ENGINEERING ABSTRACTS

Section 3. SHIPBUILDING AND MARINE ENGINEERING

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	PAGE
Air Intake and Exhaust Systems for Marine Diesels	102
Alternating Current for Ships' Auxiliaries	97
Barges for Transportation of Acids	104
Breaking-in Run of Refrigeration Compressors	98
Combustion of Diesel Fuel	101
Corrosion Research in the U.S. Navy	103
Creep Tests and their Application to Gas-turbine Design	97
Current Conducting Glass	102
Design for Great Lakes Export Cargo Ship	102
Diesel-electric Passenger Vessel	98
Economic Construction of Moderate Sized All-welded Ships	97
Erosion-corrosion	99
Fighting Fire at Sea	99
French Motorship *La Marseillaise*	103
Fresh Water Equipment in Liner *Himalaya*	102
Friction at High Speeds	104
Heat and Corrosion-resistant Coating	103
High Temperature Corrosion of Metals	104
Hydraulic Deck Machinery	99
Italian-built Tugs for Russia	101
Light Alloy in Steam Trawler	101
Magnetic Fluids	98
New Diesel-electric River Tug	101
New Economizer Installation	103
New Foamed Resin	98
Panama Canal Dredge	99
Protective Action of Sprayed Aluminium Coating on Steel	100
Polish-built Ore Carrier	101
Stainless Steel Propellers for Whaling Ships	100
Tolerance to Heat	104
Tug with Machinery of 3,200 b.h.p.	103
Waste Heat Boilers and Electrical Auxiliaries for Tankers	102
Weldability of Low-alloy High-tensile Steel	100

Economic Construction of Moderate Sized All-welded Ships

The subject of this paper is the application of electric welding to ship construction with particular reference to economy in time and material, the economy being measured in relation to the traditional method of riveted construction. Taking up the question whether an all-welded vessel can be constructed more cheaply than a riveted one, the author points out that it is as yet very difficult to show from figures which of these is the cheaper method. But it is suggested that if the job is tackled in a proper manner and the establishment concerned has had several years' experience of welding, the moderate sized vessel at least can be constructed more cheaply by welding than by riveting. In this country it is only within recent years that welding has been applied to the main structural parts of a ship and only a few establishments have gone in for welding in a big way. While the progress of welding in most shipyards might appear to be slow and cautious, it could be reasoned that this has been preplanned and is the result of wise policy. On the other hand, however, it could no doubt be argued that, except in a few cases, ship welding has developed in a haphazard manner. Signs are now evident that welding will develop much more rapidly in the immediate future. A few of the principal items which have tended to restrict welding in shipyards may be summarized as follows: (1) the natural disinclination to change from a proved and successful technique; (2) the difficulty—often very real—of altering the shipyard layout to suit welding; (3) the capital expenditure required to make such a change; (4) in some cases the unsuccessful try-out of welding due to lack of experience and suitable facilities. A few of the principal items which have tended to further welding may be summarized as follows: (1) the successful technical application of welding to ship construction by the Americans; (2) the difficulty, at one period, of getting sufficient riveters; (3) the considerable saving in weight—principally in oil tankers—with the corresponding increase in deadweight carrying capacity for given dimensions. This technical advantage of welding has literally forced some builders, against their natural inclination, to adopt welding to keep pace with their competitors.—*H. H. Hagan, Transactions of the Institute of Welding, Vol. 12, June 1949, pp. 50r-51r.*

Alternating Current for Ships' Auxiliaries

A recent report (No. 14) issued by the British Shipbuilding Research Association and published under the authorship of J. E. Richards summarizes the merits and demerits of alternating current systems for ships' auxiliaries as follows. The main advantages are as below. (1) It makes possible the use of the squirrel-cage motor with the attendant advantages of low cost, small size, and low maintenance. Most of these motors would be started by connecting directly across the line with the simplest kind of starter, and, even when reduced-voltage starting is required, the controller is simpler than that of a direct-current motor of the same rating. (2) Power can be generated and distributed at a higher voltage than with direct current, with consequent savings in size, weight, and cost of equipment, and the reduced voltage for lighting can be obtained by use of transformers. Earths are isolated to the transformer sections. (3) It would generally result in an overall saving in weight and space, and afford greater reliability with low maintenance. The machines are so rugged that it would be unnecessary to provide spare rotors. (4) Fluorescent lighting may be used with reduced fire risk and reduced heat radiation. (5) Alternating-current motors are more easily made proof against water and explosion. The main disadvantages are as follows. (1) (1) The alternating-current motor is essentially a constant-speed machine. Graduated speed control can only be obtained by methods which are either inefficient or complicated and costly. (2) The starting and overload torques for alternating-current motors are small in comparison with direct-current machines. (3) The high starting current required by squirrel-cage motors renders it difficult to provide effective overload protection, especially in large machines. (4) No suitable alternating-current winch has been demonstrated in service which, in all applications, gives a performance as good as the direct-current winch. (5) Alternating-current generators are not self-exciting and it is necessary to provide a source of direct current for this purpose, usually from a directly connected exciter. They have not good inherent voltage regulation and must be provided with automatic voltage regulators. Parallel operation is more difficult than with direct-current generators. (6) Switchboards are somewhat more complicated than in direct-current installations, but are usually smaller and lighter. (7) There is an increased danger of shock due to the high voltage used, 440 volts supply giving peak values of 635 volts. (8) The system generally is more complicated than the direct-current system and much more care and consideration must be given to the design.—*The Shipping World, Vol. 121, 27th July 1949, pp. 109-110.*

Creep Tests and their Application to Gas-turbine Design

Heat-resisting steels are used in gas-turbine construction mainly for turbine disks and blades. The turbine blades have to be connected to the disk by some mechanical means, and the commonest method is the fir-tree attachment. This type of attachment, however, involves multiple diversion of the flow of force, which is not feasible without the formation of local peak stresses and multi-dimensional stress conditions. Turbines for service in ships and electricity works must as a rule be constructed for a working life of at least ten years. Material testing departments are therefore forced by the problem of ascertaining the strength of the metal used when subjected to multi-dimensional stressing and to non-uniform stress distribution for a period of more than ten years. This task raises considerable difficulties in two main direction.s Firstly, it is impossible to carry out tests lasting as long as actual service, since such periods are never available for the preparation of the design. Secondly, tests involving multi-dimensional stressing at high temperatures and for long periods call for extremely large quantities of testing equipment. The testing programme must be drawn up so that the results obtained provide information on all the above questions, and in particular it must include the following investigations:—(1) long-period tests of smooth bars; (2) long-period tests of bars with various notch forms; (3) long-period tests of models of the elements to be used; (4) systematic investigation of the fundamental physical process. The tests with notched bars must permit the deduction of basic principles for the assessment of machine elements subjected to creep stressing, so that special tests on models can be dispensed with. There is often a tendency to underestimate the influence of peak stresses and multi-dimensional stress conditions under creep loading. But a number of failures, for instance in screwed joints, have clearly demonstrated that the sustained-load tensile strength may be considerably reduced by the presence of a notch. To investigate this effect sustained-load tests to fracture were carried out on smooth bars and on bars with different forms of notch. These investigations clearly demonstrated the pronounced sensitivity of high heat-resisting alloys to notching. This sensitivity is illustrated by Fig. 60, which shows the outcome of a sustained-load test at 700 deg. C. on a blade-root joint in which

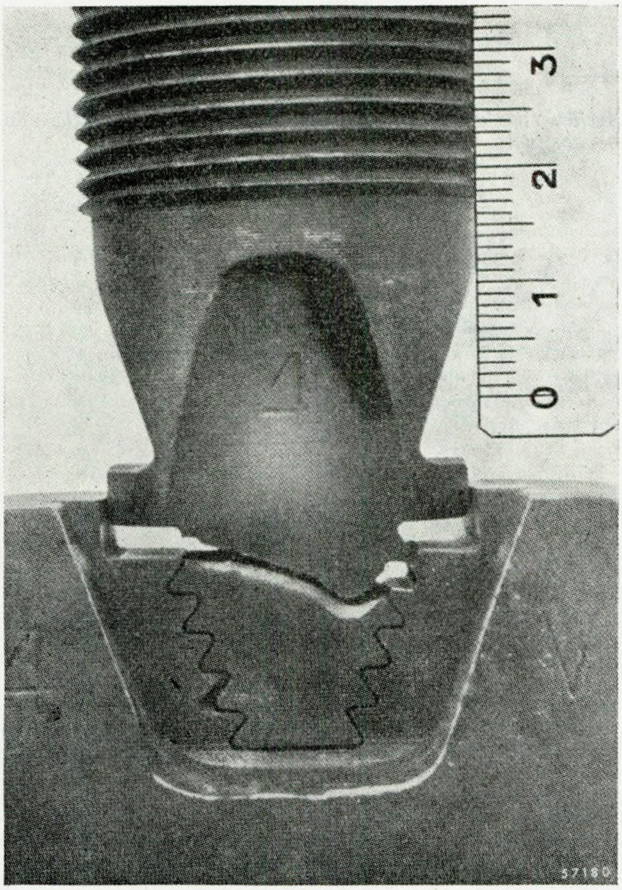

FIG. 60.—*Sustained-load test on a blade root joint in which the blades piece was composed of a steel with heat resisting properties but also of high notch sensitivity. Temperature 700 deg. C.*

the blade piece was composed of a steel with high heat-resisting properties, but also of high notch sensitivity. As can be seen the notch effect led to a crack in the blade root which caused the premature fracture of the blade, while the theoretically weaker holder piece suffered no deformation of any kind.—*W. Siegried, Sulzer Technical Review, No. 4, 1948, pp. 21-35.*

Magnetic Fluids

The magnetic fluid originally used in the electromagnetic clutch (see Engineering Abstracts, August, 1948, p. 79) developed at the National Bureau of Standards, Washington, D.C., has several unique features that make possible other important applications of the iron-oil mixture. The basic property on which all applications depend is the viscosity of a magnetic fluid being directly related to the strength of the applied magnetic field. The fluid may be changed from a liquid to a nearly solid state and back again at will. Further studies of the magnetic fluids have revealed that they can be used to good advantage in hydraulic systems, shock absorbers, and dashpots; to form casting moulds; and as variable electric resistors. If a magnetic fluid is used in a dashpot, the rate of motion of the piston can be readily controlled by magnetically varying the viscosity of the fluid. If a coil of wire is placed around the dashpot, the viscosity of the magnetic fluid will be a function of the current in the coil. The rate of response of the magnetic fluid is high enough to provide virtually instantaneous changes in viscosity, thereby making possible a shock absorber with automatic compensation. By winding a coil of wire around a fluid-carrying pipe and controlling the amount of current through the coil, the flow of fluid past that point can be closely regulated from full flow to complete cast-off. In this manner, various points in a hydraulic system can be remotely controlled from a central station.—*Mechanical Engineering, Vol. 71, July 1949, p. 600.*

Diesel-electric Passenger Vessel

In the Diesel-electric passenger vessel *Skaugum* the two propeller motors of 6,250 s.h.p. each are supplied from four Diesel alternators of 2,600 kVA. each. The latter turn at 240 r.p.m. and the propeller motors at 120 r.p.m. The auxiliaries and the hotel services, etc., are supplied from one or two of the main alternators through four transformers with a total capacity of 2,000 kVA. With the exception of the electric space heaters all auxiliary services can alternatively be supplied from the bus bars of the auxiliary Diesel generating plant consisting of two generators of 200 kVA. each operating at 380 volts. Owing to the supply of the auxiliary services from the main generators, network voltage and frequency is identical with that of the propulsion system and frequency may vary between 48 and 38 cycles per sec., with the network voltage fluctuating between 380 and 300 volts. These variations are considered acceptable for the auxiliary services which are mostly equipped with squirrel cage motors. The lighting system is, however, supplied through a three-phase transformer maintaining constant voltage.—*H. J. Kosack and W. Schmidt, Hansa, Vol. 86, 16th July 1949, pp. 685-687.*

New Foamed Resin

A new foamed phenolic resin developed by the Westinghouse Electric Corporation weighs less than 0·6 pound per cu. ft. and is therefore only about five times as heavy as air. The foamed product is obtained by exposing the liquid resin in an oven to 180 deg. C. for a few minutes. Application of this foamed resin could be extended to almost any low-temperature insulation requirement. Most insulating materials present difficulties in shipping because of their relative fragility and their large space consumption. The new foamed resin would have neither of these limitations; shipped as a liquid, one gallon of resin could be expanded "in place" at the installation site to a slab 2-inch thick and 10 × 10 feet square. At first glance this light fluffy material would seem to be too fragile for many insulating uses. But its very lightness seems to provide one of the reasons why it is not easily damaged. Because of its extremely light weight it has a very low inertia and therefore does not damage easily under shock or acceleration. Other properties of this foamed resin make it particularly suitable for insulation. It is resistant to moisture absorption and settling. As it foams into a closed area it "wets" the sides of the container and bonds with them. Furthermore it spreads itself uniformly and completely within the area since it is still liquid during expansion.—*Westinghouse Engineer, Vol. 9, July 1949, p. 123.*

Breaking-in Run of Refrigeration Compressors

The breaking-in run of compressors, if carried out under approved conditions, can do much to increase the length of useful service of these units, as the subsequent maintenance work is thereby reduced to a minimum. During this breaking-in period careful polishing of the running surfaces is an important feature, and one of the latest methods of checking the extent of polishing is to use a small instrument with fine diamond leads which run over the surface and record on a dial the results of any inequalities. Following a run of about two hours, with inspection stops every 15 minutes, partial load can be applied, after which the load is increased slightly on each re-start while continuing the periodic inspection stops. The minimum for complete break-in runs is four hours, while several days run at light-load is recommended to do the job correctly with larger machines. Cylinder heads are removed after operating several hours, and the lubrication of the walls inspected, but after the first day's run, the bearing and reservoir oil are best drained and replenished. Following the break-in run, the importance of which cannot be sufficiently emphasized, most attention has to be given to questions of lubrication, and adequate supplies of oil.—*Modern Refrigeration, Vol. 52, June 1949, pp. 134-135.*

Fighting Fire at Sea

Fire at sea is a serious matter. Once out of control, the result is disastrous. It is a well-known fact that no single fire-extinguishing medium will control every type of fire. The most common agents are water, carbon dioxide, foam, dry powder, and steam. The best known extinguishing agent is water. On many types of fire its use has been satisfactory and its ability to lower the temperature of a fire below the ignition point has long been recognized. There are several disadvantages connected with its use. These may be listed as : (a) it is productive of a large "run-off" which in a ship might create an unacceptable free surface condition with all the attendant effects on trim and stability; (b) the water damage may far exceed the actual fire damage; (c) it has a corrosive effect on fire mains and fittings; (d) pumping equipment of adequate capacity and pressure is required; (e) in the form of a solid stream it has comparatively little heat-absorbing value because of the relatively small surface area exposed to the fire. The disadvantage listed in (e) led the United States Navy in the recent war to turn to the development of equipment that would discharge water in a finely diffused homogeneous mass. The latent heat of vaporization of one pound of water at 212 deg. F. is approximately 973 B.Th.U.s. Thus, if every pound of water applied on a blaze were turned into steam by absorbing the heat of the fire, 973 B.Th.U.s would be removed from the burning mass for every pound of water applied. However, because heat absorption is possible only through the surface area, it follows that a solid stream of water issuing from a 1-inch smooth-bore nozzle in the form of solid stream will have, as a column, a theoretical surface area of slightly more than 37 sq. in. per lineal foot. If this same amount of water were finely diffused in the form of water fog, each minute particle would possess its individual surface area and the total area available for heat absorption therefore would be increased thousands of times, making it possible to approach more closely the optimum. Water possesses an inherent surface tension which tends to limit both its surface spread and its ability to penetrate minute interstices in burning material, thus limiting its effectiveness. This surface tension causes water to bridge over pores in the texture of burning material and prevents penetration to point where the heat of deep-seated fires can be absorbed. Recently, wetting agents have been developed that will reduce the surface tension of water to a point where it will be comparable with that of kerosene. As a result, it is possible to obtain much greater penetration and wider surface spread. One-tenth of one per cent by volume of wetting agent mixed with ordinary water will produce an effective reduction of the surface tension. "Wet water" for fire fighting may be available by premixing and storing for use. However, this is not a practical method for shipboard use. The use of proportioning devices which will feed the concentrate into the water stream in correct amounts is the best method to use afloat. The general use of wet water in marine applications requires further study, research, and development.—*Paper by Capt. H. J. Burke, U.S.N.R., read at the Spring Meeting of The Society of Naval Architects and Marine Engineers, 12th May 1949.*

Hydraulic Deck Machinery

The hydraulic deck machinery with which the 1,300 ton d.w. motorship *Melrose* is equipped has been manufactured by MacTaggart Scott of Loanhead, Midlothian, according to their own patented design. One of the main advantages claimed for the adoption of this new system is the large saving which can be made in the size of the auxiliary engines and generators. It has been estimated that the ship's auxiliary installation normally would have consisted of the following:—

One generator, 80 kW. driven by 120 b.h.p.
One generator, 80 kW. driven by 120 b.h.p.
One generator, 15 kW. driven by 27 b.h.p.

namely, three generators totalling 175 kW. driven by 267 b.h.p. By using this new principle of the application of hydraulic power, it has been possible to cut this installation to three generators, each of 15 kW. driven by 49 b.h.p.—a total of 45 kW. and 147 b.h.p. This is a saving of almost 50 per cent in engine power and more than 75 per cent in dynamo power. If the movement of a winch is analysed, it will be found that with a single derrick, the winch starts by hoisting under power, then the load is lowered. The empty hook is then raised again and finally lowered into the hold. Thus, in only one of these movements is any real work done. With the twin-derrick method, the first winch works in much the same way as above. The second winch delivers some actual power during the short time the load is transferred to it, otherwise it runs all the time, under no-load conditions Therefore, in each cycle of operations, of, say, two minutes duration, full power is developed during ten seconds and by only one of the two winches employed. During the rest of the cycle, both are idling or standing still. If, therefore, sufficient energy for this one hoisting movement can be stored in an accumulator, the power available for cargo handling can be cut to about one-fifth. The system comprises the following : six 3-ton cargo winches with three accumulators; anchor windlass; 3-ton capstan; steering gear controlled by telemotor; three pumps driven off the Diesels for the auxiliary generators; reservoir tank; piping system and fittings. Pressure is generated by three 10-12 h.p. hydraulic pumps situated in the engine room. The pumps are of the six plunger type, each fitted with a pressure-controlled, automatic cut-out which unloads the pump when the pressure in the system reaches 1,500lb. per sq. in. The pumps cut back in again at a pressure of 1,350lb. per sq. in. Three air-loaded hydraulic accumulators are installed. The power stored in these accumulators enables normal loading or unloading by the six winches (in pairs) to be accomplished with one pump only running. Six 3-ton cargo winches are installed in pairs. Their hydraulic motors are mounted direct on the drum shaft, thereby eliminating gearing. The duties of the 3-ton cargo winches are : three tons at 100ft. per min., 1½ tons at 200ft. per min., and light hook at 450ft. per min. On test, these winches lift three tons at 150ft. per min., 1½ tons at 300ft. per min., and light hook at 475ft. per min. Ample power is therefore available.—*The Shipping World, Vol. 121, 20th July 1949, pp. 79-81.*

Panama Canal Dredge

The dredge *U.S. Mindi* was built by the Elliott Machine Corporation, Baltimore, Md., and completed on 20th June 1942. It was designed and built specifically for continuous duty at the Panama Canal. Some of its specifications are: length 295ft. 11in., beam moulded 50 feet, displacement 3,288 tons, distance from top of rail on spud gantry to main deck 94ft. 6in. The ladder is 100 feet long and weighs 60,000lb.; the cutter shaft is of nickel steel and is 12½ inch in diameter; cutter speed is 14/21 r.p.m.; the maximum digging depth is 72 feet; the spud length is 100 feet, including point, and each weighs 138,000lb. The dredge is powered by four Foster-Wheeler boilers operating at 400lb. per sq. in., 750 deg. F. Boilers are equipped with Hagan automatic control. The main pump is driven by an Elliott 5,000 h.p. geared turbine, served by an Elliott condenser. The same company also furnished the following auxiliary equipment : a 790 kW. geared turbine, driving three direct-current generators in tandem—a 500 kW. generator supplies the cutter motor, a 165 kW. generator supplies hauling motors, and a 125 kW. generator supplies current for lighting and auxiliaries. An Elliott 50 kW. turbine-generator unit supplies auxiliary hauling motors. There are also a 200 h.p. hauling motor and a 40 h.p. auxiliary hauling motor. The 600 h.p., 600/900 r.p.m. cutter motor is worked 100 per cent overload when digging rock. Since the dredge has been in operation, it has handled hard material such as mined rock, unmined sandstone, and coral rock 50 per cent of the time, with very satisfactory results. For this class of material, a 22-ton, 8-bladed tooth cutter was used with a 3-vane impeller in the pump. The dredge, while using a 4-vane impeller, has pumped through lines up to 15,000ft. and has operated with a discharge pressure of 170lb. The best yardage output in softer material, consisting of sand, silt, and clay, is 1,501,500 cu. yd. in twenty-two days, when pumping through a 8,000-feet line. The best one-day yardage record is 83,500 cu. yd. in twenty-one hours pumping time.—*Captain H. W. Post, Powerfax, Vol. 27, No. 2, 1949, pp. 4-8.*

Erosion-corrosion

Erosion-corrosion is the deterioration caused by the combined effect of corrosion and the wear tendency produced by relative movement between the corrosive and the metal surface. The rate of corrosion can be accelerated greatly when mechanical or abrasive conditions are present, such as liquids moving at substantial velocities, solids in suspension (slurries), marked turbulence, and impingement. Unfortunately, the usual and common static corrosion test does not include the effect of erosion at high velocity. Consequently, equipment often fails within a short time, although static corrosion tests indicate a very long life. Cupro-nickel alloys long have been used as alloys resistant to corrosion by sea water. However, with the advent of increased velocity conditions in ship condenser tubes, problems involving severe conditions of erosion-corrosion became increasingly important. It was observed recently that the addition of small percentages of iron to this alloy greatly increased its resistance to sea water. Tracy and Hungerford showed that an increase in 0·50 per cent iron doubled the corrosion resistance of the alloy. Substantiating results were also obtained under low velocities by LaQue. Numerous tests were conducted on two 30 per cent cupro-nickel alloys using the erosion-corrosion equipment constructed by the authors. Experimental heats were made in an induction furnace of the two compositions; one analyzing 69·8 per cent Cu, 29·95 per cent Ni and 0·12 per cent Fe and the other 70·10 per cent Cu, 29·24 per cent Ni and 0·59 per cent Fe. Incidentally, the 0·12 per cent iron in the first heat was not intentionally added and did not seem to affect the results to any appreciable extent. Erosion-corrosion tests conducted in synthetic sea water at 50 deg. C. on rotating disks of the iron-free cupro-nickel material averaged 39 mils penetration per year, while the 0·59 per cent iron samples averaged only 11 mils penetration per year. This indicates that an approximate addition of 0·50 per cent increases the resistance about three times under the high velocity conditions. Results for the tank tests in which the specimens were subjected to a mild swirling and turbulent motion averaged a wastage of 4 mils per year and 3 mils per year for the iron-free and iron-containing cupro-nickel alloys, respectively. This does not quite show the same ratio of attack as obtained by the other investigators, but is a close check. The average corrosion rate for the stagnant test specimens was approximately one mil per year for both the iron-free and iron-containing alloys. This shows equal resistance for tests under stagnant conditions, which is widely different from the high-velocity conditions. This again shows the practical value of this type of erosion-corrosion tests in that the results often can be correlated with actual experience.—*M. G. Fontana and W. A. Luce, Corrosion, Vol. 5, June 1949, pp. 189-193.*

Weldability of Low-alloy High-tensile Steel

This paper describes an investigation of the mechanical properties and weldability of experimental manganese-titanium and manganese-vanadium high-tensile low-alloy steels which met the physical requirements of U.S. Navy Specification 4885 (BuShips). Fifty-nine 80lb. fully killed laboratory heats were prepared with ranges of composition of 0·12 to 0·20 per cent carbon, 1·00 to 1·50 per cent manganese, and 0·01 to 0·5 per cent titanium or 0·05 to 0·15 per cent vanadium. Tensile properties, maximum underbead hardness, underbead cracking, weldability according to the nick-bend specimen and notch sensitivity as determined by the V-notch Charpy bar were the means of evaluating the relative performance of the steels in both the as-rolled and normalized conditions. Of the above data, the most noteworthy were those provided by the nick-bend specimen and V-notch Charpy bar. These data showed that small variations in the amount of titanium or vanadium produced a marked effect on the temperature of transition from ductile to brittle behaviour. The nick-bend specimen showed that welding adversely affected both the titanium- and the vanadium-alloyed steels, this effect being most pronounced for the higher percentages of titanium or vanadium. Normalizing produced a marked improvement in the ductibility of welded titanium-alloyed steels. In regard to notch sensitivity as determined by the V-notch Charpy bar, high percentages of titanium and vanadium resulted in high transition tempertures in the as-rolled condition. Normalizing produced a marked improvement in the titanium-alloyed steels, while in the case of the vanadium steels the improvement was neither marked nor consistent. Carbon exerted a marked influence on mechanical properties and weldability, while manganese had no effect on notch sensitivity. It was found that to minimize notch sensitivity, carbon and titanium in combination should not exceed 0·15 and 0·025 per cent respectively; and carbon and vanadium 0·15 to 0·10 per cent respectively. Explanation was sought for the persistent differences in mechanical performance between the titanium- and vanadium-alloyed steels. A study of the microstructure revealed that the titanium-alloyed steels contained visible nitride crystals while the vanadium steels did not. Chemical analyses for acid-soluble and acid-insoluble nitrogen indicated that increasing titanium content was accompanied by an increase in the amount of acid-insoluble nitrogen, while no appreciable change was observed in the vanadium-alloyed steels. A study of the acid-soluble amounts of titanium and vanadium before and after normalizing again disclosed a difference in the action of titanium and vanadium. In the case of titanium, acid soluble amounts decreased after normalizing, while in the case of vanadium, acid soluble amounts increased after normalizing.—*G. G. Luther, C. E. Hartbower, and D. B. Rouck, The Welding Journal (New York), Vol. 28, July 1949, pp. 289s-309s.*

The Protective Action of Sprayed Aluminium Coatings on Steel

Coatings of sprayed aluminium on steel provide an excellent means of protecting iron and steel against corrosion under widely differing conditions of exposure, and the process has been in commercial use for several years. The investigations of Britton and Evans, Sutton and Braithwaite, and Hudson and Banfield among others have shown the protective value of such coatings. The actual extent of protection afforded by aluminium on steel has not been clearly defined, and it is still not clear under what conditions aluminium affords electrochemical protection to steel. The present work was undertaken to clarify the electrochemical relationships of aluminium and steel, and to investigate the mechanism of the protective action of aluminium coatings on steel. The scope of the work has been limited to an investigation into the causes and prevention of rust-staining of aluminium coatings on steel as may occur in the early stages of atmospheric exposure. It is usual to find that the thickness and texture of the coating are satisfactory, and no permanent damage or loss in protective properties seems to be caused. The stains usually disappear slowly until, after a few months' further weathering, little trace of the early rusting remains. From his experiments the author concludes that there is a fairly rapid initial attack on the aluminium, causing the coating to become progressively less noble, until there is a reversal of potential and aluminium becomes anodic. Any practical method of ensuring that no rust-staining will occur must saturate the coating with the particular ions that will give an anodic character to aluminium, even when introduced into adverse climatic conditions immediately after treatment. Alternatively, the pores in the coating must be effectively sealed. The former method offers considerable advantages in practice, and, on the basis of the results obtained above, a further investigation was made into the efficacy of various solutions in preventing rust-staining. It was found by the author that the use of very dilute sulphuric acid solutions is of great advantage in suppressing the formation of rust-stains, although not completely efficacious. It seems that changes in the structure of the coating, resulting in the filling up of pores, are equally as important in suppressing rust-staining, as reversal of potential, but which of these factors is likely to predominate when treating with dilute sulphuric acid solutions cannot be demonstrated at the present stage. A further study of corrosion processes in the aluminium coating itself will therefore be necessary before a full answer can be given to the problem of rust-staining.—*G. Tolley, Journal of The Iron and Steel Institute, Vol. 162, August 1949, pp. 377-384.*

Stainless Steel Propellers for Whaling Ships

An interesting application of stainless-steel is exemplified in the propellers fitted to many whaling vessels. During the whaling season, the sea in the operational regions is frequently covered by areas of thin ice, interspersed with larger pieces, so that the ships' propellers are exposed to very arduous conditions. Blade damage, caused by impact with large pieces of ice, is a constant danger, while abrasion of the blade surfaces is inevitable. Consequently, propeller replacement is more frequently necessary than in other classes of vessel. Experience has shown that, under such conditions, stainless-steel propellers are especially advantageous. Their resistance to corrosion is not inferior to that of non-ferrous propellers, and the material has the further important merit that its mechanical properties are of a high order. The steel usually employed for such propellers is one containing from 12 to 14 per cent of chromium, basically similar in constitution to that employed for stainless cutlery. After appropriate heat treatment, the material, as it exists in a propeller casting, has a tensile strengh of between 40 and 45 tons per sq. in. Moreover, the steel combines toughness and ductility to a remarkable degree. An Izod impact value of between 15 and 25ft.-lb. and an elongation of 25 per cent are readily obtainable; while tests have shown that the material may be bent cold, through large angles, without fracture. This combination of properties makes these stainless steel propellers especially suitable for the ice conditions mentioned. Prior to the war, such propellers were manufactured almost entirely in Scandinavian countries, but, in the post-war period, the technique has been developed in this country. Little experience was available in any British foundry in regard to the casting of these propellers, but the problem has been tackled, with conspicuous success, by a Scottish firm of steel founders. Much experience has been gained in the production and finishing of these specialized castings. Due to the greater strength and toughness of the metal, the problems associated with the finishing of the stainless-steel blades to a high standard of smoothness are very different from those which occur with non-ferrous propellers, but great advances have been and are being made, and there is now good reason to believe that the Scottish product compares favourably with that of any other country.—*The Shipbuilder and Marine Engine-builder, Vol. 56, August 1949, p. 583.*

New Diesel-electric River Tug

A Diesel-electric tugboat recently was put in operation at the Marine Ways of Carnegie-Illinois Steel Corporation's Clairton Works. Designated the CIS6, it is used as a harbour tug to shift coal barges. The tugboat operates 24 hours a day, with three 8-hour crews, each consisting of a pilot and an engineer. The crew is assisted by barge men at the landings. Of all-welded steel construction, the craft has ⅜-inch thick hull plates fabricated from high-strength low alloy steel. The hull is 70-feet long, 18-feet wide and 9-feet deep. Draft of the vessel is 6ft. 3in. The Diesel engine is a Fairbanks-Morse 420 h.p., 2-cycle unit. It has 7 cylinders, each with 8½-inch bore and 11½-inch stroke. Its normal operating speed is 514 r.p.m. The 250-volt marine-type General Electric generator driven by the Diesel engine is rated at 290 kW. output. It supplies power to operate a 350 h.p. propulsion motor connected to the propeller by a 5-inch shaft. Rated speed of the motor is 300 to 400 r.p.m. The four-bladed, bronze propeller is 60 inch in diameter, and has a 46-inch pitch. For steering, the CIS6 has a steering rudder and two flanking rudders. One hydraulic system operates the steering rudder, and a second separate hydraulic system operates the two flanking rudders. Both steering systems are automatically controlled from the pilot house.—*Pacific Marine Review, Vol. 46, July 1949, p. 63.*

Italian-built Tugs for Russia

At the yard of Odero-Terni-Orlando of Maggiano, La Spezia, Italy, twelve steam tugs have recently been constructed to the order of the U.S.S.R. Commercial Mission in Italy. The leading particulars of the tugs are :—

Length overall	26·00 m.
Length b.p.	23·00 m.
Breadth moulded	5·80 m.
Draught	2·56 m.
I.h.p.	350
Speed, knots (about)	11

The vessels, which have been built in accordance with the rules of the R.I.N.A., are of steel construction, and are reinforced for ice-breaking duties. The propelling installation consists of a direct-coupled compound steam engine taking steam from a single coal-burning Scotch boiler, with Howden forced-draught equipment, to permit the burning of coal of inferior quality. A 3 kW. direct current generator driven at 500 r.p.m. by a steam engine provides current for electric lighting and for the motor of the forced-draught fan. A steam-driven fire pump, capable of discharging 80 tons per hour, is mounted on deck. All the tugs carried out comprehensive trials, with highly satisfactory results in regard to free-running speed, fuel consumption, manœuvrability, tow-rope pull, stability, etc. With the engine developing 350 i.h.p., the speed attained was 10·9 knots. Four of the tugs, intended for service in the Far East, were shipped as a deck cargo on board the Russian motorship *Sevzaples*. Special steel cradles and securing arrangements were erected on the deck to take the tugs, each of which had a weight of about 120 tons. Each tug was lifted bodily into place by means of two pontoon cranes.—*The Shipbuilder and Marine Engine-builder, Vol. 56, August 1949, p. 582.*

Combustion of Diesel Fuel

The author discusses both the physical and chemical aspects of the combustion process of Diesel fuel, placing special emphasis upon the chemical aspects. Each phase of the process is considered, and the effects of important variables are pointed out. Both physical and chemical processes are involved, and these operate under exceedingly heterogeneous conditions, making experimentation difficult and complicating interpretation of results. In spite of this, it is possible to explain most of the observed phenomena and to formulate a satisfactory qualitative description of the combustion process in the Diesel engine. The combustion of Diesel fuel is accomplished in two stages : (1) the ignition-delay stage comprises a period of physical delay, during which a suitable mixture of fuel and air is being formed, and a period of chemical delay, during which preflame oxidation reactions that eventually lead to ignition are occurring. During the inflammation stage extensive chemical reaction occurs, and the potential energy in the fuel is released. These stages of combustion have chronological significance for a particular fuel particle, but there is no delineation of stages in the process as a whole, because fuel is being injected while combustion is in pogress. During the period of physical delay, a jet of fuel travelling at high velocity is broken up into drops of the order of 10 to 20 microns in diameter (0·01 to 0·02 mm.). Under the conditions existing in the Diesel engine, drops of this size will vaporize in about 1 to 2 millisec. The mixing of fuel and air occurs as a result of the relative velocity between vaporizing drops and air and as a result of turbulence in the combustion chamber. The fuel/air mixture is excedingly heterogeneous, and concentrations of fuel ranging from zero to 100 per cent may exist in small regions. During the period of chemical delay, stepwise oxidation reactions are occurring by a mechanism involving chain reactions. The rate of these reactions accelerates progressively until ignition or inflammation occurs. The average rate of reaction is increased (ignition delay reduced) by increasing temperature, pressure, or partial pressure of oxygen. The cetane number of a fuel is a measure of its chemical reactivity and is, therefore, an indication of the extent of chemical delay. However, it is not possible to attach quantitative significance to the cetane number unless the fuel has been tested in the environment in which it is to be used. When inflammation occurs, the fuel/air mixture is exceedingly heterogeneous, just as in the delay period, and both oxidation and thermal decomposition reactions are occurring. There are definite indications that the average rate of the oxidation reaction depends upon fuel/air ratio and average oxygen concentration and that the rate of the oxidation reaction increases with increasing turbulence. The interrelation of reaction velocity, fuel distribution, and Diesel knock has been indicated quantitatively. Products of incomplete combustion, such as carbon monoxide, aldehydes, and smoke (unburned fuel or free carbon), are an excellent criterion of the efficiency of the combustion process. Under locally overlean conditions or when preflame oxidation reactions are chilled, carbon monoxide, aldehydes, and unburned fuel will be present in the exhaust gas. Under locally over-rich or generally over-rich conditions, carbon monoxide, free carbon, and aldehydes (to a limited extent) are formed. Considering the combustion process broadly, there are certain points that warrant particular emphasis. The cetane number of a fuel is basically a measure of its chemical reactivity or chemical delay. Under many conditions of use, chemical delay is not the rate-determining step, and the length of the delay period may depend chiefly upon physical factors involving atomization, distribution, and vaporization of the fuel in the particular environment in which it is being used. This limitation of the cetane number in rating fuels must be recognized, and differences in cetane will indicate significant differences in fuel performance only under conditions where chemical delay is the rate-determining step. The cetane number of a fuel furnishes very little basic information on the performance of the fuel during the inflammation period. Cetane number may be related to certain performance factors during inflammation; however, generalized correlations are not possible because of the effect of other variables, such as volatility. It would seem desirable, therefore, to obtain more basic information on the performance of fuels during the inflammation period, particularly the fundamental factors affecting reaction rate.—*Paper by M. A. Elliott, S.A.E. Transactions, Vol. 3, July 1949, pp. 490-512.*

Polish-built Ore Carrier

The self-trimming coal and ore-carrying vessel *Pstrowski* is of the raised quarter-deck type. Its leading particulars are: 290ft. by 39ft. 5in. by 24ft. 4in.; 2,540 tons deadweight on 17ft. 7in. draught; 11 knots speed. The vessel, which was recently launched from Gdansk shipyard, Gdansk, is the fifth of a series of six similar ships and is of partially welded and prefabricated construction. The propelling machinery, constructed in Silesia, consists of a Lentz engine, of Polish design, developing 1,300 h.p. in service. Steam is supplied by boilers of Howden-Johnson type, partly produced in Great Britain, partly in Poland.—*The Shipbuilder and Marine Engine-builder, Vol. 56, August 1949, p. 604.*

Light Alloy in Steam Trawler

The *Cayton Bay*, built at the Beverley yard of Cook, Welton and Gemmell, Ltd., for the Marine Steam Fishing Co., Ltd., Hull, is believed to be the first British vessel to have fishrooms, stanchions, and fishboards entirely of aluminium alloy. Such an arrangement not only ensures that bacterial growth is impossible and that the fishrooms are more easily kept clean and hygienic, but the use of special-type aluminium fisboards also ensures, by the greater conductivity of the alloy, a more rapid transmission of heat from the stowed mass of fish. The principal dimensions are :—

Length (registered)	171ft. 6in.
Length b.p.	168ft. 0in.
Breadth moulded	29ft. 0in.
Depth moulded	15ft. 3in.
Speed on trials	13·44 knots
Operational range	3,000 miles approx.
Fishroom capacity	12,600 cu. ft.
Fishroom capacity	3,600 kits

The propulsion machinery was manufactured and installed by Charles D. Holmes and Co., Ltd., and comprises a triple-expansion steam engine with cylinders 14½ inch, 24 inch, and 40 inch, with a stroke of 27 inch, developing 1,000 b.h.p. at 130 r.p.m. The h.p. and m.p. valves are of the piston type, while the l.p. engine has a balanced slide valve. Steam to the main engines is supplied at a pressure of 220lb. per sq. in. and at 600 deg. F. from a multi-tubular, three-furnace, coal-fired boiler fitted with a superheater of "Melesco" type and the boiler is arranged for burning coal only with Howden's hot air, forced-draught system with air-heater box built into the uptakes.—*The Shipping World, Vol. 121, 3rd August 1949, pp. 133-136.*

Fresh Water Equipment in Liner *Himalaya*

The new passenger liner *Himalaya* is equipped with a new system of fresh water distillation, invented by the company's superintendent engineer, Mr. S. A. Smith. The *Himalaya* will be the first large passenger ship to be entirely self-supporting for all fresh water services. Apart from drinking water, all fresh water used on the ship is distilled. In the equipment, sea water is given single distillation in evaporators of a new design, the steam necessary to provide the heat being taken from the turbines after it has done useful work in driving the ship. The sngle-distilled water obtained from these evaporators is sufficient to maintain the general ship's water service, and also to provide surplus which goes through a further distillation process to provide double distilled water for use in the main boilers, which are of the latest Foster Wheeler type working at a pressure of 525lb. per sq. in. The evaporators have a combined capacity of 300 tons per day and as the equipment is in continual operation at sea and replenishes the stock as soon as it is used, storage capacity need only be provided for a sufficient quantity to maintain the ship in port. The fresh water storage capacity in the *Himalaya* is only 1,496 tons, as against the 3,500 tons which would normally be carried. Unless it is given complicated æration treatment, distilled water is inclined to be insipid to the taste, and for this reason drinking water is carried in the usual way and storage capacity of 272 tons is provided for this purpose, although in an emergency this water could also be made and treated by the ship's distilling equipment. The weight of the extra evaporators is more than offset by the saving of storage capacity, and in comparison with a similar ship with orthodox arrangements, the *Himalaya* will have an additional deadweight capacity of 1,732 tons. The cost per ton of water made by this new distillation process is stated to be less than the average cost of shore supply water purchased at ports between London and Australia.—*The Shipping World, Vol. 121, 10th August 1949, p. 165.*

Design for Great Lakes Export Cargo Ship

The author examines the possibility of designing a sea-going vessel to handle profitably export traffic from the Great Lakes, the vessel to be capable of using the restricted channels and locks of the present St. Lawrence waterway. It was decided to attempt such a design with the idea of making the proposed vessel particularly adapted to the transportation of automobiles and trucks—with parts and accessories, agricultural machinery and implements, industrial machinery, with paper, paper products, and other exports of the Great Lakes to be considered as "filler" cargo. The St. Lawrence waterway imposes length, breadth and draft restrictions, the free factors being deadweight and speed. The following leading particulars were therefore chosen: length overall, 258 feet; length b.p., 250 feet; breadth moulded, 43·5 feet; draft, 14 feet; sea speed, 13 knots; displacement, 3,032 tons The shallow draft limitations make a twin screw vessel almost a requirement, and a loss in efficiency is encountered immediately due to a twin screw vessel's low propulsive coefficient To keep this loss at an absolute minimum, a twin skeg vessel is proposed. Powering calculations indicate a saving of about 12·5 per cent in a twin skeg vessel whose skegs are faired to form easy flowing lines along the sides of the hull and a hydraulically efficient tunnel at the centre line between the line of the shafts. It is realized that this is a radical departure from usual commercial form. It is considered, however, a sound departure when the saving in operational overhead is weighed against a slightlv higher initial cost. It might be mentioned that too often are substantial economies lost by refusal to add somewhat to initial costs. The unusual form lends itself well to an aft engine room arrangement, leaving the midship volume available for cargo. The powering requirements for thirteen knots sea speed are two 715 b.h.p. Diesels driving through reduction gears. Tentatively selected propulsion units are two Fairbanks-Morse opposed piston engines developing a maximum of 800 b.h.p. at 720 r.p.m. and driving 96-inch propellers through a standard reduction, giving 248 r.p.m. of shaft. This will provide 14·8 to 15 knots trial speed and easy, efficient 13 knots sea speed.—*K. M. Jones, Motorship (New York), Vol. 34, July 1949, pp. 26-27, 41.*

Air Intake and Exhaust Systems for Marine Diesels

Air filters have previously been considered unnecessary on sea-going ships, although they have been recognized as desirable on many vessels operating on inland waterways. Today, however, it is considered desirable for ocean-going ships to be fitted with air filters for such engines as will be running for extended periods, while the vessels are in port. This seems logical enough when it is realized the average amount of dirt present at most docks is estimated at 4.23 grains per thousand cubic feet of air. This means that a 400 horse-power engine, for example, which requires on the average about 1,400 cu. ft. of air per minute, will draw about 1·2lb. of dirt from the surrounding dock air for every twenty-four period of engine operation. For ocean-going vessels not requiring extended engine operation while in port, it may also be advantageous to install air filters at least for the auxiliary engines since, while the ship is first being fitted out or undergoing repairs in the shipyard, it may be necessary to run one or more of the auxiliary engines when shipyard crews are active. At such times the surrounding air may be highly charged with abrasive matter. When used, air filters should be placed in a location convenient for servicing and should be cleaned at the interval and by the method recommended by the filter manufacturer. It is also possible to obtain combination intake-filters and silencers, in a single unit, to both filter the intake-air and accomplish air-intake muffling. For crew and passenger comfort, and to insure the hearing of signals and orders, it may be advisable to install air-intake silencers, particularly if the intake is near the bridge. The degree of disturbing pulsation or high frequency sound, and type of service for which the vessel is intended, should govern each owner's decision on this point. Where superchargers are used they are frequently fitted with an acoustic silencer and screen, or filter, by the maker. One method of drawing air from the outside is to use the funnel, although this practice introduces the possibility of intake-air dilution by exhaust gases during strong down-drafts of wind. Frequently the precaution is taken of drawing the air through louvred openings on the forward side of the funnel. Intake lines should not closely parallel exhaust piping without suitable insulation to avoid excessive preheating of intake air. Flat ducts should be avoided to minimize vibration and rupture from air pulsations and to eliminate unnecessary air resistance caused by pipe friction.—*Motorship (New York), Vol. 34, July 1949, pp. 30-33.*

Current Conducting Glass

A transparent film of stannic oxide 20-millionths of an inch thick applied to glass makes it possible to carry electric current in window installations. The new glass has been named Electrapane by Libbey-Owens-Ford Glass Co. During the war many thousand lights of this glass were manufactured and employed in war equipment. Little publicity was given the Electrapane, however, as orders were issued by the U.S. Army in 1943 that strict secrecy be maintained on this development. Work has been concentrated recently on the development of Electrapene for de-icing and de-fogging purposes. The oxide film for all practical purposes is as durable as the glass surface itself. Weathering tests, abrasion tests, exposure tests, chemical solvent tests, life tests, etc., have proved this. Electrical resistance properties of the glass are fairly constant up to approximately 450 deg. F., above which temperature the resistivity gradually increases. Electrapane operates equally well on a.c. or d.c. voltage. Electricity is fed into the glass by thin metal electrodes concealed along parallel edges of the glass.—*Motorship (New York), Vol. 34, July 1949, p. 44.*

Waste Heat Boilers and Electrical Auxiliaries for Tankers

It is now normal practice to install exhaust-gas boilers in motor tankers, but the arrangements for the utilization of the energy from the waste heat thus attained vary to a considerable extent. A paper dealing with this problem was recently read before the Association Technique Maritime et Aéronautique in Paris by M. Jean Perrachon, joint managing director of the Cie. Auxiliare de Navigation, owners of a number of Diesel-engined tank ships which have been in operation for some years. The author outlined the various methods employed in tankers of producing the necessary auxiliary power, namely, to install (1) Diesel-engined generators; (2) waste-heat boilers producing as much power as available, this being supplemented by Diesel-engined generators; (3) steam-driven auxiliaries receiving steam from the exhaust gas boilers, and also, as necessary, from oil-fired boilers; and (4) auxiliaries driven directly from the main engine, apart from those which can be operated by steam engines receiving steam from the exhaust gas boilers. In two single-screw two-stroke Diesel-engined tankers now under construction the exhaust gas will not allow the production of more than 78-80 kW., although the requirements amount to more than 200 kW. It is not possible to drive a dynamo from the engine, since there are already two blowers, chain-driven from the crankshaft. The problem has been solved in the following manner. Two 250 kW. dynamos are chain-driven at 1,500 r.p.m. from the propeller shaft (running at 118 r.p.m.) through a Vulcan hydraulic coupling and speed-increasing gear. Each of these dynamos is also coupled to a steam turbine and can be declutched from the main shaft. At sea, only one of the dynamos is in operation, the other being spare. The turbine takes all the available steam, regulation being by hand. The supplementary demand for power is transmitted by the chain drive and is thus taken by the propeller shaft. If the main engine stops, the Vulcan coupling is automatically emptied and the steam turbine takes over the whole load. The switchboard is arranged for the two dynamos to run in parallel. With such a system no auxiliary Diesel engine is installed, so that when the main engines operate on boiler oil, as they will in this case, it is unnecessary to carry Diesel oil for the auxiliaries.—*The Motor Ship, Vol. 30, August 1949, p. 183.*

Tug with Machinery of 3,200 b.h.p.

The tug *Sohio Cleveland,* recently delivered by the St. Louis Shipbuilding and Steel Co. to the Standard Oil Co. of Ohio, is one of the highest powered yet built. She is 150-feet long with a beam of 35 feet, and is equipped with two 16-cylinder General Motors Diesel engines each delivering 1,600 b.h.p. at 750 r.p.m. The drive is taken through Falk 3·46 reverse reduction gears and Airflex couplings, the propeller shaft speed being 215 r.p.m. The engines are controlled alternatively from the deck-house or the engine-room.—*The Motor Ship, Vol. 30, August 1949, p. 179.*

New Economizer Installation

The modernization of the propulsion plant of the French passenger liner *Ile-de-France* included the fitting of economizers to 26 of the 32 Prudhon et Capus boilers of the vessel. These economizers are of a patented design developed by the Cie. des Echangeurs de Chaleur. Each unit comprises inlet and outlet header, 150 mm. square, to which are connected eleven economizer elements composed of fin tubes with forged CS return bends. At a rate of flow of 12 metric tons of water per hour, the water temperature is raised from 130 deg. C. to 180 deg. C., resulting in a drop in flue gas temperature from 280 deg. C. at the air heater outlet to 190 deg. C. at the economizer outlet. It is estimated that the installation of the economizers decreases the fuel oil consumption by 5 per cent.—*M. Fauconnier and M. Givet, Journal de la Marine Marchande, Vol. 31, 4th August 1949, pp. 1619-1621.*

Heat and Corrosion-resistant Coating.

A ferrous alloy part, e.g., a poppet valve, is coated first with a non-ferrous alloy having a melting point 1,100 deg. C. and then with a heat-resistant, high-melting-point and corrosion-resistant alloy having a melting point above 1,200 deg. C., applied as a second coating, by fusion. The same alloy may be employed for both first and second coatings. The first coating is machined, to reduce its thickness to the minimum required to insulate the second coating from diffusion of iron or other undesirable constituents from the ferrous base into the second coating. The first coating may be an 80/20 nickel-chromium-base alloy, and the second a highly complex nickel-chromium-base alloy containing a substantial percentage of aluminium.—*W. T. Davies, H. E. Gresham, and M. A. Wheeler, Brit. Pat. No. 618,607, The Nickel Bulletin, Vol. 22, July 1949, p. 124.*

French Motorship *La Marseillaise*

The new French motor passenger liner *La Marseillaise* attained on recent official trials a maximum speed of 24 knots. The main particulars of the vessel are:—

Gross register	15,900 tons.
Length overall	593·7 feet
Length on waterline ...	565·7 feet
Length b.p.	545·5 feet
Beam	75·4 feet
Depth	26·9 feet
Displacement	18,900 tons
Cargo	3,500 tons or 8,700 cu. m.
Machinery (24 hrs. rating)	30,000 b.h.p.
Service speed	21 knots

There are two machinery compartments, that for the propelling plant being amidships and aft of the auxiliary machinery space. The Sulzer main engines were built in 1942 and were constructed by the Cie. de Construction Mecanique Procedes Sulzer at St. Denis, near Paris. Each engine has 11 cylinders, with a diameter of 720 mm. and a piston stroke of 1,250 mm. The continuous output at 131 r.p.m. is 8,330 b.h.p. with a maximum rating for 24 hours of 10,330 b.h.p. at 141 r.p.m. During the trials in the builders' shops in Paris this maximum output was maintained with an m.e.p. of 5·88 kg. per sq. cm. (86lb. per sq. in.). Between half load and full load the fuel consumption varied only from 161 to 164 gr. per b.h.p.-hr. respectively, or about 0·354 to 0·361lb. per b.h.p.-hr. In the engine-room is a periscope device which allows the engineer to observe the colour of the exhaust. Fresh water cooling is employed for the pistons and cylinders. Extensive use is made of the exhaust gases for raising steam. At sea three steam generators, operating on the La Mont Sulzer system, provide all the steam required, whilst in port an auxiliary Nelvin boiler is utilized. The waste-heat boilers operate at 6 kg. per sq. cm. and have a heating surface of 190 sq. m. The normal hourly evaporation is 7 tons, with a maximum of 12½ tons. Steam produced by the boilers is delivered to an independent drum with a volume of 4·4 cu. m. The circulation of the water in the boiler is effected by an electrically driven pump with an hourly capacity of 66·5 cu. m. and the water level is controlled automatically. The auxiliary boiler used in port has an hourly output of 800 kg. of steam with a maximum of 1,000 kg. This vessel is the first French passenger ship and one of the first passenger vessels yet built in which alternating current is used exclusively for auxiliary purposes throughout the ship. There are four generating units in the auxiliary engine-room, each of which comprises a six-cylinder 1,050 h.p. Sulzer two-stroke Diesel engine running at 250 r.p.m., and driving a three-phase 750 kW. 50-cycle 220-volt alternator, a 12 kW. 40-volt exciter and a 3·7 h.p. fan for cooling the alternator. The engine has cylinders 360 mm. in diameter with a piston stroke of 600 mm. Asynchronous squirrel cage motors have been adopted for driving all the machinery except that necessitating special characteristics. The motors driving the cranes, capstans and windlass are designed for two speeds.—*The Motor Ship, Vol. 30, August 1949, pp. 170-173.*

Corrosion Research in the U.S. Navy

The Office of Naval Research, established by an Act of United States Congress in August 1946, is charged with the overall responsibility for the United States Navy's scientific research programme, and for the past three years has been sponsoring a broad, long-range programme in fundamental research covering practically all branches of the physical, biological and naval sciences. This programme is executed largely by means of research contracts with academic, industrial, private and government institutions. Equally important functions are the co-ordination of the scientific research effort throughout the Navy and the dissemination of research information resulting from such endeavours. Referring to the corrosion and oxidation of metals and alloys at elevated temperatures, the authors point out that these phenomena are rapidly becoming problems of major importance to the Navy. At the Ohio State University "Fundamental Studies of Corrosion" are being carried out as part of the Office of Naval Research programme. The major objective of these studies is the investigation of the formation, breakdown, and nature of surface films formed during the corrosion of metals at normal and elevated temperatures. The composition and structure of these films are being investigated by chemical and metallographic examination and by electron-diffraction studies. The mechanism and rate of formation, limiting temperatures and other pertinent factors are being investigated. Such information is useful for prediction of the service life of alloys operating at high temperatures and is valuable for the scientific development of improved alloys. One interesting observation of some preliminary studies of 18-8S at 1,800 deg. F. was that oxide films formed in low-oxygen atmosphere are more protective to further oxidation than scales formed in higher-oxygen atmospheres. This indicates the possibility of developing pre-induced films by pre-treatment for increased oxidation resistance. It is well known that most metals, including the common heat-resisting alloys suffer a progressive deterioration in strength and in ductility when they are stressed at high temperatures for a considerable length of time. Whether deterioration is due solely to the effects of time, temperature and stress or whether atmosphere reactions are an important cause of deterioration has not been investigated thoroughly in the past. There is some evidence in the literature that atmosphere reactions have an important effect on high temperature deterioration of metals. For instance, it has been shown that, during stress-rupture tests of steels in oxidizing atmospheres, the slope of the rupture-time curve (which is a straight line on a log-log plot) changes abruptly after a finite test time. The change of slope occurs at the same time as inter-granular oxidation occurs, and generally the fracture changes from a ductile transcrystalline failure to a brittle intergranular type. The same metal tested in an oxygen-free atmosphere does not exhibit these characteristics. The effect of atmosphere reactions on heat-resisting alloys, a potentially important problem in high temperature power plants, has been investigated only to a limited extent and the results are not conclusive. In order to investigate these effects, Prof. O. C. Shepard at Stanford University is studying the "Effects of Atmosphere Reaction on the Deterioration of Metals at Elevated Temperatures". This programme first will determine whether atmosphere reactions have an important effect on the stress-rupture properties of high-temperature alloys and then by the use of simple, pure metals determine the mechanism and nature of these effects.—*J. J. Harwood and F. Schulman, Corrosion, Vol. 5, July 1949, pp. 203-217.*

Barges for Transportation of Acids

For the river transportation of hydrochloric acid The Dow Chemical Co. have recently placed in service five new barges specifically designed for this purpose. Each of the new vessels, which are 195 feet long, 35 feet wide and 11 feet deep, has four rubber lined tanks with a total capacity of 1,000 tons of hydrochloric acid. The tanks are positioned in the hold so that the four domes are located in the centre of the barge. A steel platform is built around the domes for a working area used during loading and unloading. The platform slopes outboard on either side of the centreline, so any spillage will drain overboard. A coaming around the platform floor prevents acid from draining into the hold. There is a railing on the platform and the stairs to the deck for the safety of workmen. Tar and sand have been applied to the barge deck plating below the platform to prevent slipping. The barges are designed for easy towing, having a 30-feet bow rake and a deep transom stern. They are of welded steel construction throughout and specially strengthened to withstand "rough" operations in the Intracoastal Waterways where sharp bends and narrow channels cause vessels to sideswipe the canal banks. Eight steel-plate rubbing plates are welded to the sides of the barges at points where contact with other barges of lock walls is most frequently made. The tanks, 12 feet in diameter and 73-feet long, are strapped in steel saddles anchored to the floor of the hold. Seven saddles are provided for each tank.—*Marine Engineering and Shipping Review, Vol. 54, August 1949, pp. 56-57.*

High Temperature Corrosion of Metals

Metals can react with gases in a variety of forms. First, the products of interaction can be either volatile or not. Volatile products obviously cause a detrimental attack and rapid destruction of the metal phase. Examples are tungsten at tempertures over 800 deg. C. in an oxygen-containing atmosphere, or iron in chlorine at 300 deg. C. or higher. However, non-volatility of reaction products alone does not guarantee sufficient resistance of the metal to its environment. Non-volatile products form a scale on the surface of the metal, and the behaviour of this scale substance may determine the further course of the reaction. Where, at constant temperature and reasonably slow reaction rates, the scale acts as a barrier hindering mutual access of metal and gas, two general causes may be distinguished: the specific volume of the scale formed is smaller than that of metal phase consumed, or the reverse. Is the first case, generally the scale cannot cover the metal surface efficiently and the reaction is hindered only partially. The amount of attack is directly proportional to the time elapsed and therefore this form of metal-gas reaction is said to follow a linear or rectilinear time law. However, if the specific volume of scale formed is larger than that of metal phase consumed, the scale forms an effective barrier between the metal and gas. Reactants have to get into the scale and diffuse through the scale. Consequently, the processes at both scale-gas and scale-metal interfaces, and the process of diffusion through the scale, become rate-determining. The case is of great practical importance as the scale becomes protective under these conditions. Temperature generally increases the rate of scaling reactions. The increase is roughly 1·2 to 2·0 times per 10 deg. C. (18 deg. F.) temperature increase if the temperature differences are not too large and the scaling is of practical importance, i.e., not extremely slow. Thus, the same thickness of scale on a certain steel in air has formed in ten minutes at 1,000 deg. C. as in 120 minutes at 800 deg. C. This does not apply to temperatures where a new oxide phase may appear. For instance, the appearance of an FeO phase in the complex oxide scale on iron, which occurs at about 550 deg. C. causes appreciable acceleration of scalin~ because of the high permeability of the FeO lattice to iron ions. At low temperatures the adsorbed oxygen layer on the surface of the metal does not form an oxide phase and the scaling does not start at all. At very high temperatures the reaction can sometimes pass into combustion with melting of the metal or scale. The rate of scaling usually does not change with the rate of flow of gas if the gas is pure oxygen. If a gas mixture or gas producing oxygen by dissociation (steam or carbon dioxide) is employed, the flow rate becomes important. Oxygen from the mixture reacts with metal and the non-reacting constituent accumulates in the neighbourhood of the scale, blocking the access of fresh oxygen. Flow removes the stagnant layer and greatly increases the rate of scaling. Undoubtedly, various vapours and gases influence the rates of scaling if present in the gas phase. Thus, small contamination of sulphur in combustion are ruinous and cause a pitting form of attack. The scaling in steam, carbon dioxide, nitrogen dioxide, etc., may be considered as scaling in the oxygen formed by the thermal dissociation of the corresponding gases. The presence of water vapour does not influence the scaling in air at high temperatures appreciably, although minor yet unexplained effects have been reported. Changes in temperature during scaling can cause cracking of the scale and acceleration of oxidation. Cracking depends to a considerable extent on the shape of the specimens, e.g., the scale on metal strips cracks much easier than on round cylinders. However, in some cases it has been found that the change in temperature does not introduce any complications. The experimental programme on this problem of reactions of gases with metals at high temperatures is being supported by the U.S. Office of Naval Research.—*A. Dravnieks and H. J. McDonald, Corrosion, Vol. 5, July 1949, pp. 227-233.*

Tolerance to Heat

Experiments in man's ability to withstand extreme heat indicating that approximately 23 minutes may be the average limit of human tolerance at a temperature of 240 deg. F., were reported at the semi-annual meeting of the American Society of Heating and Ventilating Engineers, on 22nd June, at Minneapolis. During the tests, it was noted that the mucous membranes in the respiratory passages cooled the hot inhaled air by as much as 100 deg. F. in a few inches of travel. Heart rate as high as 160 beats per minute were reached but electro-cardiograms taken during and after heat exposure revealed "no distinct indications of heart damage". The maximum mean skin temperature observed was 107 deg. F., reached in an exposure at 240 deg. F. During four tests, the authors of the report found that their subjects were able to tolerate temperatures ranginng from 237 to 242 deg. F. from 20 to 25 minutes, for an average tolerance limit of 23·5 minutes. Six exposures to temperatures of 218 to 224 deg. yielded tolerance times from 25 to 30 minutes in duration, for an average tolerance limit of 28 minutes. At 199 to 203 deg., the limit of tolerance ranged from 31 to 35 minutes in four exposures, with an average of 33 minutes. The average tolerance limit of four tests at temperature range 179 to 181 deg. was 48·5 minutes. Two tests at 140 to 142 deg. were terminated at 63 and 64 minutes each before the limit of human tolerance was reached. The authors emphasized that the tolerances applied strictly only to the conditions of the experiments.—*Journal of the Institution of Heating and Ventilating Engineers, Vol. 17, July 1949, pp. 233-234.*

Friction at High Speeds

Recent work of the National Advisory Committee for Aeronautics in the United States has revealed that piston friction in an engine decreases with increasing jacket temperatures up to 220 deg. F. This throws some light upoi the viscosity effect, for one might have expected that friction would have increased above 150 deg. F., due to the thinning out of the oil and its failure to sustain the load beween piston rings and cylinder walls. Unless the load between two rubbing faces is abnormal, one can usually lubricate better under high speeds than under low speeds. To form and maintain a fluid film of oil between the faces a minimum rubbing speed is required. Unless such hydrodynamic conditions are permitted the mere weight of the faces will suffice to squeeze out the film and allow high friction. As the speed is increased there operates a wedging action which draws an oil film in between the rubbing members, to produce what is customarily called "fluid" conditions of lubrication. It is this wedging action which provides the better lubrication at moderate and high speeds, compared with very low rubbing velocities, and makes possible the lubrication of such as high-speed spindles, reduction gears and engines. While friction may be comparatively low where fluid film conditions are possible, it will build up with increased rubbing speeds. This is due to the higher shearing velocities in the oil film, being essentially a viscosity effect. Under such circumstances one might say that lubrication is no longer a problem, provided one has selected the right viscosity lubricant for the work. It is under boundary conditions that one encounters the most interesting developments, and some of these have been explored by the National Advisory Committee for Aeronautics where the problem has been taken into the range of very high speeds. Up to 10,000ft. per min. sliding velocity have been used, and a detailed analysis made of the kind of friction encountered. Estimated loads of from about 100,000lb. per sq. in. to 250,000lb. per sq. in. were employed in the test apparatus, with different metals, lubricants and chemical conditions of the rubbing surfaces. The following are some of the conclusions reached: (1) Friction decreases for increasing rubbing speeds for dry and boundary lubricated surfaces. (2) The formation of iron oxide on the metal surfaces may bring about a reduction in friction. (3) The law that friction is proportional to load for high rubbing speed. (4) To obtain comparable results in friction measurements it is essential to ensure a standard finish of the surfaces.—*Practical Engineering, Vol. 20, 19th August 1949, p. 153.*