TECHNICAL ABSTRACTS

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SHIPYARDS AND DOCKS

Strength and Stability of Dock Blocks. Part 2—Stress Measurements During Tests of a 2/3rds Scale Model of a Composite Block for No. 6 Dock at Chatham. WINDER, R. H. B., and VAUGHAN, H. G. *Naval Construction Research Establishment, Rosyth. Report No. N.C.R.E./R85(B)*, July, 1949.

An account is given of stress measurements and of a study of the incidence and distribution of yield in the steel base of a 2/3 scale model of a composite steel and timber dock block. The model was made from mild-steel plate with a lower yield stress of 19.0 tons/sq. in. equivalent to 9.5 tons/sq. in. shear; and the results showed that the structure was strong enough for practical use.

The steel base withstood a load sufficient to destroy the timber capping, with very little deformation itself. This load was 267,500 lb (118 tons), equivalent to 256 tons full scale. With the timber capping replaced by a steel girder, the state of the model under the highest load applied, i.e., 395,000 lb (176 tons), equivalent to 396 tons full scale, seemed far removed from complete collapse.

The manner in which the panels started to buckle depended on their initial configuration after welding, and their subsequent behaviour depended upon the nature of the applied load.

The results have been used to estimate the residual welding stresses in the panels.

A number of photographs are included.

LAUNCHING

Launching Lubricants. *Scientific Lubrication*, **1** (1949), p. 17 (Sept.).

Two lubricants known as "Basekote" and "Slidekote" are claimed to be an improvement upon the white tallow and other preparations previously used on the slipways, and yet to cost considerably less. They are readily applied and give excellent adherence to the slipways, possess high load-carrying properties, are unaffected by extremes of temperature, and, when properly applied, possess excellent resistance to water. Basekote is applied hot the day before the launching, while Slidekote is applied just prior to launching. Both lubricants have been successfully used for the launching of all types of ships. For the launching of the M.V. *Goldhind* at Faversham Shipyard, the Basekote was applied to the eight slipways two nights before the launching and was subjected to night frost. After launching, the ways were still perfectly covered and there were no signs of dragging away or cracking. The thickness of the coating was almost identical with that of the original layer, and it was scraped off and retained for re-use with very little loss.

STRUCTURAL DESIGN AND ITS APPLICATION

Cargo Ship Design. *Fairplay*, **173** (1949), p. 86 (7 July).

Lines on which moderate-sized cargo ships of 9,000-9,500 tons deadweight may be developed are considered in this article. In general, a ship should be of the largest possible size for the trade in which she has to engage. Particulars are given of representative diesel-engined ships of the class delivered within the last year, and it is pointed out that the most striking differences between them lie in the lightweight. This may be explained in terms of the specification and equipment. The relatively low block coefficients are necessary if a reasonable speed is to be maintained in rough weather, and the margin of power recommended to maintain speed at sea in adverse weather conditions is 30%.

The cruiser stern and raked bow are now universally adopted. Rounding of the stern above the water line is required to minimize pitching, but at and below the water line the rounding should be small. Sections of a moderate V-shaped form in the after body give good propulsive efficiency, and in the fore body reduce the effect of slamming. The centre of buoyancy should be forward of amidships. A large water-ballast capacity should be provided, and it is suggested that deep tanks should be arranged forward and aft of the machinery spaces and the capacity of the double bottom increased.

The bulkheads are usually carried up to the shelter deck. Attention should be paid to cargo-working arrangements in the design. Welding is recommended for the main hull structure as far as possible, as the weight of the ship is decreased and freedom from minor leakages is assured. Also the block coefficient can be reduced.

In conclusion, it is suggested that the design of ships is still being stultified by the obsolete tonnage regulations, and that welding cannot be used with the maximum efficiency until suitable rolled sections are available. The design of the hull must depend to a great extent on the type of machinery adopted.

A New Stern for Easy Steering. *Shipbuilding and Shipping Record*, **74** (1949), p. 45 (14 July).

A profile and deck plan are given of one of a number of motor-driven river tankers building at the yard of De Haan and Oerlemans, Heusden, Holland, to the firm's patents. The principal feature of these craft is the arrangement of the stern which enables them to be turned in their own length without the help of tugs and against currents. The invention, which is shown in a diagrammatic sketch, consists basically of the adoption of balanced rudders and skegs of aerofoil section. The rudders are hand-operated by a simple mechanism of rods and gearing. A tunnel built between the skegs serves the dual purpose of directing water into the propeller and protecting it from damage. The lines of the stern are modified to ensure an easy flow to the propeller, thus improving both propulsive efficiency and manœuvrability. It has been possible to design a fuller stern above the waterline, giving better placing for the windlass and chain lockers.

No alterations, repairs, or adjustments have been necessary even on the earlier experimental ships, the first of which was built in 1938-9.

MARINE POWER INSTALLATIONS (GENERAL)

Merchant Ship Propulsion. BAKER, L. *Engineers' Digest*, **10** (1949), p. 258 (Aug.).

The designer has to consider a number of possibilities when choosing a

type of propulsion from the possible alternatives of Scotch boilers and reciprocating engines, water-tube boilers and reciprocating engines, slow-running marine-type diesel engines, high-speed diesel engines, high-pressure water-tube boilers with steam turbines and double reduction gearing, gas turbines and atomic power. The author discusses the use and application of each.

The broad division at present appears to be that below about 8,000 s.h.p. the machinery fitted is of the double-acting, two-cycle type with an all-in fuel rate of about 0.4 lb/b.h.p./hr. on marine diesel fuel and 0.44 on boiler fuel. Above this power and up to 15,000 s.h.p. a single-screw turbine is fitted. This usually operates at about 550 lb/sq. in. and 850°F with an inclusive fuel rate of about 0.58 lb/s.h.p./hr. Above 15,000 h.p. twin-screw or multiple-screw turbine installations with a similar or slightly better fuel rate are general, except where the " hotel " load is excessive.

In the immediate future, one may expect the double-acting diesel to be replaced by the single-acting two-stroke, while the single-screw turbine operating at 600 lb/sq. in. and 950°F is ready to take the place of both single- and double-acting diesel engine for certain trades. In the higher power ranges the general position is likely to alter more slowly. From the long-term point of view, it may be prophesied that the gas turbine and atomic power may come forward as challengers, but it is the author's opinion that, at the present rates of development, it is likely that atomic power will be the more serious challenger of the two and that it is more likely to stay the pace that has been set by the steam turbine.

The author feels that the adoption of complicated binary-cycle installations is unlikely until each of the component machines has been fully developed and tested.

Multi-Engine Cargo Ships. *Shipping World*, **121** (1949), p. 255 (7 Sept.).

By adopting a multi-engine propulsion system, using fast-running diesel engines with transmission through oil-operated reverse reduction gears, a considerable saving in space and weight can be secured at an appreciably reduced cost. A brief description is given of the S.L.M. oil-operated marine transmission, which is suitable for this type of engine drive. These transmissions have been used successfully in motor torpedo boats and the largest type of Admiralty tank landing craft ; designs exist for coupling up four engines through oil-operated gears up to 10,000 b.h.p., and gears are under construction for transmitting 16,000 b.h.p. employing eight engines and twin screws. Gear ratios are made to suit the propeller, the maximum being 6 : 1. Long astern running on full load is possible without overheating, and after years of service the gears show little sign of wear. The oil tanker *Juanita Beazley* is an example of a ship operating with two sets of diesel engines giving a total of 2,000 b.h.p. and transmitting through oil-operated reverse reduction gearing.

Other advantages of this type of propulsion are that, when the ship is on light or ballast voyages and full power is not required, complete units may be shut off, with considerable economy in fuel, lubricating oil, and wear and tear ; if anything goes wrong with one engine it can be shut off ; spare engines can be carried aboard, facilitating the institution of systematic overhaul by the ship's staff ; mechanical efficiency is high and torsional vibrations are easily dealt with ; the machinery runs smoothly and quietly ; and manœuvring is easy and quick.

Sixteen Shipyards Asked to Bid on Commission's Prototype Cargo Ship. *Marine Engineering Shipping Review*, **54** (1949), p. 43 (July).

Plans were issued by the United States Maritime Commission on 10th May, 1949 to sixteen shipyards, with invitations to bid on a prototype cargo ship to serve as a basic model for large-scale shipbuilding in any future national emergency.

General characteristics are as follows :—

Length o.a.	477.5 ft
Length b.p.	450 ft
Beam, moulded	66 ft
Depth to weather deck	41.5 ft
Draught, design load waterline	28.5 ft
Draught, scantling	31.25 ft
Gross tonnage (approx.)	8,800
Net tonnage (approx.)	5,300
Normal power	12,500 s.h.p.
Speed	18.5 knots

The ship, which will have a curved raked stem and cruiser stern, with two complete decks, will be built as a full-scantling type with minimum freeboard to the main deck. The necessary structure for later installation of tonnage hatch and well and tonnage openings will be incorporated for ease of conversion to shelterdeck type. The vessel will be constructed of steel on a transverse system of framing. Shell butts and seams will be welded, the connection of shear strake to main-deck stringer will be riveted gunwale angle, and the main deck will have a riveted seam strap outboard of the hatch sides. In general, all other connections will be welded. Decks in the superstructure generally will be supported by a system of pillars and girders.

Five cargo holds are to be provided, three forward of the machinery spaces and two aft. Deep tanks for clean salt-water ballast or dry cargo will be fitted over the entire length and breadth of No. 3 hold.

The main propelling machinery will consist of a cross-compound double-reduction geared turbine of the latest marine design, driving a single propeller at about 90 r.p.m. Steam will be generated by two water-tube boilers, fitted for burning fuel oil under forced draught. In general, the auxiliaries are motor driven, deriving their power from a turbine generating plant consisting of three 300-kW sets. Accommodation will be provided for 12 passengers and 52 crew.

Inboard profile and arrangement plans are given.

The French Motor Passenger Liner "La Marseillaise". *Motor Ship*, **30** (1949), p. 170 (Aug.).

The keel of this French passenger liner was originally laid in 1939, but it had to be relaid after the Armistice in 1946, and the ship was not finally completed until 1949. She belongs to the Messageries Maritimes and has an overall length of 593.7 ft, and a displacement of 18,900 tons. She carries 3,500 tons of cargo, and up to 416 passengers. She has triple-screw diesel machinery of 30,000 b.h.p. The Sulzer main engines each have 11 cylinders, the continuous output at 131 r.p.m. being 8,330 b.h.p. with a maximum rating for 24 hours of 10,330 b.h.p. at 141 r.p.m. On official trial, a maximum speed of 24 knots was attained. Extensive use is made of the exhaust gases for raising steam. The auxiliaries, including fresh-water, sea-water, and lubricating pumps, are nearly all electrically driven. There are four generating units in the auxiliary engine room, and also an emergency generating set.

La Marseillaise is the first French passenger liner in which alternating current is employed for the operation of the auxiliaries.

Reheater-Engined Booth Liner " Denis ". *Marine Engineer*, **72** (1949), p. 269 (*Annual Steam Number*).

The principal particulars of the single-screw steamship *Denis* and her sister ship *Dunstan*, are as follows :—

Length o.a.	357.75 ft
Length b.p.	335 ft
Breadth, moulded	50.5 ft
Depth moulded to upper deck	22 ft
Draught on summer loadline	20.9 ft
Corresponding deadweight capacity	4,915 tons
Gross tonnage	2,990 tons
Total bale capacity	317,800 cu. ft
Service speed	11.5 knots

These cargo ships were built by William Pickersgill and Sons, Ltd., Sunderland, and engined by George Clark (1938), Ltd. The *Denis* has four holds, and extra cargo space is provided in the raised forecastle and poop. Two deep tanks of 600 tons capacity for liquid cargo are provided at the forward end of No. 3 hold ; they are fitted with large oil-tight hatches. Dry general cargo or water ballast can be carried in them if required. The accommodation is arranged amidships on the new popular single-structure system. A description is given of the equipment installed for handling the cargo and lifeboat landing equipment. Protection for the helmsman from glare during operation in the tropics is provided by fitting the centre panel of the wheelhouse window with darkened glass.

Descriptions are given of the steering gear and of the accommodation provided for both passengers and crew. The propelling machinery includes a superheated triple-expansion engine incorporating the North Eastern Marine Engineering Co's. reheat system. The engine is one of the standard range of North Eastern reheater engines. The reheater system ensures the use of dry steam throughout the engine, and a brief account is given of its operation. Particulars are given of the boilers and of the oil separator.

Throughout the trials the machinery operated smoothly, and the vessel has now completed several voyages without incident. Trial figures are given.

Engine Bearing Failures. STOKELY, J. M. *Scientific Lubrication*, **1** (1949), p. 12 (July).

The frequent use of copper-lead and cadmium-alloy bearings for heavy-duty diesel engines has brought about a number of problems ; and the lubricating oil is frequently blamed for troubles that occur in such bearings. The difficulty of differentiating between failures caused by fatigue and corrosion is a real one, and quite apart from these two causes there may be many contributory factors. This condensation of Mr. Stokely's original paper (which was presented to the Society of Automotive Engineers in California) describes the types of failure which occur, and summarises the factors contributing to failure. It also deals with corrosion resistance and the conditions causing corrosion, and describes the procedure for field and laboratory examination of bearing failures.

Split Roller Bearings. *Shipping World*, **121** (1949), p. 163 (10th Aug.).

One of the most interesting features in new ships entering service is the extent to which the use of split-roller bearings is being adopted for the inter-

mediate shafts. During and since the war, a number of vessels of various types have been fitted with such bearings. The main advantages of the roller bearings are : less frictional loss, self-alignment, and less maintenance required, while the need for tunnel water service is obviated.

Results of Research on Atomic Ship Propulsion Encouraging. *Marine Engineering Shipping Review*, **54** (1949), p. 58 (July).

The results of the investigation of the problems connected with the propulsion of U.S. Navy ships by atomic power are encouraging, but it is emphasized that the application of atomic energy to ship propulsion will not be possible for a number of years. Problems studied include heat transfer, that is, getting the heat generated from an atomic-energy source to the place where it is to be used ; the most suitable type of atomic reactor for this service ; and the question of control.

FUELS AND COMBUSTION TECHNOLOGY

Catalytic Combustion of Fuel Oils in Marine Service. *Marine News*, **36** (1949), p. 28 (July).

It has been shown by experiment that the addition of certain catalysts to fuel oil results in substantial economy and an increase in cleanliness. The principle involved is the complete combustion of the fuel which enters the combustion chambers, preventing harmful deposits on the walls. A number of practical instances of the advantages of catalytic combustion are mentioned. The effect on a number of ships using a catalyst in the fuel oil include :—

1. Better efficiency. Over long periods the fuel saving has range from 6 to 12% in marine boilers.

2. Unburned fuel is not carried into the boiler and superheater tube banks to form slag.

3. Unburned fuel is not carried into the air heater and economizer heating surfaces to cause a fire hazard.

4. More uniform heat transfer.

DIESEL AND OTHER I.C. ENGINES

Three Years' Service on Heavy Fuels. *Shipbuilding and Shipping Record*, **74** (1949), p. 287 (8 Sept.).

The Anglo-Saxon tanker *Auricula* has completed three years service during which her 4,000 i.h.p. diesel engines have been run on fuels ranging in viscosity from 1,200 to 1,500 secs. Redwood 1 at 100°F. Details of the experimental work carried out with diesel engines burning this type of fuel, preparatory to their installation in the tanker, and the results of her first twelve months service have been described in a previous paper by Mr. J. Lamb (see Abstract No. 1476, Jan., 1948). Accounts of previous inspections of the *Auricula's* machinery have also been published (see Abstracts No. 1265, Oct., 1947, and 2122, Oct., 1948). Photographs of a number of engine components are given in the present paper, which show their satisfactory condition after three years service, during which the ship has covered 217,823 miles between pilot vessels, and has operated for 18,100 hours. The piston rings were found to be in good condition and the liner of No. 2 cylinder, in service for 21,576 hours, showed a maximum wear of 0.067 in (1.71 mm), and a minimum of 0.03 in (0.80 mm).

On the basis of the prices ruling at present at Curaçao, and the daily con-

sumption at sea during the past three years, the saving effected in the fuel bill due to operating on high-vicosity fuel is £7,734 per annum. The fuel was purified in accordance with the recommendations made in Mr. J. Lamb's paper, and the amount of solid matter extracted per ton of fuel treated varied from 23 lb to 10 oz in the case of the purifier, and 160 oz to 2 oz in the case of the clarifier. Engine-room requirements have not caused any delay in port, and stoppages at sea which can be attributed to the fuel total $6\frac{1}{2}$ hours only.

Although no major difficulties have been encountered, the high sulphur content of the fuels used—$2\frac{1}{2}$% to 3%—has had an adverse effect upon certain parts. The piston cooling-water telescopic-pipe packing is unsuitable for this type of fuel ; and attention had to be paid to the packing of the piston-rod oil scraper situated at the top of the crankcase in order to prevent acid-containing substances from entering the crankcase and contaminating the lubricating oil. Good progress has been made towards the elimination of these troubles.

During the past twelve months, experiments have been carried out in the burning of fuels having a limiting viscosity of 3,500 secs. Red. 1 in the test engine at Hawthorn Leslie's, St. Peter's Works, and it has been decided to operate the main engines of the *Auricula* on this grade of fuel when she puts to sea. This will necessitate fitting a different type of fuel injection-valve nozzle.

Mr. J. Lamb pointed out that the real purpose of the experiments was to increase the fuel flexibility of diesel engines generally. By the end of the year there will be 16 Shell Group ships operating on high-viscosity fuels.

A New 4,500 B.H.P. Engine. *Motor Ship*, **30** (1949), p. 126 (July).

Successful tests have been carried out by Messrs. John G. Kincaid of the first two-stroke, single-acting, crosshead design of the eccentric-type, opposed-piston, propelling engine which is being installed in the motor vessel *Braeside*.

An illustrated description is given of the engine which has six cylinders 24.4 in. in diameter, the main piston stroke being 55.1 in and that of the exhaust pistons 18.5 in. Maximum continuous rating is 4,500 b.h.p. at 115 r.p.m., the mean indicated pressure being 92.4 lb/sq. in. The engine has ample width of bedplate when compared with the overall height. On account of the head-room available, the pistons and rods can be completely withdrawn vertically.

The crankshaft is of the fully-built type, the webs being of cast steel. Integrally cast with each crankweb is an eccentric for operating the exhaust-piston gear. Each pair of eccentrics is coupled by eccentric straps and rods and four steel side rods to the cast-steel yoke of the exhaust piston. The exhaust pistons are therefore driven by, and, in turn, transmit power through the eccentrics on the crankshaft.

The cylinders are of vanadium cast iron, cast in one piece, and are water-jacketed above the flanges by which they are bolted to the scavenge belt. The scavenge air has a clear blow-through, ensuring a fresh charge of air for each compression stroke. The scavenge air is supplied by two positive rotary blowers each driven by Renold triplex chains from the crankshaft. The fuel pumps are independent units operated by a camshaft driven by chain from the crankshaft. The main and exhaust pistons are oil-cooled and the engine is force-lubricated throughout.

The overhauling arrangements are very complete, and the gear supplied enables maintenance work in port to be cut down to a minimum. The engine runs smoothly and quietly.

PROPELLERS AND PROPULSION

Nozzles Outside and Inside Propellers (German). WENDEL, K. *Hansa*, **86** (1949), p. 713 (23 July).

The author considers two types of nozzle operating in conjunction with ship propellers : the Kort nozzle and the Schnitger nozzle. The former is stationary and surrounds the screw ; the latter is built into the propeller and rotates with it. A number of earlier publications on screw nozzles are used and summarized in a bibliography (see Abstract No. 2624, May, 1949).

Both types entail only a slight increase in the production costs of a vessel, so that in the author's opinion it is always advisable to employ a nozzle if an improvement in efficiency can be expected with confidence. A nozzle has three beneficial effects :—

(1) A larger quantity of water is enclosed in the nozzle and conducted into the screw race, the propeller efficiency increasing with the amount of water passing through the race.

(2) The jet leaves the propeller practically without contraction, so that the outlet losses are reduced.

(3) The propeller thrust is augmented by a nozzle thrust resulting from the distribution of pressure on the nozzle walls.

The second of these effects makes the largest contribution to the improvement of the screw efficiency. On the other hand, the author admits that a nozzle always increases the resistance of the ship, but states that, if there is no significant additional wavemaking, this added resistance should not outweigh the improvement produced by the nozzle.

Using some published results of tests on fixed nozzles, the author develops a theory which he applies to calculate the characteristics of Kort and Schnitger nozzles for a passenger ship and a trawler. Equations are also derived for the determination of the optimum radius of the rotating nozzle ; for the particular case of the passenger ship, this is found to be 0.32 R, R being the tip radius. Some secondary effects of the Schnitger propeller are also discussed.

Flexible Couplings for Main Propulsion Engine Drives. MACLENNAN, G. G. *Torque*, **1** (1949), p. 7 (Sept.).

The first important practical consideration in the question of shafting is alignment. In small vessels the hull is prone to work appreciably in a seaway, and consequently flexible couplings are a necessity. Experimental work is being carried out in one of H.M. destroyers which is propelled by single-reduction geared turbines providing 20,000 s.h.p. on each of the two propellers. Flexible couplings have recently been fitted between the main engines and propeller shafts, and tests are in progress to see how this equipment behaves under the extreme conditions of heavy underwater explosions such as those caused by depth charges close alongside. Similar strains are set up when ships run aground, which is an argument for the fitting of such couplings (if successful) in all ships, and not just war vessels.

The second consideration is one of torsional vibration in the shafting system, and here the interposition of a well-designed elastic or damping element can be of great assistance.

Another application is that of the ship powered by geared diesel engines, where some form of elastic coupling is needed to damp the shock loading on the gear teeth.

A thoroughly satisfactory flexible coupling can be designed and made up of

Silentbloc bearing units, which will accommodate all reasonable malalignment and will damp torsional vibrations to an acceptable degree.

Tooth Shaving Spur and Helical Gears. *Times Review of Industry*, 3 (1949) p. 58 (Sept.).

A new method of gear shaving, known as the Finroc process, has been developed for finishing the teeth of straight spur gears and single and double helical gears. It is claimed that this process, in addition to removing completely the undulations formed in helical gears, cut by hobbing, also gives better results in correction for errors of profile, pitch, helix angle, and surface finish. A range of seven machines is being made. The cutter and the gear are mounted on parallel axes, the gear driving the cutter, which in addition is arranged to reciprocate in the axial direction.

POWER TRANSMISSION

Some Interesting Examples of Geared Diesel Drives. WEYMOUTH, H. P. *Transactions Institute of Marine Engineers*, **61** (1949), p. 163 (Sept.).

The Author reviews the numbers and types of vessels fitted with geared diesel engines, most of which are in the speed range 300-400 r.p.m. and drive through flexible couplings to gearing with the ratio of reduction arranged to give low propeller speeds and high propulsive efficiency. Of the three main types of flexible couplings now in use, mechanical, hydraulic, and magnetic-slip couplings, the last are the most popular. An illustrated description of the construction and operation of each type is given. The advantages claimed for geared-diesel machinery include the ease of production of the smaller engines, reduced machinery weight, and sometimes lower first cost. In passenger vessels the advantages include shorter and lower engine rooms and lower centre of gravity. This class of machinery has been selected for the M.V. *Dongara*, now being constructed at Liverpool. A twin-screw arrangement with three engines coupled to drive on each shaft is described, the third engine in each case being primarily for driving the generators for supplying power for operating the electric winches in port, but arranged to drive through magnetic couplings to the gearing when at sea.

Increase in the Power Transmission Capacity of Gears (German). HIERSIG, H. M. *Stahl u. Eisen*, **69** (1949), p. 695 (29th Sept.).

The paper discusses properties, design, and advantages of spur-gear drives with a correction of both pinion and gear teeth (so-called V-drives). They are particularly useful where high torques have to be transmitted at low or variable speeds and where unexpected, very high peak loads can occur under rough operational conditions. Correction has hitherto mainly been confined to the pinion (V-O drives). The solution described has the additional advantages that, without altering the centre distance, the numbers of teeth of both pinion and gear can be less than those at which a normal design (O-drive) would lead to an undercutting of the teeth.

The form of V-drive numerically investigated has a total number of teeth of gear and pinion which is three less than the minimum number of teeth of a corresponding V-O drive with an equal centre distance. It is called V-3 drive and has been patented by the German firm that developed it. Calculations show that it is superior to older designs on account of its higher power-transmission capacity, higher strength of the teeth, and lower wear of the tooth flanks.

There are a number of references.

STEAM ENGINES AND STEAM TURBINES

Reheating in Steam Turbines. REYNOLDS, R. L. *Transactions American Society of Mechanical Engineers*, **71** (1949), p. 701 (Aug.).

An outline is given of the history of the reheat cycle, in which steam is re-superheated after expanding through the high-pressure section of the turbine, and the improvement in thermal efficiency to be derived from its use under various operating conditions is discussed. Such factors as regenerative feedwater heating, pressure drop through the reheater and its piping, and the temperature to which steam is reheated affect the gain in thermal efficiency obtainable with reheating. Reheating reduces throttle and exhaust-steam flows, exhaust moisture, and heat absorbed by the condenser. The effect of all these factors is illustrated by curves.

WELDING AND OTHER METHODS OF CONSTRUCTION

Weldability of Low-Alloy High-Tensile Steel. LUTHER, G. G., HARTBOWER, C.E., and ROACH, D. B. *Welding J.*, **28** (1949), p. 289-s (July).

It was the purpose of this investigation to determine the mechanical properties and weldability of experimental manganese-titanium and manganese-vanadium high-tensile low-alloy steels. 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 steels. Normalizing produced a marked improvement in the ductility of welded titanium-alloy steels, but there was little improvement in welded vanadium steels. In regard to notch sensitivity as determined by the V-notch Charpy bar, high percentages of titanium and vanadium resulted in high transition temperatures in the as-rolled condition. Normalizing produced a marked improvement in the titanium-alloy steels, but in 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% respectively; and carbon and vanadium 0.15% and 0.10% respectively.

Explanation was sought for the persistent differences in performance, and the results of a study of the microstructure and of chemical analyses are described.

A Summary of the Research Work Conducted under the Direction of the Ship Structure Committee. JONASSEN, F. *Society Naval Architects and Marine Engineers, Chesapeake Section, paper read* 3 Dec., 1948.

A summary of the research carried out during and since the war on the causes of structural failure of welded ships. The work has been done with the approval of the Board to Investigate the Design and Methods of Construction of Welded Steel Merchant Vessels, and is sponsored by the Ship Structure Committee.

The research programme included studies of welding stresses and investigations of ship steel under multiaxial stresses (produced by notches), involving in many cases the testing of full-scale specimens, welded and unwelded. In addition, effects of variation of design of full-scale specimens of typical ship sub-assemblies have been studied.

Full-scale tests have been conducted on a number of different types of ships. These studies have included determination of locked-in stresses, bending tests in still water, and exploration of stress conditions produced by temperature differences.

It is concluded that locked-in stresses are not important factors in welded ship failures and that, even though design improvements are effective in reducing the incidence of ship failures, less notch-sensitive steels should be used.

A number of diagrams and photographs and a bibliography are included.

Welding Development in the Royal Dockyards and Shipyards since 1939. ANSCOMB, R. *Transactions Institute of Welding*, **12** (1949), p. 81 (Aug.).

The Author reviews the growth of ship welding since 1939 and some of the obstacles to further expansion, especially in connection with the training of welding engineers, the limitations of cost, the development of argon-arc welding plant, especially for aluminium alloys, and the use of radiography. A number of examples are given of comparisons of relative costs of welding and riveting and the Author concludes that, with proper design and control of the erection of welded ships, realistic schemes of payment by results, the best use of modern equipment, and the continued use of riveting when it is obviously cheaper, the finished products should be as cheap or even cheaper than their riveted counterparts.

The welding equipment of the Royal Dockyard at Portsmouth is also described, and details are given of some branches of the work undertaken there, including carbon-arc welding of high-tensile brass propellers.

Developments in the Metallurgy and Technique of Welding Aluminium Alloys. HOULDCROFT, P. T. *Metallurgia*, **39** (1949), p. 16 (Feb).

The increased use of aluminium and its alloys in recent years is due in no small measure to the greater use of welding in their fabrication. This is true of practically all the aluminium-consuming industries, but especially of those using sheet and sections. This contribution to progress has resulted from developments in the metallurgy and technique of welding aluminium alloys.

Aluminium itself and many of the medium-strength alloys can be welded readily by several methods. The high-strength materials, including alloys of the duralumin type, present certain difficulties as regards fusion welding, but may be joined satisfactorily by resistance-welding methods. Spot welding of these alloys is now well established, and flash-welding techniques are in an advanced state of development.

Strain-Ageing in Welding Structural Steel. BRUCKNER, W. H., and SANDBERG, S. W. *Welding J.*, **28** (1949), p. 397-s (Sept.).

Tests were made of $\frac{1}{2}$-in thick rolled plates of A.S.T.M. A.70-44 steel of firebox, rimmed-steel grade in which welds were made. Strain-ageing tests were carried out with taper-drawn, work-brittleness bars of plate and weld deposit cold drawn to provide a strain gradient of 0 to 10% reduction of area. Hardness tests were made to follow changes in hardness with time and temperature for definite strain levels. Charpy V-notch impact tests were made over a range of temperature, to determine notch sensitivity and transition

temperatures of base plate and weld deposit in the original condition, strain-aged and in the thermally stress-relieved condition. The weld deposit was laid down in such a manner as to fully recrystallize all previously deposited weld metal. Under the conditions of testing, positive indications of sensitivity to strain-ageing were observed for the base metal for tensile strains as low as 0.5%. For the weld metal, strain-ageing was not indicated for tensile strains of less than 2%. The weld metal appeared to be sensitive to quench-ageing, and both base and weld metals after thermal stress relieving had a higher transition temperature in impact than in the original condition. The latter observation suggested the possibility of temper brittleness resulting from heating the materials to 1,100°F and cooling slowly for stress relief.

Spot Welding Galvanized Steel. BEGEMAN, M. L., HIPPLE, M. L., and CULLUM, L., JR. *Welding J.*, **28** (1949), p. 385-s (Sept.).

A detailed description is given of investigations into problems relating to the selection of the major welding variables, namely, welding current or per cent. heat, the weld period, the tip pressure, and the material being welded, in spot welding of 20- and 22-gauge galvanized steel of various thickness coatings. A number of recommendations are made.

Further work was carried out on the number of successive welds that could be made with one set of electrode tips, before excessive pick-up of zinc changed the weld strength and appearance. Preliminary tests suggested that if the electrode cooling water is replaced by a refrigerated fluid at low temperature the tip life will be increased and less zinc will be picked up by the electrodes. A comparison was therefore made between the physical properties of spot welds at normal and low coolant temperatures to determine whether or not increased tip life could be obtained by refrigeration of the tips, and to observe the effect of the cold tips on surface appearance and weld strength. The Authors conclude that refrigeration is only justified if the tips used are expensive to obtain and recondition and unusually high welding speed is necessary.

A bibliography is given.

On the Theory of Flame Cutting (German). GRASSMANN, P. *Z. Angew. Phys.*, **1** (1949), p. 449 (Aug.).

The Author develops a theory of cutting with the oxy-acetylene torch and, with the help of simplifying assumptions, attempts to construct equations which give the relationship between "cutting-groove lag" and gas pressure and torch feed. "Cutting-groove lag" is the lag of the lower edges of the cutting grooves in relation to the upper edges, and is due to the accumulation of the slag near the lower edges. The equations are found to be qualitatively in satisfactory agreement with the results of cutting experiments which the Author and other research workers have carried out, although there are occasionally considerable quantitative discrepancies. The Author believes, however, that these could be avoided by an improvement of the theory.

For a proper cutting action the following conditions should be complied with :—

(1) The ignition temperature of the metal and the melting point of the slag must be below the melting point of the pure metal.

(2) The impact of the cutting jet must be as great and the viscosity of the slag as small as possible, so that the slag layer does not become too thick and the rate of reaction is accordingly not reduced to less than the feed of the torch.

(3) The ratio of combustion heat to heat conductivity must be so high that the combustion process is capable of maintaining permanently the ignition temperature in the cutting groove.

There are a number of references.

Welding Dissimiliar Metals. *Steel*, **125** (1949), p. 72 (26 Sept.).

If similar metals are spot-welded, the highest resistance is between the interfaces of the two sheets, but in the case of dissimilar metals the highest resistance may be located in one of the metals. The problems encountered in resistance welding of dissimilar metals are discussed and suggestions made for their solution. The recommended method of obtaining heat balance during the spot welding of combinations which differ widely in heat and electrical conductivity is the use of two dissimilar electrodes. Conventional alternating-current spot welding has been found suitable in many cases for welding the refractory metals. In order to reduce oxidation and decrease electrode deterioration, the refractory metals have been satisfactorily welded under certain liquids such as carbon tetrachloride and water. It has been found desirable in many cases to interpose between the two metals a third metal which alloys readily with both refractory metals to be joined together. It has also been found possible to use straight butt welding for attaching refractory metals to base metals.

CORROSION, FOULING AND PREVENTION

Investigation of Cavitation Corrosion. PETRACCHI, G. *Engineers Digest*, **10** (1949), p. 314 (Sept.).

This article was originally published in *La Metallurgia Italiana*, **41** (1949), p. 1 (Jan.-Feb.).

The Author discusses the various theories of the fundamental causes of cavitation corrosion, and describes corrosion-fatigue tests and cavitation tests carried out on a number of materials. It is concluded that cavitation is not initially destructive because of the mechanical stresses to which it gives rise, but because these stresses are associated with a corrosive action which is primarily of an electrical nature. Tests are now in progress on the protective effect of cathode coupling with much higher current densities, to determine the limiting values for which destruction of the metal occurs as a result of mechanical fatigue ; on the effect of the vacuum pockets which presumably give rise to much higher potentials than the metal surfaces ; and on the variations of current passing through the specimen during each stress reversal.

Report on Marine Growth Investigations carried out during Recent Years. *Admiralty, Department of Research Programmes and Planning, ACSIL Translation No.* 414 (*PG* 41646), *ACSIL/ADM*/49/235.

The first part of the report covers a number of problems in connection with the investigation of marine growth, including the amount of poison liberated from a painted surface by the action of sea water. This is followed by a description of experiments on the solubility of purely toxic components in sea water and of an investigation of the degree of poison concentration on the surface of a painted plate. A further chapter deals with the question of poison storage by marine growth. After a discussion of the chemical and kinetic properties of paint with regard to the behaviour of the anti-fouling poisons, the practical conclusions are given in a short chapter dealing with rapid testing methods and ageing processes. An outline of the synthesis of anti-fouling toxins is given. In addition to the chemico-physical investigations

and the chemical analysis a brief survey of the biological research work is given, in which particular attention is focussed on rapid testing methods.

The second part of the report deals with the influence of metals on marine growth, the prevention of marine growth by the application of galvanic coatings, and the toxic action of organic and inorganic heavy-metal combinations in paints.

Phosphate Processes for Iron and Steel with Special Reference to Rust-Proofing. HALLS, E. E. *Metallurgia*, **40** (1949), p. 159 (July), and p. 193 (Aug.).

Initially developed to protect iron and steel against corrosion, and still principally used for that purpose, the phosphate processes have greatly increased the scope of their usefulness. In recent years, phosphate treatments have been developed for imparting wear resistance in numerous cases in which metal-to-metal contact is involved in the functioning of a mechanism. In some instances sheet or strip is phosphatised to assist drawing operations in pressing and to reduce wear on tools.

In the rust-proofing field, phosphate coatings in themselves are not usually very rust-resistant ; it is a combination of the phosphate coating with an organic finish subsequently applied that fulfils the role of corrosion resistance. Some of the advantages of phosphatising as a preliminary to the application of organic protective coatings for the prevention of corrosion of iron and steel are summarised.

The cleaning processes which are necessary as preparatory treatments for phosphatising are described, and details are given of the phosphatising, rinsing and drying operations.

From a table showing the results of salt-spray tests carried out on a number of samples, some of them phosphatised and others not, it follows that while the number of coats, surfacing, and nature of the primer all influence the durability of the finish, the phosphate treatment makes a valuable and infallible contribution to serviceability. A second table gives the results of experiments with finished assemblies subjected to a salt spray. It is seen here that phosphate treatment ensures adhesion and the retention of adhesion in a degree greatly superior to that given by special primers. It gives a useful life to one-coat finishes, fulfils the role of a rust inhibitive primer, and in conjunction with the latter it augments the rust inhibition.

A further application for phosphate coatings on sheet stock and on components concerns wear resistance. The Author refers in this connection to the work by R. E. Shaw and W. H. Spencer. " Scuffing " is a serious trouble in modern engines which can be largely overcome by iron-manganese phosphate coatings in conjunction with a lubricant. An explanation of this, with illustrations, is given.

Forms of Corrosion in Condenser Tubes. PUMPHREY, W. I. *Air Treatment Engineer*, **12** (1949), p. 251 (Sept.).

An account of the electrolytic theory of corrosion is followed by a discussion of the types of corrosion that occur in condenser tubes constructed of alloys in which copper is the principal alloying element. The principal forms of attack are dezincification, oxide attack, and impingement attack. Of these, the first can be reduced by keeping the tubes at a low temperature and by ensuring that steam inlets are so placed that overheating is avoided. Impingement attack can be reduced by reducing the amount of air in the circulating

water to a minimum and by avoiding churning of the water as much as possible. The formation of vortices should be avoided.

A list is given of alloys that are now being used for the manufacture of condenser tubes because of their resistance to corrosion. Where sea water is used, aluminium-brass condenser tubes are being used to an increasing extent, particularly where turbulent water conditions are present. Cupro-nickel 70/30 shows the best all-round corrosion resistance to salt water, but does not appear to be the most satisfactory alloy for use with tidal water or contaminated harbour water. Admiralty and arsenical copper continue to give good service in condensers using fresh water, although red brass condenser tubes pitted and failed in a short time where brackish water was used.

Possible methods for reducing corrosion in condenser tubes include water treatment and tube treatment. It is recommended that the tubes should be cleaned by rodding or brushing, or by treatment with a dilute solution of hydrochloric acid. Tubes annealed at low temperature in an oxidising atmosphere have a fine crystal structure which is very resistant to corrosion. The inner surface of the tubes can be protected by the pre-formation of scale, by a layer of tin or by oiling. The latter affords good protection for low rates of flow. Failure due to dezincification has been reduced by using bell-mouthed tubes, replaceable ferrules, bushes designed to be easily replaced, which cover the inlet end of the tube for some inches, and brass vanes inserted in the condenser in a suitable position.

A brief note is included on the method devised by Moore and Kleinheksel for testing the efficiency of methods of preventing corrosion.

Eleven references are given.

New Anti-Fouling Method. *Syren and Shipping*, **212** (1949), p. 375 (31st Aug.).

A new anti-fouling composition for ships' bottoms, as well as a special method of application, has been evolved by a Swedish engineer. It is now being tested on the hull of the Swedish Transatlantic Company's motorship *Hjalmaren* on a voyage to tropical waters. The preparation is applied to the hull by means of a pneumatic gun at a temperature of about 212°F and solidifies as it cools.

Interim Report on Exposure Trials of Weatherwork Paints. *Admiralty Chemical Department, Chemical Report No. P*/1/49, *ACSIL/ADM*/49/204.

Details are given of exposure trials of weatherwork paints at three sites, on the roof of a building facing south with the plates exposed at an angle of 45°, on ships lying in Portsmouth Harbour, and at the extremity of Stokes Bay Pier. The results show that no failures due to corrosion of the metal occurred during the roof-exposure trials. The straight linseed-oil enamels showed serious and extensive cracking, and the behaviour of some of the synthetic paints, though greatly superior to that of the linseed-oil enamels, was rather disappointing as regards gloss retention. Some also showed signs of chalking in the nine-month period of the trial. The trials on the ships showed that many alkyd paints will, in fact, chalk in time, and that the mere substitution of alkyd paints for oil types will not eliminate the chalking problem. The failure of some of the systems tested on the Stokes Bay site was very rapid, and was due in most cases to inability to protect the underlying metal. Modifications of the existing DNC/M/73 and DMC/M/75 Specifications and the introduction of an intermediate under-coating between the primer and finishing coat are recommended.

MATERIALS : STRENGTH, TESTING, AND USE

Steel in Shipbuilding. LOMAS, J. *Engineers' Digest*, **10** (1949), p. 271 (Aug.).

The main developments in the use of steels in the shipbuilding industry lie in the direction of new materials for non-standardized parts, or the improvement by research of the quality and performance of the standardized materials. It is hoped that research into the prevention of rusting on ship plates will lead to the production of a reasonably priced steel capable of withstanding salt-water corrosion. Paint films are being studied, those containing poisons being used to prevent fouling at present.

The low-carbon steel used is specified to be produced by the open hearth process, either acid or basic type. The Author comments on the growing use of stainless steel for the propellers of ships, especially in Germany and Sweden, the use of steel instead of bronze for shaft liners, and the cathodic protection of steel tank bottoms by the use of magnesium anodes. Investigations have shown that a rust-free scaly steel can be spot-welded satisfactorily, but in rusty, scaly steel welds have a less satisfactory consistency and cause a more rapid rate of electrode deterioration.

Several new anti-corrosive processes have been developed. Corrugated steel plates in the superstructure of 18,000-ton transport vessels reduce the number of stiffeners and the amount of welding required. Examples are given of various types of alloy steels used in dredgers. The introduction of copper into steel castings to increase yield and tensile strengths, the use of a low-carbon steel with a chromium-diffused surface for boiler air-heater tube and diesel applications, and a series of investigations into the effect of size on the cleavage fracture of ship plates are discussed.

An X-ray thickness gauge in use in mills for rolling steel sheets, and a new method of stress relieving applied to large ocean-going ships, in which the object of the operation is temporarily to expand the plate on both sides of the weld differentially in relation to it, are described. Investigations have been carried out on the metallurgical properties of welds of the high-nickel, high-chromium type, the corrosion of stainless-iron turbine blading and the causes of failures of welded ships. Fatigue failure in the tailshafts of large ships have usually been traced to fabrication or design defects. A new cleavage tear test for ship plate is mentioned.

Transition Temperatures of Ducol W.27 and Heat Treated D.W. Steels. *Admiralty Engineering Department, H.M. Dockyard, Portsmouth, Central Metallurgical Laboratory. Metallurgical Report DNG. ACSIL/ADM/49/570.*

The results are given of the determination of the transition temperature for Ducol W.27 and heat treated D.W. steel in the " as-received ", strain-aged, and quench-aged conditions. Both steels are shown to have low transition temperatures in the " as-received " condition, which are raised by straining and ageing. Ducol W.27 steel is unaffected by quench-ageing but the heat-treated D.W. steel is adversely affected. The significance of the quench-ageing of heat-treated D.W. steel and its practical implications in welding are discussed.

The Effects of Metallizing Procedures on the Fatigue Properties of Steel. WILLIAMS, W. LEE. *American Society for Testing Materials, Preprint* 20, 1949. *Paper to be published with written discussion.*

This paper presents the results of part of an investigation to determine the effects of metallizing and related methods of surface preparation on the flexural and torsional fatigue properties of steel. The four conventional methods of

surface roughening, namely electric bonding, grit blasting, rough threading, and grooving and knurling, have been investigated. The use of shot peening in conjunction with electric bonding has also been covered. An analysis has been made to show the principal reasons for the observed reductions in fatigue strength and the way in which these are related to the size of the tested section.

The grit-blast process is preferred for all applications where the bond strength is adequate. The electric-bond method is the least desirable from the standpoint of stress concentration, but is preferred to grooving or threading on small parts, because it requires a smaller undercut. The rough-threading procedure is less damaging than grooving and knurling for parts subjected to flexural stresses, although both exert about the same effects in torsion.

Light Alloys and Future Developments. WATKINS, G. L. R. *Shipping World*, **121** (1949), p. 129 (3rd Aug.).

In order to increase the efficiency of ships, the structural material needs to be distributed more efficiently in the strength girder so as to save marginal weight, and here the application of aluminium alloy has great possibilities. Machinery can also be considerably lightened by the use of aluminium alloy. Should atomic power be used on board ship, extensive shielding will be necessary, and for this aluminium alloys are ideal because of their very low neutron absorption.

Rubber in Shipbuilding. LAWRIE, J. *Engineers' Digest*, **10** (1949), p. 279 (Aug.).

The salient use of rubber in shipbuilding is that of vibration absorption, particularly as rubber-to-metal bonding enables rubber to be used in shear as well as in compression. Of the methods available, chemical bonding by means of alloys is thought to be the most satisfactory. Some of the applications discussed are anti-vibration mountings for ships' engines, sound suppression by lining walls with foamed latex-type rubber, " Cutless " rubber-lined bearings for solving the problem of lubrication of propeller shafts running in submerged bearings, deck coverings, especially in rubber-cement mixtures, rubber compositions applied to the hull to smooth down the irregularities of overlapping shell plates, and protective coverings for exposed metal parts.

The Author also refers to the recent development of heat-providing elements consisting of sheets of specially compounded conductive rubber, which are electrically heated and are built into flexible, waterproof, heating panels. This development appears to have important marine applications.

Developments in Nitrogen Case Hardening. CHURCHILL, S. C. *Mechanical World*, **126** (1949), p. 5 (1st July).

The majority of steels used for nitrogen hardening have a carbon content between 0.2 and 0.5%, the average value being about 0.3%. Without the addition of an alloying metal, the maximum hardness which could be obtained with such steels would be 300 Brinell, and the hardened layer would be extremely thin. By the addition of suitable alloying elements it is possible to obtain a range of hardness from 600 to 1,200 Vickers Pyramid Number. Of the four metals which have been found to give the desirable properties in the hardened case and the core, aluminium by itself has the greatest hardening effect, but the hardened layer is very shallow and tends to be brittle. Greater depth of case can be obtained with chromium but the hardening effect is little more than half that of aluminium. The addition of suitable proportions of the two gives a maximum hardness combined with satisfactory penetration. The penetration characteristics of molybdenum are good, and the fact that the maximum hardness obtainable is not high reduces the risk of embrittlement,

particularly in steels in which nickel and chromium have been added to give high core strength. For maximum wear resistance, the surface skin of the nitrided steel should be removed by burnishing, since the nitrides in this skin are not in the form which produces maximum hardness. The average depth of this skin is about 0.001 in.

Steels specifically alloyed for nitrogen hardening should be fully treated to give optimum mechanical properties before final machining to shape and size. Parts which undergo heavy machining cuts should be stabilised at the appropriate temperature before final grinding. Curves are given to illustrate the relation between depth of case and hardness values for various grades of nitralloy steels.

Nitrided steels remain stable when exposed to temperatures as high as 930°F for periods up to one hour, though prolonged exposure at this temperature will lead to some loss of hardness. By varying the carbon content it is possible to produce steels with a core strength between 40 and 70 tons per sq. in combined with high ductility. Steels containing aluminium are available with tensile strengths from 60 to 80 tons per sq. in, good ductility, and good impact properties. Fatigue failure is rarely initiated on nitrided surfaces, and nitrided steels offer high resistance to attack by a large number of corroding substances which are met in ordinary conditions of land practice.

Ferritic Steels for Gas Turbines (French). WOOD, G., and RAIT, J.-R. *Rev. Metall.*, **46** (1949), p. 387 (June), and p. 463 (July).

The Authors describe the achievements of British metallurgy in the development of new heat-resistant low-alloy steels of the ferritic type for gas turbines.

These steels are to be operated at temperatures between 1,020°F and 1,200°F. Their history goes back to 1941, when a British firm of aircraft manufacturers tried them out for the disks of gas turbines. Their scope extends, however, to stationary and marine plant, and it is intended to find ferritic steels which will withstand temperatures beyond 1,200°F. They have the following advantages over austenitic steels which have similar uses : their price is lower, and they are more economical in use ; forging, heat treatment and machining are easier ; their elastic limit is higher ; and their thermal elongation is lower. It is possible to produce sounder and larger forgings in ferritic than in austenitic steel. The latter, on the other hand, has a higher strength at high temperatures, is more resistant to oxidation and is easier to weld.

The Authors discuss in detail the different types of ferritic steels which have been developed during recent years. The latest and most promising group of these alloys has a chromium content of between 2.5 and 3% with additions of molybdenum, tungsten and vanadium. The Authors also describe modern laboratory creep-testing methods, and tabulate and analyse the results of many such tests. The aim of the experimenting metallurgists is to keep the creep rate down to a minimum and give the alloy a maximum resistance to oxidation.

It is found that the tempering temperature is important for the behaviour of the steel, since it affects the structure, in particular the formation of spherical carbide grains. This has a bearing on the heat resistance. A preliminary high-temperature heat treatment (1,900°-2,100°F) is apt to improve the quality of the alloy very substantially. It seems that the carbon content has a great effect on heat-resistance properties, and steel containing 0.15% appears to give the best results. The carbide-forming constituents are equally important ; they seem to enter into solution with the austenite at the high forging and

annealing temperatures, and are subsequently precipitated during tempering ; this greatly affects the heat-resisting properties.

Complex carbide structures of the tungsten-molybdenum-chromium type are, however, undesirable, since they tend to reduce the heat resistance greatly. Again, a simple increase in the chromium content to 10% and more is in itself not capable of improving the properties. The 3% Cr-Mo combination seems to give the best results. The Mo-content should not exceed 1%. If it is desired to increase the ultimate strength at high temperature still further, the addition of new elements is necessary.

Since the steels behave differently from the points of view of creep resistance and ultimate strength at high temperatures, they should be classified according to both their creep rate and service temperature. The nature of the ambient atmosphere plays an important part also, since steels with a higher content of certain constituents will withstand oxidation better.

There are two references and a short discussion on the paper.

Materials and Tests of Materials to be used in the Construction of Hulls and Hull Fittings of H.M. Vessels. *Admiralty Naval Construction Department. Specification, Part I.C.*, Aug., 1946.

This specification deals with the quality and tests of materials used for hulls and hull fittings. It is mainly concerned with metals, but includes notes on non-metallic materials as well. Distinguishing colour marking of iron and steel materials, a schedule of dimensions for rivets, cleats and eye-plates to be secured by riveting and welding, steel tubes, steel wire ropes, and standard tensile test pieces as dealt with in Appendices.

The Ageing of Iron and Steel (French). FAST, J. D. *Société Française de Métallurgie, summary of paper 3M-1A read at the Autumn Meeting*, 3-7 Oct. 1949.

The Author investigated the effect of oxygen, nitrogen and carbon on the ageing of non-alloyed and manganese steel. He started with pure iron to which he added known quantities of one or more impurities.

Vickers hardness tests showed that carbon and nitrogen produce substantial age-hardening of iron without any other additions. Oxygen, on the other hand, has a very weak effect on ageing through quenching. The addition of 0.5% of manganese has no effect on the action of carbon ; but the same percentage suppresses almost completely the ageing through quenching of a steel which contains nitrogen. This remarkable behaviour of manganese is confirmed by measurements of the damping capacity.

The maximum damping capacity due to nitrogen of wires subjected to torsional vibrations is raised and shifted to higher temperatures by an addition of 0.5% of manganese. Heating to 390°F for some hours is required to liberate a substantial quantity of nitrogen from alloys which contain manganese.

Oxygen does not produce any strain-ageing of steel. The principal cause of this phenomenon is nitrogen, of which an amount of less than 0.001% is sufficient for the maximum degree of strain-ageing. Even at ordinary temperatures, this type of ageing will set in at a fairly high rate. Strain-ageing caused by carbon occurs at a noticeable rate only if the temperature is sufficiently high, e.g. 212°F. This difference in the action of carbon and nitrogen is probably due to the different solubility of these elements in iron. A rough approximate formula is given for the ageing rate, which involves the coefficients of diffusion and solubility of carbon and nitrogen. Manganese has no appreciable effect on strain-ageing produced by nitrogen or carbon.

Investigations on Aluminium Alloy Riveted Joints under Static Loading. FRANCIS, A. J. *Colston Research Society, University of Bristol, paper read at Symposium on Engineering Structures*, 19-23 Sept., 1949.

The paper deals with the behaviour of statically loaded riveted joints of the type in which frictional effects are negligible. In the first part, joints under axial tensile load are considered. A distribution method is given for determining theoretically the loads carried by the rivets in the elastic range, and non-elastic behaviour is dealt with by means of graphical constructions. The theory is confirmed by experiments on aluminium-alloy riveted joints. some of which are described. Both theoretically and experimentally, the partition of load is found to be non-uniform at working loads (the end rivets carrying more load than the inner ones) but to approach uniformity towards failure. It is also shown theoretically that, in a joint which fails in the rivets, the failing load may be considerably less than the sum of the strengths of the individual rivets ; a relevant experiment is described.

The second part of the paper deals with eccentrically loaded joints. It is found theoretically that in the elastic range the loads carried by the rivets differ considerably from those given by the conventional method. Experiments confirm the theory and also show that, owing to redistribution of load among the rivets in the non-elastic range, the failing load of an eccentrically loaded joint may be appreciably greater than the conventional value, which is obtained by assuming that both under the axial load and the end couples the rivets are very flexible compared with the connected members. The bearing which the investigations have on the design of joints is discussed.

A list of references is given.

Some Engineering Problems Associated with Metals in Elevated Temperature Service. SEFING, F. G. *American Society of Mechanical Engineers, Paper No.* 49-F-14, *read at Fall Meeting, Erie, Pa.*, 28th-30th Sept., 1949.

This paper draws attention to some of the high-temperature effects, up to 1,000°F, usually disregarded in engineering thinking. Special consideration is given to the importance of associating failures of, and changes in, metals in high-temperature service with the changes in properties under these conditions from those prevailing at room temperatures. The effects of high-temperature service up to 1,000°F upon the properties of metals can be found tabulated in handbooks and the current trade literature.

Thermal stresses resulting from cycling of service temperatures or occasional heating and cooling are shown to be of threatening proportions. In addition, these thermal stresses often tend to concentrate at certain areas in the design, thus exceeding the fatigue limit or, indeed, the tensile strength of the metal.

Changes in metal structure with time at temperatures up to 1,000°F can and do occur. The use of specially designed alloys to prevent these metallurgical changes is shown to be the sensible approach to such problems. Wear resistance in cylinders, and other metal-to-metal wear service, is reviewed as affected by elevated temperatures. Abrasive wear resistance is explained to change materially with elevated temperatures because of the many factors other than hardness involved.

Internal stresses in equipment resulting from fabrication can be released at elevated temperatures, resulting in distortion or rupture. The importance of stress-relief annealing to permit of greater working stresses is reviewed, with examples.

Because elevated-temperature service involves metallurgical, design, and

maintenance problems, the need for greater co-operation between the engineers in all these fields is emphasized. Furthermore, because new metals and better metallurgical controls are constantly being developed, it is urged that specifications and engineering codes be reviewed constantly to take advantage of these improvements in metals and alloys.

Contribution to the Study of the Plastic Deformation of Iron and Mild Steel (French). BOULANGER, Ch. *Société Française de Métallurgie, summary of paper* 3S-5A *read at the Autumn Meeting*, 3rd-7th Oct., 1949.

Mild steels and iron that has not been specially purified show many anomalies when subjected to mechanical tests. The more important ones are :—

(*a*) An upper elastic limit followed by a stage where the deformation occurs in local streaks.

(*b*) The existence at different temperatures of waves of plastic deformation which run through the test specimen and result in a discontinuous tensile test curve.

(*c*) The existence of zones of hot- and cold-brittleness.

(*d*) An ageing effect after hardening, and after cold working followed by low-temperature annealing.

These anomalies are mainly caused by the crystalline structure of the ferrite and the presence of impurities, such as graphite, nitrogen, or oxygen in weak solid solution. The Author has studied this problem by carrying out tensile tests with fine wires and strips over a wide range of temperatures and test speeds, using a special testing machine developed by Mr. Chevenard. He was thus enabled to specify the effect of the purity, grain size, and thermal or mechanical treatment as a function of temperature and speed of deformation.

He investigated in particular the disappearance of the stage of local deformations through grain growth in normal and purified metal. It is shown that ageing and the discontinuities in the tensile stress-strain curves were due to the presence of carbon, nitrogen, or oxygen in solid solution in the structure. These anomalies could easily be eliminated by treating the metal with electrolytically-formed hydrogen. They reappeared during case-hardening in gaseous atmospheres containing carbon, nitrogen, or oxygen. A study has also been made of the stability of solid solutions of these elements in ferrite, the metal having been hardened excessively. These experiments supplied valuable information both on the ageing effect and on the stage of local deformations.

Creep and Relaxation of Metals at High Temperatures. *Engineering*, **168** (1949), p. 237 (2nd Sept.).

This article discusses two reports by A. E. Johnson issued by the British Electrical and Allied Industries Research Association, " The Relaxation of a Chrome-Molybdenum Bolt Steel at Elevated Temperatures " and " The Relaxation of Two Low-Carbon Steels at Elevated Temperatures." These reports analyse the effects of some of the factors that may influence creep at high temperatures, and also check the validity of the analysis against the results of relaxation and normal creep tests specially carried out at the National Physical Laboratory. The tests were made on carbon steels and on a chrome-molybdenum bolt-steel at temperatures up to 977°F for periods up to nearly two years. In general, the results indicated that, within the range of conditions applied, the normal creep properties of these materials could not be used to predict their relaxation characteristics ; and that the time- and strain-hardening theories of creep which were considered were not entirely satisfactory.

Applications of Stellite. *Oil Engineer*, **17** (1949), p. 161 (Mid Sept.).

Stellite is a cobalt-chrome-tungsten alloy and is braze-welded on a steel surface with an oxy-acetylene reducing flame without melting the base metal. A number of examples of its use are given, including hard-surfacing of valves, cams, tappets, fuel-pump triggers, and rocker arms.

The production of precision castings by the lost-wax process is also described. Typical parts manufactured include extrusion dies, high-pressure air valves, and steel-strip guides.

BOILERS AND STEAM DISTRIBUTION

Developments in the Elimination of Oil from Boiler Feed Water. EMMERSON, G. S. *Marine Engineer*, **72** (1949), p. 251. (*Annual Steam Number.*)

Although the problem of overheating and priming caused by the presence of even a small quantity of lubricating oil in the boiler feed water has long been recognized by engineers, it is doubtful whether it is generally appreciated that a layer of oil 1/50 in thick on the tube of a boiler operating at 150 lb/sq. in. will increase the temperature of the tube wall at that point by about 600°F. The smoke-tube Scotch marine boiler has a greater tolerance for oil than the water-tube boiler, and it is evident that the danger of oil contamination depends on the temperature, pressure, and boiler loading. The problem has not attained serious proportions up to the present in the marine field because of the almost universal use of the smoke-tube boiler in all but turbine installations, and because the condensate from the modern turbine is practically free from oil. There has, however, been a trend towards an increasing use of water-tube boilers with triple-expansion engines (e.g., in Liberty ships), combination machinery, and uniflow engine for marine propulsion. The condensate of the uniflow engine has a much higher emulsified oil content than that from the common multi-expansion marine steam engine.

The oil is present in the condensate in two forms ; free oil, which is easily removed by the usual type of filter, and an emulsion, which cannot be separated in this way. The actual deposition of oil from this emulsion depends to a considerable extent on the nature of the feed water. This is illustrated by the example of two dredgers operating in the same river. The boilers of one dredger were washed out with raw water from the river and, because of priming, some of this water found its way into the feed-water make-up. No trouble was experienced due to the deposition of oil. The boilers of the second dredger were washed out with distilled water and no raw water was introduced into the line. In a period of eight months, 327 tubes had to be replaced.

The principle of chemical coagulation has been applied to the production of filters for separating the emulsion of oil and feed water. The reagents most commonly used are aluminium sulphate and sodium carbonate (soda ash). The marine sand filter of this type suffers from the serious disadvantages of requiring a large supply of back-wash water and a considerable amount of supervision, but it has been known to give satisfactory results over a number of years. The United States Maritime Commission have been carrying out investigations on the subject. Filters using diatomaceous earth have been found to give the best results for the removal of oil from the condensate. Advances have been made in the development of filters employing the principle of edge filtration and excellent results have been obtained, but no very detailed information has yet been released.

A special type of diatomaceous earth has been developed specially for the breaking-up and absorption of condensate emulsions, the earth being processed

with alumina ; it is now widely used with leaf-type filters. An illustrated description is given of these filters, which are very easily cleaned and have extremely good performance. Filter cycles of 90 hours have been obtained with uniflow engines operating with superheated steam without appreciable traces of oil in the boilers. It should be noted that oil concentrations found in uniflow-engine condensate range from 20 to 40 p.p.m., the bulk being highly emulsified.

GAS TURBINES

The Design and Operation of the Parsons Experimental Gas Turbine. BOWDEN, A. T., and JEFFERSON, J. L. *Proceedings Institute of Mechanical Engineers, paper to be published with written discussion.*

The paper describes the principal design features of the Parsons 500 h.p. experimental industrial gas turbine, and records the operating results obtained in running the plant since December 1945.

A section is devoted to some of the preliminary investigations on the compressor, combustion and heat-exchanger components, undertaken prior to the building of the unit.

One of the most important questions remaining to be answered in gas-turbine operation is the quality of the oil fuel which can be regularly and reliably burned. Details are included in the paper of operating results using a residual oil fuel. Considerable trouble was experienced as a result of deposits on the turbine blading ; these deposits were analysed and compared with the parent oil-fuel analysis, and photographs of spindle and cylinder blading show the nature of the build-up.

A Danish Marine Gas Turbine. CHRISTENSEN, H. P. *Transactions Institute of Naval Architects, paper read* 30th Aug., 1949.

The development of the gas turbine for industrial purposes in Denmark is described and the possibilities of this method of propulsion for marine use are summarized. A marine gas-turbine unit of 3,000 h.p. was designed, with an open cycle comprising a low-pressure and a high-pressure compressor with inter-cooler, an effective heat exchanger, two combustion chambers, and a high-pressure and a low-pressure turbine. The metallurgical problems involved are discussed.

The essential advantages of the marine gas turbine are saving in space and weight, a somewhat lower fuel consumption compared with the steam turbine, and less maintenance and quieter running than with the diesel engine. The 3,000 b.h.p. gas-turbine unit installed in the passenger ship *Hans Broge* is described and illustrated.

The Exhaust-Heated Gas-Turbine Cycle. MORDELL, D. L. *American Society of Mechanical Engineers, Paper No. 49-F-6, read at Fall Meeting, Erie, Pa.*, 28th-30th Sept., 1949.

The Author describes and discusses a gas-turbine cycle in which the combustion chamber is placed behind the turbine, raising the exhaust temperature to a level at which all the heat required for the compressor air can be supplied by the heat exchanger. The possibilities of such a cycle for the utilization of low-grade solid or liquid fuels are explained, and attention is drawn to the convenience with which steam can be generated from the otherwise wasted heat, and to the overall thermal efficiencies that may be obtained by a combination of gas and steam turbines.

AIR CONDITIONING, VENTILATION, AND REFRIGERATION

The Absorption Refrigeration Cycle Applied to Marine Use. HENDERSON, G. *Society of Naval Architects and Marine Engineers, Pacific Northwest Section, paper read* 10th Feb., 1949.

In designing marine refrigerators it is essential to choose a refrigerant which is adapted to the cycle being used, thus minimising the risk of fire. The plant must be capable of efficient operation regardless of the rolling and pitching motion of the ship. The flow of liquid and vapour through the piping and equipment must be independent of rapid changes in the head of liquid.

A description is given of the Latta Bros. refrigeration cycle and equipment, which uses ammonia as a refrigerant. The flash point of ammonia is approximately 932°F and the explosive range is very narrow. Since the absorption system is used, superheated vapour is never produced and there will therefore be no dissociation with the formation of hydrogen. Coast Guard regulations allow the use of ammonia-absorption systems where they do not allow ammonia-compression systems. Ammonia is a very efficient refrigerant.

From an economic point of view the absorption cycle is superior, both in original outlay and in operating cost. It can operate on steam, using bunker fuel which can be obtained for approximately half the price of the diesel-engine fuel required for the compressor cycle. The plant described operates at an efficiency of about 50%.

The novel features of the plant are the distillation column, the absorber, the pump used for the concentrated ammonia solution, and the heat exchanger. The distillation column is of an entirely new design which operates at maximum efficiency even when the ship is rolling and pitching heavily. The purity of the ammonia produced is 99.97%. The absorber has been so arranged with pressure-balanced headers that the flow of dilute ammonia solution and the operation of the apparatus are independent of the motion of the vessel. The pump for the concentrated ammonia solution has been designed to operate as a metering device to control the flow of liquid in the absorption cycle. The unit will therefore operate over its entire range.

The Scatter of Observations of the Heat Gained by Ventilating Air in H.M. Ships. GRAY, J. A. B., Surgeon-Lieutenant, R.N.V.R. *Medical Research Council, Royal Naval Personnel Research Committee*, June 1946. *ACSIL/ADM/48/931.*

Measurements of temperature, humidity, air velocity, radiant temperature and carbon dioxide concentration have been made in H.M.S. *Mull of Galloway*. The results of the thermal measurements are presented as heat, temperature, and humidity gains, and also as effective temperatures. Charts showing the frequency distribution of heat gains have been constructed, and these show approximate agreement with the corresponding normal distribution curves. Data on the standard deviation of the distribution of heat gains are summarised. An opportunity was also taken to observe thermal conditions and carbon dioxide concentrations in H.M.S. *Mull of Galloway*, from which it was concluded that the latter is not a hazard in surface warships. It is concluded that it should be possible to predict the wet-bulb temperatures that may occur in compartments in the tropics, and to estimate the frequency of occurrence of different temperatures. In this way it would be possible to calculate the number of occasions when excessive temperatures are to be expected. There is a list of references.

VIBRATION AND SOUND-PROOFING

Vibration of Marine Turbine Blading. NOLAN, R. W. *Society of Naval Architects and Marine Engineers, Chesapeake Section, paper read* 18th Feb., 1949.

After reviewing briefly the behaviour of a simple vibrating structure and defining the terms used, the Author considers the causes of damping in a turbine ; elastic hysteresis, steam damping, and rubbing friction. The exciting forces acting on turbine blades are discussed. The variations in the tangential steam forces acting on the blades may be due to variation of pressure around the periphery of the wheel, lack of uniformity in nozzles or blading, impulse excitation, or external forces such as errors in spacing of the gear teeth or soundness of the journal.

The pattern of the exciting forces will be repeated periodically, usually once for each revolution of the turbine, and can be broken up into a series of sine and cosine curves. The frequencies of these harmonic components will be integral multiples of the frequency of the original curve. Whenever the frequency of one of the various harmonics of the exciting force coincides with a natural frequency of the blade, resonance will occur, and the bending stresses induced may, when superposed on the already high centrifugal stresses, cause fatigue failure. The use of the Campbell Diagram in tuning turbine blades is described and illustrated by an example. It may be impossible to avoid resonance, due to impulse excitation, at or near maximum speed and the blades must therefore be designed to withstand such conditions. Several methods of changing the frequency, and the calculations involved, are described. For blade testing, a vibrator is used to determine the natural frequencies of blading, and combined tensile and fatigue tests are carried out. The question of a factor of safety is discussed. Designers prefer statistical methods aided by comparative stress and vibration calculations. It is emphasized that great care must be exercised in proportioning all fillets on turbine blading.

The Author concludes that, although the design of blading to resist vibration is far from an exact science, high efficiencies are being obtained and blade failures from fatigue reduced considerably.

There are two references, and some comments on the section of the paper on shock excitation are given in an Appendix.

INSTRUMENTS AND CONTROL DEVICES

Gauges for Cylinder Bores and Crankshaft Deflection. *Engineering*, **168** (1949), p. 345 (30th Sept.).

Illustrated descriptions are given of a collapsible cylinder-bore gauge for the rapid measuring of large diesel-engine cylinders without the necessity of removing the heads, and a crankshaft-deflection gauge. The cylinder-bore gauge consists of a horizontal member pivoted near its centre to the end of a long vertical tubular member with the dial gauge at the upper end. Gauges of this type can be supplied to suit any bore and stroke. The crankshaft-deflection gauge has a fixed point and a movable spring-loaded point which are placed in centre-pops made on the inside opposite faces of an adjacent pair of crank webs. When the crankshaft is rotated, any misalignment of the journals is indicated on a dial gauge actuated by the movable point. Two special features are the fact that the handle also serves as a counterweight to keep the dial gauge always facing the operator, and the provision of a spring-loaded knee joint near the centre of the gauge to allow it to kink without falling out if hit by the connecting rod.

Surface Finish Measuring Instrument. *Notes on Interview between Dipl. Ing. A. Forster and Mr. P. H. Cleff, E.-in-C. Department, Admiralty, Bath. at H.Q. R.N.S.R.B., Minden,* 6th Dec., 1948. *ACSIL/ADM/49/171.*

This is a stylus instrument. The surface to be tested is moved automatically and with adjustable speed underneath a very fine "jumping" sapphire stylus, whose every instantaneous contact position can either be observed on a screen or be recorded on a moving 35 mm film by means of a concentrated light beam in conjunction with a mirror attached to the stylus slide. The chief advantage of this instrument lies in the greatly increased measuring range of approximately 4 in, which allows both the surface finish and the surface undulations or geometrical form accuracy to be measured.

Two attached articles, written by Forster, give an illustrated description of the instrument and show the results of some surface measurements.

Cine Photography under the Sea. *Admiralty, Department of Chief of Naval Information, Bulletin No.* 23.

The Admiralty have recently developed methods for taking cine-films under the sea in normal daylight and by artificial illumination at night. A frogman diver wearing a self-contained air-breathing set swims in perfect freedom with the camera at depths down to 100 feet.

The cameras are electrically-driven and powered by portable batteries in water-tight cases. Aperture and focussing controls can be adjusted whilst the diver is swimming towards the subject being filmed.

Experimental work in the Mediterranean in 1948 determined quantitatively the distance at which photography was possible for different conditions of water clarity, object tone, sunlight angle, working depth, and exposure. Different monochrome and colour emulsions were used. In the clearest conditions of all, objects up to 30 ft away were sharply recorded. Artificial light projectors were specially designed for use on the sea bed.

The methods have been applied for wreck survey in damage and salvage investigations, marine life studies, sea-bed topography, and propeller performance. Slow-motion films have also been made of the discharge of torpedoes from a submarine.

The work is continuing in the Royal Naval Scientific Service on behalf of the Director of Boom Defence and other Admiralty Departments.