TECHNICAL ABSTRACTS

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On Propeller Theory. BURRILL, L. C. *Transactions of the Institution of Engineers and Shipbuilders in Scotland* (1946-47) *p.* 449.

The object of this paper is to describe the present-day theories of propeller action and their development from the early momentum and blade-element theories, and to show that a common line of thought may be traced in all these theories.

The Author begins with a historic survey which covers Froude's axial momentum theory and the later blade-element theory. He then refers to the modern vortex theory, paying tribute to the work on airscrew theory by the late H. Glauert. He points out that the vortex theory may be regarded as a combination of the earlier two theories, as the action of each blade element is examined by the method used in the blade-element theory ; the resultant velocity relative to each section is obtained by combining the augmented axial velocity and the slightly reduced rotational velocity. The principle of the vortex theory is that the induced velocities are those occasioned by the system of free vortices which spring from the blades and thus constitute the slipstream of the propeller.

The theory is first set out for propellers with an infinite number of blades, and then extended to the case of a small number of blades ; an expression is given in this case for the hydrodynamic efficiency, including the effect of slipstream rotation. The Author then finds a relation between the lift and drag coefficients on one hand, and the angle of incidence on the other hand, assuming that lift and drag data are available for a series of aerofoils of infinite aspect ratio, and introducing a lift slope factor into his equation for the lift coefficient. The effect of the drop in pressure in the final wake, which is due to rotation of the slip stream, is investigated ; it is found to be small in the outer parts of the propeller, but appreciable at its inner sections.

There is a bibliography.

In the written discussion, which does not contain the Author's reply, Prof. A. M. Robb defends the older blade-element theory and disagrees with the Author's remarks on a discrepancy in the efficiency between the momentum and blade-element theories, and on the alleged unsatisfactory results of calculations carried out with the blade-element theory in comparison with test results. He also charges the new vortex theory with taking no cognizance of drag ; of being inapplicable to blade sections with a circular back, in which nose and tail are the same ; and of giving insufficient account of the lateral force acting on a propelled shipbody if there is difference in velocity on the two sides of the hull. Dr. G. S. Baker stresses the necessity for " cascade " tests. Messrs. J. F. Allan and R. W. L. Gawn declare themselves in favour of the modern vortex theory ; Mr. Allan considers it not only applicable to screw propellers, but also to steering. Dr. J. F. C. Conn asks the Author for a further explanation of his assumption that the correction factor for propellers with a small number of blades is equal to the Goldstein factor for the ultimate wake, and for more details on the lift slope factor.

Mare Island's Accurate Method of Propeller Manufacture. METCALF, M. M. *Journal of American Society of Naval Engineers*, **59** (1947), p. 33 (*February.*)

A new method of propeller production has been developed by the Mare Island Naval Shipyard in California. Modern screws for high-speed warships can be cast with an accuracy of $\frac{1}{32}$ in. on the pressure face, and $\frac{1}{16}$ in. on the suction face of the blades.

The Author describes first the old cumbersome and inaccurate methods of moulding propellers in sand pits with wooden patterns. Now, however, screws can be moulded by semi-skilled workmen in much less time, although the propellers may be of intricate aerofoil or hydrofoil type. A concrete pit, containing heavy circular, machined floor-plates is used. Cast-iron cope and drag boxes, which are interchangeable, serve to accommodate screws having different diameters and pitch characteristics.

The pattern is made of manganese bronze and hand finished ; it is single-bladed with a bastard pitch and a variable thickness shrinkage allowance. After the blades are cast, their dimensions are checked with a precision pitchometer with the aid of a chart. The suction faces are then drill-spotted and chipped and the blade edges are chipped to very accurate edge templates. The entire backs of the blades are finally ground and polished. An Akimoff machine is used for balancing the finished propeller dynamically. The paper describes the moulding, casting, and machining operations, and illustrates them with a series of photographs.

Motorship with Variable-Pitch Propeller. *Shipbuilding and Shipping Record*, **69** (1947), p. 383 (17*th April*).

This article describes the motorship *Corvus* recently delivered by Eriksbergs Mek. Verkstads to the Bergenske D/S for their North Sea trade. Her principal dimensions are 245·0 × 40·0 × 24·25 ft. and the deadweight is 1,975 tons at 16·67 ft. draught. A 5-cylinder Diesel engine, developing 1,450 i.h.p., gives a speed of 12 knots. A Kamewa variable-pitch propeller is fitted having a diameter of 11·5 ft. The movable blades are controlled by a servo-motor inside the propeller hub, so that the forces that arise during the turning of the blades are confined within the body of the hub and no load is transferred to the shaft coupling or thrust bearing. Bridge operation of the Kamewa propeller is effected by means of a pneumatic telemotor. One lever only is used, by which both the engine revolutions and the propeller pitch are adjusted.

The Evolution of Diesel Engine Block Weldment Design and Fabrication. OWENS, J. W. *Welding Journal* (*New York*), **26** (1947), *p.* 240 (*March*).

The Author enumerates the technical production and managerial factors that determine whether Diesel engine blocks should be made of cast iron, cast aluminium, or steel weldments. The production of these blocks involves many fundamental principles of welding design and fabrication, and inspection problems. The Author claims that his company has been successful in overcoming all difficulties, and there have been no failures on the test bed, or in service, of a block weldment of the thousands of engines which have been constructed for marine, stationary, and railroad service since 1938. Furthermore, blocks damaged in service are being salvaged and returned after repair with standard parts. Fabrication cracks and lamination troubles have been overcome with the aid of magnetic particle inspection, and by the use of appropriate steels.

Success in production depends both on the adoption of suitable fabrication technique and on the appropriate design of the parts to be welded. Both aspects are discussed by the Author in relation to the work of his company.

The Protection of Iron and Steel by Metallic Coatings. HUDSON, J. C., and BANFIELD, T. A. *Iron and Steel Institute, advance copy of paper to be published with written discussion.*

This paper gives an account of the observations made on the behaviour of a wide range of protective coatings applied to mild steel exposed to field corrosion tests, as part of the investigations of the Protective Coatings Sub-Committee. The tests cover periods up to 5 years in the case of atmospheric exposure, and 2 years in the case of immersion in sea-water. The coatings under investigation were aluminium, cadium, lead, tin, and zinc, together with 82/18 cadmium-zinc alloy and 88/12 lead-tin alloy (" terne "). They were applied in one or more of three standard thicknesses by a variety of processes, including cementation, electro-deposition, hot-dipping, and spraying. In the last case, specimens were prepared by the molten-metal pistol, the powder-pistol, and the wire-pistol process. The principal conclusions drawn from the results of these observations are as follows :—

1. Zinc is the most generally useful metal for the protection of steel, both when exposed to the atmosphere and when immersed in sea-water.
2. Cadmium coatings are inferior to zinc coatings of the same thickness, both in the atmosphere and in sea-water.
3. Aluminium coatings sprayed by the wire pistol or the molten-metal pistol protect steel well in the atmosphere or sea-water.
4. Lead, " terne," or tin coatings cannot be recommended for steel immersed in sea-water.

Some Gear Cutting Inaccuracies and Their Effect on Gear Loads and Gear Noises. DOREY, S. F., and FORSYTH, G. H. *Transactions North-East Coast Institute of Engineers and Shipbuilders*, **63** (1947), p. 267 (*April*).

In 1939 the Authors were asked to ascertain the cause of repeated failures in gearing. Observation indicated that there were present exceedingly high frequency vibrations. It was thought that if the axial and torsional oscillation of the gear pinion meshing with the gear wheel could be measured, the cause of gear failure could be determined.

This was found to be the case, and the measurements led to an analysis of the periodic errors arising in gear-cutting machines and to a method of determining additional gear loads deduced from the measured amplitudes and frequencies of torsional and axial vibrations.

Details of the first part of the work were given in a paper " An Investigation into the Failure of a Single Helical Geared Turbine System due to Combined Axial and Torsional Vibration " read before the Institution of Naval Architects in 1942. The present paper reports calculations relating to double-helical gears and a complete analysis of the periodic errors arising from the gear-hobbing machine.

The conclusions indicate :—

1. The necessity for removing periodic errors in gear-cutting machines.
2. Existing marine gears have additional loads which may be twice the normal transmission load.
3. The future trend in gear-box design should be towards smaller gear boxes produced with greater accuracy—which may at the same time have a higher factor of safety.

The Fouling of Internal Combustion Engines, in Particular of Piston Engines (Dutch). VAN DER MINNE, J. L. *Ingenieur ('s Gravenhage, Holland)*, **59** (1947) *p. Mk.* 27 (*18th April*).

This paper, published with a brief discussion, is confined to reciprocating engines ; jet-propulsion motors, whether or not in combination with gas turbines, are left out of consideration. The principles laid down are stated, however, to be generally applicable to other types of internal combustion engines as well.

The subject is the study of the oxidation products of liquid fuel and lubricating oil formed in the engine, their effect, and how to avoid them. The causes of these residues are mainly incorrect fuel injection, incorrect adjustment of the engine and excessive lubrication. In correctly adjusted engines three types of oxidation products are formed :—

1. Oxidation sludge, during the " fluid phase."
2. Lacquer, as a secondary product, during the " gas phase."
3. Soot or carbon residue, as a tertiary product, which occurs in the overloaded motor when not the whole of the injected fuel comes in contact with oxygen.

The presence of oxidation sludge is noticeable by the darker colour of the lubricant. It is formed at temperatures between 212° F. and 572° F. The sludge consists of a small quantity of oxidation resin which gets into the oil and subsequently becomes insoluble in the lubricant. It can, however, be dissolved in organic solvents like benzol.

" Lacquering " occurs in Diesel engines running at low loads, particularly if old-fashioned fuel injectors, working with compressed air, are used. The product is bright-black and soluble in alcohol. It can be formed only at temperatures too low for oxidation. If, on the other hand, atomizing of the fuel is insufficient and there is a lack of oxygen, soot will be deposited. Lacquering is typical of fast running Diesels with petrol as fuel. The source is small quantities of lubricant which get into the cylinder. Spattered lubrication oil is also liable to form sludge which will set in the combustion chamber. Soot deposits are due directly to combustion in the cylinder and will be noticed on the piston, especially its underside.

The paper describes also the mechanism of the formation of deposits in petrol engines.

Measurement of Corrosion Pits in Boiler Tubes. THORNTON, B. M. *Engineering*, **163** (1947), *p.* 229 (*28th March*).

The Author describes a device designed to detect and measure corrosion pits in boiler and other tubes, which are inaccessible for mechanical or visual inspection.

An electro-magnetic apparatus is used, consisting of a head containing primary and secondary coils mounted on the end of a flexible tube, and of an instrument box with regulating equipment and a suitably calibrated microammeter, the reading of which gives the position and size of the corrosion pits. If the head is brought near a magnetic metal, the eddy currents set up in the metal and the back magnetic field which they produce cause an out-of-balance current in the search coils, which is used as a measure of the distance of the head from the surface, i.e., the depth of the corrosion pit. The details of construction and the procedure for tube testing are described ; the latter is very simple. Experiments carried out proved the instrument to be very reliable, and it is claimed that considerable saving of time and cost is achieved compared with the alternative of removing the tubes for inspection and replacing them afterwards. There is a circuit diagram, and photographs of the instrument box and of two designs of head.

Marine Steam Engines : New Reciprocating Designs. *Times Review of Industry*, **1** (1947), p. 29 (*February*).

Many new ships now under construction are to be fitted with steam reciprocating propulsion machinery. Fuel consumption will be considerably higher than with steam turbines or oil engines, but this will presumably be offset by the saving in first cost, and the lower maintenance charges when account is taken of the service on which the ships will be employed. Much of this machinery consists of direct-condensing triple-expansion engines, many with Bauer-Wach exhaust turbines, but a tendency to revert to compound working is becoming apparent ; this is justified with highly-superheated steam, which allows expansion over a wider range of pressure before condensation commences. The Fredrikstad steam motor, working on the Woolf double-compound principle, is being fitted in sizes of 1,200-2,000 h.p. in a number of vessels being built in this country. Each of the equal halves of the engine has a small common piston valve regulating the admission and exhaust of the H.P. cylinder. Steam from the H.P. cylinder passes direct to the L.P. cylinder, which is arranged with uniflow exhaust. Ports of very large area reduce the pressure drop between the cylinder and condenser to a minimum, and the engine is consequently able to utilise a high vacuum. Trials with steam at 220 lb./sq. in. and 580° F. have shown an oil-fuel consumption of about 0·8 lb./i.h.p. hr., including propulsion auxiliaries. Some 14-knot cargo liners with triple-expansion engines and exhaust turbines are being fitted with oil-fired water-tube boilers with air heaters and superheaters, and some other vessels are having boilers on the shelter deck to increase the available cargo space.

Brown-Escher Wyss Gas Turbines. *Motor Ship*, **27** (1947), *p.* 469 (*March*).

This is a short description of an installation for a cross-channel ship, which may be considered as a hot-air turbine, since the combustion gases do not mix with the closed-cycle air. The plant is characterised by a constant-speed H.P. turbine driving the compressor, and a L.P. turbine driving (through reduction gear) a variable-pitch propeller, thus eliminating a reversing turbine. The compressors raise the air pressure from 90 to 340 lb./sq. in. in three stages with intercooling, and the combustion air is supercharged to 30 lb./sq. in. by a supercharging set driven by the exhaust turbine from the air heater.

It is estimated that the installation, designed for 6,000 s.h.p., has a thermal efficiency of 31%, and with higher power (over 8,000 s.h.p.), using reheating, may reach an efficiency of 34%. The life of such an installation would be about 100,000 hours.

Gas Turbine Test Results show Actual Performance better than Guaranteed. PFENNINGER, H. *Power*, **91** (1947), *p.* 68 (*April*).

This article describes the performance of a Brown Boveri 4,000 kW. single-shaft gas-turbine set, which was run on the test bed in Baden, Switzerland in July, 1946. Designed for emergency service at the *Chimbole* power station in Peru, the unit has no regenerator and is guaranteed for an overall thermal efficiency of 18% at full load.

Seven tests were run with shaft speeds ranging from 3,570 to 3,780 r.p.m., with corresponding net outputs of 560 to 3,810 kW. The results are summarised in a table and two diagrams showing the fuel consumption, overall thermal efficiency, turbine and compressor efficiencies, and inlet and exhaust gas temperatures. An overall full load thermal efficiency of 19·5% at 1,020° F. inlet gas temperature was obtained, compared with the guaranteed figures of 18% at 1,100° F. It is stated that but for the capacity limit of the alternator the unit

could produce 5,000 kW. at 21% overall thermal efficiency with the gas temperature raised to 1,100° F. During tests, the set was started from cold and brought to full load in a period of ten minutes.

The method of finding the average temperature at the turbine inlet and the efficiencies of the turbine and compressor are described. There are also two diagrams showing the variation of r.p.m. at sudden load changes from full to no-load, and from no-load to full.

Chromium-Plated Cylinder Liners. *Motor Ship*, **27** (1947), *p.* 496 (*March*).

Particulars are given of the long-period operation of the engines, with chromium-plated cylinders installed in three vessels.

In the case of the 10,000 tons gross passenger liner *Bloemfontein*, the cylinder-liner wear did not exceed a few tenths of a millimetre after almost uninterrupted service during which some 400,000 miles were covered. With the 11,000 tons liner *Tjitjalengka* the wear averaged 0·6 mm., and piston-ring renewals were negligible after the vessel had covered 300,000 miles.

The lowest recorded figure for the total wear of chromium-plated cylinders of about 0·1 mm., or about 0·02 mm. per annum, was found in the engines of the 15,000 tons tanker *Papendrecht* after continuous war-time service since December, 1940.

Air Conditioning Afloat. BERRES, D. S., REDMAN, E. A., and LIVELY, G. P. *Journal of American Society of Naval Engineers*, **59** (1947), *p.* 1 (*February*).

The Authors of this paper, who are engineers in the Bureau of Ships of the American Navy Department, discuss the development of air conditioning plants in U.S. Navy vessels, and the advantages of such installations for the proper operation of warships.

The paper starts with a review of the Navy practice prior to 1940, when heating and cooling equipment was not yet standardised. An "effective temperature," had, however, been developed by the American Society of Heating and Ventilating Engineers. This was adopted by the Navy Department, and it constitutes an arbitrary index of comfort combining into a single value the effect of dry-bulb temperature, humidity, and air movement. Since 1942, the different parts of mechanical cooling installations have gradually been standardized for naval purposes. Standard plant sizes of 1·8, 3·8, 6·2, 11·0, and 17·0 ton capacities have been developed. Three types of refrigerating machinery are now under investigation :—

1. A recently designed high-speed Freon-12 compressor, which is smaller and lighter than the conventional compressor.
2. The conventional steam jet system with minor modifications.
3. A new absorption system in which chilled water is produced and circulated in a closed system to cooling coils. This system is at present only in the preliminary experimental stage.

Standardisation now embraces fans and ventilation heaters, and specifications have been drawn up for different types of cooling coils. The paper discusses particulars of these.

In addition, physiological research has been carried out on the effect of adequate air conditioning on the crews of naval vessels, and has proved its beneficial influence. Experimental cooling installations will be fitted in a number of American Navy ships, amongst them the U.S.S. *Salem* and *Newport News*.

Tanker's Air Conditioning. *Journal of Commerce (Shipbuilding and Engineering Edition)*—(1947), *p.* 2 (*24th April*).

The motor tanker *British Empress* is the first fully air-conditioned tanker to be built. The installation is capable of maintaining an effective temperature of 78° F. in the living spaces, under the most arduous weather conditions likely to be encountered in service. Under certain conditions of operation a portion of the conditioned air is re-circulated, but an adequate supply of fresh filtered air is constantly introduced. No air is re-circulated from the bathrooms, washplaces and pantries. The European hospital is provided with a separate cabinet-type air-conditioning unit, but if this should break down the main system can be used. The native hospital is only served by the main system. In neither case is the air from the hospital re-circulated.

All fresh air introduced into the system is first passed through Thermotank viscous type air filters, consisting of coarse and fine mats coated with a viscous and odourless oil.

Elastic Behaviour and Creep of Refractory Bricks under Tensile and Compressive Loads. MONG, L. E., *National Bureau of Standards (Washington, D.C.)—Journal of Research*, **38** (1947), *p.* 229 (*February*).

Creep tests were carried out on nine brands of firebrick, including two high alumina, four fire-clay, two siliceous, and one silica. Creep tests with either tensile or compressive stresses were made at eleven temperatures, ranging from 25° C. to 950° C. The duration of the tests was approximately 240 days. At the lower temperatures small changes in length occurred, which were independent of the direction of stress. The following results were obtained for the lowest temperature at which creep was significant :—for high alumina, 700° to 850° C., for fire-clay, 600° to 700° C., and for siliceous and silica, 950° C. It was not possible to correlate the results obtained with tensile stresses with those obtained with compressive stresses. Specimens of the different brands showed widely differing capacities for load carrying at 950° C. Repeated heatings caused growth of silica bricks.

Moduli of elasticity at room temperature were determined before and after the various heat treatments. The changes were large for silica bricks and small for the fire-clay bricks.

Boiler Oil for Diesel Engines. *Motor Ship*, **27** (1947), *p.* 485 (*March*).

This is an extract from the latest report of the engine performance of the Anglo-Saxon Petroleum Co.'s motor tanker *Auricula*, which is now trading regularly across the Atlantic, burning Ordoil of 1,250 seconds Redwood 1 at 100 F.

The main motor was switched over to Ordoil one hour after the Liverpool Pilot had been dropped, and continued to operate satisfactorily on the same fuel until one hour before arriving off Curaçao, when the motor was switched over again to Diesel fuel.

The report deals with the temperature of the fuel and the behaviour of the purifier and fuel pumps during the voyage ; the condition of various parts of the engines, including fuel governing lubrication, and cooling systems, is being examined. The fuel consumption has averaged 0·324 lb./i.h.p. hr. It is stated that :—

1. All temperatures and pressures are the same as would be obtained with Diesel oil.

2. The amount of sludge extracted by the purifying equipment varies considerably, although the fuel received for each voyage has similar characteristics.
3. The sticking of a fuel-pump plunger, upon changing over fuels, is of rare occurrence.
4. Hot Ordoil is more searching than cold Diesel oil.

The tests carried out at sea gave all the information required, and, on the next voyage, after minor alterations, the engine will be manœuvred, as well as operated normally, on Ordoil.

Reduction of Fire Risks in Ships. *Journal of Commerce* (*Shipbuilding and Engineering Edition*), (1947), *p.* 8 (*1st May*).

Research is being carried out by the Admiralty Chemical Department at Portsmouth on the reduction of the fire risk of paints and other materials used in ships. A primer pigmented with aluminium powder in " leaf " form has been found to have very good fire-resistant properties, mainly because of the good thermal conductivity of the aluminium, which ensures an even distribution of heat over the surface, with the reduction of blister formation. The addition of titanium dioxide or antimony oxide to the top coat greatly increases its fire-resistant properties. The surface is unfortunately matt. A cementiferous paint has been invented by Dr. U. R. Evans, of Cambridge University. It is inorganic, consisting of a zinc oxychloride cement with a high loading of zinc. It has a powerful corrosion-inhibiting effect, and shows great promise as a fire-retardant coating ; but it consists of two parts which have to be mixed together immediately before use, and it is not easy to apply. Its colour is grey. A partially hydrolised silicon ester painted over this primer gives a perfectly incombustible system with excellent weather-resistant properties. A matt white surface can be obtained by pigmenting the silicon ester paint with titanium dioxide and barium sulphate.

It is also essential that textile fabrics shall be treated to reduce their fire risks. Examination of a large range of materials has shown that urea phosphate, readily soluble in alcohol, has good fire-proofing properties. The desired speed of impregnation can be obtained if an alcoholic solution is used with a small proportion of wetting agent. A complete process specification is being drawn up with full details of the plant required with a view to introducing the process in H.M. dockyards in any future emergency.

Laying up the American Navy. *The Engineer*, **183** (1947), *p.* 163 (*14th February*).

When the war in the Pacific ended in 1945, the U.S. Navy was reluctant to scrap its enormous number of redundant warships, and hence methods were devised of laying them up, so that deterioration of materials would be prevented and so that the warships could be restored to active commission as soon as possible. Nearly 2,000 ships of various types are being laid up, and in such a way that 10-30 days will suffice to bring a ship back into commission.

Vessels are being coated with hot plastic and berthed in nearly-fresh water in order to minimise hull corrosion and fouling. The most important feature of the internal preservation of a ship is conversion of the interior into a number of air-conditioned zones in which the humidity is kept down to about 30% so as to eliminate deterioration, corrosion, and oxidation. Each zone has a dehumidifying machine, and the dried air is, in general, circulated through the piping of the fire main. The zones are accessible to maintenance personnel for checking humidity readings, etc.