas-generator exhaust pressure for Baldwin-Lima-Hamilton Model B free-piston gas-generator*

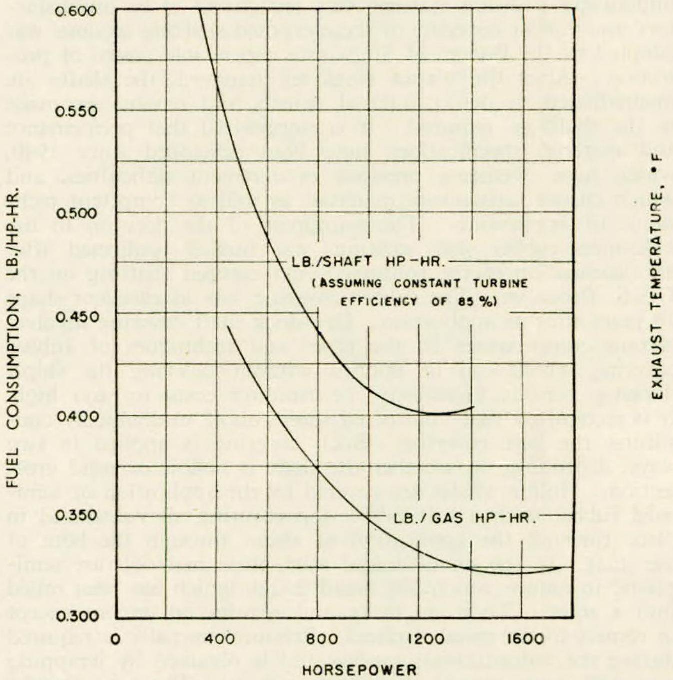

FIG. 12—*Variation of specific fuel consumption with horsepower for Baldwin-Lima-Hamilton Model B free-piston gas-generator*

Meeting of Schiffbautechnische Gesellschaft

The winter meeting of the Schiffbautechnische Gesellschaft was held in Hamburg from 18th November to 21st. A series of seven papers was read. "Systematic Development of Hull Shapes" was the title of a paper read by Professor Dr. Ing.

Weinblum, who pointed out that this important matter in the past had not received the attention which it deserves. The author showed how existing research results can be classified for reference and study. Particular stress was laid upon the analytical treatment of hull surfaces. Dr. J. D. van Manen in his paper on "The Results of Systematic Research on Propeller Nozzle Systems" gave results obtained with the propeller series B 4-55 and the nozzle profile N.A.C.A.4415. A diagram in the paper gives test results for different nozzles for the combined system of propeller and nozzle. "Outstanding Problems of Marine Refrigerating Technique" was the title of a paper read by Dr. Ing. O. Prinzing, who stated that the world fleet of refrigerated vessels at present amounts to some 600 units having refrigerated spaces of 35,000 to 520,000 cu. ft. Some 300 of these vessels are of post-war construction. About 50 per cent of the post-war vessels are equipped with Freon-12 plants, 40 per cent with carbon dioxide plants, and 10 per cent with ammonia plants. In the latest German practice the use of carbon dioxide has been abandoned, and ammonia plant has been given preference. The advantages and disadvantages of Freon-12 and Freon-22 are discussed. There is a tendency towards adopting high speed compressors of 650 to 1,000 r.p.m., although at present compressors with speeds of 375 to 480 r.p.m. are in the main employed. Dr. Ing. H. Voigt reported on "Recent Findings and Experiences of Ship Vibration Research". His recommendations included proposals regarding the optimum distance between propeller and rudder. The natural frequency of the rudder should be determined in the design stage. "The Gas Turbine as a Ship Propulsion Unit" was discussed by Dr. Ing. Friedrich, who believed that the employment of gas turbines offers especially favourable possibilities in the range of powers from 1,000 to 18,000 s.h.p. As gas turbines can be employed from powers of 1,000 s.h.p. upwards, they will be applicable to cases where power requirements are too small to justify the installation of a steam turbine. "The State of Development of Gas Turbine Plant" was further discussed by Dipl. Ing. Wehrlin, who mainly referred to gas turbines of Brown-Boveri make. He believed that gas turbine plant will best be combined with a variable pitch propeller installation. In his paper "Comparative Operating Results of Marine Diesels with Diesel Oil and Heavy Fuel Oil", Professor Dr. Ing. Pflaum gave pertinent data obtained on a single-acting six-cylinder two-stroke Fiat-Borsig Diesel engine of 3,600 s.h.p. at 125 r.p.m. When operating with Diesel oil, this engine can carry an overload of 140 per cent, as compared with 120 per cent in the case of heavy fuel oil operation. In order to prevent cylinder corrosion, cylinder wall temperatures must not be allowed to fall below 200 deg. C. Injection pressures can conveniently be measured by fixing resistance wire strain gauges to the fuel lines.—*World Shipbuilding, February 1954; Vol. 4, pp. 27-28.*

Unsteady-flow Water Tunnel

A project for investigation of fluid friction and cavitation phenomena in unsteady motion has been in progress since 1948, at the M.I.T. Hydrodynamics Laboratory under the sponsorship of the Office of Naval Research. Its object is to obtain for transient-flow conditions through conduits and around immersed bodies the same kinds of basic information that have been obtained for steady-flow cases. Unsteady-flow experiments require special laboratory apparatus and techniques, and the initial phase of this programme involved the design and construction of a pilot-model unsteady-flow water tunnel, together with suitable instrumentation for producing and observing accelerating and decelerating motions. The unsteady-flow test apparatus was designed to incorporate the following desirable features: 1. The water stream should have rectilinear motion and initially be free of turbulence. 2. The acceleration and velocity of the stream should be controlled at either arbitrarily fixed values or according to some programmed variation. 3. The local pressure in the test stream should be controllable such that cavitation can be produced or prevented as desired. The ranges of variables initially specified were as follows: 1. Velocities up to 100ft. per sec. 2. Accelerations up to 5ft. per sec. per sec. with at least a 20-sec. test duration or higher acceleration for shorter intervals. 3. Local pressure intensities in the unobstructed test stream ranging from 4lb. per sq. in. absolute upwards. The apparatus chosen for this purpose is a non-return unsteady-flow water tunnel. The erected equipment is shown in a schematic section in Fig. 2.

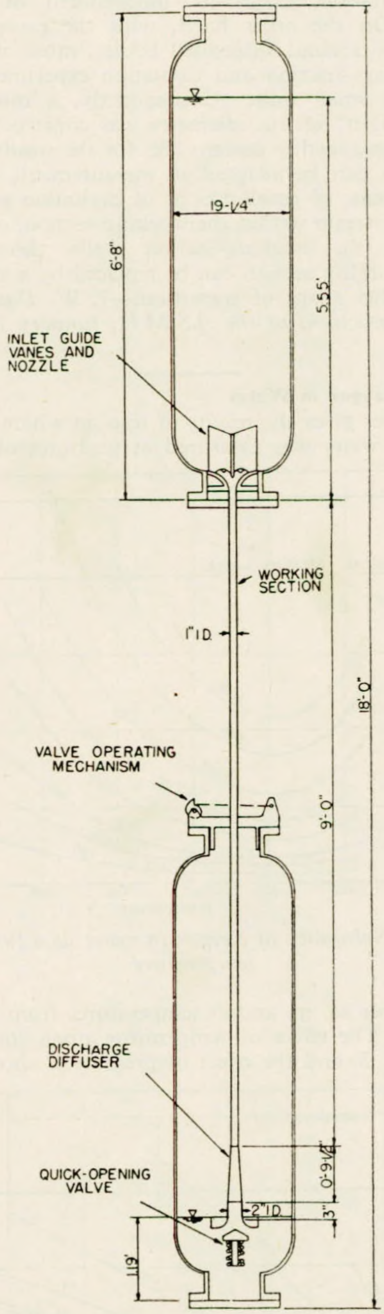

FIG. 2—*Schematic section of non-return unsteady-flow tunnel*

The tunnel proper consists of two cylindrical tanks mounted one above the other and connected by a vertical pipe or working section extending into the lower tank. Water is caused to flow from one tank to the other under pneumatic control; compressed air in the spaces above the water surfaces in the two tanks is used to provide an adequate driving force for desired accelerations and degree of control. Flow is established on release of a quick-opening valve in the pipe below the working section. This basic arrangement permits flow in either direction, although in the design of the equipment, downward flow was given primary consideration. Thus the entrance nozzle is located at the bottom of the upper tank to ensure proper flow into the working section. The apparatus constructed is actually a small-scale model of a proposed larger apparatus. The small size is a consequence of the early realization that the main problems with this unconventional equipment were to be those of instrumentation, essentially independent of the size of apparatus. On the other hand, with the exception of tests involving flow around suspended bodies, most of the contemplated boundary-friction and cavitation experiments would be possible in a small unit. Consequently, a model having a "working section" of 1in. diameter was constructed in preference to a larger, costlier design. As for the steady-flow tunnel, the apparatus can be adapted to measurements of boundary-layer phenomena, of resistance, or of cavitation on bodies supported in the stream within the working section, or to measurements along the working-section walls themselves. The cylindrical working section can be replaced by a venturi section or by any other shape of transition.—*J. W. Daily and K. C. Deemer, Transactions of the A.S.M.E., January 1954; Vol. 76, pp. 87-95.*

Solubility of Oxygen in Water

This paper gives the results of tests in which the solubility of oxygen in water was measured at pressures of 1,000, 1,500 and 2,000lb. per sq. in. and at temperatures from 32 deg. F. to 625 deg. F. The effect of temperature upon the solubility is shown in Fig. 3, and the effect of pressure is shown in Fig. 4.

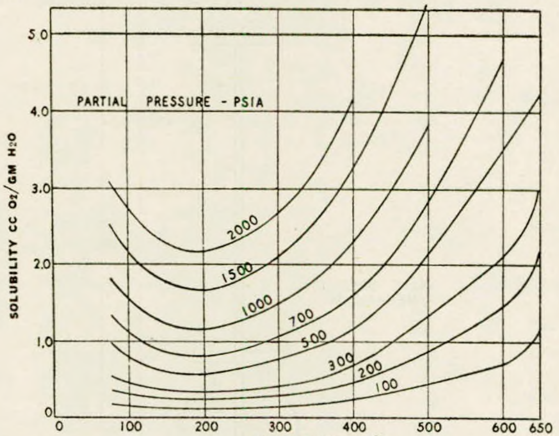

FIG. 3—*Solubility of oxygen in water as a function of temperature*

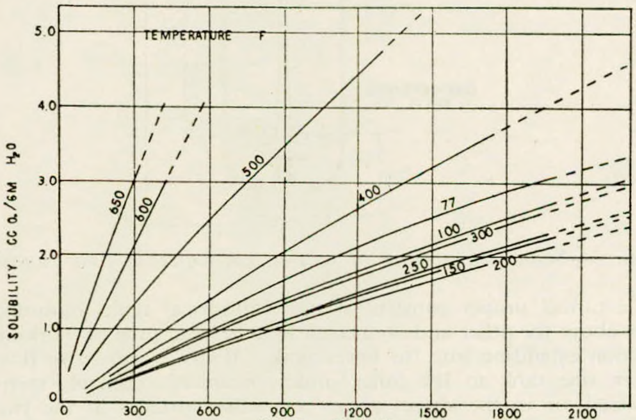

FIG. 4—*Solubility of oxygen in water as a function of pressure*

The "partial pressures" in Figs. 3 and 4 are fictitious values which were obtained by subtracting the saturation vapour pressure of water from the total pressure. The true vapour pressure of the water in the solution may have been greater or less than the saturation vapour pressure of pure water. Oxygen shows unusually high solubility at 32 deg. F. The solubility decreases with increasing temperature in the range from 32 to 233 deg. F. and then increases with increasing temperature as shown in Figs. 3 and 4.—*L. M. Zoss, S. N. Suciu, and W. L. Sibbitt, Transactions A.S.M.E., January 1954; Vol. 76, pp. 69-71.*

Cathodic Protection of Interior of Cargo Compartments in Oil Tankers

Following a brief outline of the theory of cathodic protection, its adaptation to oil tankers is considered and the several factors which had to be taken into account by the authors are discussed. The galvanic method of cathodic protection using magnesium-alloy anodes was chosen as the most practicable for the compartments of oil tankers, and a large-scale trial was begun on the 12,250-ton d.e.s. *Auris* in October 1952, engaged in the carriage of "white oil" cargoes. Three tanks were selected each comprising three compartments. It was thus possible to study the variations in anode composition and current density introduced by the authors. One of the first effects to be noticed was the rapid shedding of heavy scale, and it was estimated that a total of some 60 tons was removed from the protected tanks. An analysis of the results of the experiment, which extended over twelve months, showed that in spite of the relatively short time that the tanks were ballasted, protection had been considerable. It was greatest around the bottom of the compartments where the effect of the anodes would be greatest, and least towards the top. It was estimated that the reduction in corrosion was some 75 per cent near the bottom and a few per cent less than this in the upper region of the tanks. Gas freeing was reported to be much more easily accomplished in the descaled and protected compartments. Precautions were taken to ensure that the fairly large quantity of hydrogen gas evolved when the compartments were ballasted was allowed to escape freely to the atmosphere. The importance of adequate and correct ballasting is stressed. The longer the time in ballast the greater the degree of protection. It is recommended that, to ensure that protection reaches the deckhead when a compartment is ballasted, the water level should be within the hatch coaming. The application of cathodic protection to compartments of ships engaged in carrying crude oil is given particular mention at the end of the paper.—*Paper by J. Lamb, E. V. Mathias, and W. G. Waite, read at a meeting of the North East Coast Institution of Engineers and Shipbuilders on 26th March 1954.*

Shipyard's Need for Cranes

The method of prefabrication in a shipyard requires better and more flexible crane arrangements. In this article the weights and sizes of certain typical sections are discussed, also their variations with different sizes of ships. The number of heavy lifts does not exceed about 200 per ship. If the time of lifts were taken into consideration, the heavy lifts' share of the total crane capacity would amount to one-third. The choice of arrangement of the building berths and storage spaces would influence the possibility of the simultaneous use of two or more cranes. Lifting heights are also discussed. For increasing sizes of ships the weight of the largest sections should be stabilized at about 80-100 tons. The shipbuilder of the future will need a handy type of standard berth crane, of not less than 50 tons lifting capacity and maximum out-reach of 130 feet and heights of the hook of same distance above ground. The rail gauge of the cranes should be about 50 feet and the base may with advantage be given the modern three-legged design.—*N. G. Eckerbom, European Shipbuilding, Vol. 3, No. 1, 1954; pp. 9-16.*