The
INSTITUTE of MARINE ENGINEERS
Founded 1889. Incorporated by Royal Charter, 1933.

Patron: HIS MAJESTY THE KING.

SESSION 1938

Vol. L. Part 9.

President: Sir E. JULIAN FOLEY, C.B.

PRESIDENTIAL ADDRESS.
The State and the Marine Engineer.

READ

By SIR E. JULIAN FOLEY, C.B.

On Friday, September 30th, 1938, at 6 p.m.

CHAIRMAN: MR. R. RAINIE, M.C. (Chairman of Council).

YOU will probably not be surprised that I was surprised when your Council asked me to be President of The Institute for this year. Looking through the list of previous Presidents I felt that the Council did me, a Civil Servant with no technical qualifications, a great honour, but I came to the conclusion that the honour was really paid to the Department—the Mercantile Marine Department of the Board of Trade—of which I happen to be a member. For that Department not only has a number of marine engineers on its staff, but is, by the nature of its duties, very closely connected with the professional functions of marine engineers.

I was extremely glad by accepting the invitation to emphasise that close connection and I have much enjoyed the opportunity of meeting the members of The Institute and seeing at closer quarters more of its work. I am particularly fortunate that in my year the International Conference of Naval Architects and Marine Engineers in London and the International Engineering Congress at Glasgow brought me into contact with the marine engineers and naval architects of many countries.

You attach to the Presidency, so far as I know, one and only one really onerous duty. And that is, the giving of an Address to The Institute. For the marine engineer, properly so called, this is not difficult. He is always prepared to talk at length and instructively about marine engineering, but for the non-engineer things are not quite so simple. In the end it seemed to me that the best thing to do was to follow the cue that you had given in asking me to be your President, and to talk to you a little about the State and marine engineering.

The relations of the State to marine engineering and to marine engineers are both direct and indirect. They are direct in so far as the State as shipowner employs marine engineers to design, build and operate its ships. The chief organ of the State for this purpose is, of course, the Admiralty.

The State is also directly related to marine engineering in that through the Board of Trade it is responsible for giving certificates of qualification as marine engineer, and for employing a number of marine engineers on its survey staff.

The grant of a Royal Charter to The Institute of Marine Engineers was another instance of direct relationship with the State.

Indirectly the State is connected with marine engineering and marine engineers through the powers exercised by the Board of Trade in relation to ships; through action it takes which either helps or hinders the welfare of the shipping and shipbuilding industries and, therefore, affects the field of activity of the marine engineer; and through its inquiries into casualties, which may affect the future careers of marine engineers responsible. The exercise by His Majesty of his power to recognise by medal or other decoration exceptional service by marine engineers is another example of the connection of the State and the marine engineer.

Turning first to the direct relations of the State with marine engineering, it is well to remember that progress in marine engineering has been mainly due to British engineers. At one time, we are informed, 80 per cent. of the world's sea-going steam vessels came from British yards. With few exceptions, one very important one being the introduction of the Diesel engine, all the greatest improvements in marine engineering, as in steamship construction, originated in this country, and from the very beginning of marine engineering the State played a very important part.

An early example is found about the seventh decade of the 18th century, when the Government made a grant of £5,000 to Dr. Lind, Surgeon-in-Charge of Haslar Hospital, for introducing distillation of fresh water from sea water on board ship.

Then it is worth recalling that the British Government gave, early in the 19th century, financial assistance, though on a very small scale, to William Symington whose marine engine patent of October, 1801, was one of the earliest and greatest steps in marine engineering.

To go further afield, the Government of India about 1823 offered 20,000 rupees to a British subject who would permanently establish steam communication with India before the end of 1826. Though the conditions of the reward were not fulfilled, the ship built for the purpose, the "Enterprise", reached Calcutta and was ultimately purchased by the Indian Government.

These were interesting indications of Government interest in marine engineering, but the Admiralty as shipowner and as shipbuilder gave much more solid help. The first steam vessel, H.M.S. "Lightning", to take part in naval warfare and the first for the command of which a commission was granted was built for the Admiralty at Deptford in 1823 and engined by Maudslays.

In 1830 it was decided to send mails to the Mediterranean by steam and the Admiralty, despite the views expressed by the First Lord, Lord Melville, in 1828 "that the employment of steam "vessels was calculated to strike a fatal blow to the "naval supremacy of the Empire", inaugurated, with steam vessels, the long-distance overseas mail service. Most of the vessels used were built in the Royal Dockyards and two of the naval officers employed (Commander Otway and Engineer John Dinnen) left records invaluable for the history of marine engineering.

In 1837 another Government department, the Post Office, placed a mail contract, to be carried out by steam vessels, with the Peninsular Steam Navigation Company for Spanish ports. This was extended to other Mediterranean ports, and the Company adopted the name of the Peninsular & Oriental Steam Navigation Company, under which it has ever since carried on the mail work begun by the Navy.

The Indian Government showed further interest in steam by getting Robert Napier to build the "Berenice" in 1836 for their service, mainly for mail work.

The Admiralty contributed to the establishment of the trans-Atlantic steamship services, on which much pioneering work was done in the fourth decade of the 19th century, by sending H.M.S. "Rhadamanthus", built by the Admiralty at Devonport, to the West Indies in 1833, a voyage in which steam was intermittently used. Then the Post Office took a hand by giving a grant to the Cunard Company for carrying mails to the United States—the first to be given for this work.

By this time the Admiralty was making such great progress in the number, size and power of its steam (paddle-wheel) warships, that in 1837 a steam department was set up at the Admiralty and an engineering branch was organised the same year. The Admiralty requirements gave much work to marine engine builders, Admiralty custom greatly helping marine engineering firms like Boulton, Watt & Co., the Butterley Ironworks and Maudslay Son & Field, to whom most of the naval contracts went in the first half of the nineteenth century. These early vessels did more towing than fighting and were valued by the Navy for that purpose.

When screw propulsion came into use (and, by the way, the first British ship with screw propulsion, though it is true it was operated by a hand capstan, was a Government transport, the "Doncaster" in 1802) the Admiralty, once converted, gave great encouragement to its development, screw propulsion being adopted for all classes of naval vessels after the famous tug-of-war between the "Rattler" and the "Alecto" (in 1845).

The Admiralty did not contribute much at first to the development of the compound engine, but this altered when the Admiralty Committee on Designs, appointed in 1871, reported in favour of fitting compound engines in all future naval ships.

A little later, in 1875, Froude, with Admiralty help, began his classic experiments on the resistance of ships, which gave to the world something the engineer had to know, a means of assessing the power required to drive his ship through the water. Froude laid the foundations of all experimental tank work, which is now being continued by the Admiralty, by private firms such as John Brown's and Denny's, by the National Physical Laboratory and in every shipbuilding country in the world.

The requirements of warships, with their steadily increasing size and speed and weight of armament, led to great developments in steam auxiliaries of all kinds.

The invention of the torpedo and its adoption by the navies of the world gave, under the leadership of the Admiralty, a great impetus to air compression machinery and electric generating plant, and to the construction of faster and faster war vessels of all classes. The Yarrow boiler was originally designed for destroyers.

Admiralty requirements aided the development of the triple-expansion engine, and when the "Turbinia" had shown what she could do in 1897, the Admiralty ordered a turbine-driven destroyer. The result of the work of the Admiralty Committee on Designs (1904) under Admiral Fisher was the decision to fit turbines for all ships of the Royal Navy, and the laying down of the turbine-driven "Dreadnought" at Portsmouth in 1905, with all that that implied.

The development of the internal-combustion engine, the invention of which is regarded by many laymen, in view of its application, as one of the greatest disasters of modern times, has been furthered by Admiralty work mainly in respect of submarines.

Besides the enormous stimulus given to marine engineering by the Admiralty as shipowner and shipbuilder, it has also contributed to technical and scientific marine engineering progress by carrying out various enquiries and trials. To take a few examples, in 1849 it initiated an inquiry into the working pressure of marine boilers. At about the same time investigations and trials of coals suited to the steam Navy were carried out at Admiralty cost and direction. In 1874 the Admiralty Committee on Boiler Corrosion began inquiries which extended over four years and were of great value to marine engineering. The Admiralty Committee on Designs in 1892, to report on the machinery for warships, was an important contributor to "the battle of the boilers", and reference has already been made to the Admiralty Committee on Designs appointed in 1904 under Admiral Fisher.

The adoption of oil fuel, so important to naval vessels, was largely due to the work of the Admiralty Experimental Station at Portsmouth.

In the matter of technical education, the Admiralty opened in 1811 the first British School of Naval Architecture at Portsmouth, and in 1837 it promulgated orders for the training of engineers for the Navy. In 1843 it opened Dockyard Schools for apprentices and in 1864 it opened the Royal School of Naval Architecture and Marine Engineering at South Kensington (the first school in this country for training marine engineers), which was later transferred to the Royal Naval College, Greenwich.

This is a very brief reference to the great part played by the Admiralty in marine engineering and it is perhaps useful, in these troubled days, to remember that the efforts given to produce successful fighting machines have often served the gentler arts of peace.

The other organ of the State which has the most direct relations with marine engineering is the Mercantile Marine Department of the Board of Trade. I do not know of any other Department to which Parliament has given such detailed powers of control—if you will, of interference—as those given to the Board of Trade over the operations of the shipping, shipbuilding and marine engineering industries. This has been the case since the establishment of the Department under the provisions of the Mercantile Marine Act, 1850. Up to that time nine different Government departments were responsible for administering merchant shipping laws embodied in some 48 Acts of Parliament. The Act of 1850 centred the general statutory supervision of the Mercantile Marine in one Department, and subsequent legislation has increased the powers of the Board of Trade to make rules and regulations and to issue instructions for the survey of ships and for many things that pertain to the employment of ships, their officers and crews.

It is worth while correcting a popular fallacy that legal restrictions as they exist to-day in these industries are due to a modern desire to interfere with the freedom of maritime transport. That is quite wrong. When the sea carriage of goods and passengers between ports in a country was extended to ports in other countries, experience soon showed the necessity for some degree of uniformity in maritime practice and common customs and usages came into being. States embodied these customs and usages in legal enactments. To go no further back than the sixth century you find the earliest sea law—the Rhodian—included by Emperor Justinian in his code of laws. It contained passages dealing with measurement of capacity, sea-worthiness, wages of crews, rights of passengers, anchors and cables, masts, bolts, collisions, wrecks, salvage, demurrage, charter party, bills-of-lading, etc. This Rhodian sea law has formed the foundation of all subsequent maritime law. So from earliest times sea transport, in all its aspects, has been the subject of State regulation.

In this country merchant shipping legislation has, for the last 80 years, been unceasing, reflecting the changes from sail to steam—in 1824 we had only 114 steamers with an aggregate net tonnage of 11,733 tons—from wood to iron and steel—the first sea-going iron ship was built in 1832—and the changes brought about by the development of new types of machinery and fuel so well known to members of this Institute.

"The letter killeth, but the spirit giveth life". Legislation is of very great importance, but the spirit in which it is applied is at least equally vital. There are those alive to-day who tell me that in early days the Department issued instructions, rules and regulations without consulting shipowners, shipbuilders and marine engineers. But for many years now the policy of the Department has been to seek the co-operation of those concerned before any substantial change is made in its instructions, rules and regulations. If the questions to be dealt with are specially difficult, the practice is to appoint departmental committees to enquire into the subject and to obtain help from the industries in manning those committees. The recent committee dealing with the examinations for marine engineers seeking Board of Trade Certificates of Competency in which this Institute assisted is a case in point. Since 1906 we have had the help of the Merchant Shipping Advisory Committee—a statutory committee so constituted as to express the views of the various interests concerned with the Merchant Navy—on which marine engineers have been represented from its beginning.

This policy does not, and should not, relieve the Government Department of its responsibility for initiating and pursuing measures for the improvement of conditions in the Mercantile Marine, but it ensures that measures proposed shall receive enlightened criticism from those most directly affected. Such a policy is made possible by the essential fairness of our people, and the results of their deliberations are the best tribute to the work such committees have done and continue to do.

It is important to note that, despite numerous Acts of Parliament, real supervision of ships by the State in this country does not go further back than 1850; and just about a decade before that there took place one of the most important events in our legislation touching the relation of the State and industry. This was the appointment of factory inspectors in 1833, followed by the first mines inspectors some 10 years later and by the first Board of Trade Surveyor in 1851.

When the State took this step it did two things of great importance. First, it went a long way to make its orders effective and secondly—and this was the greater change—it brought into the relations between the State and industry the independent, impartial, experienced person, who on the one side could advise the State what could reasonably be expected from the industry and on the other could interpret to industry what was couched in the ambiguous language of the law, the necessity of securing certain public interests.

This was one example of the tendency to substitute for the idea of the State as authoritarian the idea of the State as a public service. Under it the official representative of the State department becomes less and less the wielder of a brief authority and more and more the co-operator, the adviser, the helper, the expert in certain aspects of industrial activity.

The change is enormously important. In contact with the inspector or surveyor industry finds that "the higher power than they can contradict" is represented by accessible and tolerable creatures, often human, always possessing at least the outward semblance of humanity.

The mind which lies uneasily dumb beneath paper regulations, so clearly drafted as to appear mere jargon, or cold and stilted official letters, stirs to indignant activity in face of a human critic, at sound of a human voice, and finds that what can't be endured can often be cured by reasoned argument. From that to the stage of friendly consultation and collaboration is a short step, and that is the way the relations between the State and the marine engineer are best—and usually—maintained.

In the case of marine engineering—and indeed in the case of any living and changing industry—such relations are vital. The adaptation of State requirements to changing conditions can only be wisely made by co-operation between those who practise the industry and the advisers of the State. The consolidating Merchant Shipping Act is that of 1894, to which the 1906 Act made valuable additions in the direction of empowering the Board of Trade to deal with the problems of shipping by rules, regulations and instructions to surveyors. If anyone looks at the changes in marine engineering practice since 1894 he will appreciate that only an elastic system could prevent State regulation from hampering and crippling progress. Such a system we have, and it works well because of mutual help and co-operation between industry and State officials.

No one looking at the world to-day would, I imagine, prophesy that the State will play a decreasing part in the operations of industry and commerce. The public interests to be safeguarded in industrial operations are not less important than during the great mechanical improvements of the nineteenth century. In addition, the activities of certain governments in controlling, stimulating and assisting national effort are always likely to call for corresponding or countervailing measures by other states. But, given the kind of relations between the representatives of industry and of the State which exist in the case of marine engineering—as well as the other branches of the shipping and shipbuilding industries—we may hope that the activity of governments may increase, rather than handicap, industrial activity.

I would not end this address without thanking the marine engineers for their steady, unfailing and effective help to the work of the Mercantile Marine Department and assuring them of the Department's admiration and appreciation of their efficiency, energy, resource and good comradeship.

Prior to the reading of the foregoing Address, the **Chairman of Council** (Mr. R. Rainie, M.C.), referred to the circumstances in which they were meeting (i.e. within a few hours of the agreement which had been reached at Munich between the principals of the four countries chiefly concerned in the Czecho-Slovakian crisis). On his suggestion and with the President's approval, the members present unanimously agreed to send the following telegram to the Prime Minister :—

"The Rt. Hon. Neville Chamberlain,
10, Downing Street, S.W.1.
Members of Institute of Marine Engineers assembled at opening meeting of session desire to express deepest gratitude for your great achievement on behalf of humanity in preserving European peace.
FOLEY (President),
RAINIE (Chairman of Council)".

The Chairman thereupon introduced the President, who was heartily welcomed by the large audience, in the following terms : "The Institute of Marine Engineers has departed from its usual practice in electing to the Presidential Chair neither a shipbuilder, a shipowner nor an engineer, but a distinguished civil servant.

I have had the opportunity of meeting our President on occasions when he was not engaged on departmental affairs, but engaged in those pursuits of judiciously eating, mildly drinking and gracefully dancing, when the cloak of office and officialdom being discarded the real human being is more clearly discerned, and I congratulate you in consequence of your departure from established custom.

Shipowners, shipbuilders and engineers elected in the past to our Presidential Chair are, so to speak, in the business and are usually well known to you all, but I have it from Sir Julian himself that his life has been spent in what he described as a 'silent service', and possibly you are not yet fully aware of the high qualities of mind, heart and character possessed by the man you have honoured this year.

Born and educated in Liverpool and, shall I say, polished at London University, our President entered the Transport Department of the Admiralty in 1907. He rose through various grades to be Director of Military Sea Transport in the Ministry of Shipping and later to be Director of Sea Transport under the Board of Trade, finally reaching the elevated position he now occupies as Head of the Mercantile Marine Department and Under Secretary of the Board of Trade.

You will see, therefore, from this record that he has been closely associated with the administration of that branch of industry which gives employment to the majority of our members, and he is, I suggest, fortunately for us, breaking away from the tradition of the 'silent service' to which he belongs to address us on 'The State and the Marine Engineer'. I would ask you, Mr. President, to deliver that Address".

On the conclusion of the Address the **Chairman of Council** again rose and said : "In introducing our President to this meeting I remarked that I congratulated The Institute on its departure from established custom, and I now feel sure you will be prepared to congratulate yourselves. We have listened to many Presidential Addresses in this hall and that which you have heard to-night has, I suggest, given marine engineers a new angle from which to look upon their relationship to the State and those who act for the State.

We, and the majority of citizens who are outside that circle which encloses in comparative security our Civil Service, have been apt to think that there is a general tendency for people in Government offices to underrate the intelligence of the man in industry and commerce, this point of view, no doubt, particularly applying to the Treasury. We must have listened, therefore, with great pleasure and a considerable amount of relief to our President's Address, and in particular to that section of it which dealt with the Mercantile Marine Department of the Board of Trade's relationship with shipowners, shipbuilders and marine engineers.

We appreciate, I am sure, his correction of what he calls the popular fallacy that legal restrictions in our industry are due to a modern desire to interfere with the freedom of maritime transport, and appreciate still more the motives which he indicates actuate the Department of which he is the Head, which motives he summed up in the quotation 'the letter killeth but the spirit giveth life'. It is with the greatest pleasure, gentlemen, that I propose that you accord a hearty vote of thanks to our President, which proposal I will now ask the Vice-Chairman of Council, Mr. Timpson, to second".

The **Vice-Chairman of Council,** seconding the proposal, said : "Mr. Rainie has, I think, clearly expressed your feelings. We must congratulate our President on his excellent Address and must also congratulate ourselves on having secured so competent and able a President. I have much pleasure in seconding the vote of thanks".

The **President** suitably acknowledged the vote of thanks which the meeting expressed by prolonged acclamation.

ASSOCIATE MEMBERSHIP EXAMINATION, MAY, 1938.

The following are the papers set for the recent Examination:—

APPLIED MECHANICS.

Monday, May 16th, 1938. 10 a.m. to 1 p.m.

Not more than *six* questions to be attempted.

1.

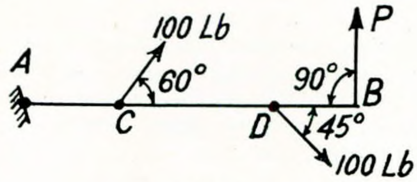


FIG. 1.

An arm AB (Fig. 1) hinges smoothly on a bearing at A and coplanar forces are applied to it as shown. The weight of the arm is 50 pounds and its centre of gravity is 3 feet from A. Determine the magnitude of the force P and the magnitude and direction of the force applied to the arm by the bearing at A. AC=2 feet, CD=3 feet, AB=7 feet.

2.

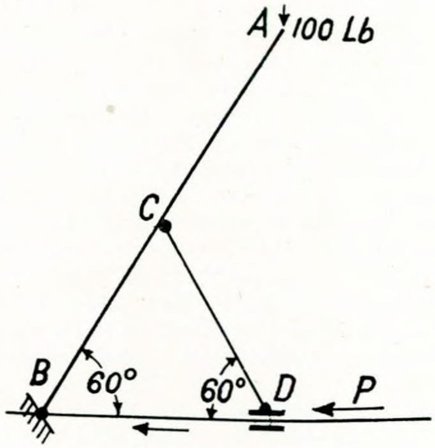


FIG. 2.

In the mechanism shown (Fig. 2) AB is 10 feet long and weighs 100 pounds. Its centre of gravity is at the mid-point C. CD is of uniform section and weighs 50 pounds, D being constrained to move in a straight line. Find the value of the horizontal force P acting on the sliding block at D to prevent motion if a load of 100 pounds is applied at A. Neglect frictional resistances.

3.

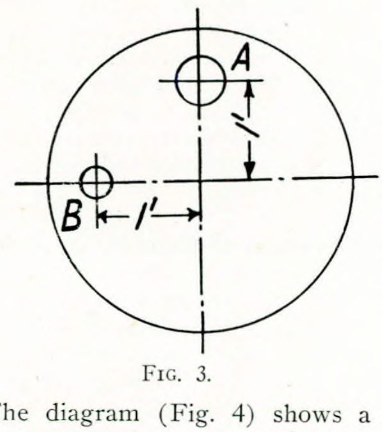


FIG. 3.

State precisely what is meant by each of the following physical quantities: mass, momentum, moment of momentum, and moment of inertia. Which of these, if any, are vector quantities? Give reasons.

A uniform disc (Fig. 3) is to revolve about an axis through its centre. Two holes have been drilled, A $1\frac{1}{2}$ inch diameter and B 1 inch diameter. Determine the position of a third hole 1 inch diameter in order to secure running balance.

4. The diagram (Fig. 4) shows a crank and connecting rod mechanism. If the crank is rotating clockwise at 300 revolutions per minute, determine the torque required at the crankshaft to accelerate the sliding block B when θ is 90°. The block B weighs 64 pounds.

AB= 4 feet, AC= 1 foot.

Prove any formula used.

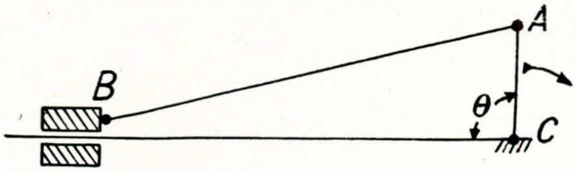


FIG. 4.

5.

FIG. 5.

Fig. 5 shows a light batten AB having a body weighing 16 pounds fixed to its outer end at B. The inner end at A is securely fixed to a wall. If the stiffness of the batten is such that the 16 pounds applied steadily causes a deflection of 2 inches, calculate the periodic time of an oscillation. If the amplitude is 4 inches what is the maximum speed of B? Prove any formula used.

6.

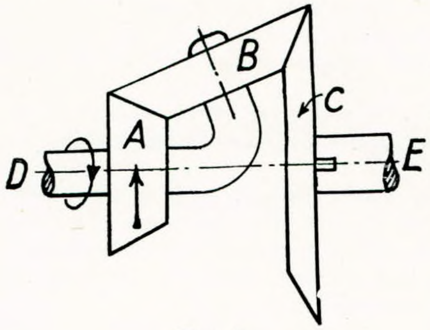


FIG. 6.

In the epicyclic gear shown (Fig. 6) the shaft D carries round with it the wheel B. D revolves at 200 revolutions per minute clockwise; A 100 revolutions per minute anticlockwise. Determine the speed and direction of the shaft E to which C is attached. A has 60 teeth, B 45 teeth and C 90 teeth.

7.

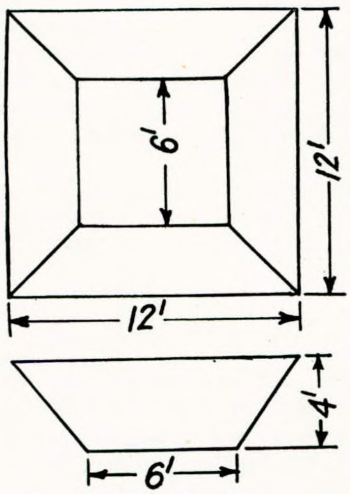


FIG. 7.

A vessel shaped as an inverted frustrum of a pyramid as shown (Fig. 7), is filled with water. Find the whole pressure of water on one of the sloping sides and the centre of pressure on that side.

8. State Bernouilli's Theorem. Obtain an expression for the loss of head due to a sudden enlargement in a pipe line running full. Any assumptions made should be clearly stated.

9. Show how to calculate the value of the gyroscopic couple acting on the main bearings of a turbine rotor when a ship is turning or pitching. Establish from first principles any formula used. Give diagrams to show exactly how the forces would act in each case.

10. Explain by the Principle of Dynamical Similarity how a model may be used to study experimentally the resistances to motion of a large vessel.

PROPERTIES AND STRENGTH OF MATERIALS.

Monday, May 16th, 1938. 2 to 5 p.m.

Not more than *five* questions to be attempted. All questions carry equal marks. Credit will be given for orderly statements showing how the numerical answers are obtained.

1. Describe the construction and method of operation of a tensile testing machine capable of testing to destruction mild steel specimens of, say one square inch cross sectional area. Illustrate your answer with simple line diagrams.

2. Derive an expression showing the connection between the moduli of elasticity and rigidity, introducing any other elastic constant necessary.

A bar of steel 1·5 inches diameter was subjected to a tensile load of 10 tons. An extension of 0·0034 inches was measured on an 8 inch test piece and the change of diameter was found to be 0·00019 inch. Find the value of the modulus of rigidity for this material.

3. A beam is 40 feet in length and is freely supported on two supports. One support is distant 6 feet from one end and the other support is 10 feet from the other end of the beam. The total loading of the beam amounts to a uniformly distributed load of 0·5 ton per foot run. Sketch and dimension the shear force and bending moment diagrams and calculate the position of the points of contraflexure.

4. In the construction of a turbine rotor the discs are invariably manufactured from a steel forging. What stresses are these discs subjected to when the turbine is running? Give the reason for preliminary heat treatment of these discs before erection and indicate how this may be carried out in practice.

5. Apply the Theorem of Three Moments to find the reactions at the three supports of a continuous beam whose spans are 200 feet and 150 feet. The uniformly distributed loading is 2 tons per foot run.

6. Derive a formula for finding the diameterof a shaft, given the safe limit of shear stress and a steady applied torque. In actual practice circumstances may arise which may cause this formula to be modified. State what these conditions may be and what modifications would be necessary.

7. Show that when a load is suddenly applied to a bar, but without shock, the intensity of stress produced is double that produced by the same load applied gradually.

A steel bar 50 inches long is subjected to tension by a weight of 400 pounds which falls vertically 3 inches before commencing to stretch the bar. Find the diameter of the bar so that the stress intensity produced may not exceed 18,000 pounds per square inch.

Take $E = 30 \times 10^6$ pounds per square inch.

8. Derive an expression from which the deflection of a close coiled spring may be calculated, stating clearly the symbols and units adopted. In such a spring there are 10 free coils of 3 inches mean diameter. The axial load is 20 pounds. If the spring is made of steel wire of diameter 0·25 inch and the modulus of rigidity is 12×10^6 pounds per square inch, find the maximum shear stress and the total deflection.

9. Extensive use is now being made of special or alloy steels. Write an essay giving an account of some of the modern developments in the use of such steels. Indicate the composition and mechanical properties of the examples you select, and the heat treatment necessary to give the specified properties.

HEAT ENGINES.

Tuesday, May 17th, 1938. 10 a.m. to 1 p.m.

Not more than *six* questions to be attempted. Callendar's Steam Tables, Temperature-entropy and Total Heat-entropy charts are supplied for the use of the candidates. All questions carry equal marks.

1. One pound of air at atmospheric pressure (14·7 pounds per square inch absolute) and at 15° Centigrade is compressed to 300 pounds per square inch absolute in a jacketed cylinder. If 10 pounds of cooling water are supplied per pound of air compressed, calculate the rise in temperature of the water on the assumption that the whole of the rejected heat is absorbed by the cooling water. The law of compression is $PV^{1 \cdot 2} =$ a constant. $R = 96 \cdot 3$ foot pounds per pound per degree Centigrade, $\gamma = 1 \cdot 4$, and $C_v = 0 \cdot 169$.

2. What are the advantages of compounding in steam engine practice? Determine the cylinder diameters of a compound condensing engine which is to develop 250 I.H.P. under the following conditions:—

Admission pressure to H.P. cylinder 120 pounds per square inch absolute.
Exhaust pressure from L.P. cylinder 3 pounds per square inch absolute.
Cut-off in H.P. cylinder at one third stroke.
Total ratio of expansion 12.
Mean piston speed 560 feet per minute.
Diagram factor 0·88.

Neglect the effect of clearance and assume no drop in pressure at release from the H.P. cylinder, and hyperbolic expansion.

3. The analysis of a sample of Welsh steam coal by weight was Carbon, 87·8 per cent.; Hydrogen, 4·10 per cent., and the remainder ash. Find the minimum quantity of air required for complete combustion of 1 pound of this coal.

If 18 pounds of air are supplied per pound of coal, find the weight of the products of combustion and also the percentage composition of the products of combustion by weight. Also find the percentage analysis of the dry flue gas.

4. Describe with the aid of suitable sketches the cycle of operations of a four stroke Diesel engine.

Obtain an expression for the ideal thermal efficiency of a Diesel engine in terms of the ratio of specific heats, the ratio of compression, and the ratio of the volume when the fuel valve closes to the clearance volume.

5. The following figures were obtained on a test of a new type of lightweight six cylinder oil engine. The engine is single acting and operates on the four stroke cycle. The bore is 12¾ inches and the stroke 13½ inches.

R.P.M.	250	300	350	400	450	500
B.H.P.	65	122	203	304	433	600
Fuel in pounds per hour ...	30·9	51·3	78·2	112·6	160·5	228

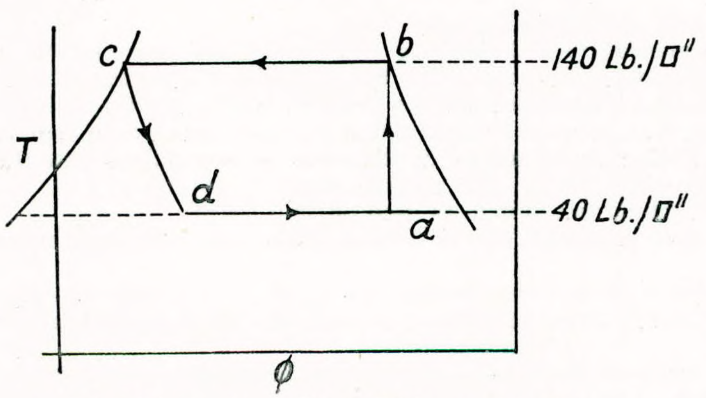
The calorific value of the fuel oil was 19,000 B.Th.U. per pound. Plot the following curves on a base of revolutions per minute :—

(*a*) Fuel in pounds per B.H.P. hour.
(*b*) Brake mean effective pressure in pounds per square inch.
(*c*) Percentage brake thermal efficiency.

Comment on the performance of the engine from the curves plotted.

6. Briefly describe with the aid of a neatly drawn sketch how tip leakage can be prevented in a Parsons reaction turbine. In a stage of a reaction turbine the inlet and outer angles of both moving and fixed blades are 36° and 22° respectively. Themean blade circle diameter is 4 feet, the blade height is 5 inches, and the speed is 1,200 revolutions per minute. If the mean steam pressure for the stage is 40 pounds per square inch absolute and the dryness fraction 0·94, calculate the weight of steam flowing through the stage per second.

7.



The figure shows a temperature-entropy diagram for the theoretical cycle of an ammonia refrigerating plant. The plant is required to make half a ton of ice from and at 0° Centigrade per hour. The heat extracted during evaporation of the NH_3 is only 85 per cent. of that shown on the diagram.

From the following data determine (*a*) the weight of NH_3 circulating per minute, (*b*) the horse power required to drive the compressor, and (*c*) the bore and stroke of the twin cylinder single acting compressor.

Total heat at a=274 C.H.U. per pound.
Total heat at b=310 C.H.U. per pound
Total heat at c= 22 C.H.U. per pound.
Dryness fraction of wet NH_3 at a=0·91.
R.P.M. of compressor=150.
Mean piston speed=150 feet per minute.
Mechanical efficiency of compressor=65 per cent.
Latent heat of ice=80 C.H.U. per pound.
Specific volume of dry-saturated NH_3 vapour at 40 pounds per square inch absolute=7·0 cubic feet per pound.

8. Describe with the aid of a neatly drawn diagrammatic sketch and a PV diagram, the operation of a two-stage air compressor. What are the advantages of fitting an intercooler and why is it necessary for the cylinder clearance volumes to be kept down to a minimum?

9. The inlet pressure to the nozzle group of a stage of an impulse turbine is 40 pounds per square inch absolute. The inlet steam temperature is 440° F. Determine the outlet area of the nozzle group in square inches, the outlet pressure being 10 pounds per square inch absolute and the steam flow 12 pounds per minute. The nozzle efficiency is 92 per cent. The specific volume of superheated steam may be calculated from Callendar's equation :—

$$V = \frac{1{\cdot}2464\ (H - 835{\cdot}2)}{p}$$ where H is the total heat in B.Th.U. per pound.

10. How does feed heating by bled steam improve the thermal efficiency of a steam turbine?

A turbine is supplied with steam at 160 pounds per square inch absolute with 180°F. of superheat and exhausts at one pound per square inch absolute. Steam is bled from a stage where the pressure is 18 pounds per square inch absolute. Determine the weight of steam bled per pound of feed water and also the theoretical thermal efficiency.

ELECTROTECHNOLOGY.

Tuesday, May 17th, 1938. 2 to 5 p.m.

1. Explain the general construction and principle of operation of the rotary converter.

A supply of 10,000 volts is connected through a step-down transformer to the slip rings of a rotary converter and is required to produce 500 volts on the direct current side of the machine.

If the rotary windings on the alternating current side are connected to six slip rings in diametrical formation, what voltage is required between the adjacent slip rings of the converter?

2. What precautions should be observed by a man in charge of lead-acid accumulators in order to maintain the battery in first class condition?

Give reasons for each precaution mentioned and explain the probable results of non-compliance with the rules laid down.

3. Illustrate the arrangement of three single-phase transformers connected together for three-phase working.

(*a*) With the primaries in delta and the secondaries in star.

(*b*) With the primaries in star and the secondaries in delta.

If the supply pressure is 6,000 volts and the step-down ratio of the transformers is 12 : 1, determine the secondary line voltage in each of the above cases.

4. Explain the meaning of "earthing" and why is it usually advisable to earth all metal protective coverings of cables, appliances, etc.?

Quite recently a fatality occurred under the following conditions :—

A metal table lamp was correctly connected to a 2 pin plug and socket, and near by was a vacuum cleaner correctly connected to a 3 pin plug and socket. The flex of the lamp had been trapped at the lamp holder so that the insulation had been destroyed and the live wire was in contact with the metal part of the lamp. The person killed was holding the lamp and at the same time was in contact with the metal case of the vacuum cleaner. Explain by means of diagrams of connections how the accident happened. The supply was alternating current with earthed return.

5. Describe the "single-conductor" direct current system as used on ship board.

Under what conditions may this system be advocated for British ships, and why is it more popular in ships of Continental countries?

Sketch a wiring diagram showing the necessary switchboard connections, instruments and control appliances for two compound-wound direct current generators arranged to run in parallel on the same busbar on the "single wire" system.

6. Describe with a diagram of connections the Ward-Leonard variable-voltage control system of speed variation for direct current motors.

Give two examples from actual practice in which this system has been found particularly suitable.

7. A single-phase supply has connected to it the following loads in parallel :—

(*a*) A lighting load of 15 amperes, current in phase with the applied voltage.

(*b*) An induction motor taking 20 amperes, power factor 0·75 ($\cos\theta = 0{\cdot}75$. Angle of lag=41·5°).

(*c*) A synchronous motor taking 24 amperes leading 35° in front of the applied voltage.

Determine the resultant current taken from the mains and the phase difference from the applied pressure.

8. A 3-phase induction motor is arranged for star and delta connections. The supply is 430 volts at 50 cycles. Determine the current in each phase winding of the motor, and also in the mains, when connected (*a*) in star, (*b*) in mesh or delta.

Assume the output of the motor in each case to be 150 brake horse power, at an efficiency of 90 per cent., and a power factor of 0·83.

9. What precautions should be taken to protect cables on ship board from mechanical or other damage under the following conditions?

(*a*) Under any circumstances when exposed to risk of mechanical damage.

(*b*) Cables in machinery spaces, or where unavoidably exposed to the weather or to the action of sea water.

(*c*) Cables entering cold-storage chambers.

(*d*) Cables fixed within cold-storage chambers.

(*e*) Cables passing through decks or watertight bulkheads.

10. The dimming of a group of lamps in a theatre is brought about by a non-inductive resistance in series with the circuit. The valve of the resistance is 20 ohms. The supply is 220 volts, 50 cycles, and a current of 5·5 amperes flows with the dimmer in use.

It is desired to substitute an induction coil in place of the resistance. If the resistance of the induction coil is 0·2 ohm, determine the inductance. Compare the power lost in the two dimmers.

11. A shunt motor has an armature resistance of 0·25 ohm and a field resistance of 160 ohms. When running idle the motor takes 3·5 amperes and when fully loaded 30 amperes, the supply being 200 volts. Determine the efficiency of the motor at full load.

NAVAL ARCHITECTURE.

Tuesday, May 17th, 1938. 2 to 5 p.m.

Not more than *six* questions to be attempted. All questions carry the same marks.

1. State the chief advantages and disadvantages of electric welding in ship construction, as compared with rivetting.

2. In the case of an existing tramp steamer of, say 8,000 tons deadweight, built about 15 years previously, a complete survey of the hull is required. Give a list of those items which would require the most careful examination.

3. Make outline sketches of :—

(*a*) A section through a weather deck hatch coaming.

(*b*) A gear-operated lifeboat davit.

4. Give definitions of the following terms :—

(*a*) Length Between Perpendiculars.

(*b*) Freeboard.

(*c*) Gross Tonnage.

(*d*) Floodable Length.

5. State any one of Simpson's Rules for calculating areas. Calculate by Simpson's Rules the capacity in tons of sea water of a tank 24 feet in length, with circular cross section, 10 feet in diameter at one end and increasing at a uniform rate to 15 feet diameter at the other end.

6. For a tramp steamer of about 8,000 tons deadweight for which no data is available, what procedure would be necessary to determine whether the ship would be stable if fully loaded with homogeneous cargo.

7. Explain the effect on ship stability of :—

(*a*) Free water in an empty cargo hold.

(*b*) Freely suspended weights, as for example, when the ship's derricks are lifting a heavy weight.

(*c*) Consumption of fuel from bunkers.

8. For any ***known*** vessel, at service speed in average weather conditions give approximate values for :—

(*a*) Ratio of skin friction to wave resistance.

(*b*) Propeller efficiency.

(*c*) Ratio of EHP to BHP.

(*d*) Fuel consumption in tons per day.

9. A propeller absorbs 3,000 S.H.P. at 120 R.P.M., with a speed of advance of 14·5 knots and propeller efficiency 0·60. Calculate the thrust in tons and the torque in pounds-feet.

10. A certain ship is known to run in fine weather conditions with an "apparent slip" of about minus 0·8 per cent., and with a wake velocity of about 2·5 knots, giving a "real slip" of plus 18·6 per cent. What is the speed of the ship in knots?

MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, May 18th, 1938. 10 a.m. to 2 p.m.

Not more than *one* question to be attempted.

Drawings are to be finished in pencil. In marking the papers the quality of draughtsmanship will be taken into account. All calculations are to be handed in with the drawings.

Either

1. Figure 1 shows a cast steel main bearing member for a small vertical marine steam engine. The maximum bearing load is 11,000 pounds, acting alternately upwards and downwards, the

reactions being taken by the steel columns supporting the cylinders. Design the lower half of the columns, the studs for the bearing, and the bearing cap. Determine the bending moment at the centre of the main member when the load is downwards and when it is upwards, and, neglecting the curvature of the main member, determine suitable dimensions for the central section.

Allowable stresses: columns, where subject to tension only, 5,000, and where subject to alternate tension and compression, 2,500; bearing studs, 7,000; bearing cap, 12,000; cast steel member, 7,000 pounds per square inch respectively.

What is the maximum range of stress in the central section?

Make a fully dimensioned drawing of the assembled member, showing three co-related views in orthographic projection, one half of each view showing a section through the centre line of the bearing, the other half being an outside view.

Or

2. Figure 2 is a pictorial view of the pump levers and pump crosshead for a reciprocating marine engine which has a stroke of 36 inches, and runs at 110 revolutions per minute. The air pump bucket is 17 inches in diameter and the stroke is 20 inches. The bilge pumps, working together, are to be capable of dealing with 6,500 gallons per hour. Determine, from the data supplied, the values of the dimensions indicated by lettering on the figure, and subsequently prepare working drawings of the components shown. Data:—

Air Pump Bucket loading ...	22 pounds per square inch
Bilge Pump loading	15 " " " "
Allowable bearing pressures:—	
Pump Link pins	300 " " " "
Engine Link pins	200 " " " "
Pump Lever gudgeon pin ...	200 " " " "
Allowable stresses:—	
Pump Crosshead	3,500 " " " "
Pump Lever	2,000 " " " "
Air Pump Rod under threads ...	2,500 " " " "

Bolt Table.

Diameter over threads in inches.	*Area at bottom of threads in square inches.*
1·0	0·554
1·25	0·894
1·5	1·299
1·75	1·753
1·875	1·986
2·0	2·311

MARINE ENGINEERING KNOWLEDGE.—Morning Paper.

Thursday, May 19th, 1938. 10 a.m. to 1 p.m.

Not more than *four* questions from Section A and *two* questions from Section B to be attempted. All questions carry equal marks.

Section A.—Boilers.

1. Give an outline sketch of a transverse section of a cellular double-bottomed ship, showing three cylindrical multitubular marine boilers abreast. Show clearly how these boilers are secured in position. Indicate the position of the collision chocks, stating their function, the usual clearances allowed in their fitting, and the possible dangers arising if these chocks are not fitted.

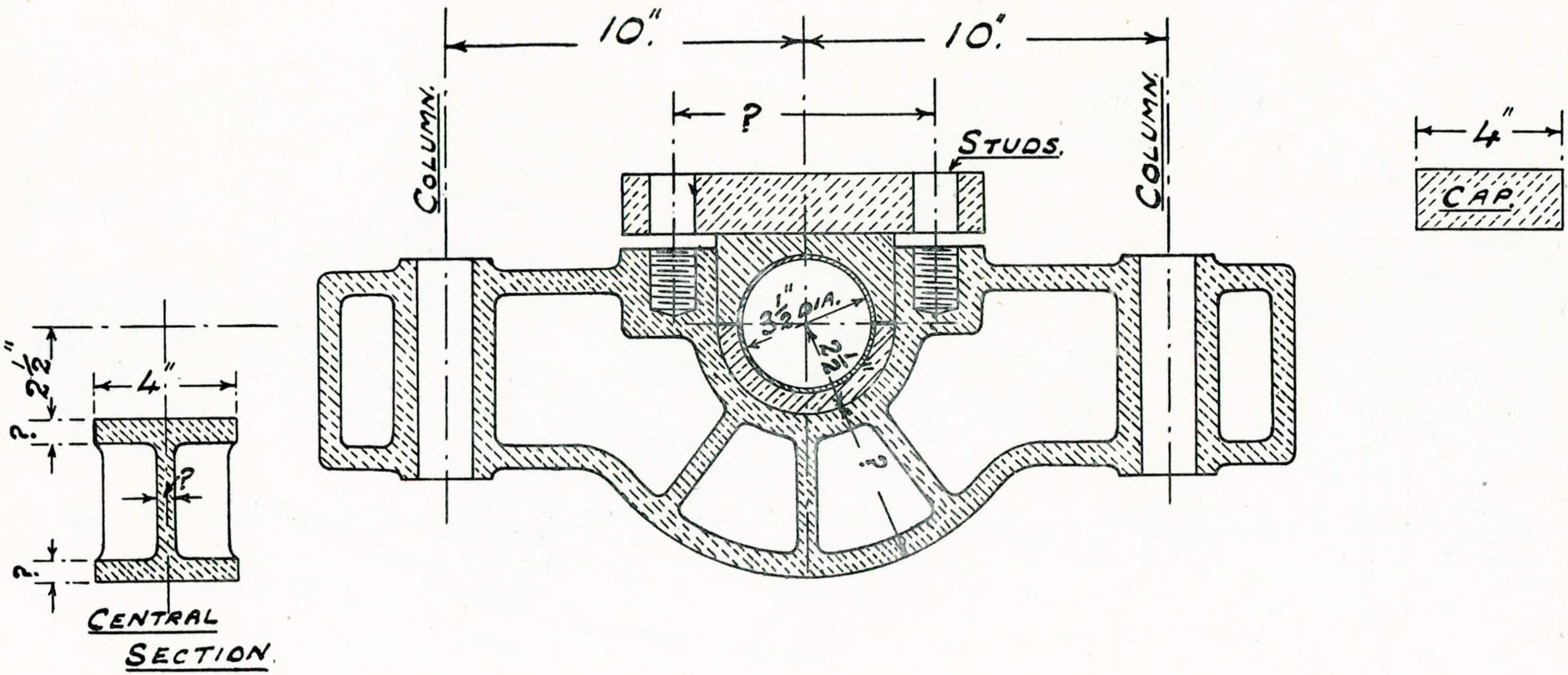
2. Sketch and name three different types of furnace corrugations employed in cylindrical multitubular marine boilers. Outline briefly their manufacture, stating the thickness of metal employed. Indicate by a separate sketch how such a furnace is secured in position. Enumerate the possible causes leading to a failure of the furnace crown, and state how a moderate failure might be repaired.

3. Describe with sketches the complete fittings of a water gauge, employing a hollow column, suitable for recording the level of water contained in a cylindrical multitubular marine boiler. Tabulate the possible causes leading to false readings in the gauge glass, and explain the advantages of the hollow column, when testing the gauge to ascertain the true water level in the boiler.

4. Describe an internal steam pipe, an internal feed pipe, a scum pan, and a zinc plate as fitted to the interior of a cylindrical multitubular marine boiler. Give the reasons for these fittings, and mention the positions of the two pipes and the scum pan relative to the normal water level in the boiler. State the special precaution necessary in fitting the zinc plate.

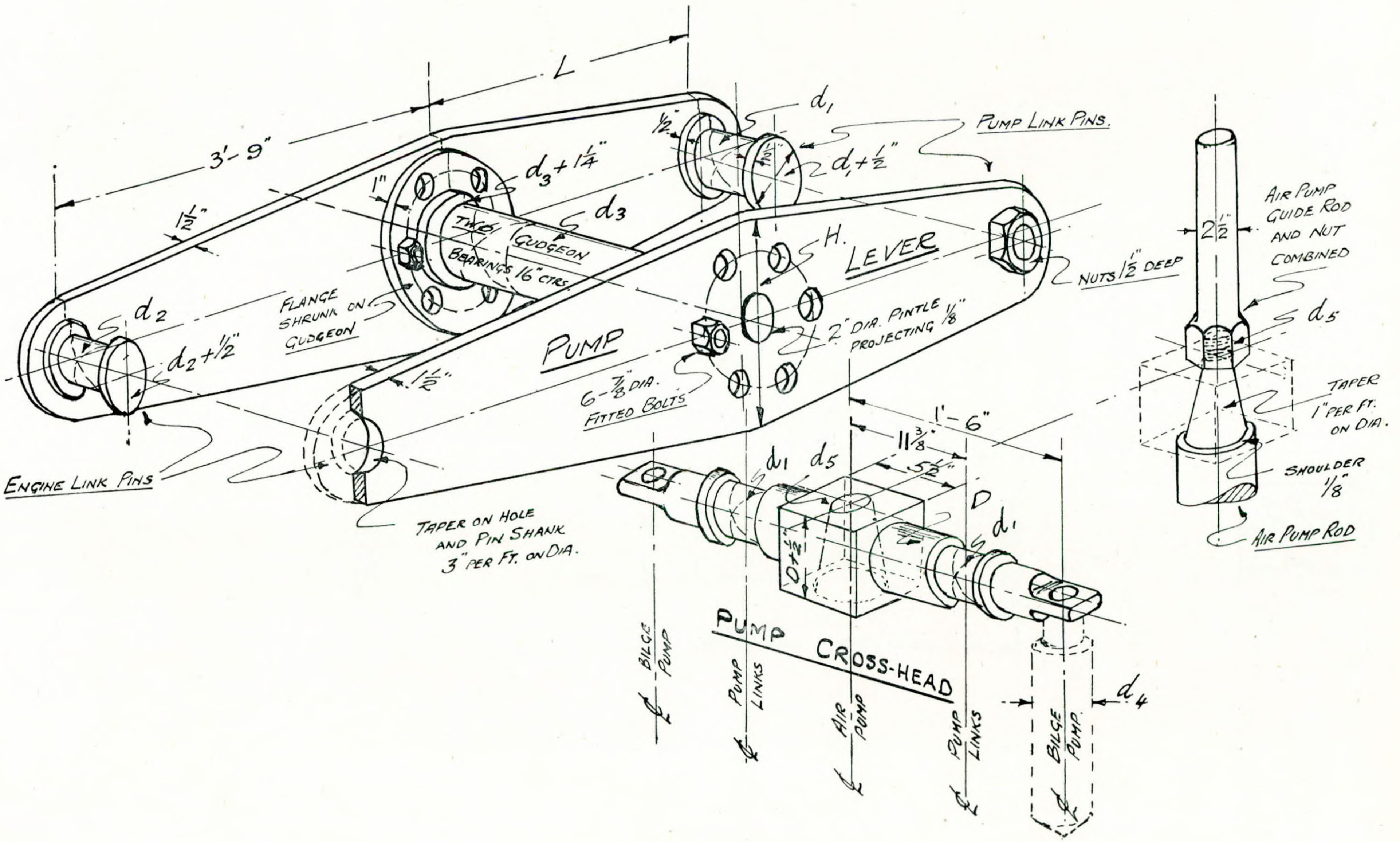
MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, May 18th, 1938. 10 a.m. to 2 p.m.



MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, May 18th, 1938. 10 a.m. to 2 p.m.



5. Sketch a longitudinal section through one of the water drums of a water tube boiler of the Yarrow type, showing particularly the shape and method of attaching the end plates. Give the dimensions of such a drum suitable for withstanding a pressure of 500 pounds per square inch. Indicate how this drum may be secured to the ship's structure and explain how it is accommodated for movement due to its expansion under heat. Tabulate the mountings usually fitted to this drum.

6. Describe the periodic tests that should be applied to the feed water of a water tube boiler, stating the results expected in each case. What are the reasons for the precautions taken when observing these readings? In the event of extra feed being required from what source is this obtained? Would ordinary raw fresh water be suitable?

Section B.—Reciprocating Engines.

1. Describe the construction of a three-throw built up crank shaft, suitable for a marine triple expansion steam engine designed to develop 3,000 indicated horse power, giving the approximate dimensions. State the method of securing the crank pins and journals of each section, and the method of joining each complete unit to its neighbour. Is it necessary for the journals of each crank to be of the same diameter? To what extent are these cranks interchangeable, and how is the thrust of the propeller prevented from inducing additional bending stresses in the webs?

2. Show by a sketch an arrangement for relieving the load acting on the face of a double ported slide valve of a large steam engine. Show also on the same sketch a method of relieving the dead weight of the valve from the eccentric straps. The valve need only be indicated in outline as an outside view.

3. Describe briefly the general construction of a modern pear-shaped condenser used in conjunction with a marine reciprocating steam engine. State the materials used and sketch the ends of a tube, showing its connection with the tube plates and method of making the tube watertight and indicate the directions of flow of the cooling water. To what extent are these tubes subject to deterioration and what means are adopted to overcome these troubles?

4. Sketch one guide shoe and guide plate used for a large marine reciprocating steam engine employing the open type of crosshead. Show how the shoe is attached to the crosshead block, and how the anti-friction metal employed is secured to the shoe. Show how the guide plate is cooled and lubricated and explain how, in the event of it becoming too hot, it might be restored to a normal working temperature without undue damage.

MARINE ENGINEERING KNOWLEDGE.—Afternoon Paper.

Thursday, May 19th, 1938. 2 to 5 p.m.

Not more than *three* questions from Section C or D and *three* questions from Section E to be attempted. All questions carry equal marks.

Section C.—Internal Combustion Engines.

1. Sketch a liner suitable for the cylinder of a large marine Diesel engine, showing the method of attachment and the arrangement for keeping the cooling space watertight. Give the physical properties of a metal suitable for the manufacture of the liner.

2. Enumerate the valves required to be fitted to the cylinder head of a two-stroke cycle port scavenging marine Diesel engine, and state clearly the function of each. Describe how each of these valves is actuated and mention how the adjustment of the lift and the period of opening may be effected.

3. Sketch a section through a simple jet carburetter suitable for a light oil engine, and clearly describe its function. What is the essential difference between this type of engine and the Diesel with reference to the manner of introducing the fuel and the air?

4. Sketch a section through a fuel valve suitable for a large marine Diesel engine designed to work on the principle of blast injection and indicate the exact way in which the fuel is prepared for complete combustion. State the oil and air pressures employed, and mention the advantages and disadvantages of this system.

5. Describe an opposed piston heavy oil engine and discuss the advantages to be gained in this design.

Section D.—Turbines.

1. Describe a method of controlling the speed of a marine steam turbine that can be operated from the forced lubricating oil system. What is the usual oil pressure, and how is this pressure maintained? How can this system be operated by hand in case of emergency?

2. Sketch the connection between the turbine rotor shaft and the first reduction gear pinion of a double reduction turbine. Show how the coupling is lubricated and explain the reason for its flexibility.

3. Describe in detail the procedure observed in "warming up" a marine turbine installation pre-

paratory to running. Mention the vacuum maintained during the process and give reasons for the figure chosen. If the turbine is of the reaction type what special clearances are taken?

4. Sketch the rotor shaft of the high pressure stage of a pressure-compounded marine steam turbine. Include in the sketch two complete adjacent wheels and the diaphragm between them. Indicate how the wheels are secured to the shaft.

5. Describe the instrument fitted to the shaft of a marine steam turbine by means of which the shaft horse power may be calculated. What data are taken from the instrument and the engine in order to calculate the shaft horse power developed. Explain carefully the derivation of the constant found stamped upon the apparatus.

SECTION E.—AUXILIARIES.

1. Describe a direct contact exhaust steam feed heater and give the approximate temperature of water attained. Explain how such high temperatures can be dealt with by the boiler feed pumps.

2. Sketch and describe an expansion joint as fitted in the main line of high pressure steam piping, which provides for alteration of length in the pipe due to changes of temperature. What periodic attention does this joint require?

3. Describe a system of forced draught fitted to a battery of steam boilers. State the temperature and pressure of the air at various points in the circuit. Show by a sketch the control at the furnace front and comment upon the advantages of the system over natural draught.

4. Describe with the aid of a diagrammatic sketch a system of burning oil fuel in a battery of steam boilers. State with reasons the temperature and pressure of the oil in the system.

5. State possible causes which might lead to the outbreak of fire on board vessels using oil fuel installations, and describe how these dangers may be minimised.

STUDENTSHIP EXAMINATION, 1938.

The following are the papers set for the recent Examination:—

ENGLISH AND GENERAL KNOWLEDGE.

Monday, May 23rd, 1938. 7 to 10 p.m.

Both Sections 1 and 2 to be attempted. 40 per cent. of the total marks will be obtainable for Section 1.

SECTION 1.

Write an essay about 500 words in length on one of the following subjects:—

(*a*) The Panama Canal.
(*b*) The origin and development of the British Navy.
(*c*) Impressions of the first year of your apprenticeship.
(*d*) English literature during the last twenty years.
(*e*) The importance of mineral wealth for a nation's prosperity.
(*f*) "Dictatorship or Democracy".

SECTION 2.

Not more than *five* questions to be attempted. All questions carry the same marks.

1. Describe briefly *one* of the following characters: Oliver Twist, Othello, Jean Valjean, David Balfour, Sir Peter Teazle.

2. From what countries do we obtain the following: rubber, iron ore, nickel, copper, silver?

3. With what scientific discoveries do you associate *six* of the following: Faraday, Galileo, Archimedes, Whitworth, Napier, Montgolfier, Pasteur, Newcomen, Savery?

4. State briefly *either* (*a*) the causes leading to the formation of the First Parliament, 1265, *or* (*b*) the influence in England of the Roman occupation.

5. What are the principal planets in the solar system? State the reason given for the belief that there may be life of a form similar to our own on Mars.

6. Who is your favourite author? State briefly what feature of his works you find most attractive.

7. Explain why the English language contains many words of Latin origin.

8. Describe the main achievements of *one* of the following: Wolfe, Cook, Luther, Garibaldi, Disraeli.

9. Write an explanatory sentence about each of the following: atom, molecule, valency, compound, mixture.

10. Name seven important non-European ports in the British Empire, stating the country in which each is situated. Describe the main items of produce dealt with at one of these ports.

Studentship Examination Papers, 1938.

ELECTROTECHNOLOGY.

Tuesday, May 24th, 1938. 7 to 10 p.m.

Not more than *six* questions to be attempted. All questions carry equal marks.

1. Give one instance of the use of each of the undermentioned materials in electrical engineering work or appliances. State the advantages claimed for the choice of the materials for the purposes specified.

Bakelite, slate, phosphor-bronze, wood, silk, asbestos, black tape.

2. A circuit consists of four 100 watt lamps connected in parallel across a 230 volts supply. Inadvertently a voltmeter has been connected in series with the lamps. The resistance of the voltmeter is 1,500 ohms, and that of the lamps under the conditions stated is six times their value when burning normally.

What will be the reading of the voltmeter?

3. What is meant by the periodicity of an alternating current supply? Why has a frequency of 50 cycles per second been chosen as standard?

An alternator driven at a speed of 1,500 revolutions per minute has four pole pieces. Determine (*a*) the frequency of the supply produced, and (*b*) the speed of a 32 pole synchronous motor connected to this supply.

4. Explain clearly the precautions taken in the following cases in order to ensure protection against personal accident and/or fire :—

(*a*) A portable drilling tool in a machine shop.
(*b*) A simple lighting fitting and switch control in a bath room.
(*c*) A direct current motor in a woodworking shop.
(*d*) An electric iron used in a domestic kitchen.

5. Given that one British Thermal Unit equals 778 foot pounds, deduce the value of the multiplier to reduce kilowatt hours to British Thermal Units.

The heat liberated by burning one pound of coal equals 12,000 B.Th.U., and 84 pounds of coal are used per day in heating a house. If the cost of the coal is £2 16s. 0d. per ton and that of electricity ½d. per unit, compare the costs of heating by the two systems. For the purpose of comparison assume the same efficiency for both methods.

6. What is meant by "residual magnetism"?

In what materials is this property most highly developed?

(*a*) Give an example from actual engineering practice in which this property is made use of, and explain its advantages in the cases named.
(*b*) Give an example in which the presence of residual magnetism would be detrimental to the working of the apparatus or machine involved, and explain how it is prevented.

7. Draw a diagram showing the connections of a lamp-charging board and circuit, suitable for charging one or more 6 ampere, 12 volt motor car starter batteries from 230 volt direct current mains.

One such battery is charged for a period of 12 hours at a constant current of 6 amperes. Assuming the average pressure required to charge the battery to be 13·5 volts, calculate the total cost of charging and the cost of the energy taken by the battery with electricity at 2d. per unit.

8. An escalator at a tube station is operated by an electric motor from 550 volt mains. Each step of the escalator is 8 inches high and there are 150 steps in actual use when running. If there are 50 people standing on the escalator of an average weight of 130 pounds, and the journey takes 40 seconds, what is the brake-horse power output of the motor, assuming the efficiency of the gearing to be 75 per cent.?

9. Draw an explanatory diagram of the construction of the apparatus and connections required for a simple battery-bell circuit.

Explain the actions taking place in the various components of the circuit when the bell is being rung.

10. What is meant by "power factor", and why is it desirable to maintain it as near unity as possible? Illustrate your answer by reference to the following example :—

A motor takes 200 kilowatts at full load when connected across 500 volt mains and operates at a power factor of 0·75. Means are taken whereby the power factor is raised to 0·95. The charges for electricity are on a basis of £4 10s. 0d. per kilovolt-ampere of maximum demand per annum, plus 0·5 pence per unit.

Studentship Examination Papers, 1938.

MATHEMATICS.

Thursday, May 26th, 1938. 7 to 10 p.m.

Not more than *six* questions to be attempted. All questions carry the same marks.

1. (*a*) Solve the equations (i) $3x^2 - 2x - 4 = 0$

(ii) $x + 2y + z = 7$

$3x + 7y + z = 5$

$2x - y - z = 3$

(*b*) From the formula $T = 2\pi\sqrt{\frac{k^2 + h^2}{gh}}$ find h if

$T = 4$; $k = 2{\cdot}5$; $g = 32$; π may be taken as $\sqrt{10}$.

2. Prove that if N is a positive number $\log_{10}\sqrt{N} = \frac{1}{2}\log_{10}N$.
Using logarithms

(*a*) find the value of f, given that $f = \frac{4{\cdot}274}{\pi}\sqrt[3]{t^3 - a^3}$ where $t = 7{\cdot}24$, $a = 6{\cdot}19$ and $\pi = 3{\cdot}142$.

(*b*) find the value of t given that $\frac{t}{t_0} = \left(\frac{p}{p_0}\right)^{\frac{s-1}{s}}$

where $s = 1{\cdot}4$, $p = 3{\cdot}27\ p_0$ and $t_0 = 520$.

3. If $e = 2{\cdot}718$ prove that $\log_{10}N = 0{\cdot}4343 \log_e N$ where N is any positive number. Hence find the values of $\log_e (2{\cdot}34)$ and $\log_e (0{\cdot}716)$.

If $P = p_1\left(\frac{1 + \log_e r}{r}\right) - p_2$

calculate the value of P, if $p_1 = 62{\cdot}4$, $p_2 = 17{\cdot}6$ and $r = 3{\cdot}2$.

4. A rectangular tank with a square base of side x feet and no lid is to have a volume of 10 cubic feet. Prove that if the tank is to be made of sheet metal of negligible thickness the area of sheeting is $x^2 + \frac{40}{x}$ square feet.

Plot a graph to show the variation of this area with x, from $x = 1{\cdot}0$ to $x = 5{\cdot}0$, using as large a scale as possible. From your graph find the value of x for which the area is least.

5. The cross-section of a prism is an equilateral triangle of side 12 inches. One plane end is perpendicular to the length while the other is oblique so that the parallel edges of the prism are of lengths 9 inches, 14 inches and 22 inches. Calculate the angles and the lengths of the sides of this oblique end.

6. A trough has a rectangular base 40 inches long and 8 inches wide. The sides and ends slope outwards from the base at 45 degrees. If the depth of the trough is 6 inches, find the number of gallons of water required to fill it. ($6\frac{1}{4}$ gallons = 1 cubic foot).

7. Show that a chord which subtends an angle θ degrees at the centre of a circle of radius r cuts off from the circle a segment of area $\frac{1}{2}r^2\left(\frac{\pi\theta}{180} - \text{Sin}\ \theta\right)$

Two circles of radius 6 inches and 8 inches have their centres 10 inches apart. Find the area common to the two circles.

8. Prove that in any triangle ABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

A surveyor measures a straight line AB and finds it to be 58 yards long. D and C are two other points on the same plane and the angles BAC, ABC, BAD and ACD are measured and found to be 47, 73, 84, and 68 degrees respectively. If B and D are on opposite sides of the line AC calculate the distance AD and the least distance from D to the line AC.

9. The absolute pressure p pounds per square inch of a given mass of gas as it expands from volume $V = 2{\cdot}0$ cubic feet to $V = 6{\cdot}0$ cubic feet is measured for different values of the volume V as follows :—

V =	2·0	2·3	3·3	3·9	4·6	5·3	6·0
p =	58·2	37·2	23·8	16·8	11·2	7·4	4·6

Plot a graph to show the relation between p and V. The work done in the expansion is represented by the area bounded by the curve, the axes of V and the ordinates V = 2 cubic feet and V = 6 cubic feet, the dimensions being taken to their respective scales.

Calculate the work done in the expansion and state the units of your answer clearly.

10. The following values of p and r are connected approximately by a law of the form $p=Ar^n$

r=	4·1	4·6	5·8	6·4	6·9
p=	20·75	24·67	34·91	40·48	45·30

Show that the equation can be written in the form $Y=nX+C$ where $Y=\log p$, $X=\log r$, and $C=\log A$.

Plot a graph with values of Y as ordinates and X as abscissæ and find the values of n and C as accurately as possible. Write down the law connecting p and r.

APPLIED MECHANICS.

Friday, May 27th, 1938. 7 to 10 p.m.

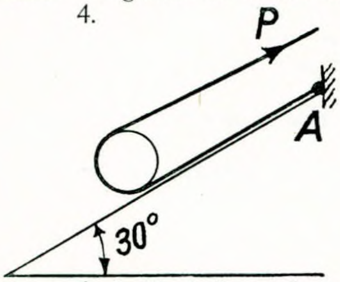
Not more than *six* questions to be answered. All questions carry the same marks.

1. A plank AB weighing 100 pounds is 12 feet long. Its centre of gravity is 7 feet from A. It is supported and kept horizontal by two ropes, one at A inclined at 30° to the vertical, and the other at B. Find the direction of the second rope and the tensions in each.

2. A triangular plate ABC is cut from a flat sheet of metal. It is of uniform thickness and rests horizontally on 3 props, one at each corner. What is the load on each prop, if the weight of the plate is 50 pounds? A load is placed on the plate increasing the load on the prop at A by 2 pounds, that at B by 3 pounds, and that at C by 1 pound. AB=3 feet, AC=4 feet, BC=5 feet. Find the position of the load.

3. Water is issuing horizontally from an orifice in the side of a tank. If the speed of the water is 30 feet per second and 75 gallons leave per minute, what is the backward reaction on the tank? A gallon of water weighs 10 pounds.

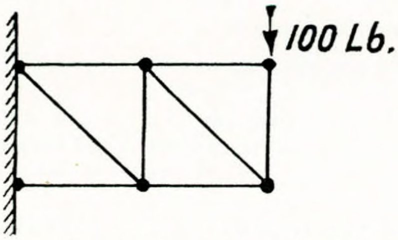
4.



A barrel is being hauled up a slope of 30° by a rope attached at A at the top of the slope, passed round the barrel and hauled parallel to the slope at its upper end. If the efficiency of the arrangement is 85 per cent. what is the mechanical advantage? Find also the value of P if the barrel weighs 200 pounds. Would it make any difference if the direction of P were horizontal?

5. A block is made to slide up a rough inclined plane of 10° slope by a horizontal force. The same horizontal force will suffice to pull the block up a steeper smooth plane. If the coefficient of friction for the rough plane is 0·105 what is the slope of the steeper smooth plane? If the block weighs 100 pounds find the value of the horizontal force. Prove any formula you use.

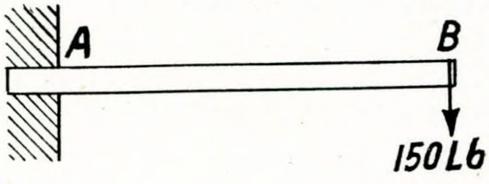
6.



A framework with hinged joints is made up of two adjacent squares with diagonal stays as shown. If a load of 100 pounds is supported at the top outer joint, find the magnitude and nature of the force in each member.

7. A wire 20 feet long has its ends securely fastened to the opposite walls of a building 15 feet wide. If the fastenings are each at 10 feet above the ground, what will be the total stretch of the wire if it supports a weight of 100 pounds at the centre of its length? The sectional area of the wire is 0·01 square inch and the modulus of elasticity is 30×10^6 pounds per square inch.

8. A cantilever AB 4 feet long supports a load of 150 pounds at its outer end. The weight of the metal is 28 pounds and the section is uniform. What is the resultant of all the forces applied to the outer portion of the cantilever by the portion embedded in the wall? What is meant by the Bending Moment and also the Shearing Force at the wall end? Find the values of each. Sketch B.M. and S.F. diagrams for the cantilever.



9. State Newton's three laws of motion.

A small heavy body is attached to the bottom of a light flexible string 4 feet long. The top of the string is securely fastened. The body is allowed to fall when the string is taut and horizontal. On reaching the lowest position the string breaks. If the level floor is 12 feet below the fastening, where will the body hit the floor?

MACHINE DRAWING.

Monday, May 30th, 1938. 7 to 10 p.m.

Attempt Section A and not more than *two* questions from Section B. 70 per cent. of the total marks will be obtainable for Section A.

SECTION A.

On the accompanying sheet you are given details of an engine crosshead, piston rod end, guide shoes, etc.

You are required to draw the following views of the crosshead and its shoes, properly assembled :—

(*a*) A view looking on the side of the crosshead (i.e. along the centre line of the gudgeon pin). Half of this view is to be a section on the centre line and half is to be an outside view.

(*b*) A view looking on the face of the shoe; half of this view is to show the shoe cut away to expose the side of the crosshead.

(*c*) A plan complete.

Scale: 3 inches to 1 foot.

All views to be properly arranged and projected.

SECTION B.

Not more than *two* questions to be attempted from this section.

1. Distinguish between a key and a cotter, sketching an example of each and state the purposes for which each may be used.

2. Name the materials used for (*a*) a connecting rod, (*b*) a condenser tube, (*c*) a bed plate for a reciprocating engine, (*d*) a blade for a high-pressure turbine.

3. Sketch and describe any three methods of preventing a bolt from turning as the nut is tightened.

HEAT ENGINES.

Tuesday, May 31st, 1938. 7 to 10 p.m.

Not more than *six* questions to be attempted. Callendar's Steam Tables are supplied for the use of the candidates. All questions carry equal marks.

1. Show that the work done by a gas when it expands isothermally is given by the expression $W = P_1V_1 \log_e \frac{V_2}{V_1}$ where P_1 is the initial pressure and $\frac{V_2}{V_1}$ the ratio of expansion.

Calculate the amount of heat which must be supplied when 0·4 pound of air at 400° C. absolute is expanded isothermally to 4 times its initial volume.

R (the gas constant for air) = 96 foot pounds per pound per degree Centigrade.

2. Describe how you would carry out a test on either a steam engine or an internal combustion engine in order to determine its mechanical efficiency at full load. Carefully explain how you would calculate the mechanical efficiency from the readings.

3. Explain the meaning of the following terms as applied to steam engines :—(*a*) outside lap, (*b*) inside lap, (*c*) diagram factor, (*d*) mean piston speed, (*e*) back pressure, (*f*) cushion steam, and (*g*) "Willans" line.

4. A marine oil engine, operating on the four stroke cycle, has eight single acting cylinders 610 millimetres diameter by 1,040 millimetres stroke. At 150 revolutions per minute the average mean effective pressure, from a set of indicator diagrams, was 96 pounds per square inch. Determine the indicated horse power. If the engine has an indicated thermal efficiency of 0·37 and the calorific value of the fuel oil is 19,000 B.Th.U. per pound, find the weight of fuel used by the engine per hour.

5. Distinguish between the higher and lower calorific values of a fuel.

A fuel used for an oil engine has the following percentage composition by weight: carbon, 87; hydrogen, 12; sulphur, 1. Find from first principles the minimum weight of air required for the complete combustion of one pound of fuel.

(The composition of air by weight is O_2, 23 per cent. and N_2, 77 per cent.).

6. In a direct contact feed heater live steam at a pressure of 15 pounds per square inch absolute and of dryness fraction 0·97 is mixed directly with the feed. The rate of flow of the feed water from the heater is 20 pounds per second and its temperature is 180° F. The temperature of the water entering the heater is 80° F. The radiation loss from the heater amounts to 1·5 B.Th.U. per pound of feed water leaving the heater. Calculate the weight of heating steam supplied per second.

7. A two cylinder double acting steam winch engine has to develop 50 I.H.P. at 300 revolutions per minute. The admission pressure is 90 pounds per square inch absolute and the exhaust pressure is 15 pounds per square inch absolute. Cut-off occurs at 70 per cent. of the stroke and the diagram factor is 0·8. Assuming hyperbolic expansion and that the stroke is 1·5 times the bore, find the dimensions of the cylinders.

8. Explain what is meant by supercharging and state some of its advantages.

In an oil engine the compression follows the law $PV^{1 \cdot 36}$=a constant. The temperature at the beginning of compression is 95 degrees Fahrenheit, and the pressure is 14·4 pounds per square inch absolute. Calculate the compression ratio for a maximum compression pressure of 480 pounds per square inch absolute. Also find the corresponding temperature.

9. A certain amount of heat energy is available at the inlet to the nozzles of an impulse steam turbine. Carefully explain how this heat energy is converted into work on the rotor shaft. Summarize the losses which would take place between the stop valve and the turbine coupling.

10. A steamship has engines developing 4,000 I.H.P. and the steam consumption is 9·4 pounds per I.H.P. hour. The calorific value of the coal is 13,500 B.Th.U. per pound, and the total grate area of the furnaces is 149 square feet. The steam pressure is 300 pounds per square inch absolute, and the degrees of superheat at the boiler stop valve are 160 Fahrenheit. If the boiler thermal efficiency is 80 per cent. and the feed water temperature is 140 degrees Fahrenheit, find the rate of firing in pounds per hour per square foot of grate.

LLOYD'S REGISTER SCHOLARSHIP EXAMINATION, 1938.

The following is the paper, in addition to the Studentship papers, set in the recent Examination:

PRACTICAL ENGINEERING.

Wednesday, June 1st, 1938. 7 to 10 p.m.

Four questions to be attempted.

1. Write a short description of the various classes of work on which you have been engaged during the past twelve months. Give particulars of the materials employed and the reasons for their choice.

2. Describe, with the aid of sketches, any special repair job on which you have been engaged. State why the repair was necessary and any lessons you may have learnt as the result of your experience on the work involved.

3. Describe fully one of the following :—

   (*a*) The method of boring a stern frame and the "fitting in" of the stern tube.
   (*b*) The "bedding in" of a crankshaft.
   (*c*) Checking the alignment of an engine.

4. Draw the sectional elevation of any type of marine boiler. State the advantages and disadvantages of the boiler compared with other types.

5. Describe the whole process of machining, together with the machines used, one of the following articles, viz. :—

   (*a*) Valve box.
   (*b*) Connecting Rod.
   (*c*) Any type of valve gear.

Special Reception (International Conference of Naval Architects and Marine Engineers) Committee of the Corporation of London.

Dinner in the Guildhall Art Gallery.

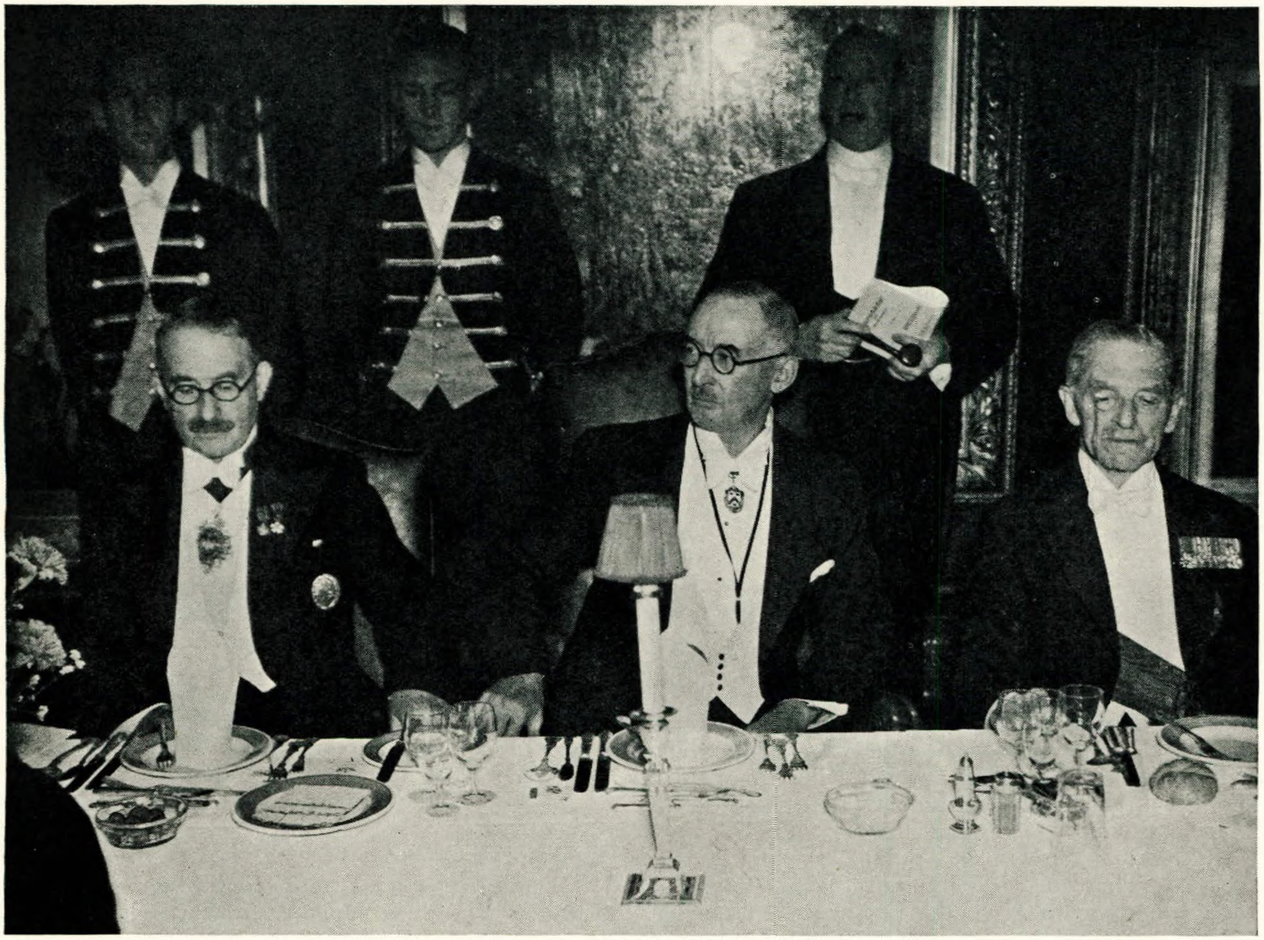
Mr. Alfred Robertson, as Chairman of the Special Reception Committee which arranged the Civic Reception at Guildhall to the Delegates attending the Conference in June, presided over a most enjoyable function in the Art Gallery at Guildhall on Monday, 26th September, 1938. The occasion was the Dinner given by the Members of the Special Reception Committee to mark the successful conclusion of the event in June.

Those present included the Right Hon. The Lord Mayor, the Rt. Hon. Viscount Stonehaven, P.C., G.C.M.G., D.S.O., LL.D. (President, Institution of Naval Architects), Alderman Sir George Truscott, Bt. (Chairman, Visiting Committee), Alderman Sir W. Phene Neal, Bt. (Governor, Irish Society), Sir E. Julian Foley, C.B. (President, Institute of Marine Engineers), Alderman Sir George Wilkinson, Robert Rainie, M.C. (Chairman of Council, Institute of Marine Engineers), Col. and Alderman Sir John Laurie, T.D., A. T. Wall, O.B.E., Admiral Sir Charles J. C. Little, K.C.B. (Second Sea Lord), Alderman Sir Howard Button, Alderman Frank Newson-Smith, Colonel and Alderman R. W. Eaton (Sheriff), J. M. Dewar, Major G. H. M. Vine, Deputy (Chairman, City Lands Committee), Alderman F. S. Alexander, Sir John Pakeman, C.B.E. (Chairman, Officers and Clerks Committee), Col. and Alderman A. C. Davis, D.L., J.P., C. Stanley Crosse (Chairman, Bridge House Estates Committee), Sheriff W. H. Champness, Lt.-Col. C. W. Whitaker, M.A., Deputy, (Chairman, Special Committee), F. A. B. Lord, Deputy, George E. Withers, J. H. White, Deputy, Major J. Godfrey Martin, D.S.O., R. W. Vick, E. S. Underwood, Major J. Lockhart Gow, M.C. (Chairman, Coal and Corn and Finance Committee), Lt.-Col. Sir Hugh Turnbull, K.C.V.O., K.B.E., J.P. (Commissioner of Police, City of London), Captain G. S. Elliston, M.C., J.P., M.P. (Chairman, West Ham Park Committee), G. L. Elkington (Chairman, Improvements Committee), Francis C. Polden, F. J. Forty, B.Sc. (City Engineer), Frank G. Carpenter, A. E. Field, H. E. Jowsey, F. H. W. Church, W. G. Hatch, S. R. Simonds, Oliver Bull, Sir Charles McRea, E. M. Gover (Chairman, Library Committee), J. L. Douthwaite, Henry Maguire (Chairman, Freemen's School Committee), E. H. Dutton, Deputy (Chairman, Elementary Education Committee), F. J. Craker, Archibald Galloway, J.P., C. F. Lewis, Col. R. J. Blackham, C.B., C.M.G., D.S.O., William Foxton, F. W. Youldon, F. W. Brundle (Chairman, Air-Raid Precautions Committee), A. P. Gorman (Chairman, Valuation Committee), Captain E. C. Pryce, J.P., C. Zulver, A. E. Crighton, H. F. Parshall, B. C. Curling (Secretary, Institute of Marine Engineers), Ronald Pearse, (Editor, "Syren and Shipping"), Sydney Leader, G. P.Trentham, H. Roper Barrett, A. D. W. Robertson, W. E. Wright, A. M. Goldney, J. C. Lowrie, Eng. Rear-Admiral W. M. Whayman, C.B. C.B.E., G. V. Boys, M.A. (Secretary, International Conference of Naval Architects and Marine Engineers), A. F. C. Timpson, M.B.E. (Vice-Chairman of Council, Institute of Marine Engineers), S. J. Fox, J. P. Taylor (Editor, "Shipbuilding and Shipping Record"), Sir H. Percy Shepherd (Chairman, Police Committee), E. H. Anning, Frederick Whittingham, J.P., T. F. Clarke, Capt. G. J. C. Welch, M.C. (Chairman, Gresham Committee [City Side]), T. A. Crompton, C. C. Speechly, S. N. Kent, G. S. Baker, O.B.E., D.Sc., Irving B. Gane (Chairman, General Purposes Committee), Raymond D. Poland (Chairman, Law and City Courts Committee), W. Fred Bonser, O.B.E., Sir Arthur Holmes, K.B.E., Gerald McDonald, J. T. Greenwood, D.L., J.P., W. T. Boston, S. H. Greenaway, H. J. Burgess, F. A. Horner (Chairman, Airport Committee), Frederick Youldon (Chairman, Epping Forest Committee), R. T. D. Stoneham (Chairman, City Schools Committee), William C. Brett (Chairman, Spitalfields Market Committee), Alfred Ridout (Chairman, Billingsgate and Leadenhall Markets Committee), W. N. Bacon, Richard Meldrum, S. G. Morris, A. C. Hardy, B.Sc., Captain Alfred Instone, J.P., H. G. Bryson, V. C. Hunt, G. W. Bodman, Dr. M. T. Morgan, M.C. (Medical Officer of Health, Port of London), Captain R. R. S. Hewett (Chairman, Port of London Health Committee), Dr. C. F. White (Medical Officer of Health, City of London), W. R. Andrews (Chairman, Public Health Committee), L. C. B. Bowker, O.B.E., M.C. (City Remembrancer), W. E. Shipton (Deputy Governor, Irish Society), F. J. Caunter (Chairman, Rates Finance Committee), Frederick Rowland (Sheriff-Elect).

Viscount Stonehaven (President of the Institution of Naval Architects) proposed the civic toast and warmly thanked the Corporation for the hospitality it had offered. There was "no end", he added, to the service which the Corporation had rendered to the Empire.

He said he was particularly grateful to Mr. Alfred Robertson for having originated the idea and for what he had done in carrying through the preliminary negotiations, as well as the subsequent proceedings.

The Lord Mayor, in reply, said that no one would accuse him of being a pessimist when he expressed the opinion that no banquet had ever been held in those historic surroundings at such an anxious time as the present. Their hearts and thoughts went out to the Prime Minister and the Cabinet, and, whether his efforts were successful or not, Mr. Chamberlain would go down to history as



The Dinner in the Guildhall Art Gallery of the Special Reception (International Conference of Naval Architects and Marine Engineers) Committee of the Corporation of London. The upper view of the high table shows (left to right) The Lord Mayor, The Chairman (Mr. Alfred Robertson) and Viscount Stonehaven.

the greatest peacemaker the world had ever known. (Hear, hear). He had carried nobly one of the heaviest burdens of responsibility ever placed on the shoulders of a man, and he was sure it was the wish of all present that a message should be sent to him, expressing the hope that success would attend his efforts. (Cheers). A telegram was thereupon despatched by the Lord Mayor through the Chairman expressing "admiration of and gratitude to the Prime Minister for the great efforts he is making for the peace, not only of our own Empire, but of the whole world".

Continuing, the Lord Mayor said that we were living in days electric with alarm, but we had implicit faith in our Navy, and in the skill of naval architects and engineers. The City delighted to honour those who had made it the capital City of a maritime nation.

Sir John Pakeman, C.C., gave the toast of "The Institution of Naval Architects and the Institute of Marine Engineers", saying that he remembered crossing the Atlantic nearly fifty years ago for the first time, and contrasting the vessels of those days, praiseworthy though they were, with the floating hotels of to-day. We were a sea-going nation, and every Britisher was a sailor by instinct.

Sir Julian Foley (President of the Institute of Marine Engineers), responded.

Alderman Sir George Wilkinson submitted the toast of "The Guests", reminding the company that three hundred years ago the Corporation fitted out a ship at its own expense and presented it to the King. Unfortunately, that ship, the "London", blew up when going down the Thames. It was replaced by the Corporation, and accepted by the King. Ever since then there had been a ship in the Navy called the "London".

Admiral Sir Charles Little (Second Sea Lord) and Mr. Robert Rainie, M.C. (Chairman of Council, Institute of Marine Engineers), replied.

Mr. Deputy White proposed the health of the Chairman, remarking that Guildhall was most fortunate in always having men at its disposal to give specialist advice. Such a one was Mr. Alfred Robertson. He had done his "job" well and he had no hesitation in telling him so. In conclusion, the Deputy, on behalf of the Committee, presented Mr. Robertson with a handsome gold cigarette case, inscribed as follows:—

Presented to
Alfred Robertson, Esq.
by the Members of
THE SPECIAL RECEPTION
(INTERNATIONAL CONFERENCE OF
NAVAL ARCHITECTS & MARINE ENGINEERS)
Committee of the
Corporation of London
in appreciation of the
able manner in which
as Chairman he conducted
the deliberations of the
Committee.

Guildhall, E.C. 1938.

The Chairman, in reply, warmly thanked his colleagues for their support, for the splendid gift they had made which would serve as a souvenir of the event for many years to come, and the officials at Guildhall for their ever-ready assistance.

Press Reception and Dinner.

Following the delivery of Sir Julian Foley's presidential address at The Institute on Friday, 30th September, the Council held a reception and dinner at the Abercorn Rooms, Bishopsgate, for Press, Publicity and Literary representatives. The Council was represented by Sir E. Julian Foley, C.B. (President), R. Rainie, M.C. (Chairman of Council), A. F. C. Timpson, M.B.E. (Vice-Chairman of Council), A. E. Crighton (Vice-President), Eng. Com'r. W. A. Graham, O.B.E., R.N.R. (Vice-President), Eng. Rear-Admiral W. M. Whayman, C.B., C.B.E. (Vice-President), A. R. T. Woods (Vice-President), Eng. Lt.-Com'r. A. W. Richardson, R.N.(ret.), (Member of Council), A. Robertson, C.C. (Honorary Treasurer), A. C. Hardy, B.Sc. (Associate Member of Council and Chairman of Publicity Committee), G. T. Marriner (Member of Publicity Committee), Eng. Lt.-Com'r. H. J. Nicholson, R.N.(ret.) (Member of Council and Publicity Committee), G. Ridley Watson, B.Sc. (Member of Publicity Committee), V. D. Wethered, B.Sc. (Member of Publicity Committee) and B. C. Curling (Secretary).

The guests included J. P. Taylor, "Shipbuilding and Shipping Record", R. Taylor, "The Shipbuilder", Capt. C. Birchall, "Journal of Commerce", S. Gresty, "Lloyd's List", G. R. Hutchinson, "The Marine Engineer", F. W. McMurtrie, "The News Chronicle", H. E. Hancock, "The Shipping World", W. Roylands Cooper, "The Engineer", Ronald Pearse, "Syren and Shipping", A. Belch, Deputy Chairman, Shipbuilding Conference, C. Luke, "The Times", J. P. Petree, "Engineering", A. P. Chalkley, "The Motor Ship", John Gayfer, "The Steam Engineer", A. A. Morris, "The Fuel Economist", Lt.-Col. F. H. Budden, Engineering Public Relations Officer, H. Stalker, Press Association, Ltd., E. van Lennep, Illustrated Newspapers Ltd., G. W. Hubbard, C. T. Birdwood, "Fairplay", Preston Benson, "Star Man's Diary", D. Naylor, "Overseas Daily Mail", A. W. Ballardie, "Petroleum Times", Captain Bendtsen, "Scandinavian Shipping Gazette", M. Martinsen, "Norwegian Journal of Commerce", Paul Rotha, The Realist Film Unit Ltd., Hector Bywater, "The Daily Telegraph and Morning Post", and Clarence Winchester, "Amalgamated Press Ltd.

During the proceedings the company was

addressed by the Chairman, Mr. R. Rainie, who said:

"Gentlemen, I am addressing a group of prominent men, and I trust friends, in the literary, press, publicity and broadcasting fields, and I may say quite frankly, that when we invited you to dine with us we did so to give ourselves the opportunity of letting you hear something of the marine engineer from the marine engineer's point of view, and something about The Institute, which is the principal scientific body representing the marine engineering industry and profession.

You will remember an expression we hear so often, used to clench an argument—"I saw it in the papers". So, confronted by the power you represent—the power of the printed word—a simple soul like myself should approach this situation with tact and discretion. I trust it will not be tactless or indiscreet to refer to an incident which happened a few years ago, which I would ask you to remember when I make my concluding remarks to you. The "Lochmonar" ran aground in the Mersey Channel, and in one of the big dailies a description of the happening contained a paragraph which read somewhat as follows: 'At last the firemen flung their shovels on the floor and made for the ladders'. Gentlemen, the 'Lochmonar' was then, and is now, a motor ship.

To return to our subject, however, the marine engineer has been in the past rather an inarticulate person. The Press has often had cause to feel annoyed with him when, with the best will in the world they stretch out their hands ready to help him, and have met with nothing but discouragement. On his part, however, in the past the marine engineer may have had good reason to be inarticulate, because he had nothing to talk about. The days of a boiler, a pump, and what we know as the old 'up and downer' driving the screw are a thing of the past. I suggest that ability to open a valve, swing an oilcan, and swab a piston rod may have represented to the popular mind adequate qualifications for those sent to sea in charge of such plants. Things are different now. The engine room of a modern vessel is a complicated and scientifically designed power house. The Diesel engine, steam turbine and electric propulsion, together with all the services requiring power have turned the machinery compartments of the modern vessel into a highly scientific and almost laboratorical portion of the ship. The training and scientific knowledge of the men in charge has in consequence to be of a very high order indeed. They have duties far beyond the mere keeping of all these appliances functioning; the financial result of their control is a vital factor in these days when it is difficult for the shipowner to make money, because it is owing to him, the marine engneer, that more and more power can be placed in less and less space and the fuel burned in any given period decreased. The marine engineer is therefore occupying a position of greater importance and he is much more responsible for the safety of the ship to-day than ever before. His job is one of ever increasing complexity, whereas the job of navigating a propelled vessel from "here to there", due to the mechanical and electrical devices designed for that purpose, is one of ever increasing simplicity.

Concerning the Institute, I would mention that it is incorporated by Royal Charter, that its objects and purposes are to promote the scientific and practical developments of marine engineering in all its branches, and to maintain and improve the status of marine engineers and the profession of marine engineering. The highest authorities on their particular subjects read papers before it. Its transactions circulate all over the world. It offers prizes, monetary and otherwise, to its students and probationer students who prove worthy in their studies. The Institute has established a standard for its Associate Membership which provides that those who enter that grade must have a scientific knowledge and practical training equal to that required by the other leading engineering institutions, and to the science degree in engineering of our universities. The recognition of this standard of our Associate Membership grade is only slowly being conceded by statutory and other authorities. That lack of speed may be due to incomplete knowledge of the present day duties and qualifications of marine engineers and a failure to realise that the man in charge of what I have called the old 'up-and-downer' has gone and has been replaced by an entirely different type. What of these men?

Richard Hughes wrote recently of seafaring: 'As a profession seagoing seems somewhat of an anomaly. It is a colossus with each foot planted in a different set of values. The raison d'être of it is economic, and yet the practice of it is judged by standards which are not economic at all, which can only be called moral, and which are peculiar to it. For the working of a ship calls for certain qualities—virtues if you like—which do not seem to be appropriate to-day to the relations of employers and employed on shore. The shore workers' liability is limited: the seafarers' unlimited. The seafarer may be called on to give the utmost that he is able, even to laying down his life. This is not an imposition on him, a piece of chicanery on the part of his employers, it is inherent in the profession he practices".

As an island nation, gentlemen, this fact is of supreme importance to us. Dominating the whole situation, as Lord Essendon recently said, is the indisputable fact that Great Britain must at all times have command of sufficient merchant ships to secure the continued life of the nation and also to serve the military and naval requirements in the event of war. Let us accept that statement of the great shipowner. As a corollary, gentlemen, we must have command of a sufficient number of men. I feel that the great majority of our people, while they may accept the statement about a sufficient number of ships, do not think beyond that, and do not picture the uselessness of that sufficiency of ships with an insufficiency of highly trained and essential personnel to operate them.

I have endeavoured to stress the training and qualifications required by that vital section of ship operators—the marine engineers. Their work is unseen. When functioning, they are out of touch with the general public, in a small community that takes them as a matter of course. The call of the sea seems fainter in the ears of our young technicians to-day than the call of the cinema, the dance hall and a technical job on shore. Something must be done about it! The Institute of Marine Engineers in setting the standard it has for its membership is, I submit to you, performing a work of the utmost importance to our nation, which in our view is not appreciated either in its importance or magnitude.

Publicity seekers are generally men who believe in bringing matters to a 'headline', but please do not think that in giving ourselves the pleasure of entertaining you we expect immediate editorial results; that is not the idea of this dinner at all, rather is it our object to establish a liaison between two great branches of industry, engineering on the one side and publishing and publicity on the other. It is for this reason that the guest list, while small, is so distinguished. It represents literary, industrial, publishing, editorial, broadcasting and the like activities, and I trust that my distinguished and varied audience will leave the Abercorn Rooms feeling that they have made close contact with what after all, is a vital part of Great Britain's activities as a nation. We want you to feel, Gentlemen, that if there is any information you should ever be in need of regarding marine engineering or marine engineers, or if there is any help you should want, you will no longer find a cold welcome but a warm understanding of the mutual advantages which accrue from close co-operation".

Mr. C. Luke of "The Times Trade and Engineering" and Captain Birchall, Owner and Publisher of "The Journal of Commerce" responded for the guests, and congratulated the Chairman and the Council on the object for which this very pleasant gathering had been convened. They intimated that the Press would willingly co-operate in disseminating information concerning marine engineering and marine engineers, and they considered that the present gathering was a good augury of their future relationship with The Institute.

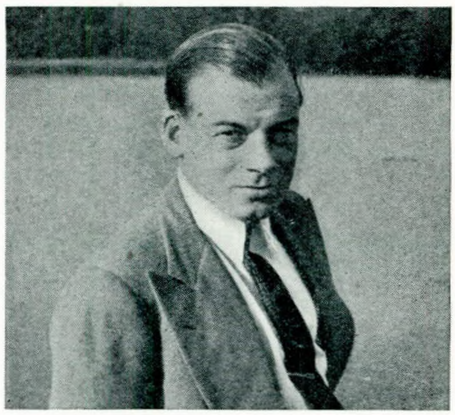
Mr. A. C. Hardy, speaking as Chairman of the Publicity Committee, explained that while The Institute was actively participating in the work of the recently formed Engineering Public Relations Committee, the purpose of the Council in arranging the present function was quite independent of, or rather supplemental to the purpose of that Committee, which was concerned with engineering as a whole rather than with the sectional interests of the various constituent institutions. He emphasised the value of the personal contacts which had been established that evening, and thanked the guests for their presence at a time when everyone connected with the Press particularly was feeling the strain of overwork and anxiety resulting from the international situation.

Mr. Alfred Robertson, C.C. (Honorary Treasurer) also spoke on behalf of the Council and expressed pleasure at the friendly response which their guests had made to the Council's overture. It was of the nature of an experiment, and the Council would be very pleased when their Chairman and the other representatives present that evening reported that there was every prospect of the experiment proving successful. Public enlightenment concerning the important rôle played by the marine engineer was long overdue, and the steps which the Council were taking to remedy this omission were in accordance with the terms of the Institute's Royal Charter.

AUTUMN GOLF MEETING.

The Autumn Golf Meeting took place at Shirley Park, Croydon, on Monday, October 3rd, 1937, by kind permission of the Shirley Park Golf Club. A brilliantly fine morning gave way to stormy weather later in the day, but this inclemency did not prevent the completion of the afternoon event.

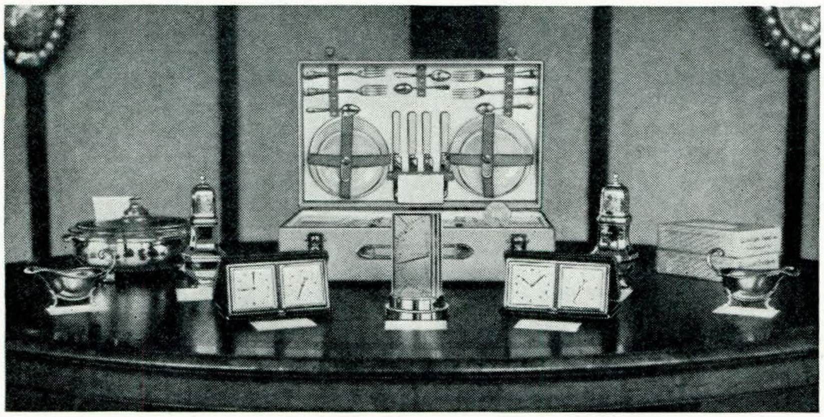
Twenty-two members took part in the medal competition held in the morning. The first prize, presented by Mr. T. A. Crompton, was won by Mr. J. G. Edminston with a net score of 74. The second prize, presented by Mr. J. M. Dewar, was won by Eng. Rear-Admiral W. R. Parnall with a net score of 78, and Mr. E. B. Irwin, who tied with Mr. E. F. J. Baugh and Mr. A. Walker with net scores of 79, was awarded the third prize, presented by Mr. O. H. Moseley, on his score for the last nine



J. G. Edmiston.
Winner of the Medal Competition.

holes.

A two-ball foursome bogey competition was held in the afternoon. Finishing four down, Mr. E. B. Irwin and Eng. Rear-Admiral W. R. Parnall won the two first prizes, presented by Mr. L. J. Le Mesurier. Eng. Rear-Admiral J. Hope Harrison and Mr. L. J. Le Mesurier, who finished five down, tied for second place with Messrs. E. F. J. Baugh and F. M. Burgis. On their score



The Prizes.

for the last nine holes the two second prizes, presented by Mr. H. A. J. Silley, were awarded to the former pair, Messrs. Baugh and Burgis receiving the two third prizes, presented by Messrs. L. G. Hughes and W. T. Williams.

Messrs. J. G. Edmiston and O. H. Moseley, with aggregate scores of 152, tied for the prize, presented by Mr. R. Rainie, M.C., for the best scratch score in both the summer and autumn meetings. Mr. Edmiston won the prize on the spin of a coin.

The prizes were presented by Mrs. Vincent, the Club's Ladies Captain, and Mr. R. Rainie, M.C. (Chairman of Council) expressed the thanks of the players to the donors of the handsome prizes and to the Secretary of the Shirley Park Golf Club for the excellent accommodation provided. He also expressed the thanks of those present to the Social Events Committee, and especially to Mr. Alfred Robertson, C.C., the Convener, to whose detailed arrangements the success of the meeting was largely attributable. Mr. Robertson responded with a suitable acknowledgment on behalf of himself, his Committee and the Secretary.

The following members took part in or were present during the day's events: Messrs. E. F. J. Baugh, F. M. Burgis, Eng. Capt. R. D. Cox, B. C. Curling, T. A. Crompton, D. M. Denholm, J. G. Edmiston, E. I. Flindt, R. M. Gillies, J. A. Goddard, D. J. Harris, Eng. Rear-Admiral J. Hope Harrison, E. C. Hatcher, S. Hogg, L. G. Hughes, E. B. Irwin, A. R. Langton, L. J. Le Mesurier, O. H. Moseley, Eng. Rear-Admiral W. R. Parnall, R. Rainie, A. G. Richardson, W. Ridley, A. Robertson, and A. Walker.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, 10th October, 1938.

Members.

Mark Bearpark, 54, Bluebell Avenue, Birkenhead.

Frederick Bertram Blakey, c/o Messrs. Standard Vacuum Oil Co., Hong Kong.

Ian Browne, 88, Broadhurst Gardens, West Hampstead, N.W.3.

Eduard August Claeijs, Kroonstreet, 34, Antwerp.

William George Russell Coates, 1, Hawthorn Gardens, Low Fell, Gateshead.

John Cameron Craig, c/o Association of Engineers, Singapore.

David Dunn, 43, Rutland Road, Wanstead, E.11.

John Gilchrist, 232, Hykeham Road, Lincoln.

William Henry Green, St. Albans, 10, Ilford Avenue, Crosby, Lancs.

Alexander Macintyre, Chinese Maritime Customs, Marina House, Hong Kong.

Dunbar McQueen, 35, Waterloo Mansions, Dover, Kent.

William Ashley Rowe, 43, Druid Hill, Bristol 9.

Arthur William John Turner, Eng.-Rear Admiral (ret.), 41, Knightsbridge Court, Sloane Street, S.W.1.

John Mitchell Webster, Balgay, 10, Boronia Avenue, Five Dock, N.S.W.

Percy Wilson, 5, Adam Park, Singapore.

Associates.

James Ball, 11B, Theatre Road, Calcutta.

Harold Chambers, 99, Skellingthorpe Road, Lincoln.

Thomas Herbert Stapylton, 5, Sydenham Crescent, Wool, Dorset.

Gordon Steel, 16, Osborne Road, Winton, Bournemouth.

Harry Waite, 56, Hotham Road, Cottingham Road, Hull.

Transfer from Student to Associate.

Herbert Hugh Courtenay, 205, Westcombe Hill, Blackheath, S.E.3.

Ernest Howey, 6, Lansdowne Road, Falmouth.

William Upton, 9, Ingle Road, Chatham, Kent.

Transfer from Probationer Student to Student.

Douglas Evan Arthur Coombs, 37, Eaton Road, Dover, Kent.

ADDITIONS TO THE LIBRARY.

Purchased.

Examination of Engineers in the Mercantile Marine.

Specimen sets of Examination Papers for First and Second Class Certificates. H.M. Stationery Office, 2d. each net.

Presented by the Publishers.

Lloyd's Register of Shipping. Rules and Regulations, 1938-39.

Metallurgical Abstracts (General and Non-Ferrous), Vol. 4, Series II. The Institute of Metals.

Journal of The Institute of Metals, No. 1, 1938, Vol. LXII, containing the following papers:—

"A Chemist's View of Metallurgy", by Desch.

"The Influence of Iron and Magnesium on the Age-Hardening of Copper-Aluminium Alloys", by Petrov.

"On the Problem of the Age-Hardening of Duralumin", by Petrov.

"The Influence of Alloying Elements on the Crystallization of Copper. Part I—Small Additions and the Effect of Atomic Structure", by Northcott.

"X-ray Examination of a Brass Cartridge Case", by Loskiewicz.

"The Physical and Mechanical Properties of Nickel-Brasses", by Cook.

"The Nickel-Copper-Magnesium Alloys", by Jones and Wolfe.

"Alloys of Magnesium. Part VII—The Mechanical Properties of Some Wrought Aluminium-Magnesium and Silver-Aluminium-Magnesium Alloys", by Haughton and Tate.

"Some Properties of Rolled Molybdenum Sheet", by Ransley and Rooksby.

"The Creep of Tin and Tin Alloys—Part II", by Hanson and Sandford.

"Sintered Alloys. Part I—Copper-Nickel-Tungsten Alloys Sintered with a Liquid Phase Present", by Price, Smithells and Williams.

"A Study of Some of the Factors Controlling the Porosity of Hot-Tinned Coatings on Copper", by Jones.

"The Influence of Surface Alloying on the Strength of Soft Soldered Joints", by Chadwick.

"Plastic Strain in Metals", by Taylor.

Thermodynamics, Fluid Flow, and Heat Transmission. By H. O. Croft. McGraw-Hill Publishing Co., 312pp., illus., 21s. net.

This book deals mathematically with problems in thermodynamics, fluid flow and heat transmission, the arrangement of the three studies being continuous in character.

The object of the author has been to bring together in one book inter-related matters in these different branches of science, in such a way that students of advanced engineering courses will be able to pass from the one subject to the other, using a common basis of dimensional analysis and a progressive train of reasoning.

The book is decidedly advanced in character, and made somewhat difficult for the individual student not attending a course of lectures based on this book, since detail discussion of the reasoning and calculations by which various physical and mathematical facts have been developed is omitted, so that the book calls for frequent excursions to other more elementary volumes in order to ascertain how the author's formulæ, graphs, diagrams, nomograms and drawings have been produced.

From the point of view of the practical engineer, this book contains a vast amount of valuable material, but it needs sifting, re-arrangement and tabulation before it can be really useful to the practical designer and draughtsman. It is, however, a most important addition to the already available literature on the three subjects covered by the title, and it is to be hoped that, in due course, the author will be able to produce a further work transforming many of the results presented into a form of everyday value to the practical engineer. The book is very well and clearly produced as to text, tables and diagrams.

Heat. By W. J. Sparrow, M.A., B.Sc. John Murray, 382pp., 145 illus., 8s. 6d. net.

The author has contrived to produce a book without having in view the requirements of any particular examination syllabus. In this way a large amount of historical and biographical material is introduced, which no doubt creates an added interest in the subject. The building up of the various theories is accomplished by means of a review of the lives of and experiments conducted by the numerous contributors to science. This is a very sound method of approach and must rouse the reader to look upon this subject in a more appreciative manner, leading him to other works such as the classics and original papers.

The early experiments of scientists, introduced in a large number of chapters, take the student through that voyage of discovery to the ultimate results in the subject of heat which are accepted at the present day. The volume contains the standard matter found in modern books on this particular subject, e.g. thermometry; effects of heat on solids, liquids and gases; calorimetry; hygrometry and properties of gases; with chapters on thermodynamics and radiation. Although the book has not been written for any particular examination, there is a collection of useful examples with answers at the end of each chapter, typical of those set in the various university examinations.

There is evidence throughout the work to create a connection between the scientific principles and their application to practical problems. In the section on thermodynamics and entropy more interest might be aroused by the addition of a description of a temperature-entropy diagram for steam.

The book has been well written with an adequate supply of representative diagrams. The author has produced an excellent volume which contains the usual subject matter found in standard text books with the additional interest of historical approach which will encourage the reader to explore fields of thought outside the particular subject.

London Ship Types. By Frank C. Bowen. The East Ham Echo Ltd., 196pp., 80 illus., 5s. net.

This book describes in detail eighty distinct ship types most closely associated with the London River, the features and difficulties of their design and running. Each type is exemplified by a well-known ship belonging to it, with historical anecdotes, and illustrated with pen-and-ink drawings by Mr. Pelham Jones, whose regard for detail in reproducing the ships is a feature of his work. There is a foreword by Captain E. C. Shankland, River Superintendent and Chief Harbour Master of the Port of London, and there is also a comprehensive index to the subject matter. While the book is intended primarily for the general reader who has an interest in ships and shipping, it is obviously of particular interest to the marine engineer, who will derive a great deal of enjoyment from its perusal, especially the historical sections. The first example in the book is the East Indiaman "Earl of Balcarres" and the last the cruising liner "Atlantis".

ABSTRACTS OF THE TECHNICAL PRESS.

New High-speed Opposed Oil Engine.

This eight-cylinder four-stroke type, rated at 160 b.h.p. at 1,600 r.p.m. is produced by the Skoda Ironworks, Czechoslovakia. It weighs 2,640lb., with bore 4·92in. and stroke 6·29in., giving a swept volume of 958in.^{3} (15·7 litres). Each block of four cylinders is a single casting with detachable head carrying interchangeable valves operated by push rod; there are two gear-driven camshafts whose extremities drive two four-element injection pumps, and variable injection timing. The built-up four-throw crankshaft runs in five roller bearings, forked connecting rods are used for one set of cylinders, while the opposing rods work between their arms. Big-end bearings are of white-metal. Forced lubrication with reduced pressure circuit for valve gears, is used in conjunction with a dry sump. A gear-driven centrifugal pump circulates cooling water, and an electric motor is used for starting. Two-chamber combustion is used; injection takes place into a swirl chamber, which is equipped with electrical heating plugs for starting. Fuel consumption is reported to be 0·462lb. per b.h.p. hr., and the engine is very flat and compact.—*"The Oil Engine", Vol. 6, July, 1938, p. 99.*

Calculating Exhaust Heat Loss.

In contrast to boiler practice, exhaust gas analysis is fairly infrequent with oil engines, although heat loss calculation is much more accurate on this basis than on the CO_2 content alone, or on the basis of obtaining heat loss by subtraction and including it with radiation. An average fuel oil contains 85 per cent. carbon and 14 per cent. hydrogen, with calorific value fairly constant at about 19,500 B.Th.U./lb. At carbon contents of 82, 85, 87 per cent., the weight of air per lb. of fuel required for complete combustion is 15·4, 14·7, 14·25lb. respectively. The relation between excess air, exhaust weight, and heat loss is as follows:—

% CO_2	% excess air.	Weight of exhaust in lb.	Heat loss in B.Th.U.
3·5	330	64·4	7,720
4·0	275	56·2	6,740
4·5	235	50·4	6,050
5·0	200	45·2	5,420
5·5	173	41·2	4,940
6·0	150	37·8	4,530
6·5	130	34·9	4,180

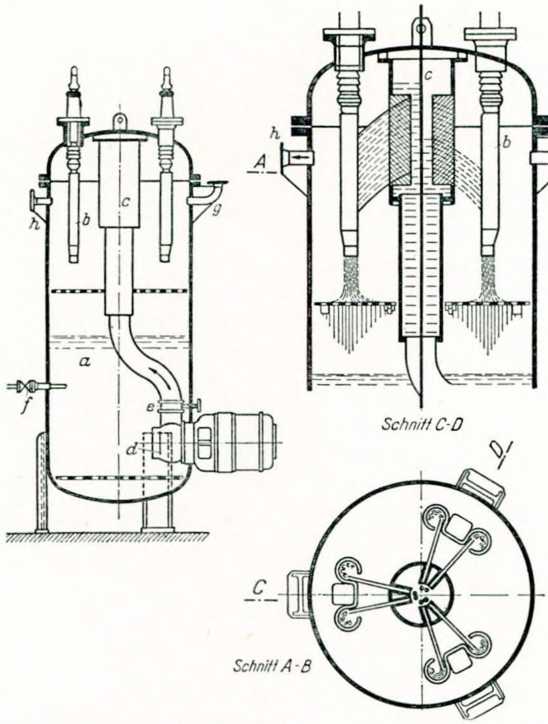
Orsat apparatus is easily connected to the exhaust of the unit or to that of any single cylinder; the natural pressure avoids any need to aspirate, since the gases can be allowed to bubble through until directed into the burette. Data are calculated for an 85 per cent. carbon fuel, inlet temperature 80° F., exhaust temperature 580° F.—*W. H. Luckhurst, "The Oil Engine", Vol. 6, August, 1938, p. 115.*

A 3 h.p. Diesel Engine.

At the Earl's Court Motor Exhibition, 1938, a 1¾ kW. marine auxiliary engine was exhibited with single cylinder of 2¾in. bore and 4in. stroke, developing 3 b.h.p. at 1,500 r.p.m. and coupled directly to a 1½ kW. dynamo supported on a common girder base. The motor is of two-stroke, two-port type with crank chamber compression, and governor acting directly on the fuel pump. Bearings external to the combustion chamber are used and the crankcase is in three sections. Main governor bearings have oil-bath lubrication; needle roller bearings are used for connecting rod, big end and gudgeon pin, and ball-bearings for the four main journals of the governor. A composite piston is employed, the heat-resisting steel head forming part of the combustion chamber. A scraper ring and four compression rings are used, the compression release valve being fitted in the cylinder head. It is claimed that the engine is quiet, free from vibration and flexible.—*"The Oil Engine", Vol. 6, Sept., 1938, p. 141.*

Water-spray High-tension Electro Steam-boiler.

A built-in pump raises the water into an axial tube pierced with columns of small holes, through which it sprays outwards to make tangential contact with the two corrugated sides of a vertical insulated metal electrode, and then falls through a collecting tube back to the reservoir, passing over a metal lattice in electrical contact with the axial spray and the casing. For each phase there are one electrode and two circuits. Steaming is regulated from zero to full load by a valve in the pump pressure circuit. (See *Schweizerische Bauzeitung, Vol. 109, 1937, p. 21*). Recent tests of a sugar factory installation gave the following performance under supervision, after the boiler had generated 50,000 tons of steam with little electrode wear—9 tons steam per hour was generated at 18 atm. excess pressure, with feed water temperature at 40°-100°C. (104°-212°F.), 6,000 kW. being consumed at 16,000 volts, three-phase 50 cycle a.c. A mixture of condensate and softened water was used for feeding, containing 40-70 mg./l. (3-6 grains/gall.) of dissolved ammonia and about 20 mg./l. (1·7 grains/gall.) of organic impurities, originating from the decomposition of sugar residues in the condensate, but there is no difficulty in changing over to river water (see *Jahrbuch des Schweizerischen Vereins von Dampfkessel Besitzern, Vol. 68, 1937*). Determinations of ignition residues in the reservoir and condensed



Water spray high-tension electro steam boiler. ("a" water reservoir, "b" electrodes, "c" spray tube, "d" pump, "e" throttle valve, "f" feed water circuit, "g" to safety valve, "h" steam exit.

water, serving as a control of steam wetness, were used to check the results obtained (A. Kleinhaus, *Archiv Wärmewissenschaft, Vol. 17, 1936, p. 127*). Overall efficiency including auxiliaries, but not including feed pumps, was 98·53 per cent. at full load and 97·48 at half load, after small corrections are applied for stuffing box leakage and steam wetness. This did not exceed 0·4 per cent. even for very alkaline water, which however determines the lower limit of steaming. The boiler can be used with relatively saline waters, although conductivity requires periodical control. In the example quoted automatic pressure and feed regulation were used.—*A. Strub, "Zeitschrift des Vereines deutscher Ingenieure", Vol. 82, 2nd July, 1938, pp. 814-815.*

Standardization.

In his address to the International Standardization Convention at Berlin in 1938, the President of the German Standardization Committee treats the question not merely from a limited technical standpoint but from the broader outlook of its service to civilization. He emphasises that standardization must always be regarded as a means, and never as an aim, as a servant and not a master. Subject to this limitation, every possible use should be made of the convenience which standardization can give, and the restrictions which necessarily result to some extent, appear justified. Where standardization requirements conflict with established legal standards, the author pleads for participation by Government representatives in the work, so that they may themselves assist in fixing limits which will be generally acceptable. He emphasizes the desirability of carrying the process beyond the frontiers of any single country, so that the advantages may be felt in international commerce, since human need is not a fixed immutable quantity and improved production methods eventually lead to increased work. Finally the author pleads for the adoption of standardization by all whom it is capable of benefiting.—*F. Neuhaus, "Zeitschrift V.D.I." Vol. 82, 1937, pp. 847-848.*

Proposal for Standardization of Welding Electrodes.

The authors give a table showing the relation between diameter (2-10 mm.), number, maximum welding current and voltage, for the 20 electrodes (bare and covered) in common use in Germany. Voltage/current plots for both types lie very near two parallel curves; in general the voltage for a given welding current is higher for covered electrodes. The advantages of standardization are stressed, especially the advantage that new investigations might be limited and in comparison of welded work of different origin the electrode variable would be eliminated substantially. It is suggested that the following seven types would be sufficient.

Type.	Lower Limit.		Upper Limit.		Permissible Operating time.
	Amps.	Volts.	Amps.	Volts.	
A	15-20	16-13	80-120	25-15	45%
B	20-30	17-13	135-170	29-17	48%
C	60-80	20-15	190-260	33-21	50%
D	65-90	22-15	250-330	36-25	53%
E	65-90	22-15	330-370	39-32	56%
F	80-120	24-15	430-480	42-35	58%
G	80-120	24-15	520-580	43-36	60%

—*K. Haas and W. Scheuring, "Elektroschweissung", Vol. 8, 1937, p. 208; abstracted in "Zeitschrift V.D.I.", Vol. 82, 27th Aug., 1938, p. 1033.*

Deflection Curve of the Shaft Axis in the Journal.

Work from 1886 to the present day is reviewed, with special reference to that of Clayton and Jakeman (*Proceedings of the Institution of Mechanical Engineers, Vol. 133, 1936*) with loads of 12·7, 35·2, 70·3 and 141 kg./cm.^{2}, at 100, 500, 1,000 r.p.m. with clearances of 0·038, 0·089, 0·193 and 0·408 mm., the journal being 50·8 mm. in diameter lubricated with a heavy mineral oil of dynamic viscosity 0·0219, 0·0077, 0·0036, 0·0010 kg./m.^{2} at 40°, 60°, 80° and 120°C. respectively (the bearing being of lead bronze 57·2 mm. long). With substantial play, pressure develops only in the narrowest portion of the film, and oil flows into the area where the development of pressure begins, while under very low pressure. This confirms the work of Stanton (*Proceedings of the Royal Society, Vol. 102A, 1923, p. 241*) and of Stieber (*Das Schwimmlager, Berlin, 1933*). With small play, comparison of the results of different observers becomes difficult owing to the increasing effect of measurement errors. The plots of $p\psi/\eta\omega$ against χ, for various values of ψ (0·00075 to 0·00805) confirm very well the results of GUMBEL (*Zeitschrift V.D.I., Vol. 65, 1921, p. 1295*) and of NUCKER (*V.D.I. Forschungsheft 352, Berlin, 1932*) but lie rather below the values of SWIFT AND HALSLEGRAVE (*Engineering, Vol. 144, 1937, p. 325*) especially for $\psi < 0{\cdot}7$. The latter, however, used a bearing 305 mm. long and 101·6 mm. in diameter; accuracy of boring is difficult to ensure over this length and the possibility of bending must also be considered. Variations in diameter over the length of the journal, and alterations of bearing dimensions crosswise and lengthwise are reported for 20-22°C. and 145-150°C., being taken with 5 mm. balls to eliminate the effect of surface roughness. Thermal expansion may actually be of the same order as the play allowed. Theoretically μ/ψ should be a function of χ; after replotting the results quoted, the author finds that the effective play (i.e. the thickness of the effective oil film or FALZ's "ideal" play) is, for the minimum play measured in practice, relatively greater than with larger values of ψ, since inaccuracies remain substantially the same. One must therefore reckon with a larger effective ψ, so that the curve which lies too high is depressed downwards. A tribute is paid to the accuracy and thoroughness of the N.P.L. work, but the author regrets that, load n, speed ω, and temperature have been treated separately as variables instead of the product $\eta\omega/p\psi^2$ by the principle of similarity.—*G. Vogelpohl, "Zeitschrift V.D.I.", Vol. 82, 9th July, 1938, pp. 832-834.*

Industrial Choice of Steel Spiral Springs for Machine Mounting.

In all cases *some* elastic play is required, supposing the amount under a load L to be δ_o. Further, suppose there are n springs of wire diameter d coiled into spirals of diameter D. For a first approximation the volume of steel in the springs used is taken as an index of efficiency [see ABSTRACTS, June, 1938, p. 46, *"Sprung Seating for Machines"*]. In general no more than $\frac{2}{3}$ of the static value of τ (6,000 kg./cm.^{2} for good spring steel) can safely be used, since the springs will be subject to dynamic in addition to static stresses. Now the volume of the spring steel is $ni\pi D\pi d^2/4$, the static load per spring $\pi d^3\tau/8D$, the number of springs required is $8DL/\pi d^3\tau$, and $\delta_o = \dfrac{\pi i D^2\tau}{dG}$, from which the number of turns is given by $i = \dfrac{\delta_o dG}{\pi D^2\tau}$ From this the volume of the steel used is

$$\frac{8\,D\,L}{\pi\,d^3\,\tau}\cdot\frac{\delta_o\,d\,G}{\pi\,D^2\,\tau}\cdot\frac{\pi^2}{4}\cdot\quad D\,d^2 = 2\,L\,\delta_o\frac{G}{\tau^2}$$

i.e. the volume of steel in the springs is independent of the number and measurements of the individual springs, and depends only on the mechanical properties of the metal, the load, and the play to be tolerated. From a commercial standpoint, therefore, the springing may be arranged as is most convenient mechanically, and may therefore be costed without an accurate knowledge of machine design. For high quality spring steel $G = 850{,}000$ kg./cm.^{2} and $\tau = 4{,}000$ kg./cm.^{2} (5,400 and 25·4 tons/in.^{2} respectively) then $V = 0{\cdot}106\ L\delta_o$. ($V$. in cm.^{3}, L in kg., δ_o in cm.).—*E. Rausch, "V.D.I. Zeitschrift des Vereines deutscher Ingenieure", Vol. 82, 30th July, 1938, p. 916.*

Ship Velocity in Channels.

It has been established by O. SCHLICHTING (*Schiffswiderstand auf beschränkter Wassertiefe, Berlin, 1933*), and by G. WEINBLUM (*Wellenwiderstand auf beschränktem Wasser, Berlin, 1937*) that resistance increases with decreasing depth and increasing velocity until the stationary wave velocity $\sqrt{g\,d}$ (where d is depth of water) is reached, and afterwards drops to below the deep water value; the phenomenon is particularly marked with canal craft. Apparently as the channel narrows the bow wave continues to pile up, until, with the attainment of the stationary wave velocity, the ship becomes freed, but trimming also has an influence. With very shallow water at high enough velocity, grounding may even occur owing to the increased velocity of the water below the vessel. In design, a simple relation, giving the effect of restricted depth or channel cross-section on deep sea velocity, would obviously be useful (see W. SCHMIDT AND H. BLANK, *Schiffbau, Vol. 39, 1938, No. 6, p. 100*). For vessels of similar form but different displacement the plots of r/D against $v\sqrt{l\,g}$ lie approximately on a single curve, especially for high velocities on the open sea, the explanation being that under these conditions form resistances, which are approximately proportional to displacement, are dominant, and frictional resistances decrease in importance. (r is the ship's resistance in kg., D the displacenent in tons, l the length in metres). But if the same procedure is used for restricted waters (useful h.p. × 75/Dv) = (r/D)/75 being substituted for (r/D), a set of parallel curves, approximately linear, are obtained according to depth of water d in m. or channel cross section in m.^{2} F. Actually the curves are short sections of an exponential. By extrapolation to zero of $\sqrt{F/S}$ (S being the ship's surface concerned), a value of $\log_e \sqrt{1/2\pi}$ is obtained, so that

$$\Delta\sqrt{\lambda} = e^{-\frac{\sqrt{F/S}}{f(\lambda_1)}}$$

The function of $f(\lambda_1)$ varies with the shapes of hull and channel. According to H. KREY, for values of $l\mathrm{D}^{-\frac{1}{3}} = 7{\cdot}22, 8, 8{\cdot}3$ ($\sqrt{\lambda_1} = 0{\cdot}5$ to $1{\cdot}1$) $f(\lambda_1) = 5{\cdot}925\ \lambda_1$, and for a short model with $l\mathrm{D}^{-\frac{1}{3}} = 5{\cdot}84$ ($\sqrt{\lambda_1} = 0{\cdot}5$ to 0·7)

$$f(\lambda_1) = 0{\cdot}265 + 0{\cdot}0473 \times (\text{channel width}/\sqrt{F}) + \lambda_1 (1{\cdot}33 + 0{\cdot}4l\mathrm{D})^{-\frac{1}{3}})$$

(see *Schiffbau, Vol. 14, 1913, p. 457*). The author quotes the results of H. ENGELS (*Modellversuche über den Einfluss der Form und Grösse des Kanalquerschnittes auf den Schiffswiderstand, Berlin, 1898*) in tabular form. For Nos. 1, 2, 3, 5, 6

$$f(\lambda_1)=0{\cdot}265+0{\cdot}069\ (\text{channel breadth}/\sqrt{F})+\lambda_1\ (1{\cdot}25+0{\cdot}4l\text{D}^{-\frac{1}{3}})$$

and for No. 4,

$$f(\lambda_1)=0{\cdot}265+0{\cdot}0625\ (\text{channel breadth}/\sqrt{F})+\lambda_1\ (1{\cdot}25+0{\cdot}4l\text{D}^{-\frac{1}{3}})$$

$\sqrt{\lambda_1}$ being 0·15 to 0·25. The results are also plotted graphically, r against $\sqrt{v^2 2\pi/lg}=\sqrt{\lambda}$ on logarithmic scales.

Since $\Delta\sqrt{\lambda}$ cannot exceed $\sqrt{\lambda_1}$, the expression may be tested by investigating the points where $\lambda=\lambda_1$, which should be at $\sqrt{F/S}\leq 1$, since the channel cross-section cannot exceed the maximum cross-section of the hull. Actually very good correspondence is obtained. The origin of the bundle of rays obtained from dimensionless expressions like $\sqrt{v^2 2\pi/lg}$, r/D, and $\sqrt{F/S}$ lies practically at the same point for different series of experiments. By interpolation therefore, from $r_1=f(D\,l\,v_1)$ for the deep sea, and $r=f(D\,l\,v)$ for a definite cross-section of channel, conditions for another channel of approximately similar section can be obtained. Alternatively the problem may be stated—(1) What is the drop in velocity for the same h.p. expended in water of different depths? In this case Δv is less than would be expected from the exponential expression given. (2) If more fuel is burned with the object of retaining propeller r.p.m. at the original value, despite the retarding effect of the restricted channel, the drop in velocity will be still less. These points are being investigated further.—*W. Schmidt and H. Blank, "V.D.I. Zeitschrift des Vereines deutscher Ingenieure", Vol. 82, 2nd July, 1938, pp. 794-796.*

Resistance of Metallic Materials to Sand Blasting and Cavitation.

Depth of penetration is reported for various metals on sand-blasting with No. 30 carborundum. In cavitation experiments, results are reported as the ratio of loss of weight to that of 18/8 stainless steel, which was found to give the lowest value.

Material.	Depth of Sand-blasting in mm.	Loss of Weight by Cavitation.
Cold-rolled steel ...	0·36	4
Commercial copper ...	0·37	27
18/8 stainless steel ...	0·41	1 (standard)
Commercial aluminium	0·52	30
Robin bronze ...	0·60	7
Cast iron	0·79	8
Brass	1·05	10

In the sand-blast cold-rolled steel and commercial copper both showed better resistance than the alloy steel. Copper and aluminium both showed very poor cavitation properties, and with the exception of these two metals, the authors believe to have established a correlation between resistance to sand-blasting and to cavitation, despite the obvious lack of similarity in the conditions involved.—*W. C. Schumb, H. Peters and L. H. Milligan, "Metals and Alloys", Vol. 8, 1937, p. 127; reproduced in "V.D.I. Zeitschift des Vereines deutscher Ingenieure", Vol. 82, 9th July, 1938, p. 836.*

Bleeding of Turbine Stuffing Boxes.

The pressure fall in a normal stuffing-box is determined by the characteristics of the labyrinth and is therefore constant; if bleeding is allowed the bled steam must issue at a pressure lower than if no bleeding occurred. Actually the pressure within the box falls, the throughput rises up to the point of bleeding and falls beyond it, the difference representing the amount bled off. So far as this is not employed in condensate heating it can be used in the same or another turbine at a lower pressure, but it represents a loss from the main stream. The author is concerned with optimum conditions, but points out that in actual design other considerations enter, *e.g.* additional complication in construction, and convenience in shape. Loss of steam is given by Stodola's formula

$$L=(0{\cdot}36\times 3{\cdot}14\times\sqrt{9{\cdot}81})\ (s\sqrt{d_a-d_e/z})\ (\sqrt{p_a^2-p_e^2/p_a v_a})$$

where d and s represent the diameter and play of the labyrinth, and z the number of combs. The second term increases with the *size* of the stuffing-box; the last is determined by the characteristics of the steam.

$$\lim_{p_e\to 0} L=\sqrt{p_a/v_a}$$

If desired the second term may be refined to take account of the *shape* of the packing. For axial stuffing boxes of constant diameter and play, the amount bled is solely dependent on z; this holds also for most common designs of radial turbines. In general the adiabatic heat loss may be written

$$h=\frac{p_a v_a}{427\mu}\left[1-\left(\frac{p_e}{p_a}\right)^{\mu}\right]$$

This holds even for superheated steam; in practical design with high pressure stuffing boxes, the back pressure of the turbine must be substituted for p_e, but for high initial pressures the saving of energy λ is rather more than is given by the formulæ. For simplication it is assumed that the efficiency η remains constant for all sections of the box, so that under ordinary conditions $l_o=L_o h_o\eta/860$, while the bleeding leads to a loss $l_1=L_1 h_o\eta/860$, and the energy recovered $l_2=-(L_1-L_2)h_2\eta/860$, so that the percentage recovery through bleeding

$$\lambda=1-\frac{L_1}{L_o}\left(1-\frac{h_2}{h_o}\right)-\frac{L_2}{L_o}\cdot\frac{h_2}{h_o}$$

since $p_a v_a$ is constant on account of the throttle effect. If pressures are expressed as ratios of p_a

$$\frac{h_2}{h_o}=\left[1-\left(\frac{\beta}{\psi}\right)^{\mu}\right]/(1-\beta^{\mu})$$

and the recovery λ is given by

$$\lambda = 1 - \frac{B_1}{B_0} \frac{\beta^{\mu}\left(\frac{1}{\psi}\mu - 1\right)\sqrt{1-\psi^2}}{\sqrt{1-\beta^2}\,(1-\beta^{\mu})} - \frac{B^2}{B_0} \frac{\left(1 - \frac{\beta^{\mu}}{\psi^{\mu}}\right)\sqrt{\psi^2-\beta^2}}{\sqrt{1-\beta^2}\,(1-\beta^{\mu})}$$

where β is the ratio of the pressure after the stuffing box, and ψ the ratio of the bleeding pressure, to that before the stuffing-box.

Curves are given for $p_a = 10$ atm. (abs.), $p_e = 1$ atm. (abs.), $\beta = 0{\cdot}1$ for a bleeding point at the middle, and at a distance of one-third from either end of the labyrinth ($z_1/z_2 = 1$, 0·5 and 2·0 respectively), for $\psi = 0{\cdot}1$ to 0·9. These have maxima at $\psi = 0{\cdot}4$, 0·25, and 0·6, with maximum possible recoveries of 20 per cent., 18 per cent. and 13 per cent. respectively. In practice, bleeding pressure and consequently ψ are usually determined by external considerations; by differentiation optimum conditions obtain when the bleeding point divides the stuffing-box in the following ratio :—

$$\frac{z_2}{z_1} = \left(\frac{\sqrt{\psi^2-\beta^2}\,(\psi^{\mu}-\beta^{\mu})}{\sqrt{1-\psi^2}\,\beta^{\mu}\,(1-\psi^{\mu})}\right)^{\frac{2}{3}}$$

and by substitution the maximum possible value of λ may be found.

On the other hand, if the tapping point is fixed by considerations of design, a graphical method must be used to obtain the optimum bleeding pressure. Curves are given for original labyrinth leakage, zero recovery, and optimum working conditions with $\beta = 0{\cdot}1$ for values of ψ from 0·1 to 1·0 and various bleeding points; further, values of $\lambda_{max.}$ are plotted for various bleeding points for values of β between 0·01 (47 per cent. at $z_1/z_2 = 3/4$) and 0·3 (8 per cent. at $z_1/z_2 = 1/1$). Three actual working examples are given.—*H. Kluge, "Siemens Zeitschrift", Vol. 18, Aug., 1938, pp. 406-411.*

Geared Diesel Machinery for Passenger Liners.

Sulzer single-acting engines of 2-cycle type geared in pairs to each of two shafts will be employed in the large new vessel ordered for their Java service by the Rotterdam Lloyd from the de Schelde Company, of Flushing. This vessel is to have a length of 631ft. with a gross tonnage of about 21,000 tons, a total of 27,000 h.p. being delivered to the twin screws. The layout corresponds closely to that for the Blohm & Voss M.A.N. double-acting engines on the new Norwegian American Liner "Oslo Fjord" and the total power output is not dissimilar to that of 30,000 s.h.p. developed by two screws each operated by a direct-coupled Harland-B. & W. double-acting 2-cycle airless-injection engine in the "Capetown Castle" class of fast South African liners. On the other hand, the Netherland S.S. Company is also building a fast ship for the Java service in which a total power—similar to that developed on two screws in the Rotterdam ship—will be given on three screws each of which is driven by a direct-coupled Sulzer single-acting airless-injection engine. The use of more than one engine geared to a single shaft has certain advantages from the point of view of shortness of prime mover and smallness of headroom required owing to the fairly light rate of revolutions; a certain additional transmission loss between the engines and the screws has however to be taken into account.—*"The Shipping World", 31st August, 1938, p. 223.*

An International Unit of Refrigeration.

The subject of the uniform determination of the capacity and efficiency of refrigerating plants in different countries was raised at the recent Conference on Refrigeration. A section of this subject is an international unit of refrigeration, and in view of the difficulties in the way of universal agreement due to the co-existence of the systems based on the ft. lb. and deg. F. as against the cm.-gr. and deg. C., it is thought that any proposed unit must be a new one and, as far as possible, a natural one. About a quarter of a century ago the Institution of Mechanical Engineers proposed as a unit the K-cal. per second, and this has been revived by Dr. Altenkirch and Professor Plank under the tentative name of the "kilofrig". This is equal very closely to 14,400 B.Th.U. per hour, that is the B.Th.U. given up by the melting of 100lb. of ice per hour, so that it may be said to provide a bridge to physical concepts familiar to us, and it is proposed to use the unit as an alternative to the standard in the publications of the Technical Institute for a period of years to familiarize its use and if possible to obtain for it a measure of international acceptance.—*"Ice and Cold Storage", August, 1938.*

Fluorescent Lighting.

The principles and the development of fluorescent lighting are briefly reviewed. This is based on one of the effects produced by the ultra-violet rays, viz. the phenomenon that the impingement of these short waves on certain substances causes the latter to give out light—not a reflection but of longer wavelength and originating in the substance. The fluorescent lamp is a combination of this principle with that of causing a gas to glow by rarefying it (partial vacuum) and subjecting it to a high-tension electric discharge. Actually both these principles already formed the subject of experiments of respectively Faraday and Becquerel and by 1910 neon was used by Claude and applied to advertising purposes. Not until 1933, however, was fluorescent material inside the tube made a practical proposition, the gas used being mercury in argon or argon plus neon, while the fluorescent powders used were sulphides, which have since been superseded by the more efficient silicates and tungstates. Finally, early in 1935, Mr. Jenkins found at the G.E.C. Wembley laboratories that pure neon is a satisfactory substitute for mercury vapour and that through its medium an electric discharge can strongly excite both zinc ortho-silicate and calcium tungstate. Though tubes can be supplied any length or shape, they are standardized in 9ft. lengths. The efficiencies increase with the length but at the expense of convenience and greater risk in handling. A very usual arrangement is three parallel tubes of which the centre is green and the others red, which may be improved by putting a frosted envelope round the central tube. The optimum blend of colours is found by tests in which attention is given to the appearance of the human skin and the colour rendering of fabrics. A 9ft. neon filled tube requires a running voltage of over 1,000 volts, or filled with neon argon and mercury vapour nearly 800 volts. The corresponding Watts are respectively 56 and 43 with a current of 60 milliamperes in each case. The need of such voltages and of installing local means to obtain it safely has led to official regulations and to the development of special step-up transformers. Thus the electrodes at each end of the tube must be completely enclosed by efficiently earthed metal boxes and any high tension wiring outside the boxes done with special metal-shielded cables. Transformers must be located as close to the tubes as possible and secondary windings must be isolated completely from the supply circuit.—*"The Syren and Shipping", 31st August, 1938, p. 382.*

Dual Fuel Engines.

The writer reviews the recent German endeavours to develop Diesel engines arranged for a more or less rapid change-over to operation on gaseous fuels with particular reference to engines of low and moderate power. The resultant dual-fuel engine is usually primarily a Diesel engine with its main strength parts designed for the Diesel cycle. The change-over from oil to gas involves a reduction in specific power output, the drop in power being the more noticeable the poorer the calorific value of the gas. The compression ratio in the case of gas fuel has a maximum value limited by the tendency to self-ignition. This is the more pronounced the higher the hydrogen content, and for such fuels 8 to 1 represents a normal maximum compression ratio, while for fuel free from hydrogen 12 to 1 can be employed, the thermal efficiency being 29 per cent. in the first and 32 per cent. in the second case. Owing to the great variation of the volume of air required for the combustion of the gaseous fuels utilized in practice a suitable mixing gear must be provided and this is in many cases combined with the governing gear. Unlike the Diesel engine, the gas engine operates with reduced amounts of air at reduced powers. For gas operation, therefore, to keep the specific power as high as possible a rich mixture with very little excess air is used on full load, but for lower loads weaker mixtures are employed so as to avoid a too rapid lowering of the compression ratio and unnecessarily high heat consumption. The writer gives particulars of typical engines as follows: In Deutsche Werke engines of up to 300 h.p. conversion takes about four to six hours, the drop in power being 10 to 15 per cent. Krupp engines are mostly of small size, the output on oil being 50 b.h.p. and on gas 40 b.h.p. per cylinder of 250 mm. bore and 350 mm. stroke when running at 500 r.p.m. Montania engines manufactured by Orrenstein & Koppel range from 40 to 120 b.h.p. in units from two to six cylinders of 140 mm. diameter by 200 mm. stroke. In these engines any power drop in changing-over is avoided by fitting a larger cylinder liner and piston. The Humboldt-Deutz build dual-fuel engines especially for oil well boring which can be converted in from two to five hours. The M.A.N. concern also build engines for this type up to 1,000 b.h.p. The Daimler Benz Co. market four cylinder 70 b.h.p. and six cylinder 1,000 b.h.p. units in which three different working cycles, viz. ordinary high pressure for Diesel, medium and low compression, are employed to cover a wide range of fuels, and three different designs of piston are used. The compression ratios for the three cycles are 18, 8, and 6 to 1, the lowest being used for running on petrol or benzole or on pressure gas, if the necessary mixing apparatus is purchased.—*"Gas and Oil Power", August, 1938, p. 193.*

Schmidt-Hartmann Steam Propulsion Equipment.

The author describes the novel high-pressure marine steam propulsion plant which the designers of the Schmidt-Hartmann type of high-pressure boiler have developed for powers between 500 and 5,000 s.h.p., that is for the range in which the high-pressure reciprocating engine still shows a decided superiority over the turbine. This consists of a Schmidt-Hartmann boiler installation supplying steam to an engine of special design permitting the economic utilization of high-pressure steam, *e.g.* from 700lb. down to condenser pressure without the interposition of an exhaust turbine in which owing to the small steam quantities involved at the lower power outputs in question a very high turbine efficiency cannot be obtained. The Schmidt-Hartmann boiler is specially designed to meet the requirements of marine engineers, who maintain that to be a real practical success a high-pressure boiler should be as insensitive to feed and boiler water conditions as the Scotch boiler. With this end in view the generation of the working high pressure is not carried out in flame or flue-gas exposed surfaces, but the heat of evaporation is supplied to the boiler water by evaporator coils solely heated by condensing high-pressure steam, with its pressure somewhat higher than that of the working steam to obtain the small temperature difference required for the heat transfer in the evaporator. The heating steam is generated in a primary system consisting of furnace water walls similar to those employed in standard practice and of water-tube boiler convection surface. This primary system is filled with distilled water and the circulation is purely thermo-syphonic, so that no circulating pump is necessary. In a small separator the primary steam is separated from the excess water which passes back into the boiler downcomers, while the steam is conveyed to the tubes of the evaporator coil located in the drum in which the working steam is generated. From here the primary condensate is returned through pipe connections to the primary boiler system, so that heating steam and condensate move in a closed circuit. In the average Schmidt-Hartmann design the circulation ratio "working steam-primary steam" amounts to 1·3 to 1·4. Particulars of a unit of normal 14,000lb. and maximum 18,000lb. per hour evaporative capacity are given as follows: design pressure 740lb. per sq. in.; final steam temperature 907° F. at normal load; heat release in the oil-fired furnaces 62,000 B.Th.U. per cub. ft. per hour, boiler efficiency 87 per cent. The high-pressure steam was in this case utilized in a quadruple-expansion engine of Lentz type delivering 1,500 i.h.p. at normal and 1,800 i.h.p. at maximum load, the corresponding fuel oil consumptions being ·638lb./i.h.p./hr. normal and ·739lb./i.h.p./maximum. The boiler was of the "twin" type permitting operation of only one boiler half to obtain high boiler efficiency at low load during loading and discharging in port and giving increased reliability of operation at sea. Outstanding among the features of the Schmidt-Hartmann engine is the manner in which the size of the l.p. cylinder is reduced. Taking the case of a normal engine expanding from 700 to 0·70lb. per sq. in. abs. a cylinder volume ratio of high-pressure to low-pressure stage of 50 or more would be required. In order to effect a reduction the Schmidt-Hartmann engine is equipped with two crankshafts coupled by reduction gearing, the low-pressure stages acting upon the high-speed and the high-pressure stages on the low-speed shaft. The engine can thus be considered as composed of two independent engines operating in parallel mechanically and in series so far as the steam flow is concerned. The power can be derived from either shaft, and by the use of a coupling each engine half can be made to operate independently if required. Particulars of a 275 i.h.p. quadruple-expansion unit of this type are as follows: The boiler steam pressure is 852lb. per sq. in.; the total steam temperature is 842° F.; cylinder diameters are about 5″ × 7″ × 8″ × 15″ × 15″ with about 10″ stroke; the h.p. and first i.p. cylinder work on the low-speed crankshaft at 200 r.p.m., the second i.p. and the l.p. cylinder on the high-speed crankshaft at 600 r.p.m.; the steam consumption is 5·6lb./i.h.p./hr. excluding and 6·38lb./i.h.p./hr. including interstage reheaters, and 7·48lb./i.h.p./hr. including 20 per cent. steam for auxiliaries; and the coal consumption based on coal of 13,500 B.Th.U. is ·803lb./i.h.p./hr. —*D. W. Rudorff, "The Marine Engineer", Steam Propulsion Number, 1938, p. 203.*

Analysis of Some Ship Model Wake Measurements.

The author discusses different methods of calculating a mean effective wake from wake distribution measurements on the model. He corrects some earlier theoretical work, in which he had arrived at the conclusion that the effective mean at any radius lay nearer to the volume mean than to the impulse (momentum) mean. This ignored circumferential variation, which has a double effect in varying the loading on a blade element as it rotates and in introducing hysteresis or lift lag. The combined effect is to bring the calculated mean wake nearer to the momentum mean, which is less than the volume mean at any given radius. Measurements of peripheral variation by pitot tube, and a comparison of the deduced mean wake at various radii with that measured by blade-wheels and by the author's drag-ring method are given for a model of the "Simon Bolivar", of about 0·7 block coefficient. The blade-wheel wake agrees fairly well with that obtained by circumferential integration of the momentum, whilst the drag-ring wake is intermediate between the volume and momentum mean. In addition to the observed pitot curves for total wake, curves for the potential or stream-line wake alone are given. These were obtained with the model towed stern first. The circumferential variation of the stream-line wake is comparatively small, and the wake fraction does not vary greatly from 0·10. The total effective wake is 0·29 (Taylor) for the smooth model, and 0·40 for the model with artificially roughened surface. The range of variation is from 0·32 (volume mean) to 0·26 (momentum mean) in the smooth condition, and from 0·44 to 0·37 in the rough condition. It is suggested that screw diameters should be kept on the small side in order to increase the loading (lift coefficient) and thus minimize the effect of circumferential variation.—*W. P. A. van Lammeren, "Schiffbau", Vol. 39, pp. 343-350, 1st October, 1938.*

Gas-Oil or Coal?

The author describes the 60 b.h.p. suction gas tug "Weide" recently taken into service by the River Oder Administration. The main engine of this vessel is operated on gas produced from lignite coke and the installation is designed so as to dispense with the use of any foreign fuel for auxiliary purposes, except after prolonged periods of rest when the main engine is run on petrol for some 5 to 10 minutes on starting. The coke bunker which contains a week's supply of fuel is situated at the forward end of the engine casing and discharges by gravity into the gas producer arranged immediately below it; hand or conveyor feeding are thus entirely dispensed with. The gas washer and purifier are combined into a unit and arranged to fit into the wheelhouse immediately forward of the casing, where they form a seat. The gas producer has a water-cooled wall, and the cooling water is supplied by a pump driven from the engine. This pump also supplies water to the washer and purifier in which the gas is filtered through coke subjected to a heavy spray of water, the dust removed from the gas being carried away with the discharged water. The purified and cooled gas passes through a dryer consisting of a large number of baffles to a centrifugal mixer in which pure air taken from the atmosphere is added to form the working fluid, which is then admitted to the three-cylinder four-stroke engine. A throttle valve arranged at the inlet which can be operated from the wheelhouse gives the skipper direct control over the engine from the full load to the no load condition. The author gives the specific consumption of a 60 b.h.p. motor using lignite coke as ·45 to ·50kg. (1·00 to 1·10lb.) per b.h.p. per hour as against ·28kg. (·62lb.) per b.h.p. per hour for petrol and ·20kg. (·44lb.) per b.h.p. per hour for Diesel oil. A comparison of running costs including capital charges based on fuel prices now ruling in Germany indicates a saving of about 5 per cent. in favour of the suction gas tug as compared with a Diesel-driven tug of the same power, viz. 60 b.h.p. —*Braun, "Werft, Rederei, Hafen", Vol. 19, No. 10, p. 271, 15th September, 1938.*

Chain Drives in Diesel Engines.

In the somewhat impulsive driving of Diesel auxiliaries, chains are particularly suitable, and further are cheaper than trains of gears, bevels and shafts, or connecting rods and levers. In general the roller type is cheaper, stronger, narrower and lighter than the inverted tooth type. As a result of flexibility the camshaft and auxiliaries can be arranged in the most suitable position, wide variation in length is permissible and jockey wheels can be used for timing. The chain can absorb cyclic speed variations up to 3 per cent. without spring couplings or shock absorbers; thermal expansion of centre distance is taken up and backlash can be eliminated completely. The resulting quietness is attractive, and the efficiency of 98·4 - 98·9 per cent. remains substantially unaltered owing to automatic adjustment to the correct pitch circle. A factor of safety of 20 is used and adjustment of the jockey pulley for wear is necessary only at long intervals. Power consumed is approximately—for camshaft drives 1 per cent. of total i.h.p. for fuel and starting valves in 2-stroke engines, and 2 per cent. for exhaust, inlet, fuel and starting valves in 4-stroke engines; for fuel pump drives 3 per cent. for solid-injection type; for combined drives 4 per cent. in 2-stroke and 5 per cent. in 4-stroke engines, but above 7,000 h.p. the figure is about 3 per cent. In designing chain drives, the smallest wheel should have as many teeth as possible up to 30, and never less than 19. Usually 0·4 - 0·6 C. steel is used, but with more than 38 teeth, cast iron, being less resonant and quieter, can be used. For synchronised drives two jockey pulleys are desirable, mounted independently or on a frame or link; in others a single one is sufficient. Long strands should be supported independently at about the middle or a countershaft may be used. About 2 per cent. of length, or two pitches—whichever is the lesser—should be provided as adjustment. Against externally induced vibration a metal or fibre damper *below* the chain with 0·1 - 0·2 in. clearance is effective; this can also be used to prevent fouling of adjacent drives. Wheel clearance should allow the chain to be lifted clear for assembly. Correct and automatic lubrication (jets or oil bath) *at the bearing surfaces* is essential. In assembly, correct alignment of shafts, wheels and teeth is very important; mal-adjustment causes noise, and excessive tension rapid wear from overloading. Detachable and cranked links instead of an endless riveted chain are deprecated and during repairs a new part should not be inserted in a worn chain. In shortening, necessitated by elongation, one inner and two outer links should be removed, and the chain rejoined with an outer link. A new loose outer plate should be fitted without enlarging the holes, and bearing-pin ends should be well supported during riveting. When a 2 per cent. elongation of the camshaft chain has been reached it should be replaced, measurement being taken over an *even* number of pitches.—*R. Coulson, "The Oil Engine", Vol. 6, August, 1938, pp. 116-118.*

New Cast Iron for Cylinder Liners.

Although quantity production articles, the liners are claimed to possess good "sweet-running" qualities, resistance to heat and corrosion and sufficient natural hardness (300-340 Brinell against 200-280 for most pearlitic cast irons). Although the P content does not exceed about 1 per cent. the working surface, as a result of centrifugal casting, contains almost 10 per cent. of phosphide (1·5 per cent P) evenly distributed as fine network, which owing to its hardness stands out slightly in relief helping to retain the oil film and reducing abrasive wear. Flake graphite is present in the iron giving good lubricating properties and allowing it to be easily wetted by the oil. The high silicon content introduced to cause graphitization also gives good scaling resistance. The pearlitic structure quickly acquires a protective skin on the rubbed surface, which wears well. Chromium, introduced to stabilize the structure at high temperatures, also confers resistance to oxidation.—*"The Oil Engine", Vol. 6, September, 1938, p. 163.*

Shipping Economics—The Tendency to Higher Speeds.

The conception of an economic ship speed was established when specific weight, bunker space, and fuel consumption differed little amongst various classes of ships. Advances during the past 10 years have doubled the power/weight ratio, halved the space occupied by engines and boilers, and reduced fuel consumption by a third. This is primarily due to water-tube boilers and turbines, but the present trend towards large steam generators is also an advance. In 1914 a length of 900ft. and 46,000 tons was necessary in "Aquitania" to attain the then economic speed limit of 23½ knots for express Atlantic ships; 25 years' technical progress has brought this within the reach of the new intermediate "Mauretania", 750ft. long and 35,000 tons gross with 42,000 h.p. twin-screw high-pressure turbines. The proposal of the Hamburg-Amerika line for a ship of almost identical performance suggests that the type will become stabilized for second-class transatlantic travel for some time. Relatively the greatest advance in speed is in the 30,000-ton "Pasteur" approaching completion for a French South America line, with length 656ft., beam 88ft., and 62,000 h.p. quadruple-screw high-pressure turbines to develop 25 knots. In the 26,000-ton "Andes" at present under construction to run in conjunction with the re-engined "Asturias" and "Alcantara", the new type Babcock-Johnson water-tube boilers of very high performance will throw fresh light on the question of economic speed. The advantage of oil fuel in high-speed vessels increases with rising length of voyage, and the new passenger liner "Dominion Monarch" with quadruple-screw Doxford propulsion giving a passage of 13,500 miles at 21 knots, will set up a record in these respects. Finally the author pleads for a revision of older standards.—*"Times Trade and Engineering", Vol. 43, July, 1938, p. 36.*

A Fast Coastal Liner.

The twin screw motor coastal liner "Cubahama" built at Leith, has just completed 15-knot trials in the Forth successfully. Of deadweight carrying capacity 1,000 tons, she is specially designed for banana traffic between the West Indies and the eastern seaboard of the United States, with twin-screw "Polar Atlas" oil engines of 1,120 s.h.p. at 250 r.p.m. Deck machinery includes six 3-ton cargo winches, windlass and capstan, operated electrically. The special ship is carefully planned to the owners' exact requirements and represents the latest development in motor-driven coastal liners.—*"The Engineer", Vol. 166, 26th August, 1938, p. 217.*

Sixty Years Ago.

In the Dublin B.A. meeting in 1878, Mr. F. J. Rowan in a paper on "The Design and Use of Boilers" advocated steam pressures up to 300lb./in.^{2}, vertical water tubes and forced draught. He also laid down that the burnt gases should pass downwards on their way to the stack, that great attention should be paid to circulation within the boiler and that flat stayed surfaces should be avoided. "The Engineer" points out how bitterly it criticised these contentions at the time. The best terminal cylinder pressure was 7 - 8lb./in.^{2} and the best expansion ratio 7 - 8; clearly therefore the best boiler pressure was about 70lb., and it was a delusion to suppose that very high pressures would lead to increased economy. Mr. Rowan's conclusions were obtained by fallacious application to steam of a statement made by Prof. Osborne Reynolds regarding a perfect gas, and further the efficiency of a boiler was not affected by the draught. The closed stokeholds of the Yarrow and Thornycroft torpedo launch boilers were adopted on account of the high rate of combustion possible. The opportunities for reading any kind of literary rubbish were appalling; they merely encouraged loose habits of thought fatal to real progress, and the paper was characteristic of the majority of contributions to societies and institutions. The author replied in kind.—*"The Engineer", Vol. 166, 26th August, 1938, p. 226.*

Aluminium and Magnesium—Age Hardening and Intercrystalline Cracking.

Age hardening is necessarily due to separation of a second phase as a result of decreasing solubility at lower temperature, but the *exact* mechanism is not yet understood, and indeed resistivity measurements have led to the suggestion that it is a composite phenomenon. Single crystals of aluminium containing dissolved copper show hitherto unobserved effects when examined by monochromatic X-ray diffraction. Further in an alloy of very pure (99·997 per cent.) Al, hot-work and even cross cold-work is necessary to dissolve the 4 per cent. of Cu on heating. On rapid cooling, no undercooling is observed; nevertheless the structure is that of the chilled commercial (less pure) alloy. The tempering of E alloy at 150° C. after heat treatment diminishes liability to intercrystalline failure under prolonged stress, but 0·1 per cent. proof stress and tenacity are lowered. Mg alloys containing A1 and Ag are improved by double-forging, first at 400°, then at 200° C. For A1 alloyed with Cu and Zn it has been shown that crystal boundary cracking is the same for specimens exposed to air and to a salt spray test, the effect being merely accelerated, and the rate of quenching after annealing has an important —even critical—effect on subsequent susceptibility to such attack; *e.g.* thin alloy strip if air-cooled or quenched in boiling water is liable to intercrystalline corrosion in sea-water spray, but not if quenched in cold water or oil. Similar attack in steel boiler plate is being investigated in terms of 4 variables—stress, corroding water, high temperature, high pressure. It appears that sodium silicate, to which boiler plate cracking is often attributed, is probably not the culprit.—*Report on N.P.L. Research, "Engineering", Vol. 146, 26th August, 1938, pp. 236-237.*

The Loss of "Princess Alice".

On the night of 3rd September, 1878, the "Bywell Castle" rammed this ill-fated paddle-steamer amidships, in the Thames, and at least 600 excursionists lost their lives in the worst disaster in Great Britain since the "Royal George" sank at Spithead. Her particulars were: length 219ft., beam 20ft. and depth 8ft. 6in., *i.e.* she was narrow and shallow, divided into three compartments by watertight bulkheads. Forward and aft plating was only $\frac{3}{16}$in., that in the centre was somewhat stouter. She was built in 1865 for Clyde passenger service, but being unsuitable, was transferred to a London company, her *structural weakness as a girder being enhanced by the addition of saloons amidships. Notwithstanding this, her recognised carrying capacity was raised* from under 400 to 899, by the simple rule of dividing deck area by 3. So slowly was the ramming ship travelling that her paint was hardly scratched, but the impact was sufficient to tear apart the plates of "Princess Alice" so that the central compartment was soon flooded, being supported by the bow and stern for a brief time. The weight of the water added to that of boilers, bunkers, and engine, was too great, however; the deck plates crumpled and the ends rose in the air throwing passengers in a heap under the bows of "Bywell Castle". The accident led to bitter criticism of the Board of Trade's incompetence in regard to passenger license certification.—*"The Engineer", Vol. 166, 9th September, 1938, p. 280.*

Materials for Use at High Temperatures.

Designers of power station plant are particularly interested in creep of metals at high temperatures, especially when exposed to superheated steam. With new research apparatus, tests up to 1,000° C. at pressures down to 1mm. Hg can be carried out over long periods and pure iron, mild steel and high carbon steel are being investigated between 350° and 950° C. A research on the effect of previous history (cast, annealed, annealed and normalised, hot rolled, hot rolled and heat treated, cold rolled) on creep in a straight mild steel and in a similar steel with 0·5 per cent. Mo, is also in progress. Correlation of mechanical properties with structure is also carefully carried out. A statistical survey of certain steels abnormally liable to creep is being carried out in co-operation with the steel industry. *—Report on N.P.L. Research, Vol. 146, 26th August, 1938, p. 237.*

The Nickel-Silver Alloys.

Apart from better known ornamental applications these alloys are used for dairy and brewing equipment, taps, handles, knobs, bolts, screws, marine hardware, telephone springs, car and electrical fittings. In general they contain 65 - 50% Cu, 15 - 40% Zn, and 7 - 45% Ni, the latter having a whitening effect. Composition and properties, melting and casting, working and heat-treatment have been extracted from over 80 articles. Attention is called to recent progress in extension of alloys containing 20% Ni (the lower grades with 10 - 12% Ni having been so fabricated for years) which are the most important in engineering. Higher pressures, first-class billets and rapid working are necessary but die-wear is not so serious as was anticipated. Further, seamless tubing is now manufactured from this alloy by means of a 1,200-ton vertical press. Welding of these alloys is difficult, but by complicated oxy-acetylene technique the problem has been solved in a French motor-car works; however, they can be brazed, soft-soldered and silver soldered with a solder containing 67% Ag, 23% Cu, 10% Zn.—*Review of "Nickel Silver: A Survey of Published Information", B.N.F.R.A., London, 1938; T. F. Pearson, "Engineering", Vol. 146, 26th August, 1938, p. 259.*

30-35 h.p. Marine Petrol Engine.

The latest BE 4M unit is essentially a modified Ford B 4-cylinder model with speed range 1,500 - 2,500 r.p.m. A bridge casting carrying gear-type water-circulating pump driven from an extension of the camshaft, is provided at the forward end. The crankshaft pulley and all the electrical gear, including coil ignition, are left in position. A cooler and filter for the oil are fitted, the latter can be removed without stopping the engine, and also a sump pump for changing lubricant. The exhaust manifold is water jacketed. Reversing gear carried in a casing bolted on the bell housing is capable of giving full power astern for long periods; the lubrication is entirely self-contained. A multi-plate clutch is fitted. The engine is rigidly supported on lugs in the front and brackets at the rear, and is produced in two types suitable for naval or commercial service. A 2/1 reducing gear can be fitted, and in twin-screw installations, to secure outward turning for both propellers, gear-wheel reduction may be used on one engine and chain reduction on the other. With direct drive the approximate characteristics are 4ft. length and 500lb. weight.—*"Engineering", Vol. 146, 16th September, 1938, p. 341.*

Modern Steam Turbines.

The author discusses first the basic principles of the turbine. The dynamic action is of two types, the "impulse" effect depending on the force produced by a change in the direction of motion of the steam, and the "reaction" effect due to change in the magnitude of the velocity. Impulse turbines, such as the De Laval act on the former principle, but so-called reaction turbines, such as the Parsons, are really impulse-reaction machines, since there is a change in both the amount and direction of the velocity, as the steam passes through the rotor blades. In the simplest type of impulse turbine there are a number of diverging nozzles directed on to the rotor blades, and the entire drop in pressure takes place in the nozzles, the latter feature being characteristic of the impulse system. Compounding, i.e., the use of a series of wheels with fixed nozzles or guide blades between, is resorted to in order to keep down the circumferential speed necessary. In the fixed-nozzle or pressure-compounded type, the pressure drop is distributed between the rows of nozzles, whilst in the velocity-compounded type having a series of guide blades, the entire pressure drop takes place in the single row of nozzles at entry, but the utilization of the steam velocity is spread over a number of stages during which the pressure remains constant. A combination of pressure and velocity-compounding is preferable to velocity-compounding alone, giving higher efficiency. Reaction turbines are always compound. The pressure falls continuously from entry to exit, *i.e.* in each row of rotor blades, as well as in the intervening rows of stationary blades. All the turbines so far described are usually of the axial-flow type, the surfaces bounding the blading being cylindrical, or more generally conical. Radial flow may also be employed, and in the Ljungstrom reaction turbine of this type alternate rows of blades rotate in opposite directions, giving a high relative speed without excessive rotational speed; as a result the turbine is very compact.—*T. B. Morley, "The Steam Engineer", September and October, 1938, pp. 519-20 and 29-32.*

Reversible and Variable Ship Propellers.

It is pointed out that although it has been customary to make marine engines reversible, this is not essential, as reversing can be and has in some recent ships been effected independently of the engine, either by means of a gearbox or by rotating the propeller blades so as to alter the pitch. The Voith-Schneider propeller has similar characteristics. If the complications of variable pitch are objected to, the fact that such screws are widely used in modern aircraft may be cited. Electric transmission is another means of varying the screw speed without altering that of the prime mover. These various alternatives have all come into consideration in connection with the internal-combustion engine, which is not so readily reversible, or so easily started as the steam engine. It is particularly below about 800 h.p. that the simplification of the engine itself by the introduction of indirect drive giving independent reversing has become popular, especially in certain coasters where control from the bridge is desired.—*"The Shipping World", 21st September, 1938, p. 301.*

High-pressure Boiler Plant with Reciprocating Engines.

A general description is given of an installation at a German factory, providing electric power and process steam. It consists of a mono-tube boiler with an output of 20 tons of steam per hour at 100 atm. and 420° C., supplying steam to two single-cylinder engines of 1,200 i.h.p. each, driving electric generators. The exhaust passes to steam transformers which generate the process steam at pressures ranging up to 16 atm., the high-pressure steam circuit being thus kept closed and separate from the low-pressure. The previously existing low-pressure boiler plant has been retained as a stand-by, and the economiser associated with it is in the low-pressure steam circuit. The low-pressure steam can be superheated by means of the high-pressure. Normally the 100 atm. plant is operated alone, and supplies the power and heat required, but it can also be used in conjunction with the 16 atm. plant, either independently or with connection through the steam transformers.—*"The Steam Engineer", October, 1938, p. 25-8.*

Ice-breakers.

The author gives formulæ for the thickness of ice which can be broken. He cites Runeberg's expression for the thickness, which becomes, in metric units, t (centimetres) $= 16\sqrt{(V/\sqrt{B})}$, where V is the vertical reaction at the bow in metric tons, and B the beam of the ship in metres. This applies whether the ship takes a run and mounts the ice, so producing a large vertical reaction, or whether the vertical reaction is that due to a more or less steady trim, the speed of the ship being approximately constant. In the latter case, for an angle of trim of 1°, the reaction may be taken as 0·025 to 0·035 of the displacement, so that the expression becomes, in terms of the displacement, $t = a\sqrt{(D/\sqrt{B})}$, where a ranges from 2·5 to 3·0. The displacement is not always known, so that it is useful to convert to a form in which D does not appear. For average proportions, stated to be: length/beam 4·1, draft/beam 0·4, block coefficient 0·47, such a form is $t = 0{\cdot}88\ aB^{1{\cdot}25}$. Alternatively, if the displacement and not the beam is known, the form $t = 0{\cdot}99\ aD^{{\cdot}417}$ may be used.—*W. V. Mendl, "The Shipbuilder and Marine Engine-Builder", October, 1938.*

Manganese Bronze Propellers.

A new method of moulding, the Randupson Sand Cement Process, is described in its application to the manufacture of marine propellers. The medium consists of a suitable grade of silica sand, 8 - 15 per cent. cement and 4 - 10 per cent. water. It can be used for about four hours after mixing, and is rammed around a pattern and inside wooden boxes. It dries without heating in 36 - 72 hours, and is characterized by strength and permeability to gases, which results in sound and true castings. Much time is saved as compared with the old method of loam moulding, using brick construction and requiring numerous drying operations and elaborate mould reinforcement. The castings produced by the new process have a denser and harder skin, more resistant to erosion. The sand cement can be reconditioned for further use. There is a vast improvement in the neatness of the foundry. —*"The Shipbuilder and Marine Engine Builder", October, 1938.*

Lincoln Arc-welding Competition.

Early in 1937 prizes for suggestions for stimulating the scientific development of arc welding were offered; 382 awards ranging from 14,000 dollars downwards have just been announced, and it is calculated (in U.S.A.) that by adoption of the suggestions industrial savings up to 1,600 million dollars would result, even when some over-enthusiastic claims are discounted, the competition having attracted papers from far beyond U.S.A. itself. The first prize was obtained by Mr. and Mrs. A. E. Gibson for a paper on the elements required to ensure business and technical success in welding, the second to A. H. Pandya and R. J. Fowler, of London, for "All Welded Grid Applied to Plane and Spatial Structures". Other British prize-winning papers are "Welding Thimble-tube and Water-tube Boilers", "Arc-welded Pier", "Welded Design of a Single-housing Planer", "Arc-welded Vacuum Pump" and "All-welded Portal Frame Bridge". The jury consisted of 31 U.S.A. authorities.—*"Engineering", Vol. 146, 23rd September, 1938, p. 369.*

Paddle Wheels.

Recently at the Albert Yarrow Tank a pair of model paddle wheels has been installed, capable of "feathering" and "spread", self-propelled by inboard driving motors and fitted with torque and thrust recorders. A shallow-draft tug with a pair of paddle wheels recessed in the after end to allow barges or lighters to be lashed fore and aft, one on each side, gave rise to this unusual apparatus. Owing to the restricted inflow of water the efficiency was very low, this being aggravated by the fact that the feathering mechanism was out of action during the demonstration. If the apparatus works as well as is indicated in the preliminary trials, very interesting information should become available during the subsequent general research.—*Report on N.P.L. Research, "Engineering", 23rd September, 1938, p. 371.*

Explosion of a Marine Auxiliary Boiler.

Important marine boiler explosions during the last century are reviewed—in the river steamer "Victoria", in H.M.S. "Thunderer" in 1876, in U.S.S. "Bennington" in 1905. The accident in s.s. "Kingswood" was quite as bad as in the latter case, when 62 people were killed, but by a miracle "the only injuries were slight cuts on the face sustained by members of the crew". When built in 1929 the vessel had a triple-expansion engine of 1,750 i.h.p., supplied by two main and one auxiliary boilers of the return-tube type at 200lb./in.^{2}. The auxiliary boiler, 12ft. in diameter and 10½ft. long, exploded while the ship was at anchor on 3rd January, 1937, in Australia. It projected itself through three water-tight bulkheads finishing up in the forepeak and knocking a hole in the plating a little above the waterline. It travelled in all 164ft., the two main boilers being driven back 4 - 5ft., with extensive damage to machinery. After temporary repairs at Port Pirie the ship was towed back to the Tyne in a voyage of 114 days. The boiler was well made of good material, but had been neglected—a dozen stay tubes had been closed with stoppers, others were seriously corroded and there was considerable scale. On the morning of the accident the water gauge cocks were opened, but not tried; previously the safety valves were examined and re-assembled without the easing gear—also without testing. The Engineer-Surveyor in Chief remarks " . . . . in no case has water shortage alone . . . . resulted in more than localised disturbance, even at full working pressure . . . ". In the present case overheating at 100lb./in.^{2} would not have thrown a destructive stress on the lower stay tubes through failure of the upper ones, even when allowance is made for corrosion. Although there is no *direct* evidence that the re-assembled safety valves were at fault there is sufficient ground for uncertainty. "It would be the height of folly if an exception [to testing after overhauling] were made of appliances upon which more than any other the safety of the ship . . . . may depend".—*"Engineering", Vol. 146, 9th September, 1938, p. 321; B.O.T. Report No. 3300.*

Explosion from a Ship's Evaporator.

B.O.T. Report No. 3309 describes an explosion on s.s. "Gothic Star" in the English Channel on 4th January, 1938. The evaporator was a closed cylindrical cast iron vessel 3ft. in diameter by 7ft. 8in. high, ⅞in. thick, fitted with 18 ⅞in. bolts, and constructed in two parts joined by a flange. When made in 1919 it was tested to 50lb./in.^{2}. The joint had been made with two rings of asbestos tape, but inside the bolts the ring was not wide enough, so that a space 1½in. wide was left between the faces; in this, rust formed, the resulting expansion forced the faces apart and in May, 1937, leakage began. The vessel left the Tyne for America on 1st January, 1938, without repairs having been effected. On 3rd January the evaporator carrying 13 - 14lb./in.^{2} gave way completely at the flanges. The upper part was blown against a deck 30in. above, two engineers were injured, one fatally. Examination revealed long existent fractures and broken bolts. The dimensions and form of the flanges were unable to resist considerable stresses and altogether the joint was less satisfactory than the usual patterns, which are well formed, machined flat, and joined with only a thin layer of material.—*"Engineering", Vol. 146, 9th September, 1938, p. 321.*

Transfer of Moments in Cross Linkages.

The increasing need of transferring a twisting moment through an angle has led the author to investigate ratios for powers and moments for linkages. It is shown that on transfer of moments through cross linkages oscillating bending forces can occur in both shafts, and that the twisting moment is also liable to variations which can lead to resonance. These moments can be investigated by means of a simple diagrammatic method. The author gives charts for the twisting moments of shafts I and II, bending moments and bearing forces of shaft I and shaft II, in relation to time, and bending moments of shaft I and shaft II in relation to the angles α and β respectively.—*H. Dietz, "Zeitschrift V.D.I.", Vol. 82, 9th July, 1938, pp. 825-828.*

Positive Displacement Rotary Pump.

For heavy oils some form of positive displacement pump is necessary and much ingenuity has been shown in designing rotary mechanisms which satisfy the requirements while avoiding bulk and low speed. In the new design a system of rollers, free to revolve without skidding, rotates within a cylindrical casing surrounding an axial shaft eccentrically mounted. Alternate rollers are mounted and fixed, so that the volume enclosed between each adjacent pair varies as the central shaft rotates, giving a pumping action. The most even flow is given by pumps with an odd number of pairs—a 5 cell pump showing a variation not exceeding 2 per cent. Normally cast iron is used for the casing and Ni-cast iron or hardened steel for the rollers; a steam jacket can be provided with very heavy oils, *e.g.* with steam at 600° F. and 30lb./in². Charts for motor b.h.p. and efficiency against head are smooth curves, approximately linear. At 60ft. head the figures are 22·5 b.h.p. and 42 per cent., at 140ft. —39 b.h.p. and 55 per cent. for a 300 r.p.m. oil-refinery pump handling oil of 200 seconds Redwood No. 1 at about 150 tons/hr. Under the same conditions with an oil of 6,000 seconds viscosity the pump showed the satisfactory efficiency of 40 per cent.—*"Engineering", Vol. 146, 2nd September, 1938, p. 274.*

Frettage Corrosion.

With dry metal surfaces (*e.g.* splined hubs of gears, fitted bolts, ball races, flanges, propeller-shafts and housings) fine Fe_2O_3 dust is formed when the mating surfaces are subject to vibration, if one of the parts is ferrous; this will occur even in what is normally regarded as a tight fit. The rapidity of the action, and consequently the amount of debris, is proportional to the amplitude of relative motion, but independent of both speed and load. Stainless steels and hard steels show the maximum effect, but soft metals are more liable to seize and show less corrosion; the minimum occurs when brass forms one of the pair. Even in contact with glass or wood, steel shows the phenomenon. Lubrication reduces its intensity and in rotational motion it does not occur—apparently under vibration the oil film gradually breaks down. An apparatus for investigating the phenomenon is described, using lapped specimens with a convex and flat face respectively to keep the contact area small. A lateral oscillation is imparted to one by a cam, under any desired load; the outer end of the arm allows the amplitude of vibration to be observed with a micrometer. It appears that minimum fretttage occurs with a maximum difference in hardness between the pair of metals.—*Report on N.P.L. Research, "The Automobile Engineer", Vol. 28, August 1938, p. 278.*

New Method of Metal Spraying.

The process depends on a Swiss "Schori" patent in which the powdered metal is *sucked* into a stream of compressed air, avoiding the packing which occurs when pressure is used. It is rapid and cheap, a covering speed of 250ft.²/hr. being claimed, and can be used also for bitumen, gums, shellac and rubber. The pistol contains no moving parts and there is said to be no danger of backfire. Inputs of oxygen, compressed air, and fuel (acetylene, butane, propane, or enriched town gas) are controlled by needle valves; spraying continues only as long as an orifice leading to the atmosphere is closed by the operator's thumb. The compressed air at 25 - 50lb./in.² must be dried thoroughly before entering the pistol, and a coke filter is desirable to remove foreign matter; the compressed air also drives an unbalanced air-motor which vibrates the powder vessel continuously; inflow of powder is controlled by a separate valve. Prior to spraying the surface is sand- or steel-blasted; immediate spraying is desirable, and absolute cleanliness essential. For different metals, pressures must be adjusted and to avoid complication a set of nozzles is provided for each. Interesting applications of the process are the spraying of tanks, hulls, bridges, machinery, aluminium seaplane floats (with Al, Zn or Cd), ammunition, mines and shells (in which it acts as a lubricant in the rifling). The coating can be hammered, riveted or bent without injury, and a patent is being taken out for a (metal and glass) mixture which forms a fusible slag, and a similar mixture with Al base is suitable for protection of iron exposed to high temperature.—*"The Eng'neer", Vol. 166, 16th September, 1938, p. 318.*

High-speed Indicators.

The writer describes the twisted tube apparatus discussed in "The Engineer", Vol. 166, 19th August, 1938 as "very ingenious" and asks for further details regarding speed of response for marking dead centre on the time base. As $\pm 1°$ accuracy is required in a locomotive indicator, the time lag should not exceed $^1/_{2000}$ sec. and he prefers a model not requiring a time base. At 1,500 r.p.m. lag must not be more than $^1/_{9000}$ sec., and he enquires whether the interval between contact and flash has been determined experimentally, suggesting that dead centre could be marked by an optical device—a fixed lamp, and two rotating lenses, one on the crankshaft, the other on the mirror drum shaft, with prism and slit, should give an accurate position on the film. A rocking mirror is impracticable at high speed, but doubtless a specially-shaped mirror drum could be designed to give a stroke base, which most engineers prefer. Admission events could be studied by putting the diagram 90° out of phase.—*T. Robson, "The Engineer", Vol. 166, 16th September, 1938, p. 316.*

Effect of Helm Action on Propulsion.

The effect of rudder inclination on propulsive efficiency has been investigated for two self-propelled models of 400ft. ships, one representing a single-screw vessel of 0·755 prismatic coefficient, the other a finer twin-screw ship of 0·73. Self-recording thrust and torque meters were included in each line of propeller shafting, and in addition the model was coupled to the resistance dynamometer on the carriage and constrained to move straight (despite rudder inclination) by a combination of smooth vertical guide rollers fixed to the carriage, and smooth horizontal rollers on a towing frame surrounding the model, and clear of the water. This simulates a ship subject to yaw from wind or sea and maintaining a straight course by use of the helm. In a series of runs the point of self-propulsion was determined, and it appears that in single-screw ships angularity of the propeller race leads to assymetry in port and starboard helm effects. Screw efficiency is little affected, but wake and thrust deduction are; further, quasi-propulsive coefficient decreases, mainly due to rudder resistance. In practice with fixed maximum torque and power, if the rudder inclination is maintained speed must decrease for more than one reason. With a single-screw ship at 11·5 knots, 5° starboard helm causes a decrease of 0·2 knots. Since in twin-screw vessels the rudder is outside the races, helm effect is less marked—10° helm demanding an increase of 2·5 per cent. power to maintain speed.—*Report on N.P.L. Research, "Engineering", Vol. 146, 23rd September, 1938, pp. 370-371.*

Professional Men and National Emergency.

A statement issued by the War Office points out the valuable service that can be rendered by men between 31 and 55 years of age, with technical, acadamic or special qualifications, but without military experience. Although unable to join recognised reserves for the Army or Territorial Army, they can become members of a newly-formed Officers Emergency Reserve, undertaking merely to come up for service if and when called on during national emergency. Engineers, whether civil, mechanical, electrical or motor car, are specially in request, and other desiderata are knowledge of foreign languages, intimate acquaintance with colonial or foreign countries, a university degree, training in military intelligence or cipher duties. Forms are obtainable from the War Office (A.G. 5 Mob.), London, S.W.1, or from the nearest Regular Army Command or T.A. unit. The journal points out that while amongst younger men there is danger of the keener spirits volunteering for duties that may on occasion clash, the temptation to force square pegs into round holes, too common in the last war, should be resisted.—*"Engineering", Vol. 146, 26th August, 1938, pp. 250-251.*

Moving-coil Vibrometer.

After many attempts an instrument was devised for the purpose of measuring vibrations set up by running machinery, particularly in hotels and laboratories where the smallest vibration is undesirable. The chief advantages of a moving coil instrument are that natural frequency and impedance can be made quite low; the latter allows long connecting leads between pick-up and amplifier; since the recording gear is not portable this is of importance where a large space is being explored. In practice with suitable precautions the frequency response and attenuation are less than 5 per cent. and 1 per cent. respectively, and even this performance can be bettered. A modified wireless loud speaker is used, the pick-up being connected to a gas-focused kathode-ray tube through a 3-stage amplifier ($\times 400$ or $\times 20{,}000$) with single-sided deflection. (For extreme sensitivity a high ratio step up transformer can be connected between pick-up and amplifier). 100ft. of 35mm. film is driven by an electric motor at 7½in./sec., time being marked by flashes every $^{1}/_{100}$ sec. from an illuminated slotted disc; alternatively a miniature kathode-ray tube can be used for timing, if mains supply is not available. The instrument must be calibrated in terms of a pure vibration and this is usually difficult outside the laboratory. Films of vibration in the basements of reinforced concrete buildings are shown, consisting of h.f. vertical vibrations at 200-300 cycles super-imposed on l.f. of 25-50. At the tops, h.f. vertical vibration was comparatively absent, and large amplitude l.f. components were clearly visible on the records, though only just perceptible to the senses.—*G. O. Eccles, Paper to Section G. of the British Association, 1938;* reproduced in *"Engineering", Vol. 146, 26th August, 1938, pp. 263-264.*

Automatic Expansion Valve for Refrigeration Plant.

The function of the valve is to cut down the supply of liquid refrigerant to the exact amount required by the evaporator, through variations in evaporator pressure. For small domestic plants working with fairly constant temperature and load conditions this is satisfactory, but for commercial applications a thermostated valve is obviously better; two types are manufactured and the one described maintains a constant temperature difference between inlet and outlet end of the evaporator coil. A valve with seat aperture of 0·11in. can control 120,000 B.Th.U./hr. with SO_2 or 96,000 with

CH_3Cl, but under adverse conditions the figures may be 25 per cent. less. A thermal bellows acts as a gland, being isolated from the valve mechanism so that the thermostatic element can be removed *as a whole,* thus avoiding the risk of moisture entering the system. The casing is held by a bayonet clip making a tight joint against an inserted rubber ring, the spindle being connected to the casing. The mechanism of operation is described in full, bellows being anchored to the thermostatic element and adjusted by a traversing disc, instead of vertically as in the conventional pattern; advantages are claimed for this. As the thermostat proper is a standard unit, a spare can be readily fitted if required.—*"Engineering", Vol. 146, 9th September, 1938, p. 311.*

Cavitation.

At present hydrodynamic characteristics of different blade sections are being studied by towing through still water in the New Tank at speeds up to 30 m.p.h. Non-curved blades of prismatic form and uniform cross-section up to 3ft. 6in. by 6in. have normal and tangential forces measured with the blade disposed at any desired angle. The relatively large size enables scale effect associated with Reynolds numbers to be investigated, anomalous results obtained with 6in. propellers in the Lithgow Tunnel being possibly due to this. The tunnel is a closed circuit about 1ft. 6in. in diameter through which water is circulated at constant speed, a model propeller externally driven under recorded speed, thrust and torque being observed through a window. Reproducible results are obtained, but by alteration of air pressure or water speed, inconsistencies occur. As speed is lowered, cavitation is found to occur at increasingly high thrust coefficients; with some designs the effect is quite marked. Experiments with water previously agitated to remove air gave a negative result, and the possibility of small quantities of oil and of the effect of pressure on surface tension are at present being explored. Nevertheless the Lithgow Tunnel is proving valuable in comparative tests. In three distinct experiments model screws showed cavitation in portions agreeing well with actual eroded areas, but also at the blade tips.—*Report on N.P.L. Research, "The Engineer", Vol. 146, 23rd September, 1938, p. 370.*

Deterioration of Structures in Sea Water.

The seventeenth report of work begun on behalf of the I.C.E. in 1916 is published, dealing with timber specimens exposed at Singapore, Wellington and Auckland in 1925, at Mauritius in 1930, on the Gold Coast in 1931, at Colombo in 1934, etc. Owing to wide differences in the impregnation of creosote + chlorodihydrophenarsazine (D.M.) in the Singapore posts no trustworthy conclusion can be drawn regarding D.M. Attacks by Limnoria and Teredo in various locations are reported and discussed, and the relative efficiencies of creosote, creosote + naphthalene or carbazole or D.M., Pintsch gas tar, copper salt, additional creosote, etc.; apparently the order of merit varies in different parts of the world. At Leith the order of merit for timbers was British oak, American elm, Baltic redwood, pitch pine. In most stations the alloy steel bars (36 per cent. Ni, and Cr steel) have shown good corrosion resistance, and copper steels were rather more resistant than ordinary steels, of which the worst was a medium steel low in S and P. In half-tide and complete immersion tests there seemed to be no tendency to cracking of the concrete frames as in air corrosion tests. Work on reinforced concrete at Sheerness, the Gold Coast and Watford showed that failure was directly due to corrosion of the steel, *i.e.* to the access of brine. Lean concretes with trass admixture were notably more resistant to cracking, more so than artificial pozzolanas. Test cylinders of portland cement (with and without additions of trass and waterproofers), moler, aluminous and iron portland cements were exposed in 1929 by the Institution of Norwegian Engineers, below sea level, above high water and at half-tide level. Deterioration was most marked in the latter condition; of the completely immersed specimens moler and aluminous cement showed substantial increase in strength over the 6-year period. Aluminous cement, and portland cement + trass, gave the best results in a rich mix between high and low water; the waterproofer gave the best results in lean mixes. A Japanese claim, that austenitic Mn steel does not rust, is *not* substantiated.—*"Engineering", Vol. 146, 23rd September, 1938, pp. 359-360.*

The New "Graf Zeppelin".

On 14th September, 1938, the new "Graf Zeppelin" was christened with liquid air by Dr. Hugo Eckener on Lake Constance, and immediately afterwards made a successful trial flight of eight hours. At comparatively low altitudes the engine noise was scarcely audible above normal street traffic. Helium can be used as lifting medium but for the present, hydrogen is employed and to minimise dangers water vapour is condensed from the exhaust gases, so that it is not necessary to release so much hydrogen to keep trim. The new craft has 16 cells containing 7,062,000 cu. ft. of hydrogen, compared with 5,500,000 cu. ft. in "Hindenburg". Propelling machinery comprises 4 Daimler-Benz oil engines, rated at 700 b.h.p. housed in 4 gondolas. "Graf Zeppelin" is a little over 800ft. long, rather less than "Hindenburg", and is designed for a cruising speed of 80 m.p.h. During the week-end the new airship completed a 26-hr. tour of Germany.—*"The Engineer", Vol. 146, 23rd September, 1938, p. 325.*

Noise Measurements Aboard Ship.

Limitations of space, weight, design, and the high degree of mechanisation all lead to a high intensity of sound aboard ship, so much so that on a naval bridge conversation may be impossible; the author is concerned lest inability to hear whistle signals may lead to collisions. As a measuring instrument the ear is untrustworthy owing to (1) variation between different ears, even in the same person, (2) liability to suggestion, (3) variation according to health, fatigue, etc., (4) conduction by the bones of the head, (5) limited ability to differentiate and lack of sensitivity to small variations. In general, loudness is determined by amplitude, pitch by frequency, and quality by wave-form, but most common sounds are complex. Psychologically the ear is sensitive and rugged, with almost instantaneous tuning to wave lengths from 56 to 0·056ft., and intensities varying by 10 million million. Ordinary sounds lie near 2,000 cycles, warning sounds above or below. The author gives charts for loudness plotted against intensity for frequencies of 20 to 20,000. According to the Weber-Fechner law the least detectable change in a stimulus is proportional to the intensity of that stimulus; from this, loudness varies directly as log (intensity measured in work units), and there is no absolute loudness, merely a difference between the loudness of two sounds. Where a specific machine is being considered, neighbouring noises must also be considered, also reverberation. There is no general correlation between intensity and distance. In actual measurement the following rules should be adopted: (1) Frequent calibration of instruments, during test if necessary; (2) Sufficient readings to eliminate stationary wave effect; (3) Use of weighting networks of 40 and 60 decibels, and flat response for frequency analysis; (4) Reporting of overall noise, zero reference, frequency weighting network used, ambient noise level, location of microphone, other conditions, *e.g.* speed changes and machinery in operation.—*H. A. Sims, "Journal of the American Society of Naval Engineers", August, 1938; reproduced in "The Engineer", Vol. 166, 23rd September, 1938, pp. 345-346.*

Ship Resistance and Test Work.

The volume of shipping test work is more nearly proportional to industrial activity than in any other department of the N.P.L.; in 1929 51 designs were tested, in 1930-1932 this fell to under 30 and rose consistently to a peak of 88 in 1936. The 68 models tested in 1937 showed an unusually varied selection of types. In eight cases improvement could be suggested without experimental testing; of the others a saving of power was realised in 39 cases, ranging from 3 per cent. to over 20 per cent.; when the costs of installing and running propulsion machinery are considered, the value of this laboratory to the Mercantile Marine needs no emphasis! Even where the alteration suggested will lead to a rise in construction costs this is usually well worth while in the end, and may lead to increased seaworthiness. In comparing tank and trial run data the importance of a clean hull, to obtain comparable conditions, is pointed out. According to the 1937 Berlin conference, present data are insufficient to allow international roughness (and corresponding skin friction) standards to be adopted, but it has been *decided to apply internationally Froude's frictional coefficients for conversion of tank data* on varnished models to full size ships. The larger question is receiving attention at various laboratories throughout the world. Recently anomalous values obtained by Froude from towing experiments on relatively short planks have been explained by assuming different transition points from streamline to turbulent flow, and the extrapolated values agree well with KEMPF's experimental values for a steel surface. These data, of course, require correction before they can be applied to the curved surface of a ship's hull. The frictional resistance of a long flat plate is considerably less than that obtained by using FROUDE's method and constants for a normal plated ship of the same length.—*Report on N.P.L. Research, "Engineering", Vol. 146, 16th September, 1938, pp. 338-339.*

Wave Making.

By means of a plane extending across the remote end of the tank, and hinged about its lower edge 2ft. below water level, combined with a zigzag arrangement of breakwaters on a shelving "beach", waves of a predetermined height and length can be generated. The resistance of the same model is found to be consistently higher in the smaller Ottawa tank (52ft.^{2} cross section) than at Teddington (360ft.^{2}) by up to 8 per cent. in smooth water and up to 18 per cent. at wave-making speeds. The wave-making components of ship resistance are being determined by mathematical study of a three dimensional form approximating to a ship's hull. For continuous variation in the entry angle the components due to bow, stern, and to mutual interference between them, have been separated. In due course the forms will be tested experimentally as models for one shape, approximating to a sine curve; correlation has already been possible. Further, an empirical correction can be applied for the effect of viscosity in reducing the wave making effect of the stern. An experimental attack on another aspect of this problem is by means of models of a 10 - 11 knot, 10,000 tons ship of length 400ft., beam 55ft., loaded to represent draughts of 24ft., 22ft., and 11ft. 6in. with a 6ft. stern trim. Groups with prismatic coefficients of 0·78, 0·74 and 0·70 are investigated, and since bow contour is the point at issue they are self-propelled with identical after body, long and fine run and deep cruiser stern to minimize interference and eddy aft. Since one-fifth of the length is parallel, the fore shoulder is rather abrupt and variation in end-fineness is necessarily very limited. Variations in bow-form comprise a half-angle between 28° and 40°, a vertical stem and a stem raked to about 40°. In the 0·78 models tested so far, neither of these changes materially affected propeller performance, the most important factor being the shape of the fore-shoulder, *i.e.* the reduction in wave-making resistance due to a small angle is not enough to offset increases in form and frictional resistances. With ballast loading and 12 knot speed the heavily raked stems showed a resistance about 8 per cent. greater than the vertical stems. In the 0·70 models now being studied it is expected that wave-making resistance will be relatively more important, and attention is being given to the possibility of compensating the resistances due to wave-making and to form. In the New Tank a feature of the work is the number of tests on speed-boat types. Since dryness in rough weather is an important characteristic of such craft, trim-changes accompanying speed-changes, as well as wave formation, are observed.—*Report on N.P.L. Research, "Engineering", Vol. 146, 16th September, 1938, pp. 339-340.*

Motor Ship "Regent Tiger".

The tanker is built with combined longitudinal and transverse framing, with two longitudinal bulkheads and one deck giving 9 tanks and 27 compartments. A double line of 12in. cast iron piping runs through, with 10in. suction strums to each compartment; four horizontal steam-driven duplex oil pumps can each handle 280 tons/hr. Steam smothering is fitted in each compartment and deck sprinkling to meet Panama Canal regulations. Gas escapes are fitted discharging at the mastheads and automatic gauges show internal oil levels. Living accommodation is of passenger standard. Main propulsion machinery is a 4-cylinder opposed-piston oil engine with bore 28·6in., upper stroke 35·4in., lower stroke 51·2in., so that good balance is obtained. Electric welding is used in its construction, since no direct load is imposed on the framework by the explosion. The crankshaft is of semi-built type with 3 throws per cylinder, two side cranks being connected to the piston by connecting and side rods; a detuner is fitted to minimize torsional vibration at a critical speed. A double-acting scavenging pump draws air in through valves in the piston, and the combustion chamber approaches the ideal spherical form. Distilled water in a closed circuit at 140° F. (60° C.) is used for cooling the cylinders, also various valves. Auxiliary machinery is driven by steam from two Scotch cylindrical boilers oil-fired under forced draft at three furnaces. Exhaust gases can also be passed in. The vessel's particulars are:—

Length between perpendiculars ...	500ft.
Breadth extreme	68ft. 3in.
Depth moulded	35ft. 9in.
Designed deadweight at 28ft. 10½in. draft	15,000 tons.
Designed service speed	12½ knots.
Speed on Trials	13½ knots.

—*"The Engineer", Vol. 166, 9th September, 1938, pp. 286-288 with three figures and three photographs.*

Horizontal Double-Acting Dry Vacuum Pumps.

In relatively slow-running horizontal reciprocating pumps high volumetric efficiency is possible, since clearance ratio can be made very small and the design leads to effective water jacketing. Seven sizes from 9½in. bore × 8in. stroke (162 cu. ft./min.), to 26in. bore × 22in. stroke (2,000 cu. ft./min.) are manufactured. Four suction valves are placed on the top and four delivery valves at the bottom, so that any moisture drawn in through the suction pipe will drain naturally to delivery. Stainless steel ported-plate spring-loaded valves with large area and small lift are used. Only one stuffing box is necessary, since the stroke/bore ratio does not require a tail rod to support the piston, and this is packed by three cup leather rings. Connecting-rod bearings are of gun-metal; big-end bearings are white metalled. Oil rings are used with the main bearings; other working parts are lubricated by drip-feed or belt-driven multiple feed. A pressure of 0·6in. with the small size, and 0·4in. with the large size, and by use of a two-stage unit 0·1in. can be attained; in the latter case, however, the rated figures are halved. Certain of the pumps can be mounted in pairs, with suitable belt pulley connected by flanges to the two shafts.—*"Engineering", Vol. 146, 9th September, 1938, p. 303.*

Non-Ferrous Metal Markets.

Despite fluctuations, the prices of electrolytic copper (£43), tin (£189 5s.), lead (£15) and spelter (£14 2s. 6d.) were little different on 30th June, 1938, from those six months previously. In this interval heavy government buying helped in prolonged quiet periods, the U.S.A. depression exercised a damping influence, and nervousness due to war fears was not sufficiently offset by buying for munitions. Nevertheless, a firm undertone persisted. For the first few months there was a steady increase in U.S.A. stocks of copper and an equally steady decline in reserves elsewhere, official consumption in U.S.A. being 25,000 - 30,000 tons *per mensem* against 50,000 in times of moderately good trading. Actually the writer believes that consumption was much greater than the official figure and was provided from hidden stocks. The Buffer Tin Pool aims at keeping the price between £200 and £230, penalising speculation and encouraging hand-to-mouth buying. The initial strength of the lead market was affected by the decline in building; less is now used in munitions than formerly and the chief support has come from cable manufacture. Spelter has been the weakest metal of all, and cartelisation, while acceptable in theory, shows many difficulties in practice; no cartel would be effective without Germany, which, as both producer and consumer, is not likely to agree to an increased price. The July/August holiday convention has spread outwards from Great Britain, and exercises a depressing influence on prices, now accentuated by legalised holidays for workmen in France and Belgium, two important metal producers and consumers. Probably, however, stocks do not accumulate, but the balance is heavily against the market. On an all-round judgment the non-ferrous prices have stood up better than might have been expected. —*"The Engineer", Vol. 166, 26th August, 1938, pp. 229-230.*

An Awkward Diesel Engine Breakdown.

Particulars are given of a Diesel engine breakdown in which the fracture of the main wheel of the timing gear maintaining the correct relative positions of the crankshaft and the camshaft, caused complete disablement. The main wheel was mounted on the crankshaft and through another wheel of equal diameter drove a layshaft parallel with the crankshaft. The layshaft in turn, through bevel wheels, drove a vertical shaft carrying at the top the fuel pump, the governor and a skew gear-wheel which drove the camshaft through a similar wheel (Fig. 2). Altogether a total of 260 h.p. was transmitted by the gear made up of the load due to the compression of both the fuel and the advance starting air valve springs, together with that due to the fuel pump and its five plungers. The main wheel (Fig. 1) consisted of two parts, the gear wheel proper A and the shroud B bolted together in halves for convenience in mounting on the crankshaft coupling at the centre of the engine, the shroud being located on the crankshaft couplings by means of an internal ring E which was machined to fit a corresponding groove in the coupling, while the gear wheel proper was bolted to the shroud by an internal flange C and a ring of fitted bolts. A key H prevented any rotation of the shroud relative to the coupling and was secured in the coupling keyway by means of a ⅝in. cheese-headed screw. The arrangement depended for its efficiency on the fit of the turned part D of the shroud on the coupling and on the key H, and in order to relieve the latter of as much direct weight as possible the shroud when bolted together in place, should just have gripped the coupling. The breakdown was due to the fracture of the cast-iron shroud and the gear wheel. The former broke into three parts, while little more than half of the latter remained on the coupling, and during the last few revolutions of the engine with the power shut off this portion of the wheel was displaced laterally along the shaft, coming out of gear with the secondary wheel above it. On re-assembling the broken parts in their correct relative positions on the engine platform, it was found that the shroud had possibly fractured first at the edge of the keyway (Fig. 3). The metal in way of this fracture showed a very coarse grain in comparison with the remaining fractured surfaces and the key which bore visible evidence of undue wear on the driving face was

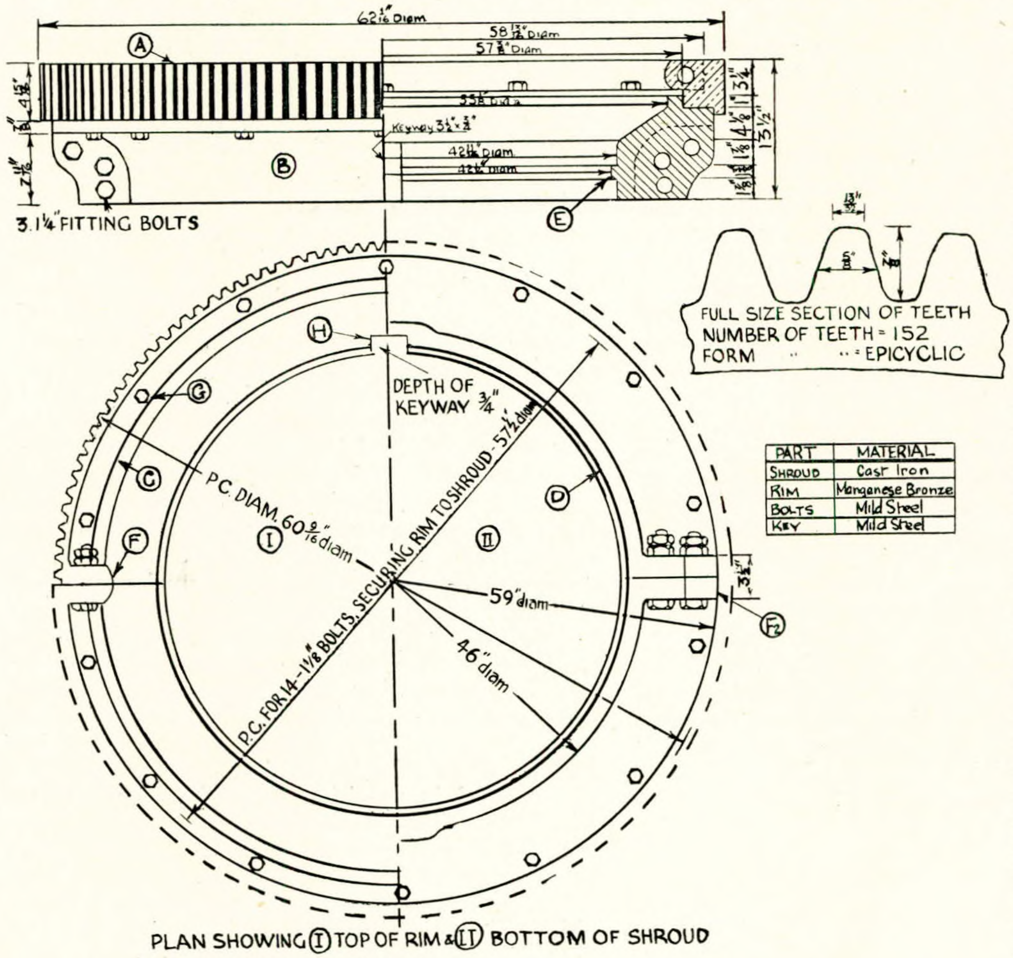


FIG. 1.—The main timing wheel of the engine.

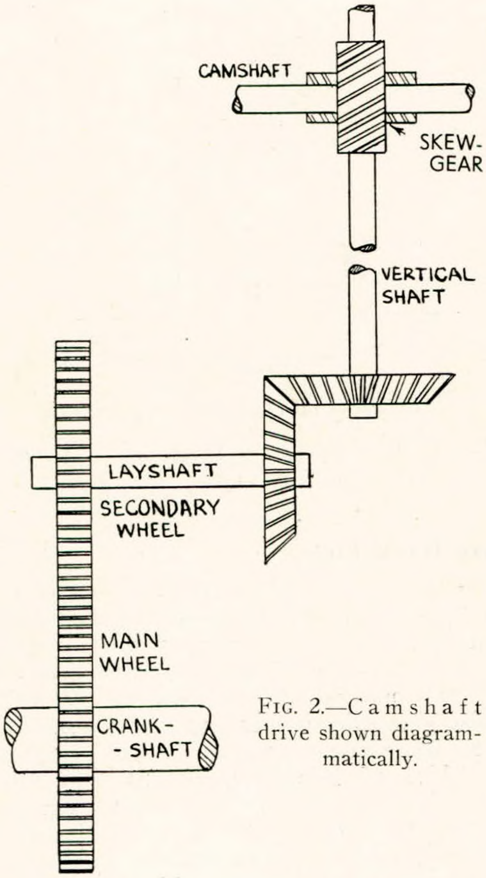


FIG. 2.—Camshaft drive shown diagrammatically.

found to be some ·015in. slack in the keyway. It also appeared that the key was made of too soft a grade of mild steel for the work imposed on it. It is probable that the shroud did not grip the coupling tightly enough when the two halves were bolted together, so that the whole load was thrown on the key. As a result of the breakdown, which precluded even temporary repairs, the vessel was forced to proceed under the power of the starboard engine alone with heavy helm, the speed dropping from 15 to $8\frac{3}{4}$ knots, which was, however, increased to $10\frac{1}{4}$ knots when the port propeller was allowed to idle, arrangements being made to prevent by means of wood shores the disconnected length of shafting from riding forward and returning with a heavy shock on the trailing block thrust face. (Fig. 5). On arriving in port the fractured timing wheel and shroud were replaced by duplicates taken from a sister vessel and a new key was fitted; but after four weeks running this was again found to be slack and an additional locking device was fitted to the shroud. This took the form of two $\frac{7}{8}$in. set bolts with nipple ends shown in Fig. 7, care being taken that the nipple ends of the bolts did not "bottom" in the holes and so force the shroud off the coupling. The set screws were locked to each

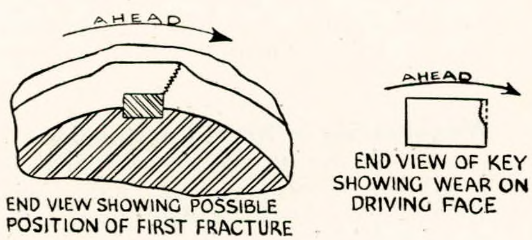


FIG. 3.—Showing location of fracture in way of the keyway.

DATE	ENGINE DISTANCE	SHIP DISTANCE	STEAMING TIME	SLIP %	KNOTS PER HOUR	REMARKS
25/7/36	342	309	21h 47m	9·6	14·13	
26/7/36	393	363	24h 29m	7·6	14·82	BOTH ENGINES
27/7/36	395	377	24h 29m	4·5	15·4	RUNNING
28/7/36	395	370	24h 29m	6·3	15·12	
29/7/36	293	197·5	22h 27m	32·5	8·79	From 4.50 P.M. to Noon. Port Engine stopped
31/7/36	335	257	24h 17m	23·3	10·57	PORT PROPELLER UNCOUPLED.
1/8/36	336	268	24h 17m	20·2	11·05	SHAFT TURNING
2/8/36	335	264	24h 17m	21·2	10·87	42 R.P.M.
4/8/36	329	257	24h 16m	21·9	10·59	
5/8/36	327	231	24h 15m	20·3	9·5	Port Shaft collar shored up

FIG. 4.—Log extract for the period of the breakdown.

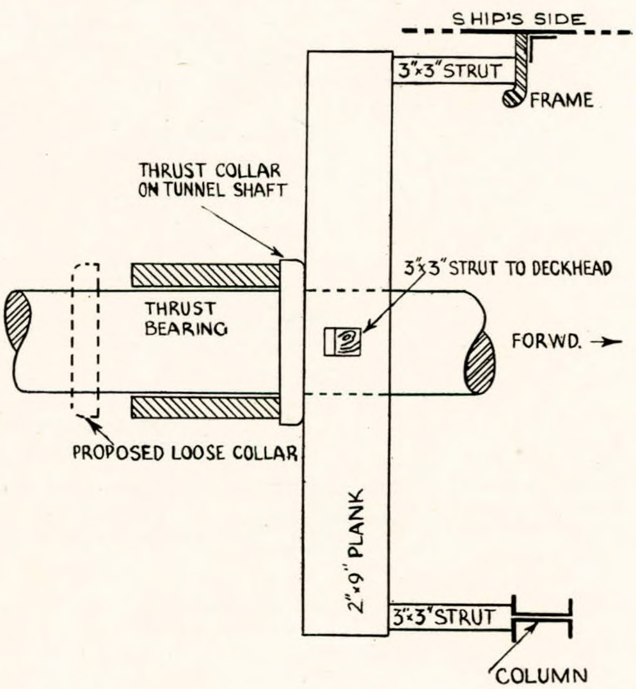


FIG. 5.—How the thrust collar of the idle shaft was shored up during passage.

other, and also to the shroud, by means of copper wire and copper locking washers. In Fig. 8 the writer illustrates an improved design which practically incorporates the shroud as a permanent fitting with the coupling to which it is bolted by means of an internal flange; although like the existing one it is made in halves with a fin D for the purpose of bolting the two halves together.—*L. J. Holman, "The Marine Engineer", July, 1938, p. 221.*

Nº 3 CYLINDER.	NORMAL RUNNING	PORT ENGINE STOPPED
COMPRESSION PRES. lbs/□	550	520
MAXIMUM PRES. lbs/□	585	640
PRESSURE RISE lbs/□	35	120

FIG. 6.—Normal and abnormal cards from the starboard engine, on which the ship was brought to port after the breakdown.

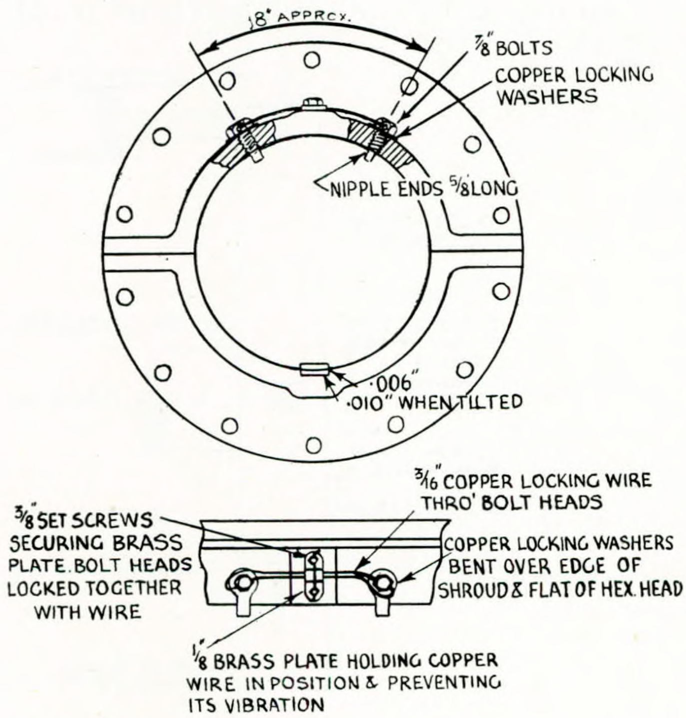


FIG. 7.—How additional security was obtained after fitting the replacement wheel.

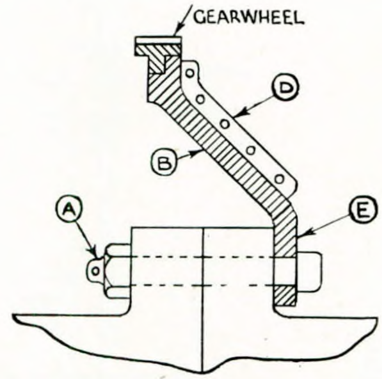


FIG. 8.—Improved form of gearwheel shroud.

German Naval Plans.

The limitation to 35 per cent. of surface vessels and 45 per cent. of submarine tonnage built by Britain, agreed to by Germany in the naval treaty, would give her 255,000 tons of battleships, allowing 87,000 tons for aircraft-carriers, 300,000 tons of cruisers and destroyers and 33,700 tons of submarines, according to an article by Vice-Admiral GUSE, Chief of Naval Operations Staff, in *Die Wehrmacht, Aug., 1938.* At present "Gneisenau" (26,000 tons) is in commission and "Scharnhorst" will shortly be completed. Two 35,000-ton battleships, two aircraft-carriers, three heavy cruisers (of which "Blücher" and "Admiral Hipper" are nearly completed) and two 10,000-ton light cruisers are being constructed. Three 7,000-ton cruisers, sixteen 1,625-ton destroyers and ten 1,811-ton others are projected or commissioned. The German submarines include twenty-four of 250 tons, thirteen of 500 or 700 tons, and thirty-one others, bringing the total ratio up to 45 per cent. Thirteen fast motor-boats are in service and eleven under construction. On completion of this program it is calculated that she will possess a modern fleet well adapted to protection of the Reich, maintenance of essential sea-routes and representation abroad.—*"The Engineer", Vol. 166, 26th August, 1938, p. 217.*

Weight-saving in Naval Construction.

Weight saving may be classified either from its application, *e.g.* hull, boilers, machinery, or from its nature (*a*) rational use of standard materials, (*b*) new materials, (*c*) new technique. Recently special steels have been widely used for saving of weight, but even more on account of their good mechanical properties. The use of aluminium alloys for partitions, gangways, paving, step-ladders, furniture, etc., is consistently increasing, while for thermal insulation aluminium foil separated by a narrow air space, is becoming popular. Further, light alloys are used for signals, tubes and accessories for lubrication. In Diesel motors light alloy pistons not only reduce oscillating masses but permit increased compression ratios (and consequent indirect saving of weight through increase of power) on account of their high thermal conductivity. Extended use of light alloys in situations not exposed to high temperatures or corrosion may be expected, especially where the material is protected from sea air by an oil coating, as in the engine room. In the case of vertical sheets, it is better not to allow the sheet to continue to the floor but to terminate it with a steel cover, but where the light alloy comes into contact with another metal, special protection is usually necessary to prevent electrolytic corrosion. In view of the total elimination of superimposed plates, welding necessarily leads to great saving of weight, not only in the hull but also in boilers and engines. Under the head of new technique must also be considered the substitution of geared turbines for direct drive, variable couplings, and substitution of tubular for cylindrical boilers. Weight per h.p. has been reduced from 63 tons in 1898 to 18 tons in 1922 and less than 11 in 1936. In mercantile vessels, reduction of deadweight is a much less urgent problem.—*R. Théry "Mécanique", Vol. 175, 1937, pp. 255-259; reproduced in "Alluminio", Vol. 7, March/April, 1938, p. 116.*

Trend of Engine Design in Motor Shipbuilding.

The triple-screw passenger liner "Oranje" to be completed in 1939, will be the fastest liner in the Dutch Eastern trade. Each Sulzer 12-cylinder engine of bore 760 mm. (30in.) rated at 9,000 h.p. and 125 r.p.m. will doubtless develop 10,500-11,000 —the highest powered single-acting engines yet developed for marine work. Apparently the recent popularity of the double-acting type for powerful Diesel engines is being challenged, *e.g.* the 27,000-ton "Stockholm", to be completed next year, will have three single-acting 2-stroke 7,000-h.p. Sulzer engines. Two powerful ocean tugs constructed in Holland stand in marked contrast in regard to machinery. In the 2,400-h.p. "Thames" two 8-cylinder, single-acting Smit-B. & W. engines at 125 r.p.m. are directly coupled to the propellers; in "Roode Zee" two 900-b.h.p. 4-stroke engines at 300 r.p.m. drive a single propeller via Vulcan clutch and reduction gearing. A few years ago the same firm ordered a salvage tug "Zwarte Zee" with two 4-stroke engines driving a single propeller *via* fluid coupling. In Britain, recent powerful tugs have been built with Diesel-electric propulsion, which has the advantage of complete control from the bridge. In the intermediate type of liner, the 10,000-ton "Noordam" of the Hamburg-Amerika line, carries 100 passengers and 9,200 tons of cargo in transatlantic service to New York. She has two 12-cylinder 2-stroke single-acting B. & W. engines, but in a sister ship double-acting 2-stroke 6-cylinder M.A.N. engines are installed, these being shorter, but higher. The fact that both have been chosen by a single company suggests that they are broadly equivalent in performance. The 12-knot petroleum ship "Regent Tiger" of 15,000 tons deadweight has a Swan Hunter-Doxford 4-cylinder opposed-piston engine of base 725 mm. (28·5in.) and total stroke 2,250mm. (88·6in.) and has living accommodation of high standard. A recently designed 30-knot, 16-cylinder V yacht engine, single-acting, with bore 7in. and stroke 7¾in., gives a maximum output of 1,000 b.h.p. at 1,750 r.p.m., with high piston speed of 2,250 ft./min. This is equivalent to a power/weight ratio of 8·6lb./h.p. which might be reduced to 5lb. by use of light alloys. It drives the propeller through a 2-speed epicyclic gearbox, controlled from the bridge by electric servo-motor.—*"Times Trade and Engineering", Vol. 43, Sept., 1938, p. 36.*

Long-Distance Transmission of Steam.

Recent papers on centralised distribution of steam to the Treforest Trading Estate (*"Engineering", Vol. 146, 22nd July, 1938, p. 97*), in Hamburg (*ibid, Vol. 140, 1935, p. 693*) and Winnipeg (*ibid, Vol. 128, 1929, p. 609*), the latter two by A. Margolis, are reviewed by Professor L. F. Geneve before the Institution of Mechanical Engineers. In 1935 S. B. Donkin envisaged complete colonies on this basis, in a paper before the Institution of Civil Engineers. Underground conduits for piping will be an appreciable item in capital cost where overhead transmission is impracticable, but in both cases the cost will be much less for high-pressure steam. Explosion risk is small and may be isolated; frictional losses are much higher, and still worse if the steam is wet (*i.e.*, it should be initially superheated); this in turn calls for special attention to joints, expansion and lagging. Three lay-outs are possible. (1) Special back-pressure turbines are installed in the central station, working with super-pressure steam and supplying steam at moderately high pressure to the factories. Base electrical load is handled at the central station, peak loads by individual back-pressure units exhausting into lower pressure steam-lines or an accumulator. (2) Factories would have all-electric drives and heating steam only would be supplied at slightly above working pressure. Steam accumulators would be required to handle fluctuating loads. (3) A central boiler plant transmits high-pressure steam direct, each factory having its own equipment. In all cases as much condensate as possible is returned. The first scheme is suitable in conjunction with the electrical grid but is inflexible from the point of view of extensions; the second is simplest and actually in use in Hamburg; the third eliminates electrical transmission losses but involves capital costs for equipment of rather lower efficiency, and has not been adopted widely. In 1930 F. CARNEGIE before the Institution of Mechanical Engineers discussed the various conditions regarding rate of flow, size of pipe, etc.; with modern lagging, radiation loss can be kept below 2 per cent. per mile. Speeds of 110 ft./sec. are used at Hamburg and Billingham, for heating only; much higher speeds are permissible at higher initial cost.—*Leader, "Engineering", Vol. 146, 2nd Sept., 1938, p. 279-280.*

Engineering Gauges and Line Standards.

As a result of rearmament, a large increase has occurred in the number of gauges submitted by manufacturers for verification, and many novel instruments have been investigated including an optical dividing head, an optical vertical comparator, a tool maker's microscope and a horizontal machine for both internal and external measurements. In some cases new testing instruments were specially constructed to meet this demand, and the reviewer pays a tribute to the ingenuity of design and quality of craftsmanship shown in them. One such appliance enables "drunkenness" as small as 0·00005in. to be detected in screws. Examination of thread forms on plug screws up to 3in. diameter, or on plaster or wax castings of ring screw gauges, can now be effected on a portable projector only 4ft. high; for larger sizes up to 8in., a horizontal type has been developed, hobs and worms being mounted at inclination. Another is a machine for measuring the pitch of large tapered screw gauges for use in connection with piping and tool joints in accordance with U.S.A. petroleum drilling specifications. The local corrosion occurring on lapped end-gauges has been found to be due to settlement of dust particles on the finely polished surfaces. This occurs not only during use, but even in the last stages of manufacture and can be avoided by suitable protection. Workshop atmosphere and non-metallic inclusions were found to be minor factors. The 24m., 100ft., 200 links and 50m. line standards have been reverified, and the surfaces of the composite meter bar—forming a link between line standard and wave length—have been re-conditioned and the graduations improved. A new dilatometer and hob-measuring machine are also being constructed.—*Report on N.P.L. Research, "Engineering", Vol. 146, 2nd Sept., 1938, pp. 266-267.*

Alternative Fuels.

Investigations on the use of palm oil, cotton-seed oil, ground nut oil and soya bean oil as fuels, conducted on behalf of Messrs. Lever Brothers, are reported. Gas oil of s.g. 0·85, calorific value 19,250 B.Th.U/lb. and viscosity 1·5° Engler at 20° C. was taken as a standard basis of comparison, and it was found that any of 29 vegetable or animal oils could be used in a heavy-oil engine provided that pre-heating was applied in some cases. Efficiency was usually 12-15 per cent. lower. With the normal grade of lubricant some absorption occurred, the viscosity dropping slightly to a constant value, although absorption continued, as shown by a steady fall in flash point. The pour point was not materially affected, and the formation of insoluble residues was diminished with use of ground nut oil, substantially unaffected with palm oil, and greater with soya bean oil. A supplementary series of corrosion tests by immersing sections of polished Cu, brass, Al, steel, galvanised iron, nickel plated iron, and Sn in the oils at varying temperature for 5 months showed that ground nut oil slightly corroded Cu, brass and galvanised iron, palm oil was slightly corrosive towards Cu and brass and worse towards galvanised iron, Ni-plated iron and steel; soya bean oil had no effect. Climatic effects might, of course, accelerate the corrosive action. Present prices are for palm oil £11 10s., cotton-seed oil £21 10s., ground nut oil £18 10s., soya bean oil £17 5s., the latter carrying an import duty of £3 10s. per ton. In the event of widespread use, a revenue tax might be anticipated. It is suggested that if the glycerides could be split off and the resulting fatty acids used as fuel, the competitive position would be much improved, but the corrosive effects and suitability of these as fuels are not, as yet, known.—*"The Automobile Engineer", Vol. 28, Aug., 1938, p. 298.*

Crankshaft and Cylinder Materials.

The author reports tests on "wet" liners in a wide variety of materials, ranging from English and French nitrided cast iron (reputed 900 Brinell), through heat-treated and untreated Ni-Cr-Mo cast iron, chill cast iron with varying quantities of Ni and Cr, centrifugally cast soft iron, a Ni cast iron, electric furnace iron, 35 per cent. Cr iron and other irons, to common cast iron. The least wear occurred with a material of 250 Brinell, but this is not necessarily the best. It was very expensive, difficult to produce, easily machined, difficult to hone, and easily scuffed; heat-treated material showed four times the wear of untreated. The best average of properties are—Brinell No. 500, good corrosion resistance, moderate cost, low scrap, ease of machining and honing, production of mirror surface when worn, absence of damage to pistons and rings. Smoothness and roundness of the cylinders are very desirable and simpler specifications for surface finish would result in better working. Recently thin "dry" nitrided liners of 1,000 Brinell have been developed. Oxy-acetylene hardening is being displaced by induction heating to eliminate a human factor. With h.f. (2,000 cycles) owing to skin effect, heating is mainly superficial and in 4·5 sec. the steel is at hardening temperature to a depth of ⅛in. Current is then turned off and the article quenched by water spray; some heat is also conducted to the core. File hardness can almost be attained and, apart from conduction, no heat is applied to any part other than the bearing surfaces. The whole crankshaft is then slightly tempered to remove internal stresses. The process confers a hardness greater than any other except nitriding; the core remains strong and such crankshafts last much longer in service than untreated crankshafts. —*L. B. Sperry, Society of Automotive Engineers (U.S.A.)*; reproduced in *"The Automobile Engineer", Vol. 28, p. 242.*

Development of the Marine Diesel Engine: New Designs of B. & W. Double-Acting and Single-Acting Machinery.

The author, who occupies the position of technical and works director of Messrs. Burmeister & Wain, briefly traces the development of marine Diesel engine design in its main aspects, viz., the competition between the four-stroke and the two-stroke cycles, single- and double-acting engines, the introduction of airless injection and supercharging, and gives particulars of his firm's latest designs. In their double-acting two-stroke engines the scavenge system is arranged on the "uni-flow" principle and eccentric driven exhaust piston valves are now fitted. A high heat-resisting chrome-molybdenum steel is increasingly used as the material of the cylinder covers with fresh-water cooling for the cylinders and oil cooling for the pistons. Methods used of late to reduce cylinder wear include hardening of the cylinder surfaces, but the author states that this treatment still involves practical difficulties, and that it is a question of first cost versus upkeep whether or not hardening is preferred. As regards the two-stroke engine, Messrs. Burmeister & Wain have so far constructed this type with trunk pistons only. In principle it does not deviate much from the double-acting type, but poppet valves have been substituted for the exhaust piston valves. The engine runs with smokeless combustion up to 8 kg./cm. (114 lb. per sq. in.) m.i.p. and up to 165-170 r.p.m., *i.e.*, piston speed of 5 metres per sec. (987ft. per min.) which can be increased by fitting lead bronze piston rings. A twelve cylinder engine of this type of 620 mm. bore and 1150 mm. stroke normally develops 5,750 b.h.p. at 122 r.p.m. and uses only 150 gr. (·33 lb.) of fuel per b.h.p. per hour at this load. To meet the increasing demands of shipowners for greater economy and power together with reduced engine space and weight, Messrs. Burmeister & Wain are further developing new designs of single- and double-acting two-stroke engines. In the lattter the most conspicuous alteration is that the exhaust piston valve has the same diameter as the main piston, which completely eliminates the cylinder cover, gives easier accessibility and a considerable increase of horsepower in relation to weight and space occupied. The experimental engine has a cylinder diameter of 550 mm. and strokes of 1200 mm. and 400 mm. for main and exhaust pistons respectively, and develops 1,100 b.h.p. per cylinder at 125 r.p.m. In comparison with a six-cylinder double-acting two-stroke B. & W. engine of the existing type developing 7,600 b.h.p. which would weigh about 61 kg. (134 lb.) per b.h.p. an engine of the new type would weigh no more than 53 kg. (117 lb.) per b.h.p. Referring to fast-running engines and geared installations, the author considers that apart from special cases it is preferable to concentrate on the perfection of the two-stroke engine coupled directly to the propeller shaft and states that at a moderate number of revolutions the double-acting engine may be produced in units of up to about 35,000 b.h.p.—*A. Houmøller, "The Motor Ship", Oct., 1938, pp. 235-237.*

Flexible Couplings to Reduce Flicker.

The writer discusses the use of flexible couplings for the purpose of reducing flicker in light supplied by Diesel generators when the degree of cyclic irregularity in the angular velocity of the shaft (*i.e.*, the ratio between the difference of the maximum and minimum speeds and the mean speed) is excessive. He points out that even if the flywheel is proportioned to ensure an appropriate degree of the irregularity resulting from the variation of the tangential efforts exerted by the inertia forces and the gas pressures, flicker will not be entirely eliminated, as in practice the shaft of a Diesel engine is not rigid. The harmonic torsional oscillations thus give rise to a supplementary irregularity of the angular velocity and if this exceeds a certain limit at the rotor of the generator, the variation of the voltage will be sufficiently great to cause flicker. Practice has shown that, other things being equal, the "degree of regularity" δ_R (*i.e.*, the inverse of the coefficient of irregularity) increases with the polar moment of inertia of the flywheel WD_F^2 and with the ratio between the polar moments of inertia of the flywheel and the rotor, viz.: $WD_F^2 \div WD_G^2$. A variation of WD_G^2, however, has practically no influence; to be exact δ_R increases slightly with a decrease of WD_G^2 especially if at the same time the rigidity of the shaft K between the flywheel and the generator is increased. Close limits are, however, imposed in the choice of the factor K so that, except in so far as WD_F^2 and WD_G^2 can be varied, the problem seems insoluble. In his researches, however, the writer has discovered that curves to a base K of the coefficient δ_P due to the first fundamental harmonic—the index of which is equal to the number of cylinders—and of coefficient δ_R cross at a certain value of K which is definite for each engine. In the zone indicated, however, the fatigue in the shaft between the flywheel and the generator would be excessive and to avoid this he proposes to choose a convenient diameter for this portion of the shaft and to replace part of its length by a suitable flexible coupling in such a manner that the coefficient of elasticity (of the shaft and the coupling) is equal to the coefficient K chosen. The writer illustrates his method of solving the problem graphically and by means of a numerical example worked out in detail for the case of a five-cylinder four-stroke single-acting Diesel engine running at 167 r.p.m. which drives an alternator with the rotor carried on an extension of the shaft, and he concludes that whatever sort of installation is in question, a suitably-designed flexible coupling will allow of fixing the critical speeds favourably in relation to the running speeds so as to avoid all flicker.—*I. Trigher, "Gas and Oil Power", September, 1398, p. 218.*

"Asama Maru".

A year ago this 17,500-ton liner was forced aground in Hong Kong Harbour by a 167 m.p.h. typhoon. As her draft was very small at the time and there was an abnormal tidal rise of 5ft. she was forced so far inshore that it was estimated that removal of 6,500 tons would be necessary to refloat her. Since she carried no cargo, all water, fuel, anchors, boats and other moveable gear, together with two of her four engines, were lifted out. Even so, it was necessary to fit ten 50-ton buoyancy tanks about the hull, and to cut a channel to deep water by removing nearly 8,000 tons of rock, etc., with dynamite. Six months after grounding the ship was refloated to Hong Kong for temporary repairs, then she proceeded to Nagasaki for extensive overhaul, refurnishing and general renovation.—*"The Engineer", Vol. 166, 30th Sept., 1938, p. 351.*

Flare Path for Empire Flying Boats.

On 24th Sept., 1938, two flying boats took off, just before dawn, on the Singapore and Durban routes. Course and take-off into wind were marked by flares at 200yd. intervals. Each of these consists of two 12-volt 18-Watt lamps mounted on a buoy and coloured amber to avoid all possible interference with navigation lights. Before a flight they are taken out in two launches and arranged on a 1,000yd. line, the craft standing by, 100yd. away, until it is clear that the flying boat will not return. The buoys are then collected and brought ashore for re-use when required. It is possible that the system will be extended for night landing.—*"The Engineer", Vol. 166, 30th Sept., 1938, p. 351.*

The Pescara Free Piston Diesel Compressor.

The Pescara free piston engine consists essentially of a single-cylinder two-stroke Diesel engine operating a piston-driven compressor, but by arranging the combustion and compression cylinders opposite each other and, in principle, connecting the two pistons directly by a piston rod, the two sets of reciprocating and rotary parts which characterize an ordinary Diesel compressor set are eliminated. The two piston combination is quite free to move in either direction according to the difference in pressure acting on the opposite sides. In actual installations, however, the opposed-piston principle is adopted to provide balanced reciprocating parts, one piston uncovering the inlet and the other the outlet ports, while the scavenge air is as a rule provided by using the back face of the compressor piston in the engine-driven compressor sets. Owing to the elimination of the flywheel some energy storing device is needed to ensure the return of the piston after the power stroke, and the energy required for this purpose is obtained from two sources, (1) the air under pressure left in the clearance space of the compressor cylinder at the end of the working stroke, and (2) an auxiliary piston and cylinder in which a fixed quantity of air is compressed during the working stroke and re-expanded during the return stroke. The volume and pressure of the air from the auxiliary compensating cushion must be so calculated that the total return energy from the two sources is as nearly as possible constant. By this means a constant compression pressure is produced whatever quantity of fuel is injected and the position of the inner dead centre is fixed. The motion of the two pistons is synchronised by a system of links and crank arms which also operate the fuel injection and lubricating oil pumps. In the absence of a base-plate, rigid crankcase or flywheel lightness is an inherent feature of the Pescara design. Thus the weight of a set of 9½in. cylinder bore delivering 630 cub. ft. per min. at a pressure of 100lb. per sq. in. when running at 600 cycles per min. is no more than 3¾ tons.—*"Gas and Oil Power", September, 1938, p. 229.*

Comparative Economic Efficiency of Various Types of Machinery.

The author surveys the alternative types of main propelling machinery available for different classes and sizes of merchant ship. For the smaller ships, such as trawlers, the reciprocating steam engine, with or without exhaust turbine, holds its own except for long-range work, when the internal-combustion engine becomes competitive. For the larger type of cargo ship, intermediate liners and tankers, there is a choice between motor and turbine, with or without electric transmission. On the whole the motor predominates up to about 10,000 s.h.p., above which the turbine holds the field. The reciprocating steam engine is found in sizes as large as 5,000 i.h.p. per shaft, but coal firing is unusual above 2,000 h.p. Figures are given showing the progressive reduction in weight and fuel consumption for various types of machinery as illustrated by data for particular ships. Thus Diesel weights have been reduced from 175 kgm. per b.h.p. to 52 kgm., and fuel consumption from 197 gm. per b.h.p.-hr. to 164 gm., the later figures referring to two-stroke compressorless engines of the trunk type. The reduction in boiler weights, comparing cylindrical and La Mont boilers is also notable; 5·4 tons per ton of steam per hour has been reached, against 14·4 tons. The cylinder dimensions of Diesels at first rose, but latterly have tended to fall; there has been an increase in piston speed. There is naturally an increase in power per unit swept volume with two-stroke against four-stroke, or double-acting engines, but little increase in mean effective pressure. Comparative figures for two 10,000-ton cargo ships of 16 knots and 6,200 h.p., one with La Mont boilers and high-pressure geared turbines and the other with a double-acting two-stroke motor, show that the former installation is considerably lighter, occupies slightly less space and has slightly lower fuel costs, but the actual weight of fuel required is appreciably less for the motor. The author considers that the modern turbine drive is likely to be found advantageous for powers above 6,000, but below this, down to 1,000 horse-power, the internal-combustion engine will remain economic.—*W. Scholz, "Schiffbau", Vol. 39, 15th September, 1938, pp. 327-334.*

Pressure Losses in Ducts.

Pressure drop is caused either by wall friction or by shock from sudden changes in direction or cross-section. The first can be measured by decrease in static pressure, the second can be estimated only by difference. As cross-section increases the velocity of a fluid stream decreases, and with no loss, an equivalent rise in pressure occurs. Efficiency of a contraction profile can be defined as the ratio of actual to theoretical pressure rise. In any system, total head to be provided by the fan is given by (velocity pressure at outlet + losses occurring in the system on both sides of the fan) and with a properly-designed divergent profile, outlet velocity and consequently fan load, can often be reduced. Shock loss is found to decrease with decreasing angle of inclination down to 3°; with a 7° section it was the same when this was placed on either side of the fan, and there is no material gain in increasing a diverging angle above 30°. Maximum static pressure is found to occur in a larger duct at approx. 22 equivalent diameters of the smaller duct from the entrance of the diverging section, *i.e.* the length of the larger duct influences the efficiency. In a 3° duct, conversion is nearly complete at 14 diameters and this may be regarded as the minimum. In limited space the authors recommend the 7° profile with appropriate after-section. With air velocity of 100 f.p.s. and 7° divergent section, 61 per cent. of the initial velocity was converted to static pressure at the exit of the smaller duct 8 diameters distant, 67 per cent. at 14 diameters, and 69 per cent. at 22 diameters; beyond this any further gain was absorbed in frictional loss. In 7° and 3° sections with air at 100 f.p.s. in the smaller duct, losses were less than 0·005in. water gauge, within experimental error for the locally-made apparatus. Shock loss in the 30° section was very small, and no advantage results from converging angles less than 15°. In such sections total loss is equal to friction loss for a parallel duct of the same length and mean cross section.—*A. P. Kratz and J. R. Fellows, Illinois University Engineering Bulletin No. 300,* abstracted in *"Engineering", Vol. 146, 9th September, 1938, pp. 302-303.*

Improving the Efficiency of Hand Work.

The author treats the problem from the psychologist's standpoint. In recent years improved machine tools have allowed shop hours to be reduced without affecting output; as a result the artificer is expected to do as much hand work in 7 hours as he previously did in 10, with resulting deterioration in quality, and nervous strain. He suggests that for synchronised rhythmic work men of dissimilar stature should not be grouped together and cites the superiority of smaller and lighter arms in light assembly, for which girls are usually employed, and recommends a rest pause of two hours at midday as on the Continent. The effect of noise in impairing keenness of vision, especially among draftsmen, is described; 35 years ago drawings above double-elephant size were uncommon; the original designs by Wren for St. Paul's, and others attributed to Watt were not much larger than half-imperial. Such small scales and fine lines were due probably to the quiet of those days. White light is better for long continued working than monochromatic and with alternating current the author advocates lamps operated on very low frequency, *e.g.* 12, with opaque shade between light and eye. He discusses nervous strain, which in the ultimate shows itself in the phenomenon of "shell-shock", and deprecates the attitude of managers who refuse to allow operatives to sit. An interesting exercise for relaxation periods (the "see no evil" monkey with hands crossed over the face shielding the eyes), said to be very restful, is described. Two-minute periods, at 11 a.m. and 4 p.m. are a great help to physical efficiency.—*J. F. Romer, "The Engineer", Vol. 166, 23rd September, 1938, pp. 338-339.*

Ferrous Metal Research in U.S.A.

In the June meeting of the A.S.T.M. committee A9 submitted a report on ferro alloys including nine new specifications. A1 suggested new specifications for quenched, tempered and normalized forgings, covering Ni steel, seamless drawn 4-6% Cr. steel, tubes for heat exchangers, condensers and stills, plates of C-Si and Cr-Mn-Si steels, lap welded and C-Mo steel seamless boiler tubes, and electrically-welded pipe. High-tensile steels for railway engines and waggons will be discussed as well as a definition of "weldability". Of four low-alloy high-strength steels investigated Collins and Dolan reported that two (0·08% C, 0·4% Cu, 1% Cr and 0·08% C, 1% Cu, 0·5% Ni) have a much higher yield point ratio than structural C steel, with about the same ductility. Impact properties depend on the type of test-piece; under repeated loads all four alloy steels showed endurance limits at least 67% higher than that of the structural steel; they were, however, more susceptible to notch effect and to corrosion under fatigue testing. A10 recommended two new specifications for corrosion resisting Cr steels and strong Cr-Ni steels and reported good progress in systematization of data. A6 reported a new method of measuring interlamination resistance, especially in oxidised sheets. P. R. Kosting reported on surface cracking in castings of 18/8 Cr/Ni steel, suggesting that these should be cooled either very rapidly or very slowly. Wrought iron was discussed by A2 and cast iron by A3, the main difference in the mechanical properties on chilling is that the modulus of elasticity for grey iron at 15,000lb./in.^{2} is only $\frac{3}{4}$ that for white. Hardness testing was discussed by Vanick and Eash and torsional testing of cast iron by Draffin and Collins of Illinois University. The high temperature committee presented a voluminous record of work on creep in straight and alloy steels, irons and nonferrous metals. It appears that extrapolation of creep from a 2,000-hr. value to 20,000-hr. gives a result lower than that found experimentally. Steel has a marked superiority at 750°-950° C. when coarse-grained than when fine-grained, the difference being as much as 21,000lb./in.^{2} according to S. H. Weaver, whose paper aroused much discussion. J. B. Kommers showed that endurance limit is not fixed, but is increased by progressively increasing cyclic understress, and reduced by cyclic overstresses.—*"The Engineer", Vol. 166, 26th August, 1938, p. 238.*

Social Relations of Science.

Attention is drawn to the decision of the British Association to establish a new division dealing with social and international relations of science, the new organisation apparently not being an addition to the twelve existing sections, but a "division". It aims at meeting more frequently than once a year and is not intended so much to inform those taking part, as to supply information to the public, coordinate work in this subject, and act in a consultative capacity for bodies or persons engaged in practical administration. Its province seems essentially to be the effect of scientific advance and social conditions upon each other. Lord Rayleigh has dealt trenchantly with the alleged responsibility of scientists for the horrors of modern war; Professor Southwell made particular reference to the part played by engineers in munition manufacture. The leader deprecates the tendency shown in some high places to wish to control scientific development and invention with the object of guiding it into paths which will bring no hurt to mankind, believing that such schemes are unworkable or, at least, not beneficial in the long run.—*Leader, "The Engineer", Vol. 166, 26th August, 1938, p. 230.*

Vibration in Ships.

Vibration will occur on any ship to which unbalanced periodic forces are applied, and will become serious if the frequency coincides with the natural frequency of the hull or of some part. In new design the primary two-nodal vertical and horizontal frequencies of the hull should be estimated, since resonance at one of these is the most dangerous possibility. The author shows that for vessels without extensive superstructure, the frequency of vertical vibration can be estimated quite accurately, and with information now accumulating even cases with large passenger erections above the strength deck will be manageable. For horizontal vibration, estimates are still liable to error. Having determined the frequencies, the naval architect should consult with the engineer regarding the r.p.m. of main and auxiliary engines; in particular, main engines should run as far as possible from the critical speed, preferably below it. To reduce amplitude to 10 per cent. of that of resonance, r.p.m. must be altered by 10-12 per cent.; this datum gives a good idea of the critical range. Even clear of this, however, unpleasant forced vibration may occur, and great attention should be given to balancing of machinery and matching of propeller blades. There remains the probability of propeller vibration due to working in non-uniform flow, and attention should therefore be paid to bossings and clearances between hull and rudder. If, despite these precautions, vibration arises, it can be countered by (1) local stiffening or better balancing of the machine, or vibration damping, or elastic mounting—if of local type; (2) by change from a 4-blade to 3-blade or 5-blade, or remodelling of the bosses—if of propeller blade frequency type. The most serious vibration is that of the whole hull, due to synchronism of its natural frequency with main engine speed. This may be reduced (3) by alteration of engine speed entailing some reduction of sea speed, as it is not always possible to develop full power at lower r.p.m., especially with a reciprocating engine already running at high mean pressure. Hull stiffening is not a practicable proposition, a 5 per cent. alteration in frequency would entail an addition of 10 per cent. to inertia. The author points out the progress in combating vibration made in recent years and considers that the extension to larger units of elastic mountings now commonly used for small auxiliary machines is only a matter of time. In two valuable tables the characteristics of 16 vessels—8 tankers, 4 cargo ships, 4 passenger ships—are summarized, *viz.* machinery, percentage load displacement during experiments, length/beam, beam/mean draft, virtual inertia factor, displacement in tons and percentage, frequency per minute calculated and observed. On the whole good agreement is obtained in the latter.—

BIBLIOGRAPHY.

[1] *"Engineering", Vol. 143, 1937, p. 103.*
[2] *C. E. Inglis, "Engineering", Vol. 135, 1933, p. 445.*
[3] *M. Constantini, "Vibration in Ships", Transactions of the Institution of Naval Architects, 1938.*
[4] *Transactions of the Institution of Naval Architects, 1884, 1893, 1894, 1895, 1901, 1911.*
[5] *Transactions of the N.E. Coast Institution of Engineers and Shipbuilders, 1931-1932.*

[6] *J. B. Henderson, Transactions of the Institution of Naval Architects, 1909.*
[7] *F. M. Lewis, Transactions of the American Society of Naval Architects and Marine Engineers, 1929.*
[8] *Moullin, Browne and Perkins, Transactions of the Cambridge Philosophical Society, 1927-1928, 1929-1930.*
[9] *Transactions of the N.E. Coast Institution of Engineers and Shipbuilders, 1932-1933; Gothenburg Society of Engineers, 1935.*
[10] *A. F. Yarrow, "Balancing of Marine Engines and the Vibrations of Ships", Transactions of the Institution of Naval Architects, 1892.*
[11] *W. White, "Some Recent Experiments with Some of H.M. Sloops", Transactions of the Institution of Naval Architects, 1892.*
[12] *Pollard and Dudebout, "Théorie de Navire", 1894.*

—*F. H. Todd, Paper read before Section G of the British Association, 1938,* at Cambridge; reproduced in *"Engineering", Vol. 146, 16th and 23rd September, 1938, pp. 345-348 and 375-377.*

Stroke/Bore Ratio in Unsupercharged Engines.

A research at present in progress concerning balance and critical speed suggests quite definitely that stroke/bore ratio should not be chosen arbitrarily, but should be equal to the ratio of the specific heat of gases at constant pressure to that at constant volume, approximately 1·405. The author plots the strokes and bores for 30 6-cylinder and 30 4-cylinder 1938 o.h.v. motor car engines arranged alphabetically, as ordinates. Through the zig-zag line thus obtained straight regression lines derived by the method of least squares are drawn. If the stroke/bore ratio was constant the "correlation" obtained would by unity, and a figure greater than $\pm 0{\cdot}487$ is evidence of a mutual relation. For the 6-cylinder engines a value of $+0{\cdot}711$ was obtained, and the mean stroke/bore ratios derived mathematically are 1·458 for 6-cylinder engines and 1·465 for 4-cylinder engines. [It is interesting to note that the arithmetical mean of the stroke/bore ratios derived without mathematical manipulation is 1·466 and 1·463 respectively].—*J. Bowie, "The Automobile Engineer", Vol. 28, September, 1938, pp. 339-340.*

Surface Finish and Engine Wear.

The author describes an apparatus for study of surface finish, a tracer point being connected to a tiny coil operating in the field of a permanent magnet. The resulting current is fed into an amplifier and reproduces the irregularities on an oscillograph. Both roughness and waviness can be recorded, the readings representing the root mean square of the irregularities; for visual observation a suitable "sweep" may be used. Photographic records may be obtained by synchronisation of tracer and film speeds. Recently two motor car firms and one liner manufacturer have adopted a controlled finish in which irregularities are limited to 5 $\mu\mu$ in. for bores and pistons, and to 1-2 $\mu\mu$ in. for certain other parts such as crankshaft and crankcase bearings, camshafts and their bearings, valve stems, piston pins, mushroom heads, etc. The process consists of rough boring with 4-blade piloted stellite-tipped cutters removing 0·06in. (150-200 $\mu\mu$ in. finish), semi-finish boring with 3-blade carbide-tipped stub bars removing 0·01in. (150 $\mu\mu$ in. finish), precision boring with single point carbide-tipped cutters removing 0·007in. (60 $\mu\mu$ in. finish), and finally hydraulic honing removing 0·0007 to 0·0010in. with accuracy $\pm 0{\cdot}0015$-0·0025in. (8 $\mu\mu$ in. finish). These stages are reproduced in photographs, in which the progressive improvement is plain to see. An engine with surface finish 13 $\mu\mu$ in. requires one quart of oil in 300 miles, with finish 9 $\mu\mu$ in. in 1,500 miles only. In hydraulic honing pressure increases with increasing area of contact between work and stone, consequently slightly coarser and softer stones can be used than in mechanical honing. The successive operations are shown for a straight six-cylinder block, final roughness being 3-4 $\mu\mu$ in. In operation the tool is lowered into the bore in collapsed condition and rotary and vertical reciprocating motion started; after one stroke it expands to a light pressure which is maintained for 25 strokes, full working pressure is then applied until released by electrical timing. With increasing use of the new apparatus for finish determination, the author looks for progressive improvement in future.—*K. W. Connor, "The Automobile Engineer", Vol. 28, July, 1938, pp. 253-256.*

[1 $\mu\mu$ in. = 1 microinch = 1×10^{-6} in.].

Cooling Pistons by Under-crown Oil Jets.

In designing pistons, crown thickness is determined by heat flow, or collapse from overheating may occur, but skirt design is governed by considerations of strength. Heat dissipation from an Al piston at 1,500 r.p.m. is approximately: 80 per cent. to cylinder wall via rings and belt, 10 per cent. to skirt, 10 per cent. to air and oil spray; at 3,000 r.p.m. undercrown cooling accounts for 20 per cent. With cast-iron pistons the value is much higher, possibly 60-70 per cent., due to its lower thermal conductivity; complete shielding of undercrown dissipation in this particular instance resulted in crown collapse with vivid temper colours on the iron. Water cooling of the piston is fairly common in larger Diesel marine and land engines with cast iron pistons, and air cooling was used in tank engines during the war. In U.S.A. recent aero engine pistons were cast with a projecting "waffle iron" and used a copious oil supply controlled by high-tension rings, and the idea spread to Britain and Germany. One successful design of T.T. motor cycle engine utilizes oil jets playing into the piston crown, and the principle is particularly adapted to air-cooled and side-valve engines. In a certain 7½in. bore, 2,000 r.p.m. Diesel engine of high performance, piston temperatures are only 100° below the melting point, and under such conditions sticking and similar troubles are much accentuated, even with special rings. Forced oil jet piston cooling is used in a recent two-cycle U.S.A. Diesel and without it the engine is unworkable, and a recent British design obtains oil cooling by external delivery and return pipes clipped to the connecting-rod. Obviously the crown temperature in Diesels must not be reduced too far, or efficiency will suffer, especially at part loads. The author considers that by special design, the cast iron piston may even return to favour in small and medium engines.—*W. A. Wilson, "The Automabile Engineer", Vol. 28, September, 1938, p. 320.*

Electrification of Hydraulic Machinery at Sharpness Docks.

The mechanisms comprise 12 gate winches opening 3 pairs of gates *via* chains, 12 wall sluices worked by direct-acting hydraulic cylinders, 3 5-ton capstans worked by radial engines with three single-acting oscillating cylinders, a 20-ton coal hoist worked *via* chains by rams, and a 1-ton turnover capstan serving the coal hoist. Formerly pressure water was supplied through cast iron pipes, the pumping equipment installed in 1893, 1908 and 1913, supplying 210 galls./min. at 700lb./in.^{2}, a weight loaded accumulator of 10in. ram and 14ft. stroke being used. After consideration it was decided to retain hydraulic operation and the existing water supply was replaced by a number of self-contained pressure oil systems divided into 5 groups. The pump sets act automatically as follow: On starting up, if control valves are shut, pressure rises almost instantaneously to its maximum; as the stroke mechanism returns to zero, no further oil is pumped but the pressure is maintained. On opening any machine valve oil is admitted and the pressure drops, the stroke control then replaces this oil in the system. Should an abnormal pressure (*e.g.* a lock surge) occur, the control will check further delivery of oil from the pump, but will release oil when the chain pull falls. Existing valves are retained, with modifications to suit oil. This change over is reported to be the first of its kind and results are satisfactory; in the case of sluices the operation is even improved. The pump is of eccentric swashplate type, eleven cylinders being disposed about the cylinder block which is itself mounted on splines on the driving shaft. For automatic operation the cage is moved by a piston under the influence of pressure oil admitted continuously to its cylinder from the pressure side.—*"The Engineer", Vol. 166, 23rd September, 1938, p. 344.*

Applications of Chemistry.

Many industrial operations, such as lubrication and coal distillation, have been carried on for years, although much fundamental research is yet required to explain the phenomena involved. In corrosion a number of factors are interdependent; from measurements at 25° C. in stagnant salines or water it appears that a high concentration of dissolved oxygen makes the metal passive, apparently due to an oxide film which cannot form completely in the presence of the acid impurities in air. In opposition to established ideas, it appears that the loose rust formed by corrosion of mild steel in stagnant salt solutions is no important barrier to oxygen access and does not appreciably influence the rate of corrosion. The L.M.S. Railway found that most of their serious boiler tube corrosion was localised, considerable portions of the tube being almost unattacked. Partially softened hard Rugby water gave almost double the rate of pitting with fully softened water rendered slightly alkaline. At boiler temperatures the chief product is black Fe_3O_4 which overlies the thin film of mill scale and the condition of the latter determines to some extent the area over which corrosion takes place. Hydrogen under pressure at high temperature is known to cause embrittlement in steel, but the same effect can occur at ordinary temperature and Bourdon gauge tubes have been known to burst. The effect of a $(CO+H_2)$ mixture is now being investigated. Other interesting researches in progress include—liquid phosphoric acid as a catalyst, corrosion of tar stills, new uses for rubber, and poly-phenolic resins for water softening; with the latter dissolved solids may be reduced from 36 to 1 part per 100,000 in a simple operation. The action of potable waters on mains conveying them is also under investigation.—*Leader, "Engineering", Vol. 146, 30th September, 1938, pp. 395-396.*

Flow in the Combustion Chambers of Hearth Fired Boilers.

The author points out the difficulties to be expected in investigating this problem and gives a bibliography of 14 references. He uses fluid flow as a tool for investigation of gas flow between grate and boiler. Combustion reactions at and above the hearth as well as the profile of the combustion chamber, are of great importance in the production and behaviour of the gases. Flow is governed by pressure, temperature, chemical composition and velocity; for equalisation of properties as is desired in industrial installations mixing necessarily plays a large part. In view of the similarity between the exchange of K.E. in the form of heat, and of physical and chemical properties, the problems may be reduced under certain conditions to a simplified form soluble by stream-line methods. From quantitative experiments with models in a wind tunnel the partition of velocity during the process of mixing of parallel streams is deduced. Formation of "streaks" occurs chiefly in modern combustion chambers with smooth profiles, in which the attainment of uniformity is incomplete. Experiments with various boiler models with water as fluid, give qualitative confirmation of the flow processes in the combustion chamber.—*L. Schiegler, "Zeitschrift V.D.I.", Vol. 82, 16th July 1938, pp. 849-855.*