TECHNICAL ABSTRACTS

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PROPULSION, RESISTANCE, AND FLUID MOTION

Coastal Waves. *Nature*, **162** (1948), p. 682 (30th October).

An account is given of the symposium held at the meeting of Section A (Mathematics and Physics) of the British Association, 9th September, 1948.

Recent investigations by the Admiralty have shown that storm waves and the swell that leaves the storm area are composed of a mixture of wave-trains, the wave-lengths of which range from a few feet up to a maximum which may be as much as 3,000 ft. Since wave velocity varies with wave-length, the visible pattern formed by the interaction of several wave trains is continually changing. Waves entering shallow water travel more slowly with a corresponding increase in height which, in the case of a long swell, may be doubled. The effect of a shallow spit extending out to sea is to tend to focus the wave-energy ; but a deep gully pointing into shallow water causes the wave-energy to be refracted towards the sides, offering quieter water in the middle. Waves travelling at 20 knots in still water would make no progress against a 5-knot tidal stream, but would steepen and break. Waves meeting a tidal stream obliquely would be refracted, and theory suggests that a tidal stream may protect an anchorage.

The resultant effect of bottom friction and viscosity on the wave-transport of water and the compensating seaward drift should be a seaward drift at the surface and a shoreward movement at the bottom ; if the waves are short, there will be a shoreward movement at the surface and the bottom and a seaward movement in the intermediate depth. Tests with models show that forward movement of the water ceases at the plunge-line, with the result that sand tends to accumulate there ; moreover, the sand does not move uniformly towards the shore but as a series of regularly spaced bars, the spacing being of the same order as the wave length. In the sea, the formation of bars is complicated by the shifting of the breaker zone relative to the beach. It has been shown that waves tend to break when the ratio of water-depth to wave-height is four thirds.

SHIPBUILDING (GENERAL)

Ships and their Future—Ships of the Future. AYRE, SIR WILFRID, *Burntisland Shipyard Journal*, **21** (1948), p. 23 (November).

The Author considers briefly the principal developments in ship design which may take place in the near future. The future of the ship is closely connected with possible developments in air transport. Referring to the air lift to Berlin, the Author draws attention to the existence of an aircraft collier, and although it can be argued that the cost of this mode of transport is totally uneconomical, this may not necessarily be so in the future.

The Author believes that ships will never disappear. Their design will depend largely on the propulsion chosen, and the possibility of application of the gas turbine and atomic energy for this purpose is not remote. It is suggested that the specialist coal, grain, ore, and oil-carriers may be replaced in the future by combined ore, oil, and grain carrying vessels.

Standards of living for passengers on board ship show trends towards spaciousness, increased comfort, and amenities which are essential to counteract the attractiveness of speed in air travel. Ships having speeds in service less than about 16 knots will hardly attract any passengers in the future.

Developments in navigational aids give greater security and confidence in navigation and reduce time at sea.

Light alloys are now available to the ship designer, and metallurgical research may solve some of the present problems which affect their wider adoption in ships' structures.

In thinking of the ship of the future, many new ideas and perhaps a fresh outlook are needed, because these will undoubtedly affect the future of the ship.

Shipbuilding and the Light Alloys. WATKINS, G. L. R. *Shipping World*, **120** (1949), p. 8 (5th January).

The advantages of aluminium alloy as a medium for shipbuilding are discussed. The use of aluminium alloy will provide a means of obtaining extra deadweight, and the fact that the alloys can be worked cold and easily formed enables bridge fronts, funnels, etc., to be streamlined, which is necessary with increasing speeds. The finer block coefficient necessitated by higher speeds has reduced capacity and carrying power, and light-alloy construction can help to restore the balance. Construction of the superstructure in aluminium alloy will reduce top weight and compensate for the reduction in machinery weight, thus giving greater stability.

The advantages resulting from aluminium-alloy construction can be utilised in several ways. In the ordinary cargo vessel, the reduction in weight will give greater earning capacity on the same displacement, by increasing the deadweight. Where this is not an advantage, the displacement can be reduced by fining the block coefficient or, alternatively, a direct reduction in draught can be accepted. Each of these cases will result either in an increase in speed for the same power or a reduction in the power used for the same speed, thus reducing the amount of fuel used per voyage.

Several vessels are named which have had part of their structure built of light metal. They include the Swedish-American liner *Stockholm* (Abstract 1693), with over 30 tons of light alloy in the superstructure, wheelhouse, navigating bridge, mast, funnel, lifeboats, etc. ; and the *President Cleveland* (Abstracts 1757 and 1846) in which about 100 tons of light alloy were used.

Trends in Tanker Construction. MORRELL, R. W. *Marine Engineering and Shipping Review*, **53** (1948), p. 59 (November).

The United States has at present some 64 sea-going tankers under construction, ranging in size from the 7,800-ton deadweight *Rio Grande* to the 30,000-ton deadweight *Bulkpetrol.* The general tendency for some time has been to design tankers of the maximum size permitted by conditions at the ports between which they are to operate. The depth and width of channel, tide, berthing conditions, storage capacity, and dry-docking facilities at these ports are all factors to be considered.

The general practice is to select a maximum permissible draught and build on it the best possible carrier. As an example, the factors involved in selecting the draught for a tanker operating in the Persian Gulf-United States trade are discussed. In the development of the big tankers overall length has become a controlling factor. Modern design has practically dispensed with upper-deck sheer. The subject of tanker depth and sheer is complicated by the many factors involved. The current length-to-depth ratios for big tankers range from 13.5 to 14.3, with length-to-beam ratios from 7.26 to 7.42. The beam in these tankers is less than twice the depth. In an attempt to obtain a balance between speed and cargo-carrying capacity, the tendency has been towards slightly fuller block and prismatic coefficients, and recent designs have succeeded in reducing the operating cost per barrel very materially.

Except for certain riveted connections, the tankers now building are of welded construction. Rules have been adopted by the American Bureau governing both the chemical and physical properties of hull steel, in order to obtain a quality best suited to welding. There is considerable divergence of opinion among designers and operators on the subject of bulkhead design, from the standpoints of weight, maintenance, and tank cleaning. Some of the tankers have fluted bulkheads with vertical corrugations, and some have flat-plate bulkheads with stiffeners.

Main cargo piping is of more or less uniform design, consisting of three systems serving three groups of tanks. In most cases, main cargo pumps of the centrifugal type, operating at up to 4,000 gallons per minute each, are installed in an after pump room, and are driven by extended shafts from the engine room.

With the exception of the relatively small tanker, the *Rio Grande*, which will have twin-screw uniflow engines, all the tankers will be powered with single-screw geared-turbine drive. Particulars are given for the various sizes of tankers. Two water-tube boilers are installed on each vessel, with the exception of a National Defence tanker, which has three. Steam atomizing oil burners are being adopted to a limited extent. The more recent designs indicate no particular trend as to speed and power.

WELDING AND OTHER METHODS OF CONSTRUCTION

Radiography as Used in Naval Construction for the Control of the Quality of Welding. SMITHERS, D. W. *Welder*, 17 (1948), p. 81 (October-December).

After a brief historical introduction, the Author defines the purpose of radiographic examination and gives an illustrated description of both portable and stationary X-ray units used for naval construction and naval repair work. The difficulties associated with the examination of welds in ships under construction are briefly enumerated, and details are given of the technique, procedure, and methods of taking records and interpreting the results.

The main conclusions are as follows :—

Considerable improvement in the standard of welding of warships has been observed since the introduction of radiography. This improvement probably extends well outside the field of the welding actually examined. A statistical analysis of the work at various shipyards showed a marked decrease in the incidence of certain welding defects in the early days of routine radiographic inspection. By far the most serious defect in structural welding is cracking. Although shipyard work is unfavourable to good welding, this was in some cases reduced over a period of a few months to about one-tenth of what it had been before radiography was a requirement. Lack of fusion is another serious defect, which has been considerably reduced by radiographic control. Slag inclusions are serious on their own account, and, because they are so frequently associated with cracking, these also have been appreciably reduced.

In spite of improvements, however, the radiographer need not yet fear that his examinations will become boring in their revelation of uniformly perfect welding. Constant examination is in fact necessary to maintain an acceptably high standard.

Repair work also opens up a wide field for radiography. The difficulties of patching by welding are well known, as also are the best methods for dealing with structural repairs of this nature. X-ray examination of the more critical positions in such repairs is desirable and in many cases essential.

The examination of test plates from welders under training, and periodically after training, and the explanation of the defects revealed to the welders themselves, provide perhaps some of the most valuable benefits derived from radiographic examination.

The application of radiography is now clear and its value almost unquestioned. It is an accepted feature of welded design in warship construction, and, when the amount of importance of the welding warrants, is included as a specified Admiralty requirement for the quality control of welding.

Highlights of Welded Ship Research. ACKER, H. G. *Society of Naval Architects and Marine Engineers, New England Section, paper read* October, 1948.

Extensive research has been undertaken, both by the U.S. Government and by private firms, to determine the basic causes of the fractures of some 160 merchant ships during the last six years. Most of these ships were of all-welded construction, and all the fractures occurred during normal operation.

An attempt has been made to assess the influence of mechanical and metallurgical factors on the behaviour of the steel.

Analysis of the failures has shown that the main problem is not overall bending moments and scantlings but the behaviour of the material in local highly stressed areas. The research has further emphasized the greater importance of details in design for welded hulls than for riveted hulls, and the necessity of using a less notch-sensitive steel than has been used for riveted construction. Low-carbon, high manganese steels are less notch-sensitive than the ordinary steels that have been used up to now. Generally, a fully-killed steel is better than a semi-killed steel and a rimmed steel is worse.

An account is given of structural tests on ships, and riveted and welded construction are compared. A number of recommendations are made which, it is considered, would reduce the probability of fracture in welded ships. These include the retention of a few riveted joints as crack stoppers in large welded ships, since it is at present practically impossible to build or repair ships free from minor defects.

A high standard of workmanship is important.

BOILERS AND STEAM DISTRIBUTION

Economic Selection of Steam Conditions for Merchant Ships. MACMILLAN, D. C., and IRELAND, M. L., JR. *Trans. Society of Naval Architects and Marine Engineers, paper read at Annual Meeting,* 11-12th November, 1948.

In their investigation of the relative advantages of marine steam plants with different steam conditions, the Authors have included a study of the initial cost of the plant. They have presented their results in a form which makes it easy for adjustments to be made for future changes in the basic prices of fuel and machinery. They make the following recommendations: For installations of about 6,000 s.h.p., steam conditions of 450 lb/sq. in. and 750°F. should normally be selected; for higher powers, 615 lb/sq. in. and 850°F. are suitable values. A rise in fuel prices would lead to appreciable saving for steam conditions higher than 615 lb/sq. in. and 850°F. for a tanker of 12,500 s.h.p., but the expected savings should be weighed against the probable risk. Although there appears to be more incentive to increase the temperature than to raise the pressure, the risk may also be greater.

Recent Research on Caustic Cracking in Boilers. WEIR, C. D. *Trans. Institution of Engineers and Shipbuilders in Scotland, paper read* 30th November, 1948.

The paper deals with the characteristics of caustic cracking; the influence of the feed water; various methods and apparatus evolved for caustic cracking research, including the Author's own autoclave device; the causes of caustic cracking; inhibitors tending to reduce it; and theories on its nature and origin.

Caustic cracks in boiler plates and shells are confined to regions where cavities may exist, and to which the main body of the feed water has but limited access. Typical locations are the riveted seams of the shell plates and the rolled-in ends of fire tubes. The cracks occur only at areas where a considerable amount of non-homogeneous stressing, accompanied by plastic deformation of the metal, is present, *e.g.*, in the vicinity of rivet holes. The cracks appear to be brittle in character, nevertheless, the material in the region of the failures does not often reveal any appreciable reduction in ductility. In riveted seams, the cracks often pass from rivet hole to rivet hole, though not in continuous fashion. They do not always traverse the lines of maximum stress. In many instances, the rivets themselves suffer from such cracks. The phenomenon is confined neither to plates of poor properties nor to faulty workmanship. Most caustic-embrittlement cracks tend to follow an intergranular course.

Although the concentration of alkalies in boiler feed water is much lower than in some laboratory tests in which the material under test did not fail, cracking occurs in practice under such conditions. The reason is that small quantities of water are enclosed in cavities like badly caulked seams, where the alkali concentration increases rapidly through evaporation of the water, and the residual highly concentrated solution is sufficient to cause cracks.

It appears also that certain substances, like lead oxide, silica, etc., promote caustic cracking, whereas neither the type of stress nor the material seem to play a predominant role, except that non-homogeneous stress distribution and machining irregularities favour the formation of cracks.

There is no fully satisfactory remedy for caustic cracking. The maintenance of high $Na_2SO_4/NaOH$, $NaCl/NaOH$ and R_2O_3 NaOH ratios are beneficial to some extent; so is cathodic polarization, and the use of sodium phosphate as an inhibitor. But the last may lead to an electrolytic production of hydrogen at the plate surface, which strongly promotes cracking. Indeed, occluded hydrogen seems to be essential for the production of caustic embrittlement.

The Author discusses the numerous theories that have been advanced to explain caustic cracking. It seems that the following is a possible sequence of events:—Initially, concentrated alkali forms a non-protective oxide film on the steel surface. This is accompanied by the formation and partial occlusion of hydrogen. Embrittlement of the metal is caused thereby and gives rise to fine intergranular surface cracks. Subsequent penetration of these cracks by the alkali results in the process of anodic corrosion. The cracks are widened and extended thereby, giving rise to intergranular fissures. The corrosion process continues through the fissured, distorted, and embrittled metal under stress, until finally rupture occurs.

GAS TURBINES

N.A.C.A. Investigations of Gas-Turbine Blade Cooling. ELLERBROCK, H. H., JR. *Journal of Institute of Aeronautical Sciences,* **15** (1948), p. 721 (December).

Analytical studies involving several assumptions show that remarkable improvements in gas-turbine engine performance can be obtained by increasing the gas temperature at the turbine inlet even when cooling losses are considered. Rim cooling with present-day metals allows little increase in the effective gas temperature over that obtainable without cooling, but blade life can be increased appreciably with small decreases in blade temperature caused by rim cooling. At a Mach number of 0.6, an effective gas-temperature increase of about 500°F. can be obtained with hollow-blade air cooling, and an increase of about 650°F. with air cooling when an insert is placed in the hollow blade ; liquid-cooled high melting point alloy-steel turbines apparently should be able to operate at turbine-inlet temperatures approaching those obtainable with present-day fuels.

Because of the difficulty of solving the turbine cooling problem entirely theoretically, recourse is had to experiments. By means of rigs of static and rotating cascades of blades and experimental procedures briefly described, data are believed to be obtainable which, in conjunction with the theory of turbine-blade cooling, will lead to methods for the rigorous design of cooled turbines.

The Coal-fired Gas Turbine. KARTHAUSER, F. B., BATTCOCK, W. V., and ROSS, F. F. *Journal of Institute of Fuel,* **22** (1948), p. 58 (December).

A coal-fired gas turbine will cost more and be less efficient than one using a distillate oil in the same cycle, and with a free choice of cycle the maximum thermodynamic efficiency obtainable will be much less. There should, however, be a limited but definite field of application for the coal-fired turbine. It may not be possible to prevent the formation of deposits in the turbine, but it can be minimized by the use of suitable coal and combustion conditions ; and such deposits as are formed can be removed by washing. The applications in which the coal-fired gas turbine is likely to be economic are primarily those in which good use can be made of the exhaust gases. These include central power generation, collieries, industry, and locomotives. Such a turbine gives more power per unit of heat than back-pressure steam plant. Several methods are available for the combustion of coal under pressure, and the choice for a given application will depend on the coal available and the performance required.

In the discussion of the paper, Dr. A. T. Bowden suggested that the open-cycle gas turbine was not suitable for the utilization of low-grade fuel, except possibly as a constant load machine. Several other speakers advocated the adoption of the closed cycle. The Authors, however, considered that the design of an air heater fired at atmospheric pressure would be both difficult and costly.

DIESEL AND OTHER I.C. ENGINES

The Influence of Valve Port Design on the Volumetric Efficiency of the Compression-Ignition Engine. DICKSEE, C. B. *Institution of Mechanical Engineers, paper presented at General Meeting of Automobile Division,* 8th February, 1949.

The Author discusses the cause of the loss of pressure in the induction system of an internal-combustion engine, and also the essential difference between the breathing conditions of a carburetting engine and those of a compression-ignition engine. He gives particulars of some experiments on the influence of valve ports of different shapes upon the breathing of a given compression-ignition engine cyclinder.

The experiments cover the measurement of the pressure loss under a steady air flow as well as the effect upon the volumetric efficiency under actual operating conditions. The engine tests comprised a series of runs over a speed range of 600-2,000 r.p.m. at full load under normal operating conditions, with two different ranges of jacket outlet temperature. The effect of a change in valve lift is discussed also. The results of the experiments show that the governing factor in volumetric efficiency is the velocity of the air at the valve opening, and that a venturi form of port provides much needed room for the accommodation of the fuel injector, without any sacrifice in volumetric efficiency, by allowing a material reduction in the diameter of the port at a short distance ahead of the valve opening. It does not, however, possess any other great advantage over a parallel port with an equal diameter of valve seat. There is an advantage in giving the valve a lift greater than one-fourth of its diameter at the seat, but the extent of this gain will depend upon the adequacy of the valve diameter for the size of the cylinder.

Free-Floating Piston Generators (German). EICHELBERG, G. *Schweizerische Bauzeitung*, **66** (1948), p. 661 (27th November), and p. 673 (4th December).

The Author discusses the theory, design, and performance of free-floating piston generators of the Pescara type. Numerous performance figures and design details are given. The engine combination described embodies the well-known opposed-piston in-line Diesel-compressor set which is frequently used for the production of compressed air for road making. The compressed air from the Diesel-compressor set is, however, employed solely for supercharging the Diesel, whose exhaust gases drive the actual prime mover, a low-pressure gas turbine.

The Diesel and compressor pistons of each side of the reciprocating set are in tandem, the injection valves of the Diesel being arranged at the engine centre, and those of the compressors at the inner side of the cylinders. The cylinder covers of the compressors form air chambers, which communicate with the air intake space of the corresponding Diesels through a spring-loaded " stabilizing piston." This arrangement is necessary for obtaining the necessary movement of the engine at the dead centres. The two pistons of each engine set are not left to move independently, but are inter-connected by a simple link system, the " sychronizer." Stabilizer and synchronizer can be set conveniently in accordance with the load conditions of the gas turbine. There is a full discussion of the working of both of these elements and of starting and stopping the generator.

There are interesting features in the fuel injection pump and distribution system which supply the six injection valves of each set. The design of the injection pump makes it possible to extend the fuel spray over the dead centres of the engine when the piston speed is zero. Four of the injection valves atomize the fuel directly into the cylinder, whilst the two others deliver the spray to pre-combustion chambers.

Large-scale tests have been carried out with this arrangement and the successful results are discussed with the aid of piston-stroke, pressure, and temperature diagrams for various load conditions. Acceptance tests of a 1,360 h.p. plant during 3,000 hours gave the following results :—

Number of oscillations/min.	613
Effective stroke	17.4 in.
Mean piston speed	1,780 ft/min.
Temperature of gases at turbine intake	950°F.
Working pressure of gases at the turbine intake	51.45 lb/sq. in. above atmospheric.
Gas delivery to turbine	8.05 lb/sec.
Specific fuel consumption	0.34 lb/h.p./hr.
Thermal efficiency	41.15%
Compression pressure	1,080 lb/sq. in.

There is a discussion of the power balance (thermal and frictional losses) of the plant.

The unavoidable pressure surges in the gas delivery to the turbine from one reciprocating set may be damped out by employing twin sets in tandem, displaced at a phase angle of 180°. In this arrangement, the air chambers and engine intakes of the sets are conveniently inter-connected by a stabilizer interposed in the connection between the former. The substantial improvement which may thus be obtained is clearly seen from pressure oscillograms reproduced in the paper.

The Author also discusses two design projects of free-floating piston generators, one being for a stationary plant and the other for the propulsion of a twin-screw liner with a total power of 16,000 h.p. The latter is supplied by two sets of twin turbines, each pair driving its propeller shaft through a gear train. One turbine of each pair is provided with an astern wheel. The working fluid for each turbine set is delivered by two twin reciprocating sets in tandem.

Comparing plant weight and specific fuel consumption of a plain two-cycle Diesel, of a simple open-cycle gas turbine, and of a free-floating piston plant, the Author concludes that the last compares favourably with the others within a power range from 1,000 to 20,000 h.p., the fuel consumption of the Pescara plant being comparable with that of a high-power Diesel. A further improvement of the performance characteristics should be possible. Other advantages of the new plant type are lower turbine temperatures and hence the use of cheaper constructional materials for rotors, blades, etc.

POWER TRANSMISSION

Transmission Systems for Marine Propulsion Gas-Turbine Power Plants. HAMMOND, W. E. *Trans. American Society of Mechanical Engineers*, **71** (1949), p. 43 (January).

Since turbine-type machinery reaches maximum efficiency at high speeds, while marine propellers reach maximum efficiency at low speeds, some sort of transmission system which will enable both objectives to be realized is required. After a brief statement of the requirements, the most important of which are reversibility and manoeuvrability, the Author discusses the various transmission systems available to-day.

The direct-current electric drive appears to have few advantages. First cost and maintenance costs are high, and efficiency low. The alternating-current electric drive is suitable for gas-turbine power plants using a separate power turbine. It compares favourably with the mechanical drives in regard to weight, but requires more space. It is rather slow in manoeuvring, and is susceptible to overspeeding.

The system of mechanical gears combined with controllable-pitch propeller is suitable for use with all gas-turbine power plants. Its flexibility is equal to that of direct-current electric drive, and its cost, weight, and efficiency are superior. It compares favourably with the alternating-current drive in regard to annual operating cost and weight, and requires less space. Its manoeuvring and reversing characteristics are superior to the other drives, and its control is simple. Mechanical reversing gear could be applied to gas-turbine power plants having a separate power turbine. Its economic position is excellent for powers up to 6,000 s.h.p., manoeuvring and reversing characteristics are good, controls are simple, and weight, space, and arrangement factors are suitable. The only disadvantage lies in the high load factors used in the design. A reversing gas-turbine power plant with mechanical reduction gear is not a practical proposition at present, since the design and development of the reversing gas-turbine have not been studied sufficiently.

The Author concludes that the mechanical reduction gear with a controllable and reversible propeller, and the direct-current electric drive should receive first consideration.

DECK MACHINERY AND CARGO HANDLING

Royal Naval Anchor Trials at Weymouth. *Admiralty : Dept. of Chief of Naval Information, Bulletin No.* 14.

During the past few years considerable technical research has been undertaken by the Admiralty on the design of anchors. The general method of testing on the present site at East Fleet is to pull the anchor by steel wire ropes through a series of blocks by a 6-ton four-wheel-drive lorry at a speed of 1.5 to 2 feet per minute. A statimeter or force recorder is inserted in the system near the anchor. At given intervals this instrument measures the force necessary to drag the anchor and, also, the force it will just hold without dragging. Pulls up to 50 tons can be measured, which are sufficient for the largest anchors, and allowance is made for the anchors to drag as much as 100 feet.

The new $5\frac{1}{2}$-ton Admiralty Mooring Anchor 7 represents the first fruits of the research programme, and its design is based on experience gained on previous trials. The new design will hold more than 8 times its own weight before dragging, whereas the old Admiralty moving anchor would withstand a pull of only twice its own weight.

Other types of anchors tested include the new improved design A.M.11, the 10,000 lb U.S.N. Standard stockless anchor and the 750 lb Danforth anchor.

MACHINE PARTS

Flame Hardening of Gears. GRÜNEGRESS, W. *Engineers' Digest*, **9** (1948), p. 429 (December).

Gear teeth above 5 D.P. can be gas flame-hardened, tooth by tooth, with sieve or slot burners adapted to the tooth form and fed at constant speed across the face width. Universal and automatic hardening machines have been developed for the treatment of spurs, bevels, worms, and wormwheels of various sizes, and for mass production, and close control of the hardness figures can be guaranteed. Alloy steel is used where very high core strength is required. Gears with teeth smaller than 5 D.P. are rotated through the flame, heated to hardening temperature, and quenched by spray or in a bath.

The advantages of flame hardening are : the possibility of using cheaper, unalloyed substitute steels ; increase in wear and rolling fatigue strength, which makes possible a reduction in gear size ; the possibility of hardening very large gears with only a small amount of heating energy ; and decreased hardening distortions which, according to experience, remain entirely within the permissible machining errors. Danger of cracking is reduced, the time saving is considerable, and finish grinding can be omitted in many cases. The hardening of worm-wheels has been made possible by the introduction of this method.

FUELS AND COMBUSTION TECHNOLOGY

Colloidal Fuels for Diesel Engines. VERMAN, C., and others. *Gas and Oil Power, Annual Technical Review Number* (1948), p. 330.

A description is given of some tests made in Delhi with a 8 h.p. Lister engine run on groundnut oil mixed with charcoal powder. Vegetable oils, despite good performance, have not been able to compete with mineral fuels because of their higher price, but the addition of charcoal makes the fuel cheaper and therefore able to compete with mineral fuel.

The fuel tested consisted of groundnut oil mixed with finely powdered charcoal of low ash content. Calcium soap of groundnut-oil fatty acid added in the proportion of 3% was found to give the best stability to the mixture over prolonged periods of storage, thus preventing settling down of the charcoal particles. Fuels containing up to 35% of charcoal were found to flow freely through the fuel system and were therefore used in these tests. To obtain comparative data, tests were made with mineral oil, groundnut oil, and colloidal fuel (groundnut oil with charcoal powder).

The results show that the maximum b.h.p. developed with groundnut oil was 98.7% of that with mineral oil, while with colloidal fuel it was only 72.8%. The best brake thermal efficiency with groundnut oil was 20.8% as against 12.8% with colloidal fuel. Tests with colloidal fuels revealed trouble in the injection system due to the abrasive action of this fuel, and after 2¼ hr of running the engine stopped by itself.

It is concluded from these tests that the injection system cannot stand up to the abrasive action of the colloidal fuel ; but the idea of using this type of fuel has some promise because of its good stability, and because of the good thermal efficiency, approaching that of ground nut oil, which can be achieved provided the injection problems are solved.

It is proposed to carry out further tests in Delhi with reduced sizes of charcoal particles and of redesigned injection systems.

MATERIALS : STRENGTH, TESTING, AND USE

Rubber as a Stress-Carrying Material and Some Design Considerations. MARSH, S. W. *Proc. Institution of Mechanical Engineers, paper read at General Meeting of the Automobile Division*, 9th November, 1948.

As a stress-carrying medium, rubber is best used either in the pre-stressed condition or bonded to metal. In designs of the latter type, it is usual for the rubber to be under compression or in shear. It has been shown that noise reduction can be obtained with well-designed compression mountings which is equal to that obtained with rubber used in shear, and the former type of mounting offers many advantages. Much higher loadings can be supported for a given effective area, and the unit can usually continue to function even if the bond fails. With rubber in shear, the maximum permissible stress consistent with reasonable life in service is of the order of 55 to 60 lb/sq. in., and where continuous flexing of the section occurs it is safer to use only 30 to 35 lb/sq. in. With rubber in compression, however, stresses up to 500 lb/sq. in. are permissible for normal applications, and loadings up to 1 ton/sq. in. can be dealt with as shock or momentary loads without fear of failure.

Formulae are given for calculating the angular deflexion for a given section of a rubber-to-metal bonded sandwich subjected to shear loading. For normal applications, the deflexion should not exceed 15° to 20°, with a maximum value under shock conditions of 30°. The permissible deflexion of a rubber unit under compressive loading is best expressed in terms of percentage deformation on original dimensions. A deflexion of 15% to 20% maximum forms a good basis for calculation, though this may be exceeded for shock loading. A formula is given for the reasonably accurate forecast of deflexion up to 25%.

Synthetic rubbers do not possess the load-carrying capacity of natural rubbers, especially under dynamic conditions, and they have a higher permanent set. Their resistance to swelling in oils and their ability to retain their physical properties at higher temperatures are, however, well in advance of what can be obtained with natural rubber compounds. Oil seals made in synthetic rubber can give long and satisfactory service.

CORROSION, FOULING, AND PREVENTION

Crankshaft Corrosion of Marine Diesel Engines (Dutch). MALOTAUX, R. M. N. A. *Ingenieur, 's-Gravenhage*, **60** (1948), p. Mk. 149 (17th December).

This is a brief summary of a paper read in November, 1947 in Utrecht. The Author gives a short history of laboratory tests made to study the mechanism of the corrosion of well-lubricated crankshafts of marine engines, which was frequently observed during the war. Prominence is given to experiments carried out by Young where a steel and a copper plate were subjected to the action of warm oil, both clean and artificially contaminated.

It is believed that during running of an engine the lubricant is contaminated with metal particles through the abrasive action of the moving parts. Moreover, the sulphur generally contained in normal oil forms sulphuric acid in the combustion chamber of the engine, and some of this acid eventually finds its way into the crankcase. It is almost impossible at sea, even with fresh-water-cooled engine, to keep all traces of salt out of the crankcase. If this occurs, the salt will react with the sulphuric acid and form hydrochloric acid, which is strongly corrosive.

This type of corrosion, which has also been observed in stationary engines used near the coast, may be counteracted by arranging scraper rings on the pistons, avoiding sea-water leakage as far as possible, and purifying the lubricant in separators during the voyage.

H.M.S. " Brecon." Corrosion of Propeller Shaft under " U.S. Metallic. Packing " Glands. *Admiralty Corrosion Committee, Hull and Non-Ferrous Corrosion Sub-Committee. ACSIL/ADM/48/1017. Metallurgical Report DMJ.*

The corrosion of propeller shafts under the " U.S. Metallic Packing " glands has occurred frequently in the Hunt Class destroyers. The cause is associated with the proximity of the copper-base alloys in the packing gland. One of the more serious aspects of this failure arises when the pitting spreads underneath the rubber sealing ring, thus breaking the oil seal of the bearing.

The remedial measures recommended are, firstly, fitting a zinc protector to the gun-metal face of the packing, and, secondly, coating the shaft entirely with either two coats of DMU followed by one coat of Detel red, or two coats of Tretol HH followed by one coat of Tretol B.

The Vacu-Blast De-Scaler. *Admiralty Corrosion Committee, Hull Corrosion Sub-Committee. ACSIL/ADM/*48/427.

An American firm has developed a machine for cleaning metal surfaces by a process which can be regarded as a development of sand-blasting. Grit is directed through a " gun " on to the surface to be cleaned, and is then sucked back through the gun, together with the scale of paint removed from the surface, into a reclaiming tank. Here the dust is separated from the grit, and it is then passed into a dust collector. An alternative gun is provided for use at right-angled intersections. The machine consists of three units : the gun, the reclaiming tank, and the dust collector.

The United States Navy have purchased over 50 of these machines, most of which are in use by the Reserve Fleet. The capabilities of the machine are being investigated at the Philadelphia Navy Yard. This report on a demonstration of the machine incorporates the views of a Reserve Fleet Officer who has had charge of a machine for over two years.

Although the machine will operate at air pressures as low as 60 lb/sq. in., the rate of cleaning is considerably lower than at 85 lb/sq. in. A 25-ft length of hose between the reclaimer and the gun is used at Philadelphia, but the Vacu-Blast Company claim that up to 75-ft length can be used. They also claim that the dust collector unit may be as much as 200 ft from the gun. The machine is operated by a switch on the gun. For work on steel plate surfaces, a hard steel grit is recommended, of which 70% will pass through a 0.028 in mesh screen. For efficient operation, the air supply must be dry, the surface must be reasonably dry, and it must not be raining. The demonstration included the removal of paint and rust from the deck of a cruiser at the rate of about a square foot per minute, possibly faster. The steel grit makes numerous small indentations in the plate surface, leaving it in an ideal condition for painting. It was stated that plating pitted to about $\frac{1}{8}$ in on the superstructure of a battleship had been cleaned successfully. The corner tool is not as satisfactory as the tool for flat surfaces, although a reasonably clean surface could be obtained with care. On a vertical bulkhead, the tool can be used with reasonable ease at waist level and below, but above this level the operator is somewhat impeded by the hose pipes. Around stiffeners and brackets, difficulty of manipulation and access detract considerably from the usefulness of the tool, and no attempt has yet been made to use it in the overhead position.

The superstructure deck of the battleship was inspected. About 9,000 sq. ft. of this had been cleaned in about $4\frac{1}{2}$ months with one of the early models of the Vacu-Blaster before repainting. The work had been completed nearly 18 months before, but there was no sign of any lifting of the paint, although the deck was so uneven that rain and snow had lain on it for long periods. In contrast to this, a small area which had been treated by ordinary scaling and wire-brushing methods required retouching, the paint having lifted in several places, with rusting underneath.

The tool would appear to be of most use on superstructures and other exposed steel surfaces of vessels which are to be laid up for a considerable period. Although for new shipbuilding and for ships in commission its general adoption would probably not be justified, it would probably lead to economy if it were used in areas of the upper works and the internal structure where access is difficult and sweating is likely.

MISCELLANEOUS

Fireproofing Wood and Deck Coverings in H.M. Ships. *Admiralty, Dept. of Chief of Naval Information, Bulletin No.* 12.

The fire protection of wood can be carried out by surface coating or by impregnation. The former has the advantage of easy application, especially to timber *in situ*, and offers high resistance to flame penetration and the spreading of fires, but impregnation with fireproofing chemicals is much more effective. The best results are obtained with pressure impregnation, the most important process in this country being the Oxylene process which utilizes an aqueous solution of mono-ammonium phosphate containing a small proportion of boric acid. The proofed timber is, however, supplied in bulk, and when cut up or shattered the portions may be less fire resistant. Whenever possible, therefore, wood will be replaced by less inflammable substitutes.

Any fireproofed material for deck covering must retain the typical physical properties of flexibility and resilience of the linoleum normally used. The most satisfactory fireproofed linoleum obtained so far consists of a material in which part of the linoxyn is replaced by chlorinated resin and part of the filler by antimony oxide. This material has given good results in extended fire trials at the Admiralty Fire Testing Ground, Haslar, and it is proposed to submit it to sea trials to assess its durability and general suitability. The investigation of entirely new types of deck covering based on materials other than cork and linoxyn, or in which these ingredients are partly or wholly replaced by less inflammable substitutes, is being carried out.