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Heat Insulation of Cold Stores.

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Introduction.

An examination of the factors involved in the process of either raising or lowering the temperature of a body reveals that the latter operation is more expensive, in that the cost of extracting unit heat from a body in lowering its temperature is several times greater than the cost of raising its temperature. This increase in the cost is due to the greater complexity of machinery which is involved in reducing the temperature than in raising it.

Since this heat extraction is such an expensive operation it is important that the energy which is expended in lowering the temperature shall be used only on the body which is being cooled and is not wasted on any other thermal action which does not assist this operation. For this reason, heat gains of any description must be reduced to a minimum and the more that they are reduced, the more economically will the plant be run.

If, as is the case with food storage, the body is ventilated by passing cold air around it, heat will be added to the system from various sources, for not only will the ordinary forms of heat addition through the walls by heat transferences due to radiation, convection and conduction occur, but the fluid flow due to the air circulation will also influence the storage conditions. While it is not intended the develop this aspect of the problem in this paper, it is interesting to note the various difficulties which fluid flow may incur. Heat may be generated by the friction between the air and the sides of the store and duct walls, principally in the latter where its velocity is greatest, while sudden enlargements, contractions and bends all require work, which sets up heat, to be done on the circulating air. The extent of this generation of heat will also depend upon the nature of the air flow, upon whether it is turbulent or not, for the air-flow effects vary as some power of the velocity, this power depending somewhat upon the nature of the air flow. To counter these heating effects it is necessary to design the store in such a manner that the air encounters as little impedance as possible so as to reduce the work done by the air in overcoming these hinderances. This may be carried out in various ways; for instance, friction may be reduced by coating the walls with a smooth lacquer or varnish, while aerofoils may be inserted at bends to reduce the heating effect due to sudden bends and, of course, suitable field resistances must be used for the circulating fan to give it a suitable speed range which will enable the air velocity to be properly controlled. These problems only occur with ventilated stores where a continuous supply of oxygen is essential, but in both ventilated and unventilated stores heat is continually leaking inside through the store walls and it is necessary to examine the character of the heat transferences causing this leakage before adopting any specific method to counteract it.

HEAT TRANSFERENCE.

Unlike most other heat problems the insulation for cold stores has to be designed to meet conditions of maintaining low storage temperatures by preventing heat from entering the stores from outside and not, as in most cases, preventing heat leaving the plant, yet all these problems involve precisely the same methods of heat transference, namely, by radiation, convection and conduction.

Radiation.

Heat may be transferred between two bodies placed within an enclosure with one at a higher temperature than the other, without adding heat to the intervening medium, simply by means of a wave motion or ray, known as radiation. The conditions in which the surfaces of the two bodies are kept affect the rate at which they emit or absorb heat, each condition of the surface possessing a definite coefficient or power for either emitting or absorbing radiant heat. Since the media in which the two bodies are placed is not affected by this transference of radiant heat, the rate of heat transference depends only upon the bodies themselves. Thus, with refrigerator cars, which tend to receive heat from the sun, the condition of the exterior coach work is important in reducing this form of heat transference. Dark surfaces absorb more heat than light-coloured reflective surfaces in exactly the same manner in which light is unreflected or absorbed by dark matt surfaces yet is reflected by light-coloured glossy surfaces. It will therefore be apparent that the radiant heat rays which penetrate dark surfaces and heat the enclosed body, are reflected by light surfaces, leaving the enclosed body unheated and cool. In practice, a certain amount of the incident heat rays is always absorbed by a body, but coatings of white reflective lacquers allow only the smallest fraction of this radiant heat to enter the store, so that it is sufficient to paint the walls of cold stores with such materials.

An empirical formula for the rate of heat transference by radiations is given by

$$q = K\ (T^4 - T_o^4)\ \text{B.Th.U./ft.}^2\text{/hr.}$$

where, T = absolute temperature of the emitting surface.

T_o = absolute temperature of the absorbing surface.

K = constant depending upon the conditions of the surfaces.

For a bright, reflective surface the value of K varies between $8{\cdot}6.10^{-10}$ and $2{\cdot}0.10^{-10}$. With a store temperature of 40° F. the rate of heat transference by radiation may be about 3·0 B.Th.U./ft.^{2}/hr.

Convection.

The process of heat transference by convection in which one part of the fluid within the store moves to another position by mixing due to alterations in density with variation of temperature, which is the method by means of which the large volume of air within a cold store tends to attain a steady, constant temperature, is intimately associated with the other forms of heat transference, *i.e.* radiation and conduction. This connection between the various modes of heat transference and convection will be more readily appreciated when it is realized that the actual passage of heat from molecule to molecule of the fluid in altering its density is an integral part of a separate process known as conduction. Not only does this process of convection depend upon the density of the fluid by means of which the heat is transferred, but it is also dependant upon its other physical characteristics such as specific heat, conductivity and viscosity as well as its velocity and the direction in which it flows. Normally, convection currents tend to make the fluid rise, but if the flow is constrained to move downwards this contra-direction affects the rate of heat transference. Since the values of such properties of the fluid as density, conductivity, viscosity and even specific heat are likely to vary with the pressure and temperature at which it is maintained, it is evident that countless variations in the convection rate may be set up by relatively small changes in the condition of the fluid, thereby complicating the whole process of analysing the method of transference. Despite these complications, it has been determined empirically that the heat transferred by convection is given by

$$q = \alpha\ (t - t_o)^{5/4}\ \text{B.Th.U./ft.}^2\text{/hr.}$$

where t and t_o = temperatures of the surface and fluid respectively.

α = experimental constant introduced to allow for the variations in the heating conditions.

Over a large surface the values of t and t_o may differ from point to point according to their position in the surface so that for an experimental analysis, average values should be taken over the whole surface to produce a reasonably correct value for q. Furthermore, the constant α has a tendency to vary under different conditions. For instance, a vertical surface may have a value of $\alpha = 0{\cdot}31$, yet for a lower horizontal surface such as the floor of a cold store the value of α may be as high as 0·38, while for a horizontal upper surface, such as the roof, this value may fall to 0·2. These variations in the value of the constant are quite obvious when the fundamental principles of convection are considered. When the sides are heated the fluid tends to rise, but as the heated gas rises it reduces the value of $(t - t_o)$ for the upper surfaces so that the heat which may be transferred by the vertical surfaces is reduced, consequently the value of α is lowered. When the floor is the heating agent, the value of $(t - t_o)$ should remain constant and the rate of heat transference should be high since the heated less-dense fluid rises away from the surface allowing cooler fluid to surge in and repeat the process, so that a pure convection process is maintained throughout the cycle with the result that a higher value for the constant α might be anticipated. When a contra-directional effect is introduced such as when the roof is heated, the heated fluid attempts to carry out its normal process and rise, but it is prevented from doing so by the surface from which the heating is taking place; therefore the temperature difference between the surface and the fluid tends gradually towards a small constant value and the corresponding rate of heat transference falls off giving a very low value for α; in fact this method of heat transference takes the value of conduction through the various layers rather than convection.

Conductivity.

Actually, the major process of heat transference encountered in a cold store is by conduction, which forms by far the greatest proportion of the total heat addition effect. Conduction is the process by means of which heat is passed from one point in a body to another by heating the intervening molecules of that body. The molecular structure of a body therefore has an effect upon the rate at which heat passes through it by the conduction process. For instance, although it must not be taken to consist of a definite principle, it will be noticed that materials with high densities such as metals conduct far more heat than the lighter less-dense substances. In this respect it will be noticed that lead with a density of 710lb./cu. ft. will conduct 243 B.Th.U./ft.^{3}/°F./hr., yet pure wool at a density of approximately 356lb./cu. ft. will only transfer 0·25 B.Th.U./ft.^{3}/°F./hr. This comparison does not hold for all substances and a more involved investigation into the molecular composition of the various bodies is needed to determine the true relationship between the densities of the substances and their conductivities.

The rate at which heat may be conducted between two points in a body depends fundamentally upon the temperature difference which exists between the two points, from which the equation of heat transference by conduction is developed,

$$i.e.,\ q=\frac{k}{d}(t-t_0) \text{ B.Th.U./ft.}^2\text{/hr.}$$

where $t-t_0$ = temperature difference existing between the two points,

d = distance between the two points, usually the thickness of insulation,

k = constant, known as the coefficient of thermal conductivity, which has different values for various materials and represents the amount of heat in B.Th.U's. conducted by 1 sq. ft. of the material 1ft. thick, in 1 hour for a temperature difference across the surfaces of 1° F.

It will be noticed here that in certain respects there is a similarity between the rates of heat transference by convection and conduction substantiating the previous observations regarding their mutual intimacy. Firstly, unlike radiation, both depend upon the temperature difference only, although convection varies as the $^5/_4$ power of this difference, but both of these transference processes are independent of the absolute temperatures themselves, the only effects of which in these two processes are to cause certain slight discrepancies—negligible for practical purposes—in the value for the coefficients of convection and conductivity. Furthermore, in the manner of which the constant or coefficient involved in convection varies according to the position of the surface from which heat is transferred, similarly the value of the coefficient of conductivity for a body will not only vary slightly with temperature, but also according to the direction in which heat is transferred. This directional effect is due to the differences in structure of a substance being more pronounced when samples are taken in one direction than in another, particularly with naturally fibrous materials such as oak which has a density of 51·5lb./cu. ft. when measured across the grain but only 51·1lb./cu. ft. when a sample is taken with the grain, the corresponding coefficients of thermal conductivity being 1·45 and 2·50 respectively. In this particular case, the small difference in density (0·4lb./cu. ft.), due to its cellular construction, may be attributed to the greater mass of fluid holding the fibres together when collected in the sample taken across the grain than that which is collected with the sample taken with the grain, thereby involving corresponding variations in the conductivity. These observations are of great importance in the development of insulating materials, since the structure of most materials contains many cells and fibres which are of great assistance in the production of reliable insulating material.

INSULATING MATERIALS.

In order to reduce the leakage of heat into cold stores it is the usual practice completely to surround them with some insulating material whose sole purpose is to keep heat out of the store. This insulator is of such a nature that it is a poor conductor of heat and it accordingly exerts a large resistance to the flow of heat from the warm exterior to the cold interior of the store. Since the transference of heat into cold stores is mainly by the conduction process, the material selected for their insulation should have a very low coefficient of conductivity, for which reason many substances such as granulated cork, charcoal, slag wool, asbestos, glass wool and cellular rubber are adopted for insulating purposes. The best possible heat insulator is a vacuum as in a thermos flask for which a coefficient of conductivity of ·004 has been attained, but as it is impracticable to produce a vacuum for the insulation of large volumes such as a cold store, the second best insulator is some gas such as air with a coefficient of 0·175. The commercial insulating materials are not good heat insulators because of the low conductivity of the solid material from which they are produced but because they are made to contain a large number of small cells containing air which offer a greater resistance to conduction than the solid material. Thus the coefficient of thermal conductivity for solid vulcanised rubber, which contains few air cells, is about 1·20, yet the cellular insulating material prepared from this same substance has a conductivity of merely 0·24, proving that 0·96 B.Th.U./cu. ft. or 80 per cent. of the original conductivity may be saved by adopting a highly cellular material for insulation. Although it might appear that an air-space such as between false walls might be the best insulator for cold stores, there are certain inherent disadvantages with this method which have somewhat restricted its use.

Ability to resist heat transference does not entirely qualify a material as a heat insulator, because certain other economic and physical factors must be considered before the most suitable substance is selected. Although a low conductivity is desirable, the possibility of leakage by the processes of radiation and convection should not be entirely ignored. Bright reflective surfaces have been used as insulators in thin cheap domestic stores where radiation effects are more pronounced when layers of crumpled foil were hung between the false walls in order to entrain air between the crumpled parts of the foil to resist heat flow. With three or four layers of such foil a conductivity coefficient of 0·32 may be obtained. Except, however, in certain cases such as the above, the effects of radiation and convection may be disregarded and the store insulated against heat leakage by conduction.

Economical thickness.

Because the rate of conduction varies inversely as the thickness of the insulation it will appear that as the thickness of the insulation increases so the loss by conduction is reduced. Unfortunately the increase in thickness of insulation also has the effect of reducing the cooling space and increasing the initial insulating costs which therefore increase the depreciation rate of the store. Between these two extreme cases of insufficient and excess insulation the most economical thickness must be selected. This may be done theoretically by analysing the total cost of the insulation in the following manner.

Thus if d = thickness of insulation

Cost of generating power against heat leakage $= A.\frac{t}{d}$

Cost of loss of cooling space $= B.d.$

Cost of depreciation of insulating material $= C.d.$

$\therefore$ Total effective value of insulation per annum,

$$L = A.\frac{t}{d} + B.d + C.d.$$

Differentiating and equating to zero for the minimum value of d,

$$\frac{dL}{dd} = -\frac{At}{d^2} + B + C = 0$$

Thus,

$$\frac{At}{d} = B.d + C.d.$$

It would therefore appear that some parabolic law relates the thickness of the insulation with the temperature difference for the most economic performance of the cold store. This theory also reveals that for the best operation the cost of the heat leakage into the store should equal the sum of the costs due to loss of cooling space and depreciation. The value of the cooling space depends upon the marketing values applying for the period during which the store is in use and upon the values adopted at the particular location of the store, while the extent of the depreciation in value of the insulation depends upon its rate of deterioration which is in turn governed by further factors to be discussed later, such as its maintenance, initial condition and suitability for the installation with which it is built. Therefore, since the constants A, B and C are the result of economical factors beyond the control or scope of theoretical analysis, the only really reliable information derived from this equation is the relationship between the losses and from which it is possible to guide the designer in the selection of a favourable thickness. A typical curve is shown in Fig. 1, in which the economical thickness of

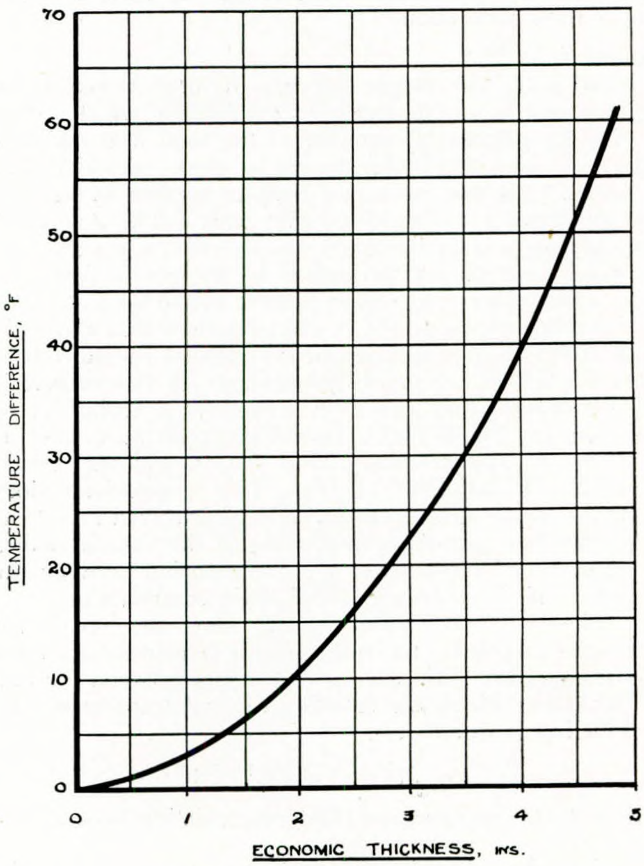


FIG. 1.

insulation is related to the temperature difference and from which it will be observed that a parabolic law is followed in which the maximum practical thickness of cold-store insulation is about 5in. The relative economies of various materials may be obtained from numerous such curves and the most suitable insulation chosen from them when the final selection is made after further considerations of their physical properties.

Physical properties.

The thermal properties of an insulator demand that it should be a poor conductor of heat, but it must also satisfy a rigorous physical examination regarding its fitness for erection. Since the insulation is part of the building construction, it should accordingly be made from the same quality of material and erected with the same degree of workmanship as the building itself. The insulation must also be strong enough to support the weight of a large bulk above it without bulging or compressing too much at the base, yet it must be capable of withstanding years of service under arduous circumstances without deteriorating or rotting, while freedom from odour is an essential quality for the preservation of foodstuffs without tainting them. In order to reduce insurance costs it is further desirable that the insulation should be fire-proof in case any fires may start in the vicinity of the store, especially when a large cargo of material prone to the effects of spontaneous combustion, such as grain, is carried. Furthermore, although by no means exhausting the list of possible features incorporated in the ideal insulating material, protection from the ravages of vermin should be borne in mind, particularly in the insulation of marine cold stores.

Strength of the insulation.

The compressive properties of an insulation cannot be viewed in the correct perspective without first taking into consideration its density, from which the actual load on the bottom of the insulation due to its weight may be calculated. The hysteresis or recovery effects of a load must also be considered since materials do not reach their maximum compression directly upon the application of a load. From experiments of Heckler and Queer for various insulants, the compression and recovery curves for various materials are shown in Fig. 2. It will be

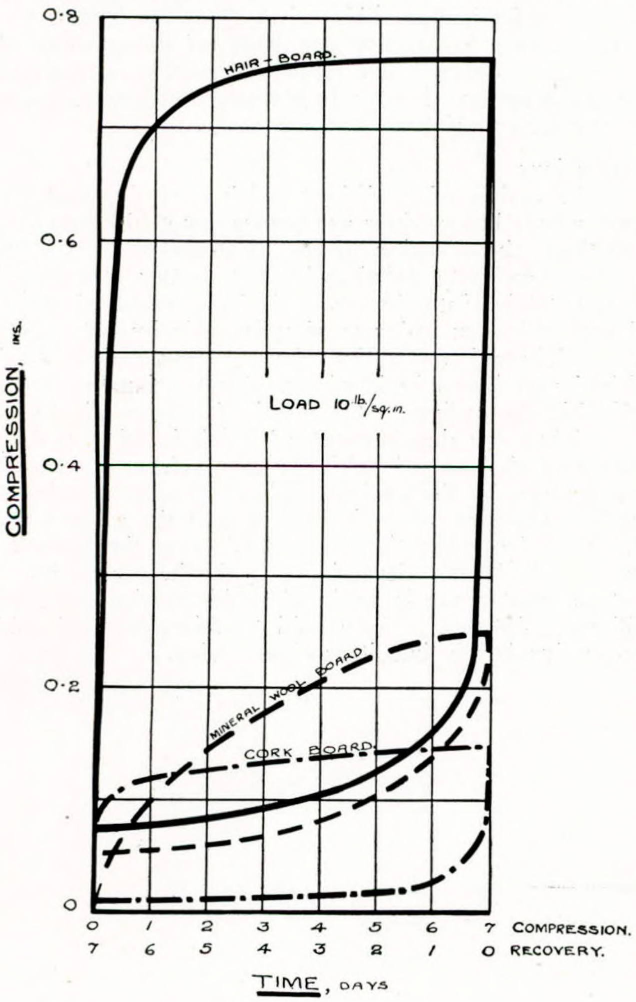


FIG. 2.

noticed that with the high maximum compression of the hair board the deformation after seven days recovery is also high, while the cork board which has a low maximum compression shows a correspondingly low deformation. It is also necessary for an insulating material to be able to suffer rough handling such as it is likely to receive during transport and during erection without breaking-up or crumbling at the edges, otherwise the more fragile materials may prove very costly to use. Not only does fragility depreciate the value of an insulant but other more artificial yet irritating factors reduce its trade value. Thus the tendency of insulating boards covered in asphalt to stick together when they are piled up closely and for saws to gum-up readily when cutting asphalt-impregnated materials are equally as aggravating as the tendency of some insulants containing foreign particles such as metal-wool and glass to blunt the edges of the tools used for shaping them, thereby increasing the time, labour and expense of their erection and prejudicing their selection.

From these observations it will be found that cork board made without a binding material satisfies the conditions admirably. From the load graphs it is apparent that the cork board does not compress so much as the other materials and it has a far better recovery than any of them. In addition, fragility tests have shown approximately that the cork board is three times as strong as the mineral-wool board and of equal strength with the hair board. Since also, this material is not made with a binder it is not difficult to cut into shape and is therefore a cheap material to erect. Unfortunately, the lack of a waterproofing coat and its organic composition render this insulator more vulnerable to the adverse effects of moisture on insulation.

Effects of moisture on insulation.

Since the humidity within a cold store is invariably controlled there is nearly always a certain amount of moisture condensed on the walls due to the prevailing hygrometric conditions either inside or outside the store. During the summer, moisture condenses inside the store and tries to penetrate outside while in the winter the reverse occurs and moisture condenses on the outside of the store and tries to penetrate inwards. This penetration of the moisture saturates the insulation and since water possesses a conductivity of about ten times that of the dry insulation it follows that the saturated insulation is useless to prevent heat leakage and therefore it does not fulfil its intended purpose.

The process of moisture penetration is explained as an effect of the different vapour pressures exerted on the two sides of the insulation. This pressure difference set up by the variations in humidity and pressure on either side of the store wall creates a motive force which drives the moisture into the insulation through the pores of the material in the form of a vapour; but as the vapour penetrates the material its temperature alters and approaches the dewpoint. At the dewpoint excess moisture in the vapour is deposited as dew, saturating the insulation as it accumulates in the cells and so reducing the insulating value of the material. In addition to the thermal changes which moisture penetration produces, the saturation of the insulation hastens the organic decomposition of this material and causes it to rot rapidly, while it also has the reciprocal effect of increasing its density and the load it must carry, consequently impairing the mechanical strength.

In order to combat the penetration of moisture into the cold stores it is desirable to select an insulating material which does not absorb much moisture, in which case capillary action and osmosis must be negligible. The store should also be designed in such a manner that it would be possible to drain off excess moisture and vent the insulation with an air-draught, while a vapour seal should be printed over the surface in order to restrict penetration. This latter requirement for the protection of cold stores against moisture penetration is the most difficult to achieve although it is seemingly an easy matter. This is due to the difficulties experienced in obtaining a material for the vapour seal which must not only combine the qualities of purity—by means of which an efficient seal is obtained—but it must also be durable in order to resist any rough usage which the store walls may suffer from accidental blows, yet it must remain flexible and elastic so as to remain unbroken during any slight shrinkage movements of the store due to temperature changes and from similar causes, in addition to which the paint must remain adhesive all the time and never separate from the store wall. In order to obtain these several requirements numerous artifices are employed such as papering the walls, but some sort of asphalt is most generally applied to the walls in one form or another and covered with a decorative coat of pigment enamel or aluminium lacquer which has no solvent effect on bitumen and can therefore be directly applied to a bituminous surface without using an intervening undercoat.

Fire- and vermin-proofing of insulation.

Little development has been made in the protection of insulating materials against fire, possibly on account of the improbability of cold stores being directly exposed to high temperatures. Precautions are nevertheless desirable in all matters applying to destructive agents, particularly fire, and from the several tests made upon various samples of proprietary insulating materials it was found that only cork board possessed really fire-proof properties; even when subjected to intense heat it did not smoulder when removed from the source of combustion. The other materials were badly affected by the source of combustion and were in a very bad state after the test. Even combination materials with an asbestos backing proved to have no resistance against fire, as the inflammable component readily burnt out leaving only the asbestos skeleton of the original board.

With food storage and particularly on ships, it is desirable to prevent vermin from destroying insulation around the stores and the stores should be constructed to discourage their presence by making conditions unpleasant for them. This can only be done by enclosing the insulation with wire netting sufficiently fine to prevent the admission of the baby vermin which can be as destructive as the parent itself. In this matter it is necessary to examine the store or hold with the greatest care at every possible place in order to leave no part unprotected through which the vermin might enter, and in particular to examine the condition of the netting to determine the extent of its rusting.

Further to these lesser yet important insulating details it is desirable to employ odourless materials for the storage of foodsuffs. This arises from the tendency of certain foods to acquire the taste of other materials within their vicinity and render themselves undesirable for consumption, thereby imposing great expense upon the storage proprietors.

Conclusions.

The variety of conditions which insulating materials must satisfy before their acceptance for cold storage use complicate the selection of the ideal material. Because of the complexity existing in this matter, research is being extended into the economical and practical aspects of the subject in order to simplify this important problem. These investigations have to contend not only with the problems in hand but also to visualise future difficulties according to the trend of refrigerating practice. Thus the development of quick-freezing and the more extended use of refrigerating trucks or cars make it necessary for the engineer to pay greater attention to the heat capacity of the insulation than the present problems require. The time required to cool the store and its contents largely depends upon the heat capacity, so that as greater use is made of rapid-freezing processes still more interest will be paid to this aspect of cold-storage insulation than it receives to-day.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Tuesday, 4th June, 1940.

Members.

John Blachford.
Alastair Dornie McRae Fraser.
Alexander Nicolson.
David Nicoll Paton.

Associates.

Thomas Hindmarch.
Thomas McMeekin.

Student.

James Denny.

Transfer from Associate Member to Member.

George Halls.

Transfer from Student to Associate.

Thomas Gibson Patton Burn.
Robert Burton Wight.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

British Standard Specification No. 84-1940 for Screw Threads of Whitworth Form.

Transactions of the American Society of Naval Architects and Marine Engineers, Vol. 47, 1939, containing the following:—

"Propeller Testing Tunnel at the Massachusetts Institute of Technology", by Lewis.
"Problems incidental to the Use of High Pressures and Temperatures in Marine Steam Power Plants", by Soderberg.
"Ship Plating under Compression and Hydrostatic Pressure", by Bengston.
"Graphical Analysis of Pipe Stresses", by Baggerud and Jernstrom.
"Modern Tanker Design", by Pluymert.
"Geared Diesel Marine Applications", by Leggett.
"Ship Ratproofing", by Clark.
"Important Considerations in the Use of High Tensile Steel Rivets in Shipbuilding", by DuBose.
"Further Form Resistance Experiments", by Eggert.
"Some Observations regarding Merchant Marine Personnel", by Seward.
"American Superliners—They Will Pay!" by Gaede.
"The 1939 Report of the American Towing Tank Conference", by Baier.

Refractories for Furnaces, Kilns, Retorts, etc. By A. B. Searle. Crosby Lockwood & Son, Ltd., 102 pp., illus., 3s. 6d. net.

The name of Alfred B. Searle needs no introduction to the student of refractories. The present book is intended as an introduction to the study of refractory materials. After discussing the meaning of the term "refractories", the author proceeds to describe the use of Seger Cones in determining refractoriness. This is followed by a very complete description of the various raw and manufactured refractory materials. The composition, refractoriness, effect of heat, shrinkage, and other properties of the various materials are described in a clear concise manner. Some of the uses of refractories are discussed, and there is a useful table setting out the properties of the various materials. A study of this book should prove of great assistance to the user of refractory materials, and should do much to remove the feeling that refractories are one of the necessary evils of industry by giving the user who has not the time to make a close study of refractories, a good insight into the range of properties of the materials available.

A Text-book of Heat, Part II. By H. S. Allen, M.A., B.Sc., F.R.S., and R. S. Maxwell, M.A., B.Sc. Macmillan & Co., 318 pp., 93 illus., 10s. 6d. net.

In this volume, as in Part I, the writers combine the work on heat of the earlier well-known authorities with an account of some of the more recent investigations. In conjunction with Part I, this book has been designed to meet the requirements of those reading for a Pass Degree in Physics, and it should also furnish a good foundation for an Honours Course.

The first part of this volume deals with the First Law of Thermodynamics and presents also descriptions of various accurate measurements of Joule's Equivalent of Heat. This is followed by chapters on the Properties of Gases, which include the Transport Phenomena of Gases, and the Second Law of Thermodynamics. Thus, the beginning of this volume forms a suitable foundation on which the engineering student can base his later study of Heat Engines. There is a useful chapter on Entropy with some very serviceable physical analogies which the physicist or engineer should find of great assistance in enabling him to grasp the meaning of this "Ghostly Quantity".

A short chapter on the various experimental methods of obtaining extremely low temperatures approaching the absolute zero is followed by the Mathematical Theory of Conduction and Radiation. The remaining chapters of the book on the Quantum Theory of Radiation, together with Statistical Methods and the Quantum Theory, Probability and Maxwell's Distribution Law, open up fields of thought which give this work a highly interesting and modern flavour, and enhance its value by creating an interest outside the usual work found in standard text-books on Heat.

Throughout this particular volume there is a lively interest continually created by many references and descriptions of recent investigations and theories. The work contains a selection of numerical examples and a number of well-produced diagrams, and there is ample evidence by its presentation that it has been written by good teachers of this subject.

Steam Conquers the Pacific. A Record of Maritime Achievement. By Arthur C. Wardle. Hodder & Stoughton, 208 pp., illus., 10s. 6d. net.

A short foreword printed on the dust cover of this publication is so apt as to be worth quoting in full. "During the Summer of 1840 while public attention was focussed on the North Atlantic steamship crossing, two small wooden paddle-steamers quietly left the Thames on a 10,000 miles voyage to the West Coast of South America. These pioneer ships established a vast undertaking which became the world's largest steamship company, and exercised remarkable influence in promoting the commercial development of half a continent. Incorporated by Royal Charter in 1840 the Pacific Steam Navigation Company was projected five years earlier by William Wheelwright ('a John Bull type of American') and this centenary book unfolds a romance of mercantile enterprise, fortitude, and success from the days of the early paddle-steamers down to the present era of the luxury liner."

Into some 200 pages the author and compiler has compressed over 100 years of endeavour and achievement in one particular enterprise of steam navigation inextricably associated with the inter-trade and development of those four republics bordering the Pacific coast of South America, Colombia, Equador, Peru, and Chile. Land communications between these countries being difficult due to the continuous and precipitous range of the Andes, sailing vessels serving the ports had long been established when Wheelwright, who was engaged in that trade, conceived the idea of utilizing the new power of steam to improve the service. For years he laboured to convince the Governments and Authorities concerned that his ideas were practicable and sound, technically and financially, and in 1840 the small wooden paddle-steamers "Chile" and "Peru" sailed from England to inaugurate the coastal service of the Pacific Steam Navigation Company. Since that date 198 vessels have been built for the company, excluding numerous store ships, coal hulks, tenders, and launches; and at one period, in 1873, it was the largest steamship concern in the world, owning the most up-to-date fleet. In recent years it has fallen from grace in that several of the later vessels are propelled by heavy oil engines: but the company still retains its distinctive appellation of Steam Navigation.

Up to the time of the opening of the Panama Canal the company maintained its West Coast Service in connection with vessels trading to and from the Atlantic side of the Isthmus and then, failing to make reasonable terms with the Canal authorities, it improved and augmented its direct service via the Magellan Straits. As the years passed and ocean trade expanded the P.S.N. Co. found it desirable to make friendly arrangements for collaboration with companies such as the Royal Mail and Orient Lines, and the reasons therefor are duly recorded by the author. Readers more or less intimately connected with the companies referred to will naturally be most interested in these accounts, but anyone and everybody even remotely associated with shipping enterprise cannot fail to be impressed by the grit and perseverance of the pioneers so ably described. And as the volume is right up to date, such readers will no doubt be specially interested in references to well-known characters still happily with us directing great mercantile marine concerns. The reviewer here confesses however his particular admiration for Wheelwright's right-hand man, Capt. George Peacock, R.N., who commanded the first P.S.N. vessels and showed remarkable energy and resource in many tight corners, such as emergency repairs and adequate fuel supplies. It was he by the way who indicated the first practical scheme for a Panama Canal, a fact emphasized by de Lesseps himself at a meeting at Liverpool in 1880. It is not without significance to note that Peacock, who was a Devon man, started as a marine engineer.

Mechanism and the Kinematics of Machines. By W. Steeds, B.Sc. Longmans Green & Co., 320 pp., 432 illus., 18s. net.

This book is attractively got up and should appeal to all practical engineers and designers who, without very much effort, wish to master the fundamental principles underlying mechanisms. The author has kept strictly within the sphere described in his title, and if one wishes to find mechanical information in addition to the movements of the mechanism parts he will have to look elsewhere; but, as a knowledge of accelerations of parts is fundamental for the solving of the dynamic forces, and as the movements of parts considered in conjunction with the principle of work disclose static forces, the subject matter paves the way to the wide field of the Theory of Machines. Starting with the elementary laws of motion (nothing being taken for granted), the author develops the principle of Geometric Design which plays such an important part in successful engineering, and it may be remarked here that if this principle were better understood or, at least, better attended to by designers, mechanical breakdowns would be much less frequent. Velocities of points and accelerations are then dealt with, and straight line motions are discussed. Toothed gearing is considered in six chapters, and the succeeding chapters specialise respectively in belt drives, etc., variable speed gears, cams, universal joints, ratchets and miscellaneous mechanisms. There are numerous examples and exercises following the chapters, with their solutions at the end of the book. Here and there some formidable looking formulæ are derived such as that associated with Coriolis's Law which deserves study, and those concerning cams, but such should not intimidate the less theoretically-minded reader. There is a comprehensive table of contents of the twenty-two chapters at the beginning and also a good index to the text. The illustrations are to be found right in the heart of the text to which they apply, and this care in production, in the reviewer's opinion, makes the work very readable and readily consultative. Incidentally, and too tempting to omit! it is a tonic to be reminded on page 154 that the Continental Module in tooth gearing, now embraced with open arms by present-day British engineers, made its ***first*** appearance under the name "Manchester Pitch" ***in this*** country.

Lubricants and Lubrication. By J. I. Clower, B.S., M.E. McGraw-Hill Publishing Co., 464pp., 332 illus., 33s. net.

This book is essentially practical and is intended for buyers, sellers and users of lubricants and for those who design and operate machinery. As such the book will naturally have an appeal to marine engineers.

Specialized phases of the subject to be found in standard works have been avoided or minimized, but the author has borne in mind that to select, apply, use and care for lubricants properly, it is necessary to possess at least a fair knowledge of the source, production, refining and theory of lubrication. In consequence such subjects are discussed more fully than has been done in previous books of this general sort. The first eleven chapters are devoted to the fundamentals of lubricants and lubrication and apply to all types of machinery and industry. The next six chapters cover in detail the lubrication of steam turbines, steam engines, air compressors, refrigerating machines, and all types of internal-combustion engine. The general principles and practices of the first eleven chapters are here applied to specific machines. The last chapter points out general principles and proper practices for storing and handling lubricants. The desirability and necessity of proper supervision and keeping records are also emphasized. In the appendix are a table and charts of considerable practical value for making volume and gravity corrections and viscosity index determinations.

Abstracts of the Technical Press

Advanced Design of Great Lakes Car Ferry.

The Matitowoc Shipbuilding Company have just received an order from the Père Marquette Railway Co. for a ferry to carry freight cars, motor vehicles and passengers across Lake Michigan between the Père Marquette lines at Ludington, Michigan, and the Wisconsin cities of Milwaukee, Manitowoc and Kewaunee. The vessel is designed for all-year round service, which involves navigation through icefields in winter. The ship is to be of all-steel construction, with a hull 406ft.×58ft.×23½ft., divided into ten watertight compartments and having a reinforced double bottom and other safety devices. The cargo capacity of the vessel will enable her to carry 34 standard-size freight cars on four tracks, the cars being loaded and unloaded from the stern. There will also be stowage for 50 motor-cars on the upper deck, special ramp loaders being provided to facilitate rapid handling of the motor-cars from quay to ferry and *vice versa*. The passenger accommodation will include a large lounge and separate staterooms furnished with upper and lower berths of the Pullman type and supplied with conditioned air, in addition to 12 parlour suites on the upper deck and a semi-enclosed promenade encircling the cabin deck. The dining saloon will provide seating accommodation for 57 passengers at one sitting. The propelling machinery will consist of two sets of 5-cylinder Skinner Unaflow engines driving twin screws and designed to develop a total of 7,000 s.h.p., steam at a pressure of 335lb./in.^{2} and temperature of 650° F. being furnished by four coal-burning D-type Foster Wheeler boilers equipped with water-walls, convection superheaters, economisers and spreader-type mechanical stokers. Electrically-operated combustion-control apparatus comprising steam and gas exit temperature recorders, multi-point draught gauges, a feed-water flow-meter and feed-temperature recorder will be installed, together with forced and induced draught fans and fly-ash recovery equipment. All the controls and gauges will be mounted on two panels, each controlling one pair of boilers. The contract speed of the ship is to be 18 m.p.h. (15·63 knots) when fully loaded.—*"The Marine Engineer", Vol. 63, No. 752, March, 1940, p. 78.*

Some Facts about Centrifugal and Propeller Pumps.

A paper bearing this title has been contributed to the current issue of the *Journal of the American Society of Naval Engineers* by Lieut.-Commander R. M. Zimmerli, U.S.N., of the Design Division, Bureau of Engineering. The author points out that whereas centrifugal pumps depend for their operation upon the high velocities imparted to the fluid pumped being converted into static pressure, the propeller pump does not depend on the action of centrifugal forces, but pushes the fluid in an axial direction parallel to the line of the shaft. This type of pump is, therefore, often termed an "axial flow" pump and is mostly used for large capacities and relatively low heads, such as for condenser circulating services. Both types of pump combine high operating speed with large capacities as compared with reciprocating pumps, and inasmuch as most essential auxiliaries in modern warships are driven by steam turbines in which efficiency depends almost directly on high turbine blade speeds, it follows that centrifugal pumps must run at high speeds to ensure good steam economy. The efficiency of the pump itself is fairly good, having been increased from 20 to 35 per cent. in small capacity pumps built some 10 to 15 years ago, to as high as 65 to 85 per cent. in medium to large capacity units of present-day design. Some of the factors which influenced this increase in efficiency were: (*a*) Smoothing out abrupt changes in the direction of flow of the water within the pump; (*b*) fairing up all surfaces in contact with the water in order to lessen abrupt changes in direction or velocity within the pump which produces excessive shock losses; (*c*) providing liberal areas for all passages and ports within the pump casing and in the impeller so as to reduce internal friction losses to a minimum; (*d*) increasing the length of the passages in the pump impellers to give the required characteristic curves necessary for certain particular operating conditions. In some cases increase in rotative speeds was possible, while in other cases a decrease in blade tip speeds for small-capacity pumps resulted in a considerable reduction in so-called disc friction losses; (*e*) improvements in types of impeller and casing wearing rings and sealing devices which resulted in less internal leakage within the pump. Some of the present-day designs of pumps have very

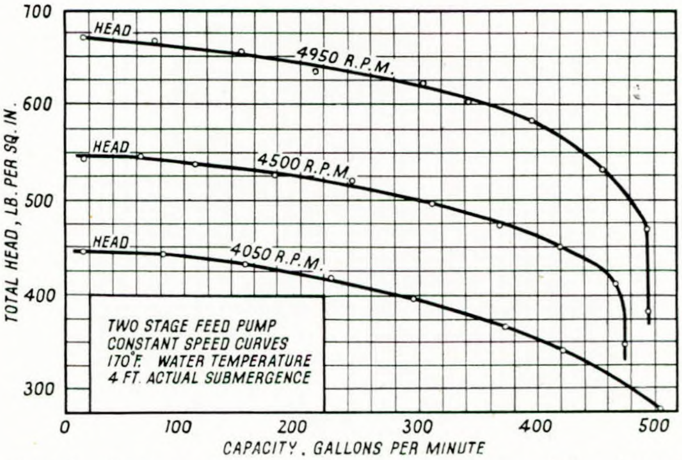


FIG. 1.—*Constant speed curves. Two stage centrifugal feed pump.*

little margin of capacity over rated capacity in spite of any increase in speed above the rated speed. The following laws apply to all centrifugal pumps: (1) The capacity varies directly as the speed. (2) The discharge pressure varies as the square

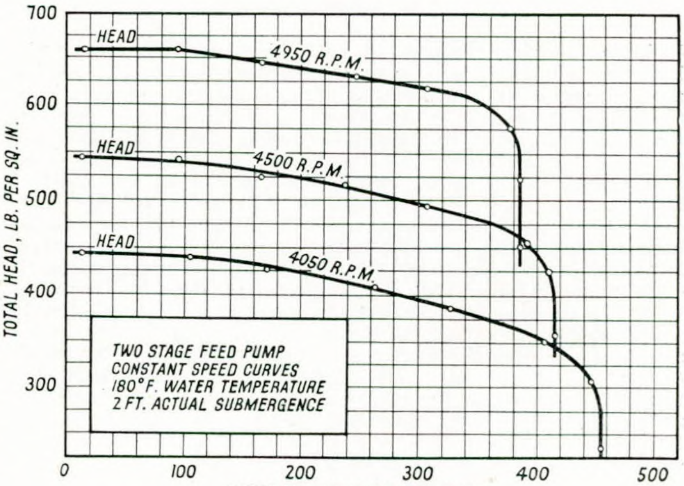


FIG. 2.—*Characteristic of same two-stage pump operating at higher r.p.m. and higher temperature.*

of the speed. (3) The horse-power varies as the cube of the speed. All these variations occur simultaneously as the speed changes, but these laws hold true only within the practical operating limits of the pump and operation beyond this limit may produce erratic performance and result in a reduction of the discharge pressure and capacity. Fig. 1 shows the constant-speed characateristic curves of a 400-g.p.m. (90-ton/hr.) pump designed to run at 4,500 r.p.m. when handling water at 170° F. at a 4-ft. submergence and discharging against a pressure of 460lb./in.². The curves indicate that at its rated speed of 4,500 r.p.m. the pump will deliver about 450 g.p.m. with stable operation, and that when the speed is increased to 4,950 r.p.m., the expected increased capacity and head are obtained only to a certain point (480 g.p.m.) at 500lb./in.² discharge pressure. Beyond this point the pump will be unstable, so that its maximum capacity will be 480 g.p.m. regardless of the speed at which it is run as long as the submergence and water temperature are maintained. In this region the pump will be cavitating, *i.e.,* the impeller vanes will push the water out to the volute casing and discharge nozzle so fast that the losses in the pump suction, the basket or suction chamber of the casing, and the eye of the impeller, will be greater than the submergence head available and the pump will pull the water apart in the eye or in the vicinity of the eye of the impeller, creating a partial vacuum at that point. In order to avoid this trouble, it becomes necessary to (*a*) design the pump with smaller inlet losses, *i.e.*, to provide larger areas in the suction passages and in the impeller, particularly at the eye, or (*b*) to reduce the temperature of the water, or (*c*) to increase the suction pressure of the pump by increasing the submergence, or (*d*) to adopt a combination of the above. Fig. 2 shows the characteristics of the same pump running at 4,950 r.p.m., with a 2-ft. submergence and handling water at 180° F. Its maximum capacity is now reduced from 480 to 386 g.p.m. at 500lb./in.², in addition to which the pump is unstable, as the discharge pressure drops off abruptly. This series of curves demonstrates that with each speed increase the maximum capacity of the pump is reduced rather than increased as might be expected from the laws of centrifugal pumps. Basically, the trouble here is that the water is too hot and the submergence (suction pressure) too low. Fig. 3 shows the characteristics of another pump designed for 600 g.p.m. (135 tons/hr.) and a discharge pressure of 575lb./in.² when running at 4,600 r.p.m. with a 2-ft. submergence and handling water at 160° F. The pump discharges nearly 700 g.p.m. under these conditions, while when the speed is raised to 5,050 r.p.m., the pump capacity is increased to 825 g.p.m. at 640lb./in.² discharge pressure. A probable maximum capacity of 900 g.p.m. is indicated, but this is problematical, as a comparison of the slopes of the 4,150-r.p.m. curve A and the 4,600-r.p.m. curve B shows that the B curve is just beginning to break at about 800 to 850 g.p.m. so that it is doubtful whether this pump has a maximum stable capacity of much more than 850 g.p.m. (note the divergence of the curves A and B from parallelism beyond the 700-g.p.m. point). The effects of submergence or suction pressure and water temperature on the characteristics of a pump are illustrated in Fig. 4, which shows the characteristics of the same pump when dealing with water at 225° F. at a suction pressure ranging from 10lb./in.², as shown by curve A, to 40lb./in.², as shown by curve B. At 4,900 r.p.m. the maximum capacity is about the same as before, *i.e.,* 750 to 800 g.p.m. with a 40lb./in.² suction pressure, but when the latter is reduced to 10lb./in.² at the same speed, the maximum stable capacity is only 450 to 500 g.p.m. The foregoing remarks are primarily applicable to boiler feed pumps, but the principle brought out applies equally well to all centrifugal pumps with the possible exception of condensate pumps. In a main condenser circulating-water system the friction loss in the condenser tubes, heads and circulating pipes, etc., increases approximately as the square of the rate of flow of water. Where circulating pumps are employed solely for the supply of circulating water, they are usually of the centrifugal volute type, turbine driven, either direct or through reduction gear, the latter drive being generally preferred as it enables both the pump and the turbine to be run at their most efficient speeds. Where circulating pumps are designed to operate in series with scoops, single-stage propeller pumps are always employed. The capacities referred to by the author in terms of g.p.m. are, of course, U.S. gallons per minute, *i.e.,* 0·83 per cent. of the equivalent capacity in impl. gal./min.—*"Shipbuilding and Shipping Record", Vol. LV, No. 11, 14th March, 1940, pp. 256-257.*

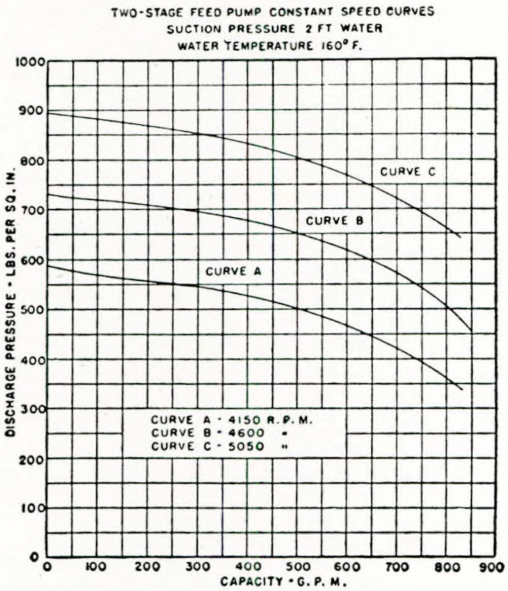


FIG. 3.—*Constant speed curves of pump designed for 600 g.p.m.*

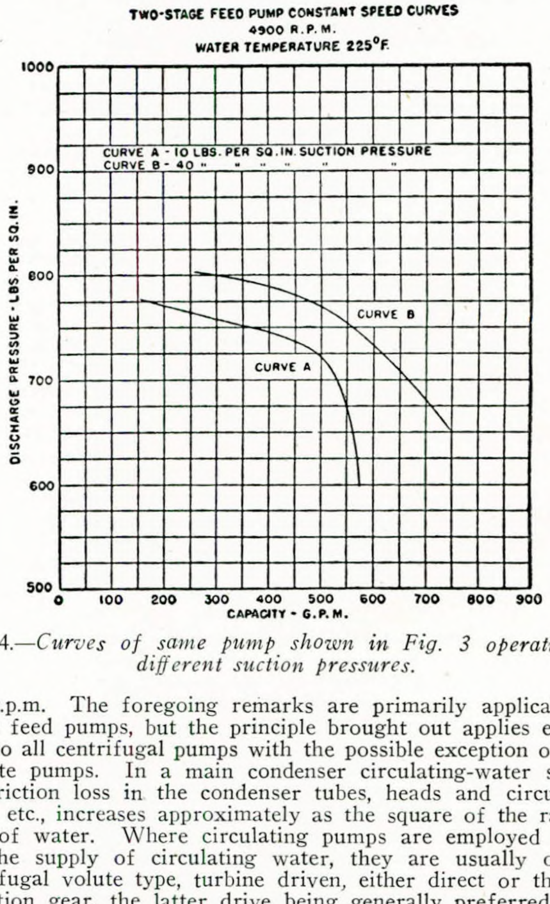


FIG. 4.—*Curves of same pump shown in Fig. 3 operating at different suction pressures.*

Vortex Pumps, or, Slip in the Centrifugal Pump.

The author declares that the current theory of the centrifugal pump does not correspond with its actual performance, as it suggests a reserve of 30-50 per cent. of pumping capacity available to the designer. The existence of this margin is questioned by the author, who proceeds to examine the energy of rotating bodies of fluid. All flowing vortices must be "hollow" to permit of a continuous admission of fluid at their centres, and the energy expressions are adapted accordingly. No discrepancy is found between the performance of a selected centrifugal pump and its corresponding hollow vortex. In order to test this conformity under widely differing conditions, the author examines the test performances of pumps of different designs and reveals the limitations to this conformity. By analogy with other forms of slip, he defines a "slip ratio" and applies it to the relation of the pump and vortex theories, the pump theory representing the capabilities of the vane and the vortex theory the performance of the pump. The author stresses the importance of studying the physical properties of the moving fluid rather than the potentialities of the actuating vane. He appends a specimen calculation sheet for a 6in. × 12in. × 350° tip centrifugal pump with a single-inlet impeller and eight vanes of 12in. outside diameter, a 6½-in. diameter inlet and a tip of 1¼-in. wide. The text of the paper is amplified by 28 diagrams and a list of references is appended.—*Paper by Owen A. Price, "Journal and Proceedings of the Institution of Mechanical Engineers", Vol. 142, No. 5, March, 1940, pp. 413-438.*

Warren Boiler Feed Pumps in New U.S. Steamships.

Among the principal pumps installed in the "Exporter" and a number of other new ships for the American Export Line are the main and harbour service boiler feed pumps, main and auxiliary circulating pumps and condensating pumps made by the Warren Steam Pump Company, Inc. The boiler feed pump, which is representative of the other Warren pumps, is a 2-in. four-stage pump with single-inlet impellers. Two impellers face in one direction and two in the other, giving hydraulic balance. The first-stage impeller is fitted at one end of the pump and the second-stage impeller at the other, this arrangement being claimed to eliminate any unbalanced end thrust, so that the high-pressure stuffing box is only subjected to the pressure of the first stage. The cast-steel pump casing is split horizontally, the suction and discharge connections being cast integrally with the bottom half. The bearing housings are also divided on a horizontal plane and are fitted with removable split-shell white-metalled bushings. The thrust bearing is of the Kingsbury design. The oil supply for the pressure-lubricating system to all bearings is maintained by a rotary oil pump driven from the main pump shaft and located below the level of the oil in the sump. An oil cooler and strainer are fitted in the oil line between the pump and the bearings. A hand oil pump is provided for use when starting. Fourteen of these pumps are being installed in seven American Export Line cargo steamships, each having a capacity of 47 tons/hr. against a discharge pressure of 575lb./in. Thirty-two additional Warren feed pumps are to be fitted in sixteen other American vessels at present under construction.—*"Marine Engineering and Shipping Review", Vol. XLV, No. 3, March, 1940, p. 76.*

Experiments with Models of Cargo Carrying Type Coasters.

The paper describes the results of experiments made at the William Froude Laboratory with models of the smaller ships employed in the coasting trade around the British Isles. The limitations on the length, draught and other characteristics imposed by the restricted waterways in which they have to work, combined with the demand for a relatively high speed, make these coasters a most interesting problem to the naval architect. The research work dealt with in the paper was confined to the determination of the effect of a progressive increase in fullness of form upon the horse power required to drive a typical coaster of certain chosen dimensions. Screws of different diameters and pitch ratios were used in the propeller experiments, so that the variation of the power with the r.p.m. could also be noted. It was found that in the case of a ship having a length of 200ft., an increase of 16 per cent. in displacement by a corresponding increase in the block coefficient would require an increase of power at 11 knots of 43 per cent., assuming that the best propulsive coefficient was obtained in each case by the use of a slow-running screw. On the other hand, the fuller ship could be run at 10 knots with 15 per cent. less power than that necessary for the fine ship at 11 knots. The effect of increased r.p.m. is to reduce propulsive efficiency, and the increase in power involved in raising them from 125 to 250 is equivalent to something like 10 to 15 per cent. This would have been substantially more if care had not been taken to utilize the reduced diameter of the faster running screws by incorporating an efficient cruiser stern in the design. The data included in the paper is claimed to suffice for the purpose of making a comparison of the relative merits of different proposals relating to the speed and power aspects of the problem. The results will not apply quantitatively to a design unless it is very closely similar to the models tested, but they should serve as a quantitative guide to the possibilities of any problem, observing that the models dealt with in the experiments were merely typical of their type and not necessarily the best obtainable. When the design has been decided in outline from such results, subsequent experiments in a tank will enable the various peculiar features of the individual design to be dealt with, and the best form obtained consistent with all requirements.—*Paper by F. H. Todd, B.Sc., and J. Weedon. "Transactions of the Institute of Marine Engineers", Vol. LII, No. 3, April, 1940, pp. 45-64.*

Coal- and Oil-fired Ships.

According to a statement made in the House of Commons by the Parliamentary Secretary to the Admiralty, approximately 47 per cent. of the British merchant ships now under construction are steamships capable of using coal as fuel. It is reported that 40 per cent. of the total number of merchant vessels now building are motorships and that 13 per cent. are oil-burning steamships.—*"The Motor Ship", Vol. XX, No. 242, March, 1940, p. 432.*

Lake Freighter to be Rebuilt as an Oil Tanker.

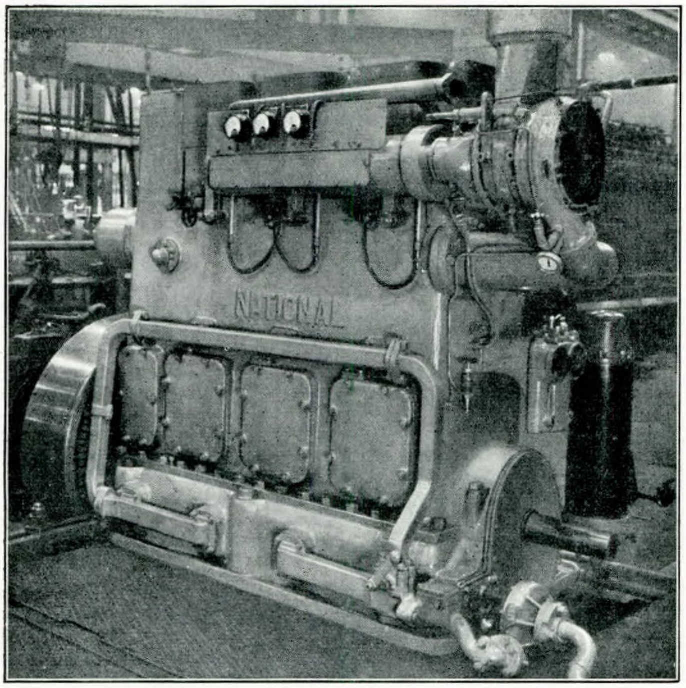
The 3,878-ton Great Lakes cargo steamer "William R. Linn" is in process of reconstruction at the Great Lakes Engineering Works, River Rouge, Michigan, where she is being converted into an oil tanker. The work is to be completed by the 1st June, 1940. The tank tops and inner walls of the ship's side are to be made oiltight and it is understood that the structure between the tank tops and hatches will be renewed throughout. A new centre-line bulkhead will divide the hold in half longitudinally and the latter will also be divided up into a number of separate compartments or oil tanks.—*"Marine Engineering and Shipping Review", Vol. XLV, No. 3, March, 1940, p. 120.*

A New High-speed Auxiliary Unit.

A well-known Dutch marine engineering firm have recently developed a 1,500-r.p.m. engine for marine auxiliary work and the propulsion of light craft. Models having 3, 4, 5 and 6 cylinders are standardized, the cylinder diameter being 150mm., the piston stroke 190mm. and the power rating 33·3 b.h.p. per cylinder. The full load m.e.p. is of the order of 85lb./in.^{2} and the fuel consumption at full load is 0·415lb./b.h.p.-hr. At three-quarters load it is 0·425lb./b.h.p.-hr. and at half load 0·448lb./b.h.p.-hr. A novel feature of the cylinder covers is the incorporation in these of spaces for Ricardo-Comet spherical combustion chambers. Valve push-rods are eliminated by placing the camshaft at the level of the cylinder covers, large rockers, pivoted on the cylinder head, conveying the cam motion to the valve-stem ends. The cylinder-head securing studs are in line with internal ribs which take the combustion loads down to spherical-headed main bearing bolts, so that there is a continuous line for taking stresses. Any piston and connecting rod can be withdrawn through a crankcase inspection door, whilst the halves of any main bearing can be withdrawn without disturbing the crankshaft. The cooling water inlet is situated just below the cylinder head joint, the bulk of the water being directed around the exhaust valve seats and combustion chambers.—*"The Motor Ship", Vol. XX, No. 242, March, 1940, p. 433.*

Pressure-charged Power Unit for Dutch Dredger.

The accompanying photograph shows a British-built pressure-charged engine intended for a dredger in Holland. It is of the three-cylinder type with a 10-in. cylinder bore and a piston stroke of 13in., the rating being 246 b.h.p. at 550 r.p.m. The photograph was taken while the engine was undergoing shop tests with special pyrometer equipment fitted. The Büchi exhaust-driven turbo-blower is mounted on the end of the air manifold and on the extreme right is a built-in by-pass-connected lubricating purifier, which is in addition to the ordinary strainer. The valve-gear covers are hinged. The water-cooling service for the four main bearings is maintained by an engine-



246-b.h.p. unit on trial.

driven pump on the right, with a change-over valve in line with the first main bearing. This allows the water to be delivered either through ducts connected to the four main-bearing housings, or to the gallery pipe supplying water to the column. The latter circuit is used while the engine is warming up so as to give a quicker rise of lubricating-oil temperature, but when the normal running level has been attained, the change-over valve is operated and the incoming cool water is fed first to the main bearings and then passes on to the column. A sand pump is driven from the fly-wheel end of the engine, while the other end of the crankshaft is extended and coupled to an electric generator.—*"The Oil Engine", Vol. VII, No. 82, March, 1940, p. 333.*

Multi-engined Motorships and Waste-heat Boilers.

The employment of four direct-coupled oil engines in a number of the new C.3 class ships built or building for the U.S. Maritime Commission has involved an interesting problem in connection with waste-heat boilers. In the case of one such vessel (the "Mormacpenn") already in service, the arrangement of the four 2,250-b.h.p. engines driving one propeller shaft through electric couplings and gearing is such that one or more engines may be cut out. It was considered, therefore, that if all the engines exhausted into a common section of the waste-heat boiler, the result might be unsatisfactory under certain conditions. Hence, the boiler is designed so that the exhaust of each propelling engine is delivered into a separate section, whilst at the same time alternative oil-firing equipment is provided. Every endeavour is made to secure the maximum possible operating efficiency in these ships and heat exchangers are fitted on all the auxiliary engines. The fuel consumption in the geared ships with high-speed engines will naturally be 3 or 4 per cent. higher than that of the vessels with direct-coupled machinery installations, but, on the other hand, the low propeller speed of 85 r.p.m. should prove useful in service.—*"The Motor Ship", Vol. XX, No. 242, March, 1940, p. 426.*

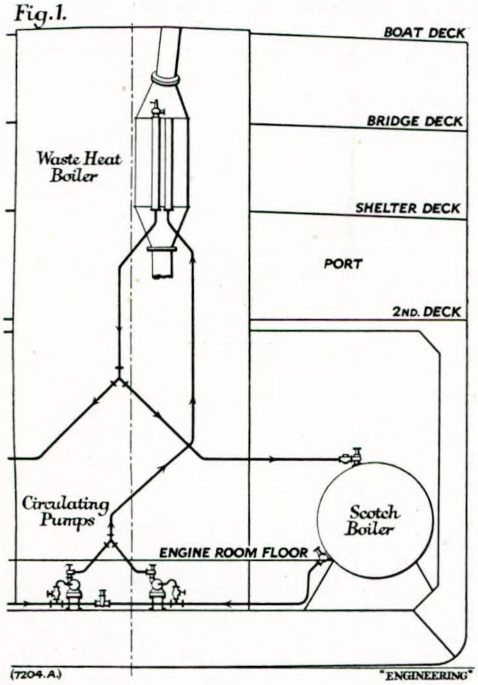
The Swedish Motor Tanker "Saturnus".

The 10,000-ton single-screw motor tanker "Saturnus", recently completed by the Nakskov Shipyard in Denmark for Stockholm owners, is a vessel 485ft. by 65ft. 9in., with a total d.w. capacity of over 15,000 tons on a draught of 29ft. 1in. The ship is of a structural type which is now becoming standardized, having two longitudinal bulkheads which form centre and wing tanks over the greater part of the length. There are nine centre tanks in all and 10 wing tanks on each side of the vessel, the total cargo-oil capacity of the 29 tanks being 726,618 cu. ft. The fore hold abaft the fore peak is arranged for the carriage of 63,000 cu. ft. (bale) of dry cargo. The erections on the upper deck comprise poop, bridge and forecastle, a large deckhouse on the poop deck being built round the engine and boiler-room casings and containing accommodation for the engineers, junior officers and crew. The senior officers' and engineers' quarters are situated on the bridge and upper bridge decks. The propelling machinery consists of a double-acting two-stroke 5-cylinder Burmeister & Wain engine developing 5,500 b.h.p. (or 6,700 i.h.p.) at 108 r.p.m. The cylinders are 620mm. in diameter, the length of the piston stroke being 1,400mm. The crankshaft is in two parts. The pistons are cooled by oil-circulation, fresh-water cooling being employed for the cylinders. The pumps for these cooling systems are driven by electric motors. Steam for the auxiliary machinery and cargo pumps is supplied by two oil-fired cylindrical boilers and by a La Mont exhaust-gas fired boiler. Shore steam connections are also fitted for the cargo-oil tank heating system. Electric current is furnished by two Diesel-driven 150-kW. generators and by a 30-kW. steam-driven dynamo. The main pump room is amidships and contains two 385-ton duplex steam pumps and an additional 100-ton pump, while a smaller pump room in the fore hold contains two 85-ton duplex pumps. A steam-driven bilge pump of 150 tons capacity is fitted in the main engine room. The steering gear is of the electro-hydraulic type with double pumps and motors, and the refrigerating machinery is electrically driven and operates with CO_2. For cooling the structure of the ship in tropical waters there are sprinkler systems along the fore-and-aft gangways. The service speed of the ship, fully loaded, is 14 knots on a fuel-oil consumption of 21·7 tons per day, but only 12·5 tons per 24 hours are consumed at 12 knots. The capacity of the vessel's oil-fuel bunkers is 1,300 tons.—*"The Shipbuilder", Vol. XLVII, No. 366, March, 1940, pp. 88-90.*

La Mont Waste-heat Boiler in m.s. "Hav".

The accompanying drawing (Fig. 1) shows the location of the La Mont waste-heat boiler installed in the Norwegian motorship "Hav", a single-screw vessel of 5,130 tons gross, built at Wallsend-on-Tyne, and propelled by a Doxford engine of 3,000/3,200 b.h.p. In addition to the waste-heat boiler, there are two oil-fired cylindrical boilers situated in the wings of the engine room and coupled in parallel with the waste-heat boiler, as shown. There are two circulating pumps drawing from the lower part of the oil-fired boilers and discharging to the coils of the waste-heat boiler, the steam and excess water from the latter being delivered to the steam space of the oil-fired boilers. Either pump can draw from either boiler, so that both oil-fired boilers can be steamed simultaneously, or one can be isolated. Either pump can also be cut out of circuit, hence the arrangement is a very flexible one. The waste-heat boiler has a total heating surface of 840ft.^{2} and was designed to deal with exhaust gases to the amount of 45,000lb./hr. at a temperature of 675° F., that of the gases leaving the boiler being 450° F. The specified steam output was 2,400lb./hr. at 120lb./in.^{2} pressure, from feed

Fig. 1.



water at a temperature of 200° F. The boiler is of the usual La Mont exhaust-heat design with 23 double spiral coils, 1¼in. in external diameter. The performance of the boiler under sea conditions is summarised in the following table which gives the results obtained on the sea trials :—

Engine r.p.m.	Temperatures, °F.			Pounds per hour.		Boiler pressure lb./in.²
	Exhaust gas to boiler.	Gas leaving boiler.	Feed water.	Quantity of gas.	Actual steam generated.	
70·8	383	365	199	33,500	141	116
82·9	473	392	199	39,200	745	115
89·9	527	410	119	42,500	1,080	113
98·1	615	435	113	46,500	1,810	116

Comparing these figures with the specified conditions, it may be noted that the exhaust-gas temperature at the highest engine speed is considerably lower (9·2 per cent. less) that was anticipated, while the volume of these gases is slightly greater (3·3 per cent. more). The boiler pressure is 4lb./in.² below that specified. Making allowance for the differences between the actual and specified conditions, the performance may be regarded as satisfactory. At the highest engine speed the actual evaporation works out at 2·15lb. of steam per sq. ft. of heating surface per hour, and—considering that the temperature of the gases leaving the boiler was 435° F. and that of the steam at 116lb./in.² pressure was 347° F.—this also must be regarded as satisfactory.—*"Engineering", Vol. 149, No. 3,870, 15th March, 1940, pp. 275-276 and 282.*

Heat Transmission in Evaporative Condensers.

The paper deals with experiments carried out in order to determine the heat transfer coefficient and to elucidate the mechanism of heat transmission and evaporation in evaporative condensers. The first of these experiments concerned the rate of heat transfer by forced convection between a steel tube of 1½in. internal diameter and a stream of air, the tube being mounted in a wind tunnel heated internally by six electric panels. The average rate of heat transfer for the tube as a whole and the local rate for each section of the tube were measured, the amount of heat transferred from the tube to the air being given by $H=0{\cdot}05V^{\frac{1}{2}}\theta K$. cal. (hour) metre length, V being the air speed in metres per hour and θ the difference of temperature between the tube and the air. The local rate of heat transfer was found to reach a maximum at the front and back of the tube and minima at the sides, these minima being at an angle of about 105° with respect to the direction of the air stream. The transfer of heat between the surface of a tube and a film of water evaporating into a stream of air was then considered. The rate of evaporation of water from a saturated surface was investigated by covering the internally-heated tube previously used with a thin sheath of linen; the linen was kept saturated with water. The rate of evaporation was given by $E=2{\cdot}53\times10^{-6}V^{\frac{1}{2}}(p_w-p_a)$ gms./sec./cm. length, V being the air speed in metres per hour and (p_w-p_a) the difference in vapour pressure between the surface and the air, in mms. of mercury. As in heat transfer by forced convection, it was found that the local rate of evaporation exhibited maxima at the front and minima at the sides of the tube. An evaporative condenser was constructed by replacing the internal heater with steam and removing the linen from outside the tube, whereupon it was found that the rate of evaporation was greater than that taking place when the linen was present to an extent depending on the thickness of the film of water on the tube. The rate of heat transfer in the experimental condenser was also found to be greatly dependent on changes in the thickness of the water film and could be increased by as much as 25 per cent. above that of the film type of cooler under the same conditions. This was attributed to the setting up of turbulence in the water film as a result of the evaporation. An equation for calculating the coefficients of heat transfer for the evaporative condenser was derived from first principles, and it was found that the simple equation at present used for ordinary condensers was approximately correct, provided the evaporation did not exceed 8 per cent. of the amount of water entering the condenser. Having observed the marked similarity between the processes of heat transfer and evaporation of water into a stream of air, a set of subsidiary experiments on the flow of air past a tube exposed to a stream of air was carried out. By photographing the air in the neighbourhood of the tube it was found that points of breakaway from the boundary layer were exhibited at exactly the same positions as those which mark the points of minimum heat transfer and evaporation. This is considered to support the theory that the transfer of heat from the surface of a solid to a fluid flowing past it, takes place by molecular conductivity through a thin layer of fluid close to the surface, the transfer reaching a minimum value where the layer is thickest and the skin friction least. The paper contains 12 diagrams and plates.—*Paper by A. K. G. Thomson, M.Sc., Ph.D., read at a meeting of the Institution of Chemical Engineers, on the 8th March, 1940.*

Further Experiments on the Evaporation of Water from Saturated Surfaces.

The paper gives an account of experiments carried out in an open-circuit wind tunnel to determine the rate of evaporation of water from various geometrical surfaces, the surfaces studied being unheated and including spheres, cylinders set transverse and parallel to the air-stream, and planes set at various angles to the direction of the stream. For each type of surface it is shown to be possible to correlate the results obtained for a range of surface lengths (or diameters) l and air speeds, u, by plotting $el\ (p_w-p_a)$ against ul, where e is the rate of evaporation per unit area, and (p_w-p_a) is the difference in vapour pressure between the saturated surface and the ambient air. The value of e is shown to be increased as l is decreased, and for surfaces of the same area it is greatest when the surface is in the form of a sphere. Comparisons are made with existing data for the evaporation of water from plane surfaces. Attention is directed to the employment of ridges for increasing the rate of evaporation from plane and cylindrical surfaces set parallel to the direction of the air stream. With plane surfaces it is also shown that a considerable increase in the rate of evaporation from a surface facing downstream can be obtained if the plane is set at such an angle to the direction of the stream that advantage can be taken of the turbulence induced by the edge of the plate. The rate of evaporation from such a surface becomes greater than that obtained when the surface faces the stream. Measurements are also included for the natural evaporation which occurs when moistened surfaces are exposed in an unventilated chamber. The text of the paper is illustrated by 18 diagrams.—*Paper by R. W. Powell, Ph.D., read at a meeting of the Institution of Chemical Engineers on the 8th March, 1940.*

The Practical Limitations of Pressure and Temperature in Marine Steam Engineering.

The paper begins by an examination of the thermo-dynamic aspect of the influence of pressure and temperature on the steam cycle, including the effect of bled-steam feed heating and re-superheating, and then goes on to discuss the various practical considerations which limit the application of pressure and temperature. Steam temperatures are metallurgical, whereas pressure limits depend more on the characteristics of prime movers and their ability to make effective use of increased pressures. In this latter case, scale effect is an important factor in determining optimum conditions. The author remarks that, generally speaking, higher pressures are more and more justified as the size of the power unit increases, and refinements in the steam cycle become more and more attractive as size and number of hours under steam increase, this last factor having an important bearing on the relativity of savings to first cost. The paper ends with a brief summary of the author's conclusions, which are: (1) That modern marine steam practice envisages the empoyment of pressures and temperatures which, for all but low-power installations (2,000 s.h.p. and below) are far higher than those now in use in a large proportion of ships at sea. The steam cycle concerned with these increases involves stage bled-steam heating, and reheating offers certain advantages in the case of large-size marine installations. (2) The generation of auxiliary power has an important bearing on overall operating efficiency. In all but small installations, electrically-driven auxiliaries show the best all-round economy, and the electric generator can be run at sea in conjunction with the all-in cycle of the main engines. (3) Apart from fuel economy, modern steam machinery offers definite advantages in the shape of reduced weight and space. This applies even to low-power installations in which the saving of fuel thereby effected might be regarded as too small to justify such treatment. (4) The high-pressure high-temperature type of prime mover must be associated with water-tube boilers, the use of cylindrical boilers in modern marine steam practice being only justifiable for powers of 2,000 s.h.p. and under, and even then only where reduction in weight and space requirements are not capable of being capitalised. (5) We cannot expect to meet foreign competition at sea during lean years unless we take advantage of every improvement that technical service can offer, provided, of course, that such improvements are based on sound engineering design and experience. The text of the paper is illustrated by four diagrams.—*Paper by Major W. Gregson, M.Sc.(Eng.), "Bulletin of the Liverpool Engineering Society", Vol. XIII, No. 8, March, 1940, pp. 20-37.*

Modern Steam Propelling Units and their Possibilities for Cargo Steamers.

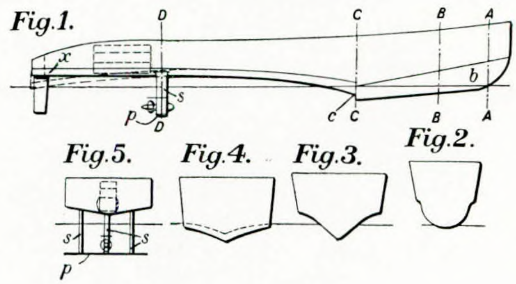
The paper on this subject deals with the thermal performance of modern steam engines for the propulsion of cargo ships. The author discusses several different types of engines as well as alternative schemes, and suggests that there is room for improvement in connection with the following points: (1) Boiler efficiency. (2) Pressure and temperature drops from the boilers to the engine stop valve. (3) Pressure drops from receivers to cylinders of reciprocating engines, frequently very severe. Since the pressure at the point of cut-off in the H.P. cylinder governs the expansion throughout the engine, this matter is deserving of attention. (4) Choice of point of cut-off in I.P. and L.P. cylinders. The author summarises the performance results of the engines considered in a table showing the indicated efficiency ratios.—*Paper by J-B. O. Sneeden, B.Sc., Ph.D., read at a meeting of the Institution of Engineers and Shipbuilders in Scotland, on the 26th March, 1940.*

Improved Form of Double-edged Hacksaw Blade.

A Hamburg firm of tool manufacturers have developed an improved form of hacksaw blade of high-speed steel for use in power saws. The new blade is of the double-edge type, but, unlike similar blades already on the market, the two cutting edges are not identical. They are marked "No. 1" and "No. 2" respectively, and the pitch and thickness of the teeth of the first-named are slightly greater than those of the second. The makers claim that this feature eliminates the jamming and breakage of the blade so commonly experienced with double-edged hacksaws with identical cutting edges, as the cut made by the No. 1 side of their saw provides adequate working clearance for the teeth of the second cutting edge.—*"Werft * Reederei * Hafen", Vol. 21, No. 3, 1st February, 1940, p. 36.*

Novel Form of Speed-boat Hull.

A new form of speed-boat hull of the kind in which an after main plane remains totally submerged when the boat is in motion and maintains the after part of the hull clear of the surface of the water, is the subject of a recently published British patent. Referring to the accompanying diagrams, Figs. 2, 3, 4 and 5 show the shape of the sections of the hull at *AA, BB, CC* and *DD,* of Fig. 1, respectively. The main plain *p* supports 70 to 80 per cent. of the weight of the boat when running at full speed and under these conditions it works on that part of the lift curve which lies just below the angle of incidence for maximum drag-lift ratio, or about 3 to 4° from the no-lift angle, and has a high-aspect ratio which may, in some cases, be as much as 25. The number of struts *s* is the minimum compatible with strength, and they are placed to give the least



(516.651)

possible bending moment in the main plane *p,* their length being greater than the maximum wave height so that the largest waves which the boat might encounter when running at speed will not cause air to penetrate to the plane. The main-plane angle of incidence is variable within a certain range, the hinged plane being divided port and starboard and placed under differential control so that the angle of incidence can be varied jointly or separately, thereby facilitating high-speed turning and improving lateral stability at speed. The remaining weight of the boat is supported by a short planing bottom *b,* ending in a step *c.* The planing bottom *b* is of V-section below the chine (Fig. 3) to give directional stability, easy riding in waves and a lateral stabilising effect when rolling. The keel line to the forefoot remains submerged at speed, so that as the stern rises off the water the forward part of the bow drops slightly. The centre of pressure of the planing bottom *b* will, therefore, move forward and thus increase the load on the main plane *p,* tending to promote longitudinal stability. The after portion of the hull ends in a flat planing bottom *x.* A screw propeller is supported from the centre main-plane strut (Fig. 5). Thin sharp-edged rudders at the after end of the hull reach down approximately to the depth of the main plane. With this construction, as the hull gains speed, the bow rises first and so increases the main-plane incidence. As the speed further increases, the main part of the hull rises under the influence of the main-plane lift and pivots approximately about the forward support.—*"Engineering", Vol. 149, No. 3,871, 22nd March, 1940, p. 320.*

Countering the Magnetic Mine.

By a brilliant invention the menace of the magnetic mine appears to have been countered. Whilst many efforts were being made to discover means for dtstroying such mines, it is reported that officers in one of H.M. Naval Establishments were developing a device which would render ships immune from the danger by ensuring that the ship would not actuate the magnetic system by which the mine is fired. With the help of scientists the invention was perfected and it has now been fitted in a number of ships, including the "Queen Elizabeth". The apparatus is termed a "degaussing girdle", the gauss being the c.g.s. electromagnetic unit of flux denstiy. The magnetic trigger of the mine is operated by the disturbance of the earth's magnetic field caused by the presence of a magnetic body—such as a steel ship—and it is this principle which is employed in the invention. The "girdle" itself is a circuit of insulated wire passing round the ship from stem to stern above the water-line, and one of the officers responsible for the invention is reported to have said that he himself was prepared to take any properly degaussed ship over any number of magnetic mines.—*"The Engineer", Vol. CLXIX, No. 4,392, 15th March, 1940, p. 245.*

Motor Lifeboats for Swedish Cargo Ships.

In Norway and Denmark every merchant ship must, by law, carry a motor lifeboat. In anticipation of similar legislation in Sweden, shipowners in that country are, in some cases, taking the matter into their own hands, the Broström Lines for instance, who own the largest fleet of merchant ships in Sweden (mostly motorships), having recently ordered 20 motor lifeboats of a standard type to be carried by their existing vessels. These boats will be clinker built, with $\frac{5}{8}$-in. pine planking and oak keels, the length being 22ft. 6in., the beam 7ft. 8in., and the draught 2ft. 10in., with a carrying capacity of 24 persons. Some of the boats will have a 10-h.p. Penta petrol engine, while the remainder are to have Diesel engines. The fuel tanks forward have a capacity of 33 gallons, which is enough for about 48 hours' running at normal output. Brass or copper air tanks are fitted under the thwarts. The engine is enclosed by a casing of galvanized plate with a hinged hatch for access to the starting handle and reverse gear lever. The boats are to be equipped with a hood to give shelter from rain and wind, cork fenders, and suitable towing bitts, as the motor lifeboats may be required to tow the pulling lifeboats. The two-cylinder Penta engines to be used in some of the boats develop 7-10 h.p. at 800-1,100 r.p.m. on a fuel consumption of 0·62 pint per h.p.-hr. The cylinders have a bore of $3\frac{1}{2}$in. and a piston stroke of $4\frac{5}{16}$in., the weight of the engine being 397lb. and that of the propeller, propeller shaft and stern tube 55lb. The overall length is 3ft. A raised starting handle is provided and the reverse gear is incorporated with the engine.—*"The Motor Boat", Vol. LXXII, No. 1,860, 16th March, 1940, pp. 240-241.*

New Emergency Floating Light.

Among the appliances developed in this country to meet the requirements of the Ministry of Shipping for an electrical lighting device to replace the calcium flares hitherto used, is the G.E.C. "Life-Light" illustrated in the accompanying diagram. It is claimed to be suitable for use in passenger and cargo ships, drifters, trawlers, tankers and minesweepers, being simple in design, robust in construction, and relatively inexpensive. The device comprises a metal cylinder which contains the lamp, dry cells and automatic switch, in addition to an annular buoyancy chamber or float. The "Life-Light" is normally stowed in the inverted position, and the light is then extinguished. When reversed (with the bulb upwards), however, it lights automatically, and when thrown into the water remains alight as it floats freely. It may be attached by a lanyard to a buoy or raft, or placed in a suitable position either for throwing overboard or for floating away if the ship sinks. As the light has at least 6in. of freeboard it should be visible from a considerable distance in all directions, as well as from the air. This freeboard should also keep it well above any oil that might be on the surface,

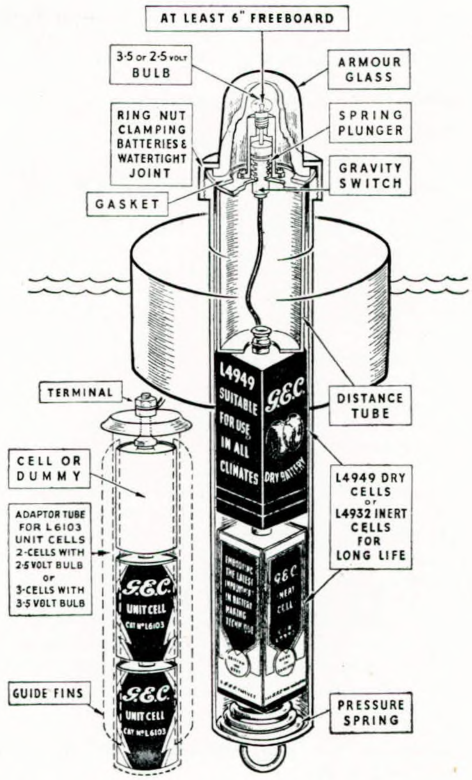


Diagram showing construction G.E.C. "Life-Light".

and since the electric bulb is enclosed there is no danger of igniting oil, even when floating in it, so that the light can be carried safely in tankers. The containing cylinder and float are of steel, while the bulb is protected by armour glass. In order to prevent the light from being obscured by oil, the well glass is rounded so that any oil that might collect on it tends to drain off, and the bulb is placed as high as possible inside the glass. There are no exposed working parts, so that the operation of the light is unaffected by ice, salt spray or abnormal temperatures. The automatic switch is of the positive gravity-action type, so designed that it cannot be operated accidentally by the jolting experienced in small craft. A continuous burning life of over 20 hours is said to be obtainable with two $1\frac{1}{2}$-volt dry or inert cells, and eight hours with unit cells of the universal type obtainable in all parts of the world.—*"The Syren", Vol. CLXXIV, No. 2,274, 27th March, 1940, p. 537.*

Alterations to the Hull Structures of the Belgian Passenger Liners "Albertville" and Léopoldville".

The Compagnie Maritime Belge's vessels employed on the service to the Congo include two twin-screw passenger liners of about 11,000 tons, the "Albertville" and "Léopoldville", built in 1928 and 1929 respectively, and driven by reciprocating engines. Being desirous of increasing the speed of these vessels by the addition of exhaust turbines to each of the reciprocating engines, the owners found it necessary to make important alterations to the hulls, including a substantial addition to the length of each. That of the "Albertville", was increased by about 23ft. 6in. to 537ft. 3in. overall, while the "Léopoldville" was lengthened by some 29ft. 6in. to 535ft. overall. The work of reconstruction was carried out by the Mercantile Marine Engineering and Graving Dock Company, Antwerp, in something like five weeks, extensive use being made of electric welding in order to avoid ordering new cast-steel stem pieces. A new stem for each ship was manufactured by welding together five steel sections to a total height of about 62ft. The plating of the extended bow was joined to the original hull plating of each ship by riveting and welding, the hawse-pipes and anchor beds being welded throughout. The original two funnels of each vessel were also replaced by a single funnel of all-welded construction.—*"Bulletin Technique du Bureau Veritas", Vol. 22, No. 2, March-April, 1940, p. 41.*

Rolling Experiments with Ships and Models in Still Water.

The paper gives the results of still-water rolling trials of the Tribal class destroyer "Nubian", together with those of the corresponding model. Comparative results of ship and model trials for an older destroyer (the V class "Vivien") and a battleship (the "King George V") are likewise quoted, and reference is made to Wm. Froude's experiments of the 1870's on the ironclad "Devastation". The author states that all these trials showed only approximate agreement between the rolling qualities of the ship and the corresponding model. In the cases of the three former ships the extinction was greater in the ship than in the model, but not to the same extent with each. Shallow water, propellers, and appendages are found to increase damping, but the condition of the model surface, the air resistance of the ship, and surface tension do not appear to have much significance. A theoretical estimate of the extinction due to surface friction combined with experiments on a naked model confirmed that friction accounts for only a small portion of the extinction. It seems probable that scale effect on bilge keels accounts for greater damping in the ship. The possible effects of reflected waves are also examined.—*Paper by R. W. L. Gawn, R.C.N.C., for publication in the "Transactions of the Institution of Naval Architects, 1940", summarised in "The Shipping World", Vol. CII, No. 2,440, 20th March, 1940, pp. 415-419.*

Some Experiments with a new Instrument for the Measurement of Heel and Trim.

The paper describes some experiments with a new instrument intended to give greater accuracy than that in common use for the measurement of small changes of heel and trim. The instrument employs the optical principle of the light beam and a fluid mirror consisting of a very small tray of oil. The instrument is supported over this fluid mirror and the light beam is projected downwards on to it. The fluid mirror remains level when the ship is inclined, the light beam is deflected, and this deflection is read on a scale. A detailed description of the heel indicator is given, together with an account of some tests carried out during inclining experiments on board a large cargo liner, a large tanker, and a small tanker. During these tests the instrument operated satisfactorily as a "pendulum" varying in length from 12ft. to 55ft. The new instrument could also be designed, the author states, as a combined heel and trim indicator, the screen being square, and the image projected being a right-angled triangle with one side parallel with the fore-and-aft axis of the instrument and one side parallel with the transverse axis.—*Paper by T. U. Taylor, for publication in the "Transactions of the Institute of Naval Architects, 1940", summarised in "The Shipping World", Vol. CII, No. 2,440, 20th March, 1940, pp. 491-421.*

Demolition of the "Mauretania".

A paper dealing with the breaking-up of the old "Mauretania" was read before the Manchester Association of Engineers on the 15th March, by Mr. M. Wilkinson, B.Sc. After explaining the method of establishing constants for estimating the price to be paid for the vessel, the author described the application of these constants in practice. He detailed the classification of both ferrous and non-ferrous metals and pointed out that the only material wasted is concrete filling and rubbish consisting of broken tiling and composition decks. In describing the actual procedure of demolition, the author referred to the $\frac{3}{8}$-in. coating of paint on the funnels and to the necessity of using gas masks by the operatives employed on cutting them owing to the quantity of lead present in the paint. The author disclosed a number of interesting figures, including the fact that the oxygen consumption was of the order of 350 cu. ft. per ton of metal cut, the daily output of the latter being from 6 to 8 tons per man.—*"Foundry Trades Journal", Vol. 62, No. 1,231, 21st March, 1940, p. 216.*

Boiler Water Gauges.

A device for use with water gauges on boilers is described by a correspondent, who suggests that it may prove useful in boiler rooms with indifferent lighting. The device in question comprises a metal plate cut to fit the open space at the back of the gauge glass protector and painted with alternate stripes of paint of contrasting colours, say, red and white or black and white. The stripes are set at an angle as shown in Fig. 1, and

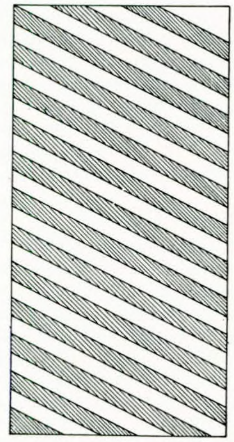


FIG. 1.—*Coloured metal plate as indicator for boiler water gauges.*

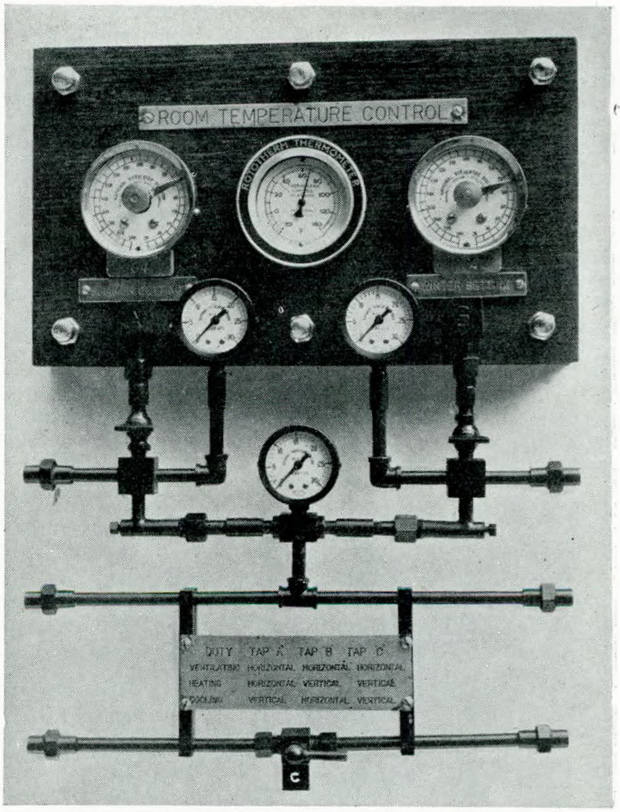
the plate is fixed permanently behind the gauge glass. The sides of the metal frame of the protector usually extend some little distance backwards beyond the side glasses, and saw slots in the extension will generally serve to hold the plates. Failing this a simple clip may be made. The effect of the refraction of light when the stripes are seen through the gauge glass is very striking, the contrast between a full and an empty glass being so marked that there can be no doubt about the height of water.—*"Mechanical World", Vol. CVII, No. 2,778, 29th March, 1940, p. 284.*

The 1939 Bulletin of the Diesel Engine Users' Association.

The Association's *1939 Bulletin* deals with: (1) Research and Design; (2) Land Power; (3) Gas Power; (4) Marine Propulsion; (5) Rail Traction; (6) Road Transport; (7) Aerial Navigation; (8) Accessories; (9) Testing and Inspection; (10) Engine Fuels; (11) Lubricants; and (12) Specifications. The section on marine propulsion omits any reference to specific installations and is merely a review for 1939 of a general nature. Contrary to what is frequently assumed, the 4-stroke oil engine maintains its popularity for marine work, more especially in single-screw tankers and cargo vessels of up to about 4,000 s.h.p., in which 4-stroke single-acting supercharged engines with under-piston blowers or turbo-exhaust blowers continue to be favoured. One large tanker company, after experience with other types, will accept only 4-stroke under-piston supercharged engines, while another important company divides its orders between this type of engine and single-acting 2-stroke engines. The present shortage of skilled Diesel engineers makes the 4-stroke under-piston supercharged type particularly attractive on account of the relative simplicity of its operation. The turbo-charged 4-stroke engine rivals the 2-stroke in efficiency as regards fuel consumption and is very economical to run and to maintain. For shipowners who take advantage of the 32 per cent. tonnage deduction rule—and this means the great majority—the space occupied by such engines requires no concession in their favour; moreover the length of the engine room is often as much determined by the auxiliaries as by the main engine. The weight of the 4-stroke supercharged engine, when constructed of cast iron, is greater than that of the 2-stroke, but this disadvantage can be largely overcome by the adoption of fabricated steel construction. Mechanical construction favours the turbo-charged unit. The advantageous effect of the higher temperature inlet air upon the life of the cylinder liners has been confirmed. Recent investigations by a shipowner into liner wear for supercharged 4-stroke, single-acting 2-stroke and double-acting 2-stroke engines of standard types showed results remarkably favourable to the first-named. Single-acting 2-stroke engines for powers up to 4,000-5,000 s.h.p. per shaft, have been installed in many new ships during the past year. Where head room is important the trunk-piston type is adopted, but in other cases the crosshead design is favoured, notwithstanding the slightly higher cost and greater weight of the latter. These disadvantages are, it is considered, more than offset by the saving in lubricating oil and general advantages of a crosshead design. Passenger ships, in particular, require careful consideration when single-acting engines are being proposed; in one important ship put into service in 1939, two valuable accommodation decks might have been saved by installing trunk-piston or trunk-guide engines instead of crosshead engines. This is too high a price to pay. A number of very successful types of cargo carriers, refrigerated vessels and passenger ships with double-acting 2-stroke engines developing upwards of 4,000 s.h.p. per shaft, were completed in 1939, and several single-screw cargo vessels with powers of 4,000-8,000 s.h.p. developed in 5 to 8 double-acting cylinders, were laid down. The most popular design of double-acting engine in British and Scandinavian ships appears to be the longitudinal scavenge type, which has 10 years of highly successful experience to its credit. The refrigerating plant of some of the refrigerated ships completed in 1939 was electric-motor-driven, current being supplied from the main switchboard in the engine room, but in some cases the refrigerating machinery was self-contained, being operated by horizontal Diesel engines arranged in the 'tween decks. The single-acting opposed-piston type of engine retains its popularity for all types of vessels with which it has been long identified, the 32,000-s.h.p. four-screw installation of the highest powered British motorship of 1939 having engines of this design. Typical new vessels for cross-Channel services have twin screws, with 10-cylinder single-acting 2-stroke engines of an aggregate power of 12,000 s.h.p., the most notable ship of this category being a combined motor-car ferry and passenger vessel having twin screws driven by 7-cylinder trunk-guide piston engines. The 4-stroke Diesel generator continues to be preferred to the 2-stroke type for this auxiliary service, but an increasing number of the latter are being installed. A common arrangement is for a double-acting 2-stroke propelling engine to be supplemented by 4-stroke generating engines. Diesel-electric and geared Diesel drives have not yet become popular in this country, but several important and representative vessels have been built on the Continent with various forms of indirect drive, *viz.,* Diesel-electric; reduction gearing with electro-magnetic couplings; reduction gearing with hydraulic couplings; and reduction gearing with flexible mechanical couplings. Although alternating current has been generally favoured for Diesel-electric sets, there is no reason why d.c. installations should not be equally attractive, taking everything into consideration. The Diesel engine is now generally employed for coastal and river craft, the types adopted being fairly evenly divided between 2-stroke and 4-stroke. The last-named are generally supercharged either by exhaust turbo-blower or by blower chain-driven from the engine. Reduction-reverse gear is a strong tendency in British vessels. Voith-Schneider propellers were fitted in several miscellaneous vessels, both British and foreign, one of the former being a motor-car ferry. Notwithstanding the growing popularity of Diesel engines, steam machinery is likely to remain a serious competitor both in the form of high-power turbine installations or for low powers by adopting the latest forms of reciprocating engine. A very important factor in marine Diesel engineering at the present time is the urgent necessity for attracting an ample number of young men who have had the requisite training. Marine Diesel-engine progress has been hampered for years by the lack of suitable sea-going engineers. There were contracts placed in 1939 for steam machinery which, but for the difficulties of personnel, would have been Diesel. When such considerations outweigh real technical and financial advantages, the position is indeed serious. Despite the intensive work in connection with the wartime naval and mercantile programmes in hand at the present time, some sound development work is being carried on in a number of directions and when the war is over quite an appreciable advance should be shown in marine Diesel engineering.—*"The 1939 Bulletin of the Diesel Engine Users' Association" (Section 4).*

Control of Air Conditioning.

The accompanying illustration shows the control panel for regulating the room temperatures in a ship recently fitted with an air-conditioning installation of the washer type. The panel has two temperature controllers—one on the right marked "summer setting", which is in use while cooling by refrigeration is being carried out, and one on the left marked "winter setting", for use when heating is required. A dial-type thermometer for



Control panel for marine air-conditioning installation.

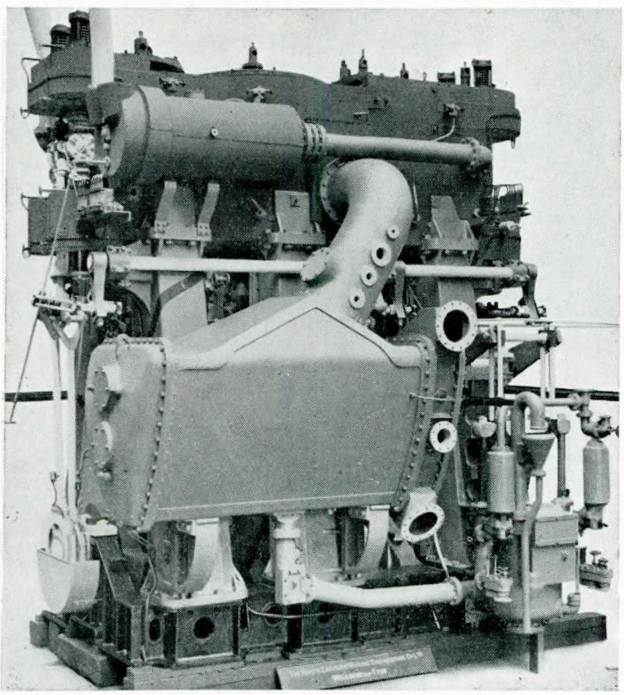
indicating the actual room temperature is also included in the panel. The controls are operated pneumatically and pressure gauges are provided to show the pressures maintained in the system.—*"The Shipping World". Vol. CII, No. 2,444, 17th April, 1940, p. 530.*

The Coal Dust Engine.

The international situation during the past 12 months made it difficult to obtain reliable information concerning the development of the coal dust engine in Germany, but there are indications that the past year has been one of considerable activity. Most German firms appear to be using the Nagel-Zinner system of injection which has been patented in this country by Messrs. Schichau, but it is reported that the German Patent Office has recently refused to grant the corresponding patent on the grounds that it had already been anticipated by the Pawlikowski patents. Certain difficulties have been experienced with the Nagel-Zinner system, such as a tendency for the coal dust to pass from the open-ended pre-combustion chamber into the main cylinder prior to ignition. This trouble appears to be accentuated with any increase of cylinder diameter and increase of engine speed, and various patents have been sought in respect of methods of overcoming the difficulty. Other difficulties encountered have been low thermal efficiency and large variations in combustion pressure in the pre-combustion chamber. The former trouble is stated to have been overcome by arranging for more rapid transfer of the ignited dust from the pre-combustion chamber to the main cylinder, and the latter by reducing the volume of dust set in motion during the injection period. Earlier troubles such as excessive liner, piston and ring wear, pitting and abrasion of exhaust valves and excessive lubricating oil consumption are claimed to have been overcome, but it is significant that five British patents have been taken out recently by Germans covering methods of preparing ash-free fuels by solvent extraction. In this country experimental work at the Fuel Research Station with a converted Diesel engine has been continued. The engine has a cylinder bore of 12in., a stroke of 18½in., and is designed to run at 230 r.p.m. The system of injection employed has proved to be both reliable and capable of metering the fuel with a reasonable degree of accuracy. For certain reasons most of the experimental work has been carried out with coal of low-ignition point and although the ignition of this fuel is satisfactory the thermal efficiency is appreciably lower than that obtained with oil in Diesel practice. Experimental work has been proceeding to determine the best size and shape of pre-combustion chamber and a substantial improvement in thermal efficiency has already been effected. There is also reason to believe that satisfactory results will be obtained with British bituminous coals after further modifications have been made.—*"The 1939 Bulletin of the Diesel Engine Users' Association", Section (10).*

The North-Eastern Marine Reheat Engine.

The marine engine shown in the accompanying illustration is claimed to represent the latest development in reciprocating machinery for ship propulsion. It has been proved that when



North-Eastern Preheater Engine.

the reheating is sufficient to eliminate all wetness from the cylinders, the resulting fuel consumption may be 10 to 15 per cent. lower than that incurred by a superheated engine of equivalent power. The reheat engine was first tried out in service in the "Hazelwood", in which vessel it was installed in 1934 as a conversion. The object of the design is: (*a*) To avoid all cylinder condensation and consequent detrimental effect on efficiency, by maintaining the steam in a superheated condition throughout the engine, including the final exhaust to the condenser; and (*b*) to achieve this object in the simplest manner possible, and without any additional complication as compared to the usual reciprocating installations found in cargo vessels. The Scotch cylindrical boiler has been retained in the design, the steam pressure used being the very usual one of 220lb./in.^{2}. The steam at service power is expanded 13 or 14 volumes, giving a mean effective pressure of about 34lb./in.^{2} in the L.P. cylinder. These figures are substantially the same as those adopted for non-reheated engines, although it does not, by any means, follow that they represent the optimum conditions for reheated engines. With a straight superheated engine operating under these expansion conditions an initial steam temperature of about 750° F. (about 355° F. of superheat) would be necessary to maintain the steam in a superheated condition throughout the engine. Such a temperature, although quite practicable, represents a considerable advance on the usual stop valve temperature of 600° or 620° F., whereas, in the reheat engine the same objective is achieved by retaining the usual stop-valve temperature and reheating the H.P. exhaust by about 150° F. It should not be overlooked that something like 70 per cent. of the world's mercantile shipping is still propelled by reciprocating steam engines. —*"The Shipping World", Vol. CII, No. 2,440, 20th March, 1940, p. 439.*

Operating Results of Turbo-Electric Propulsion.

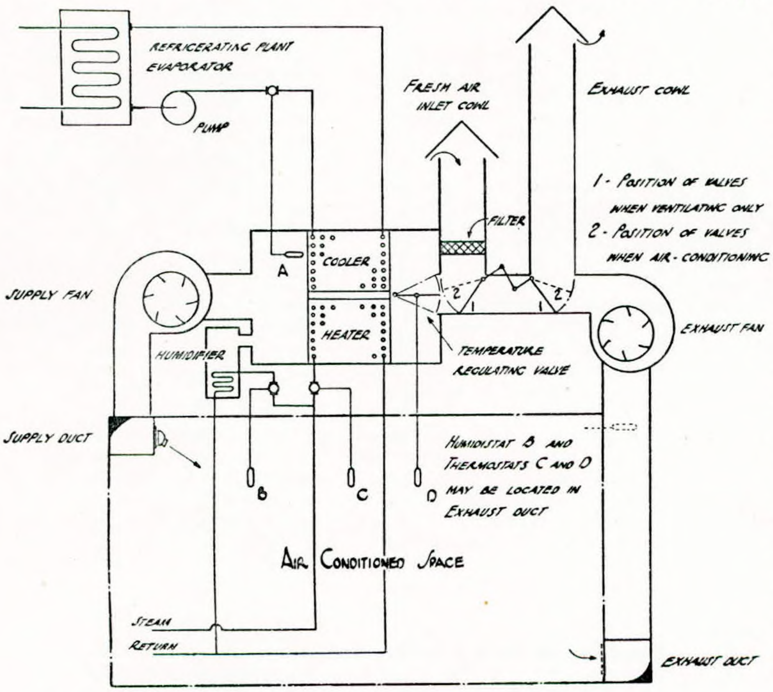
The author gives a brief outline of the operating results of eight vessels, four fitted with turbine electric drive and four fitted with turbines driving propeller shafts through mechanical reduction gears. In comparing these results the author points out that there is a considerable number of variable factors, all of which affect the overall fuel consumption of any ship. These are: (1) Efficiency of the hull and propellers, (2) efficiency of the boilers and propelling machinery; (3) steam conditions; (4) auxiliary machinery; (5) calorific value; (6) weather conditions and (7) hotel load.—*Paper by W. J. Belsey, "Transactions of The Institute of Marine Engineers", Vol. LII, No. 2, March, 1940, pp. 19-22.*

Diesel-electric Passenger Ferry Built at Buenos Aires.

The recently completed twin-screw motorship "Ciudad de Colonia" is the first vessel of her type to be built in South America. She is employed in the passenger and motor-car ferry service between Buenos Aires and the Uruguayan port of Colonia on the opposite side of the River Plate and has accommodation for 500 passengers and 40 motor-cars. The main dimensions of the ship are 200ft.×33ft.×10½ft., with a mean draught of 7½ft. The passenger accommodation comprises four large saloons and eight staterooms on the first-class deck, above which is the superstructure deck with accommodation for the ship's officers, etc. The 40-car garage is on the main deck, the cars being embarked and landed under their own power through the stern. There is also a cargo hold below the main deck. The propelling machinery—which was imported—is said to consist of a single-acting 2-stroke Atlas Polar engine with seven cylinders of 340 mm. diameter and 565 mm. stroke, developing 1,050 b.h.p. at 250 r.p.m., coupled direct to two 340-kW. 400-volt d.c. generators and a 60-kW. 230-volt d.c. exciter, arranged in tandem. Each generator operates a 450-b.h.p. propelling motor, running at 770 r.p.m., and coupled by means of helical reduction gearing to a propeller shaft running at 200 r.p.m. Bridge control on the Ward Leonard system is installed for manœuvring purposes. The vessel's machinery appears to combine the manœuvring flexibility of Diesel-electric drive with the frictional losses inherent in geared electric drive, but with none of the advantages to be derived from a multi-generator installation. However, it is possible that considerations of head-room governed the choice of machinery and that the physical limitations imposed by the shape and arrangement of the hull rendered it necessary to employ small-diameter fast-running propulsion motors.—*A. C. Hardy, B.Sc., "The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 34,991, 28th March, 1940, pp. 4-5.*

Surface Cooling Air-conditioning Plant.

The accompanying diagram of the general arrangement of a ship's air-conditioning installation comprises cooler, heater and humidifier elements, with provision for recirculating a proportion of the air in the conditioned space either through the cooler or direct to the room. The damper for regulating the proportion of the air to be passed through the cooler is controlled by thermostatic elements placed either in the air-conditioned saloon itself, or in the recirculated-air duct. The heater section forms



A THERMOSTAT CONTROLLING DEW POINT TEMP. OF AIR LEAVING COOLER
B HUMIDISTAT CONTROLLING STEAM TO HUMIDIFIER
C THERMOSTAT " " - AIR HEATER
D " " TEMPERATURE REGULATING VALVE

Diagrammatic arrangement of air-conditioning plant.

a by-pass around the cooler during hot weather conditions, when the cooler is supplied with brine from the refrigerating plant. Alternatively, the cooler constitutes a by-pass to the heater during winter weather conditions when no brine is being circulated and steam is being led to the air heater. The fresh-air inlet cowl is provided with a filter in order to guard against any accumulation of dust on the heat-exchange surfaces of the heaters and coolers. As the surface coolers are in a constantly dripping condition due to the condensation of the moisture in the outside air, they also perform a certain cleansing function on the air passing through them. The humidifier shown in the diagram is of the evaporator type in which a steam coil in an evaporating pan evaporates water under the control of a humidistat placed in the air-conditioned space.—*W. H. Glass, "The Shipping World", Vol. CII, No. 2,444, 17th April, 1940, pp. 535-537.*

Air Conditioning in Ships' Passenger and Cargo Spaces.

In the course of his observations on the above subject the author points out that there are definite ranges of temperature and humidity beyond which the human body does not respond without discomfort, varying from a feeling of coldness on the one hand to heat on the other, and that there is, therefore, what may be termed a "comfort zone" inside which it is desirable to maintain living spaces, the factors involved being temperature, humidity and motion. On board ship, where it has hitherto been usual to limit air conditioning to the public rooms, the basic inside temperature for summer conditions may be taken as 72° F. and this temperature is increased by one-third of the difference between the outside temperature and the basic temperature of 72° F., the humidity being in the vicinity of 50 per cent. The author stresses the importance of air-conditioning cargo spaces in which chilled cargo, such as fruit and meat, is carried. He also states that the effect of controlling the separate gas constituents of the atmosphere in such spaces opens up the possibility of employing higher storage temperatures than might otherwise be permissible, with a corresponding saving in refrigeration. In a reference to the work of the refrigerating plant in air conditioning, the author remarks that the steam-jet vacuum refrigerating machine is unsuitable for low temperatures, requires steam for its operation and almost three times the amount of condensing water necessary for the ordinary compressor-type refrigerating machine, and is, for these reasons, regarded unfavourably for land work. On board ship, however, particularly in steamships, both steam and an unlimited quantity of condensing water are available, and the fact that very little mechanical power is necessary, that the plant is very compact and far lighter than a compressor-type machine and that the only working parts are the circulating pumps, indicate that steam-jet vacumm refrigerating plant possesses great advantages for use in conjunction with ships' air-conditioning installations.—*Paper by Wm. H. Glass, read before a meeting of the N.E. Coast Institution of Shipbuilders and Engineers, on the 29th March, 1940.*

Improvements in Diesel-engined Tankers.

It can be said that, roughly speaking, the coal consumption of a reciprocating-engined ship with cylindrical Scotch boilers has been reduced by 30 per cent. in the last 20 years, while the corresponding reduction in the case of Diesel-engined vessels is about 20 per cent. The oil-fuel consumption of the famous "Selandia" the first sea-going ship of any size to have Diesel machinery, was 0·44lb./s.h.p.-hr. for all purposes under trial conditions, whereas in the latest oil engine installations this figure has been reduced to 0·36lb. In the case of an oil-engined tanker of 12,000 tons d.w. carrying capacity, it is estimated that the vessel built in 1920 would require to have engines of 3,500 s.h.p. to maintain a speed of 12 knots, with a daily fuel consumption of 21 tons, while in the modern ship the power would be reduced to 3,000 with a corresponding daily consumption of 14 tons, *i.e.,* two-thirds that of the older ship. Incidentally, the speeds of tankers in those days rarely exceeded 10 knots, and Diesel-engined tankers were not numerous. In 1921, the Standard Oil Company of New Jersey controlled 110 steamships and 10 motorships, the average speed of these vessels being 10 knots. Much of the reduction of the consumption of the modern marine Diesel engine, as compared with earlier installations, has been due to the adoption of solid injection in lieu of blast injection. This alteration has made it possible to do away with the relatively inefficient air compressor and to obtain higher mean pressures in the cylinders, with a corresponding gain in thermal efficiency. A further improvement has been the introduction of exhaust-gas heat recovery boilers for supplying steam for the auxiliary machinery, with a resultant saving of about 5 per cent. in the fuel bill. The marine superintendent of a well-known fleet of tankers is reported to have expressed the view that the best arrangement is to have the steering gear, winches and windlass, and one set of generators driven by steam, the other generators being Diesel-driven, for by this means full advantage can be taken of the steam from the exhaust-gas boilers when the ship is at sea. The boiler is oil-fired for port use.

The arrangement and construction of the hull of a modern tanker are now more or less uniform, and the older design, with a single longitudinal bulkhead at the centre line and summer tanks in the wings, has been almost completely abandoned in favour of the type with two longitudinal bulkheads. There are certain definite advantages to be obtained from the modern design, both from the aspect of the running and maintenance of the ship. Loading and discharging may be carried out in a very flexible manner, and it is possible to ballast the vessel when in the light condition so that stresses on the hull structure may be kept as low as possible. As regards maintenance, the omission of the summer tanks has reduced the possibilities of corrosion, as it had been found that the decks and longitudinal bulkheads of this part of the structure were particularly liable to wasting, due perhaps to the alternate wetting and drying of the surfaces. Unfortunately, there does not appear to be any sovereign remedy for corrosion in a tanker other than running the ship in the heavy oil trade during the first years of her life; when the ship is no longer new she can be used to carry refined oil, which causes all the trouble.—*"Fairplay", Vol. CLIV, No. 2,968, 28th March, 1940, pp. 490-491.*

Launch of the Swedish Liner "Stockholm".

The motorship "Stockholm", under construction by the Cantieri Riuniti dell' Adriatico for the Gothenburg-New York service of the Swedish-America Line, was launched at Monfalcone on the 14th March. The hull of this vessel was originally launched at this yard in May, 1938, and while in the fitting-out basin about two months before her trials, she was very severely damaged by a fire in January, 1939. The "Stockholm" is the largest ship ever built in Monfalcone, having an overall length of 678ft., a beam of 83ft. and a gross tonnage of 28,000 tons. She will be driven by three sets of Italian-built 10-cylinder Sulzer engines having a total output of 22,000 h.p. and designed to give her a service speed of 19 knots. The vessel has 10 decks, six of which are continuous, and extensive use has been made of welding in the construction of the decks and exterior hull plating. In order to obtain the largest possible number of exterior cabins, the usual arrangement of two long corridors along the decks has been replaced by a single central passage for all the decks on which the passenger accommodation is arranged, large openings in the decks ensuring maximum ventilation for the cabins. An extensive air-conditioning plant is being installed which is primarily intended for use during the pleasure cruises which the ship will undertake in tropical waters. In addition to the main and auxiliary engine rooms there are two refrigerating engine rooms. One set of refrigerating machinery will be used for the insulated cargo holds and the other for the air-conditioning plant. The ship is due for delivery at the end of the year.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 34,986, 21st March, 1940, p. 2.*

Diesel Engines for Warship Propulsion.

The Netherlands Government have decided to build two large minelayers to be driven by Diesel engines. These ships will have a displacement of 2,000 tons and a length of about 280ft. They will be equipped with Diesel propelling machinery of between 4,000 and 5,000 b.h.p. designed to give them a speed of 18 knots. The United States Government are reported to have placed an order with the Defoe Boat and Motor Works, of Bay City, Michigan, for a steel-built submarine chaser about 175ft. in length, which is to be driven by high-speed Diesel engines of General Motors construction.—*"Journal de la Marine Marchande", Vol. 22, No. 1,095, 28th March, 1940, p. 346.*

Japanese Cable-laying Ship "Toyo Maru".

The Japanese Government's new cable-laying vessel "Toyo Maru", recently completed in the Kawasaki Dockyard Company's Kobe yard, is a ship of about 3,719 tons gross, her main dimensions being 397ft. by 48·4ft. by 27·1ft., with a load draught of 20·8ft. The most remarkable feature of this vessel is the fact that in addition to having turbine propelling machinery she is also equipped with a Voith-Schneider propeller driven by an electric motor, to facilitate the maintenance of the slow speed necessary for laying cables. The main engines of the "Toyo Maru" comprise two sets of double-reduction geared turbines of the Kawasaki impulse type, with a total output at normal load (ahead) of 3,000 s.h.p. Each unit is made up of an H.P. and an L.P. turbine running at 5,598 and 4,240 r.p.m. respectively, the normal H.P. receiver pressure being 205lb./in.^{2} and the corresponding propeller speed 120 r.p.m. Superheated steam at a pressure of 227·5lb./in.^{2} is supplied by three Prudhon-Capus type coal-burning boilers, working under forced draught. The boilers are fitted with superheaters of the dry-combustion chamber type and plate-type air preheaters. Steam for the auxiliary machinery is supplied through de-superheaters. The electric current for power and lighting purposes is furnished by two 60-kW. and one 35-kW. generators, the latter being fitted for emergency use. It is installed in a special compartment on the shade deck and may be driven by either a reciprocating steam or petrol engine. The Voith-Schneider propeller has a pitch circle of 4ft., with six blades 2ft. 3½in. in length and is driven at 178 r.p.m. through reduction gearing by a d.c. compound-wound motor of 100 h.p. normal output. The "Toyo Maru" has successfully undergone comprehensive trials, attaining a maximum speed of 15 knots under trial conditions of loading (half-load) and using only her screw propellers.—*"The Shipbuilder", Vol. XLVII, No. 367, April, 1940, pp. 111-115.*

Japanese Passenger Liner "Nitta Maru".

The twin-screw t.s. "Nitta Maru" recently completed at Nagasaki for the Japan-London service of the Nippon Yusen Kaisha is due to leave Yokohama on the 18th May, on her maiden voyage. She has a gross tonnage of about 17,000, her main dimensions being 590ft.×73ft.×40ft., with a cargo capacity of 11,800 tons and accommodation for 127 first-, 88 second- and 70 third-class passengers. Her two sets of geared turbines develop 21,000 h.p. and steam is supplied by four oil-fired high-pressure water-tube boilers. The vessel is reported to have attained a speed of 22·47 knots on trials, which, it is claimed, is the highest yet attained by any Japanese ship. The service speed is 18 knots.—*"The Shipbuilder", Vol. XLVII, No. 367, April, 1940, p. 110.*

Hongkong to Build Ships for Britain.

It is reported that the British Government are about to place contracts for the construction of at least four cargo vessels by the Kowloon (Hongkong and Whampoa) and Taikoo Dockyards. The ships will, it is understood, be slightly smaller than the 10,000-ton motorships *Glenorchy* and *Breconshire*, the largest yet built in the Colony. Much of the steel will come from Australia, Hongkong providing the shipyard labour. Six ships were built for Britain in Hongkong in the last war.—*"Shipbuilding and Shipping Record", Vol. LV, No. 15, 11th April, 1940, p. 356.*

Small Steam-raising Plants.

A British standard test code for comparative commercial tests of coal or coke and appliances in small steam-raising plants (*B.S. 878*) has just been issued by the British Standards Institution. The new code provides for the carrying out of tests to determine the relative value of new equipment such as grates, circulators, economisers, air heaters, smoke eliminators and similar auxiliary boiler apparatus, in small steam-raising plants under ordinary working conditions. It presupposes that when fuels are being tested the plant is in no way altered between one test and another, and that running and operating conditions, *e.g.*, the load on the plant, are similar in both cases. When appliances which are claimed to affect economy, efficiency or output are being tested, it is essential that no alteration should be made to the plant except when necessary to instal and connect up the appliance under test.—*"Lloyd's List and Shipping Gazette", No. 39,126, 3rd April, 1940, p. 8.*

American Shipbuilding Methods.

The C-3 class cargo liner "Sea Arrow", laid down at Oakland, California, on the 18th March, 1939, and launched only six months later, is now ready for service and her builders—the Moore Dry Dock Company—have, in the meantime, launched a sister ship, the "Sea Star", which was on the stocks for only 63 working days. The specifications for the hulls of the C-3 standard ships provide for all-riveted longitudinal seams and all-welded transverse joints, which enables whole bulkheads with their stiffeners, as well as large areas of tank-top complete with floors and intercostals attached to be welded on horizontal welding platforms and transported complete to the site. The Moore yard employ the "Unionmelt" welding process in which the electrode is constantly covered by a highly resistant, conductive, granulated material or welding composition known as "Unionmelt". This granulated material is deposited along the seam to be welded, and the entire welding action takes place beneath it, thereby eliminating any visible arc, sparks, spatter or smoke. Within the layer of "Unionmelt" an intense concentrated heat is generated by the electric current, and the base metal electrode together with a portion of the edges to be welded are melted and fused. Molten metal from the electrode is thoroughly mixed with the melted base metal to form a weld, and in the process a subsurface layer of "Unionmelt" melts and floats as a liquid blanket over the molten weld metal. The granulated material is not a conductor of electricity when cold and so to start the weld a wad of steel wool or some similar device is employed to act as a special "fuse". Bare welding rod is continuously fed from a special reel into the weld, and the "Unionmelt" fed through the welding head is progressively laid down along the seam to be welded a few inches in front of the rod, the unfused "Unionmelt" material being picked up by a vacuum cleaner and returned to a hopper for re-use. The Moore yard found that for the economic assembly of a ship's hull by welding, a large area of platform adjacent to the ship was required. The steel members of the hull were laid out on this platform in their proper relation to one another and welded together in large assemblies, which, in the case of the "Sea Arrow", varied from 10 to 55 tons in weight.—*"The Shipping World", Vol. CII, No. 2,443, 10th April, 1940, pp. 511-513.*

German Lloyd's Technical Investigations.

An article by G. Buchsbaum of the Germanischer Lloyd in *Hansa* deals with the progress made in the amplification and improvement of rules since the issue of that society's revised classification and construction rules in 1938. One of the most important problems now under consideration, states the author, concerns the strength of unplanked decks. Theoretical investigations have shown that in multi-deck vessels exceeding 328ft. in length, the minimum thicknesses at present laid down are inadequate and that special rules should be applied to single-deck vessels. In the usual types of ships, however, particularly in cargo vessels with wide hatchways, where the deck is relatively thick, the existing rules appear to be adequate. As the buckling strength of the deck plating is affected by the bending strength of the deck beams, tables of the latter have also been checked and bending tests carried out on a specially constructed riveted structure 22ft. 3in. × 4ft. 11in. × 3ft. 3in. deep stiffened by girders and cross frames. The bulging of the deck and deflections of the beams and frames were measured accurately at loads up to 300 tons, at which collapse occurred. The experimental data confirmed the correctness of the method and figures used in the calculations. It is proposed to carry out similar tests on a second structure of the same dimensions but of electrically-welded construction, with longitudinal frames, thus obtaining data on the buckling strength of electrically-welded decks and permitting rules to be formulated. Other work carried out under the auspices of the Germanischer Lloyd includes investigations on the strength of frames, as well as physical and chemical tests on specific samples of materials. Among these were plates from ships damaged in service, corroded plates from a vessel built in 1923, and defective rivets and bolts. Preparations are in hand for further tests on electrically-welded joints between plates, which are to be made in collaboration with representatives of owners and builders of small fishing craft.—*"Shipbuilding and Shipping Record", Vol. LV, No. 15, 11th April, 1940, p. 356.*

Improvements in Ships' Steering Gear.

One of the most important improvements in the equipment of ships in recent years has been the replacement of the rod and chain type of steering gear by a steering engine coupled directly to the rudder head and controlled from the bridge by telemotor or rods and bevel wheels. Although well-designed rod and chain gear is quite reliable when properly fitted and maintained, its necessarily exposed position and the extent of the connections render it more liable to wear and tear than the more compact, but also more expensive, types situated at the rudder head. In small craft such as tugs and coasters, where power gear is not essential, the older arrangement is still largely used, but even in these classes of vessels the present-day tendency is to provide a more compact steering engine. One arrangement, of which there are several variations, consists of a hand-hydraulic and electro-hydraulic gear, the hand gear being used at sea and the power turned on when the ship is manœuvring in confined waters. The motive power for this gear is provided by a variable-stroke pump which can be operated either directly from the steering wheel by a chain drive or by means of a small electric motor. The pump is located at the base of the steering wheel and is connected to horizontally-opposed hydraulic cylinders operating the steering gear by two pipes carrying oil. An advantage of this gear is that the mechanism is always under the control and in sight of the steersman, who can change over the power from hand to motor by the movement of a lever on the pump. These arrangements have proved to be very effective in service and it is probable that this type of gear will become increasingly common in the smaller ships for which it is primarily intended.—*"Fairplay", Vol. CLIV, No. 2,970, 11th April, 1940, p. 562.*

The Problems of the Singing Propeller.

The authors state that the unusual noise emanating from what is known as a "singing" propeller is the direct result of the vibration of the blades which are disturbed by the irregular hydrodynamic actions of cavitation and vortex shedding, and induced by the extreme variations in the wake. It has been found by experiment that a blade with a sweeping plan form and sharp edge suppresses cavitation and vortex action within the working range of the propellers and that many singing propellers can be cured by sharpening the blade edges round the periphery. In addition to suppressing the disturbing forces, experiments show that the sharp edge cure provides a considerable increase in hydrodynamic damping. The authors review a variety of cases and problems—which are classified in three groups; they consider the hydrodynamic influence in the shape of wake, cavitation and vortices, and examine blade flutter, which they regard as an unlikely condition, and they describe various wind tunnel investigations of leading edge effects and water tests with model blades; a number of flutter experiments and analytical investigations are also described and the dynamical characteristics of a model propeller blade are set out. Notes emitted by singing propellers suggest that many modes of flexional, torsional, and lateral vibration are present, and the authors claim to show that the lateral types respond easily, their importance being indicated by the number of noisy propellers which have exhibited fatigue cracks conforming to the lateral modes of vibration. In conclusion, the authors declare that the most important factors to be considered in ensuring the utmost protection against singing are: (*a*) The elimination of all types of exciting forces; (*b*) the production of a blade with low responsiveness to the arbitrary forces occurring at the tip and leading edge; and (*c*) production of a hydrodynamic flow to the propeller having a minimum of disturbance. After considering each of these three factors, the authors recommend that the process of sharpening the blade edges be adopted, as this suppresses the exciting forces and damps the response of the blade. The text of the paper is illustrated by 35 plates and diagrams and a list of the references quoted is appended.—*Paper by Professor W. Kerr, Ph.D., J. F. Shannon, Ph.D., and R. N. Arnold, Ph.D., M.S., B.Sc., read at a general meeting of the Institution of Mechanical Engineers on the 19th April, 1940.*

Furnace-combustion Study.

A paper entitled "Photographic study of Steam Boiler Furnaces in Operation" by Messrs. A. A. Markson and W. H. Dargan, published in the *Proceedings of the American Society of Mechanical Engineers,* discusses the possibility of making use of cinematography for the investigation of the efficient combustion of coal in boiler furnaces. It is suggested that the cine-camera should be utilised to observe the effect of the position of the combustion air inlets, furnace baffles and so on, as well as to investigate some of the problems connected with the use of mechanical stokers. The authors also express the view that the taking of single photographs at long intervals over a period of some hours in order to produce a film which could be run through a projector at the normal speed of 16 frames per second, should make it possible to view a process which takes many hours in the furnace in a period of minutes. Slow-motion pictures and "stills" of any particular part of the process could also be obtained. The paper describes the special precautions to be taken when photographing in a stokehold.—*"Shipbuilding and Shipping Record", Vol. LV, No. 16, 18th April, 1940, pp. 379-380.*

Engine Types in German Submarines.

It is reported that the German coastal submarines of the 250-ton U1 to U24 class, designed for a surface speed of 13 knots and 7 knots submerged, are propelled by two sets of 12-cylinder Maybach engines rated at 350 b.h.p. each. These engines are of a standard type as used for rail-car propulsion in Germany on a very large scale, and there is no doubt that they could be manufactured in large numbers. At the outbreak of war there were actually some 200 or 300 of these engines on order, not only for Germany, but for other countries also. The latest type is supercharged, giving a maximum output of 600 b.h.p. at 1,200 r.p.m. No doubt a substantial number of 250-ton coastal submarines are now under construction and it is believed that each will be equipped with two 600-h.p. Maybach pressure-charged engines, which would give them a speed of 15 knots on the surface. The second class of submarine is the sea-going type of 500 or 517 tons displacement and a designed surface speed of 16½ knots, numbered U27 to U32 and U45 to U55. These craft have two sets of 6-cylinder M.A.N. engines developing about 1,000 b.h.p. when supercharged, the cylinder rating being 115 b.h.p. at 700 r.p.m. unsupercharged, and 175 b.h.p. when supercharged. This power increase of 52 per cent. is obtained with an increase in weight of 4·8 per cent., the reported weight of the supercharged engine being only 12lb./b.h.p. The engines are of the 4-stroke type with cylinders 300mm. in diameter, the piston stroke being 380mm. The fuel consumption is said to be under 0·38lb./b.h.p.-hr. with a lubricating-oil consumption of 2-3gr./b.h.p.-hr. A maximum output of 1,200 b.h.p. can be attained, the normal rating being 950 to 1,050 b.h.p. and the weight of each engine, without water and oil, is 5·75 tons. The ocean-going submarines of the U25 and U26 and improved U37 to U44 types (712 and 700 tons respectively) have machinery of 3,200 b.h.p. weighing 26·5lb./b.h.p. normally, or 22·0lb./b.h.p. when pressure-charged on the exhaust-turbo system. The fuel consumption at full power is stated to be 0·36lb./b.h.p.-hr. The engines are of M.A.N. design with a cylinder diameter of 400mm. and a piston stroke of 480mm. An output of 175 b.h.p. per cylinder is obtained at 480 r.p.m. at normal aspiration, and 260 b.h.p. when pressure-charged. The 6-cylinder engines of these U-boats develop 1,650 b.h.p. and weigh 16·5 tons. It is claimed that all these engines have been fully tested in service for some years and have given proof of their reliability, and that the components can be manufactured on a large scale and assembled according to requirements. The machinery weights involved are considered to be only half of those for corresponding machinery used in the last war, hence, substantially more fuel can be carried in similar submarines, giving a larger cruising radius and higher speeds.—*"The Motor Ship", Vol. XXI, No. 243, April, 1940, p. 12.*

The German Aircraft Carrier "Graf Zeppelin".

It is reported that the above-named vessel, the first of the two aircraft carriers to be built under the German shipbuilding programme of 1936-37, is about to be commissioned for service. Her construction was begun at the Deutsche Werft in Kiel, early in 1937, and she was launched on the 8th December, 1938, so that if the ship has now really been completed, the total time taken to build her will have amounted to under three years, whereas the British aircraft carrier "Ark Royal", completed in November, 1938, took three years and eight months to construct. The "Graf Zeppelin" has a standard (Washington) displacement of 19,250 tons, with a length of 825ft., a beam of 89ft. and a mean draught of about 18½ft. She is, therefore, about 65ft. longer than the somewhat larger aircraft carriers belonging to other navies and her relatively small beam indicates that the hull has been designed on very fine lines. The machinery installation comprises geared turbines and high-pressure water-tube boilers intended to give the ship a speed of 32 knots, but it is probable that her actual speed will prove to be more like 34 knots. Unlike other aircraft carriers, the German ship carries a relatively heavy armament, consisting of fourteen (or sixteen) 5·9-in. guns and ten 4·1-in. A.A. guns, in addition to 22 A.A. pom-poms. Some of the 5·9-in. guns—probably eight—may be mounted in turrets on the flight deck. The ship carries forty aircraft and is reported to have good armour protection against hostile gunfire and aerial attack. The general design of this German vessel differs radically from that of any contemporary foreign aircraft carrier and it is obvious that she is intended for use as a commerce raider. Although she may prove a difficult quarry for capital ships to locate and destroy on account of her high speed, she would, nevertheless, present a far more vulnerable target than any of the German "pocket battleships" to the guns of the 90 odd French and British cruisers with which she may have to deal.—*Commandant Jean de Fussy, "Journal de la Marine Marchande", Vol. 22, No. 1,096, 4th April, 1940, p. 371.*

New Diesel Electric Ferry for New York Hudson River Service.

The new Diesel-electric ferry "E. G Diefenbach", which arrived at New York on the 5th March from the Levingston Shipyard of Orange, Texas, is the first of two such vessels to be built there for the Electric Ferries, Inc.'s service between New York City and the New Jersey shore of the Hudson River. The new ferry has a length of 185ft., a beam of 55ft., and a depth of 15½ft., with a draught of 8½ft. The hull is of all-welded steel construction and of straight-frame design, no curved frames being used and the sectional profile of the hull forming a straight line on each side from the keel to the edge of the upper strake. There are seven watertight compartments. The main deck has a casing amidships for the exhaust trunks, etc., and on either side are three lanes for vehicles, giving a total capacity of 50 cars and lorries. The passenger cabin is on the deck above with a promenade along each side and an open deck at each end, providing accommodation for 400 persons. The propelling machinery consists of a General Motors 2-stroke V-type 12-cylinder Diesel engine developing 950 h.p. at 750 r.p.m. and direct-coupled to an Electromotive generator. The engine is offset from the centre line of the ship in order to clear the propeller shaft which extends from end to end of the hull. The exciter generator is mounted on a separate base and is chain-driven from the main generator shaft. The 850 h.p. propulsion motor runs at 650 r.p.m. and drives the propeller at 180 r.p.m. through Farrel-Birmingham reduction gear. An 8-ft. diameter 4-bladed propeller is mounted at each end of the fore-and-aft propeller shaft, giving the ferry a service speed of 12 knots. Electric current for lights and power is normally obtained from the exciter generator, but an auxiliary unit with a 3-kW. generator and general service pump is also provided. Two motor-driven fire pumps, each with a capacity of 210 g.p.m. at 110lb./in.^{2} are installed and there is also a CO_2 system in the engine room. The second ferry is due for delivery on the

15th April.—*"Motorship and Diesel Boating", Vol. XXV, No. 4, April, 1940, pp. 208-209.*

Problems of Diesel-electric Drive.

An article in the current issue of the *G.E.C. Journal* states that the operation of Diesel-engine-driven alternators and synchronous motors employed for main propulsion involves two important problems. The first of these arises because considerations of weight and cost make it desirable to employ high-speed machines, and this means running several alternators in parallel. As the speed control of a.c. propulsion motors has to be effected by varying the speed of the prime movers, the alternators must operate in parallel over a wide range of speeds. To ensure rapid manœuvring the alternators have to be kept in parallel during the period of time required to change over the main connections to the motors for reversal purposes. The second problem is due to the dropping characteristics of the Diesel engine torque/speed curve. Unless the engine is made very much larger than is necessary for normal full-load conditions, it is inherently incapable of overcoming the back torque from the propeller when the speed of the propeller is reduced rapidly or the propellers are reversed. In the case of turbo-electric drive, the inherent characteristic of the steam turbine gives the required rapid reversal of the propeller, but special measures are necessary to ensure that the same speed of reversal is obtained with the Diesel-electric drive. One method adopted for retaining the alternators in synchronism during manœuvring is to keep the alternators excited and to open the main motor circuit at a low current value. which is attained approximately when the engine is slowed down by about 30 per cent. of the speed. At this point the engine torque approximately balances the back torque from the propeller driven by the ship's momentum, so that the current is negligible. The main motor circuit having been opened and the alternators remaining excited and in parallel on their own bus bars, the motor field circuit is opened, and a suitable value of d.c. applied to the main stator windings of the motor. Since the synchronous propulsion motor is also provided with a squirrel-cage starting winding on the rotor, this d.c. stator excitation converts the motor into an alternator running under the short-circuit conditions, thus acting as a dynamic brake. The energy given out by the propeller is dissipated in heat in the rotor, and the speed is rapidly reduced to a value at which the back torque from the propeller is sufficiently low to be dealt with by the Diesel engine when running at reduced speed. When this point is reached the d.c. is again cut off from the stator which is reconnected for reverse rotation to the paralleled alternators. The motor then pulls up the propellers and drives them in the reverse direction as with a steam-engine drive. An alternative method involves the use of machines with special windings and gives a smoother transition from the dynamic braking to the final reversing.—*"The Marine Engineer", Vol. 63, No. 753, April, 1940, p. 98.*

The Report on the Loss of the Submarine "Thetis".

Mr. Justice Bucknill's report—issued on the 4th April, 1940—on the loss of H.M. submarine "Thetis" in Liverpool Bay on the 1st June, 1939, attributes the cause of the disaster to the opening of the inner door of a torpedo tube on the starboard side while the bow cap of the tube was open. The test cock of No. 5 torpedo tube rear door was blocked with bitumastic enamel at the time the interior of the tube was coated with enamel and the rimer provided for the purpose of clearing the test cock was not used by the officer responsible for opening the rear door prior to doing so. The Report suggests that the bow cap *may* have crept open after power was turned on to the bow-cap telemotor operating mechanism some minutes before the accident occurred. The subsequent sinking of the vessel and loss of 99 lives was brought about by a series of mishaps some of which will never be explained. It would seem to be clear that the safeguards against mishap, adequate as they appear to be, are yet insufficient and that a positive lock between the bow cap and rear door—such as is believed to be employed in some foreign navies—is desirable.—*"The Engineer", Vol. CLXIX, No. 4,396, 12th April, 1940, pp. 347-349 and 353-354.*

Early Developments in Electric Ship Propulsion in Great Britain.

The author describes two of the first practical attempts to apply electric power to ship propulsion in this country. The papers presented by H. A. Mavor in 1908 to various technical societies are referred to and the "Spinner" motor developed by him for ship propulsion purposes is described. The propelling equipment of the 50-ft. launch "Electric Arc", completed in 1910-11, is dealt with at some length, as is also that of the Canadian Lakes vessel "Tynemount", completed in 1913. The tests and trials carried out with this vessel's machinery are described and comparative data of the latter and that of three other Lakes vessels is quoted. The author points out that the machinery installation of the "Tynemount" was in advance of the period, but although regarded as a failure it provided experience and information of real value for present-day developments. To-day more than 150 ships with a gross tonnage of over 700,000 are electrically propelled, including one of the three largest liners afloat, and recent revival of interest in the electrical system augurs the still wider application of this means of propulsion.—*Paper by S. R. Yates, "Journal of the Institution of Mechanical Engineers", Vol. 143, No. 1, April, 1940, pp. 76-83.*

Denmark's Shipbuilding Industry.

The German occupation of Denmark must have a disastrous effect on the Danish shipbuilding industry, as during recent years over 85 per cent. of the tonnage building in Denmark has been on foreign owners' account. According to the latest information available 19 ships of 122,440 tons gross were under construction in Denmark at the beginning of April, 1940, of which 14 were for foreign owners. Among these were a passenger and cargo motorship of 9,100 tons gross building for the Glen Line by Burmeister & Wain, Copenhagen, and a motor tanker of 10,500 tons gross for the United Molasses Company, Ltd., under construction by the Nakskov Shipyard. The Copenhagen yard were also building a 10,000-ton passenger and cargo motorship for the Cie Générale Transatlantique, and other foreign tonnage included an 11,500-ton ship for Poland, four of 25,360 tons for Norway, two of 15,800 tons for the Netherlands and two of 13,400 tons for Sweden. It is unlikely that the Germans will allow the Danes the necessary material to complete these vessels as the latter would be of little use to the enemy at the present time and it is more probable that the Danish shipyards and skilled personnel will be utilised for warship and aircraft construction.—*"The Syren", Vol. CLXXV, No. 2,278, 24th April, 1940, p. 116.*

Activity of Dutch Shipyards.

According to the latest returns of the Bureau Veritas, the total mercantile tonnage under construction in various Dutch shipyards on the 1st April, under the supervision of the Society, amounted to no less than 115,765 metric tons. Among the vessels in hand are one 22,000 ton passenger and cargo liner, three 7,500-ton, two 4,000-ton, one 3,500-ton and one 2,050-ton passenger and cargo vessels, one 9,100-ton, one 6,000-ton and two 1,800-ton cargo vessels and two 1,500-ton salvage vessels. The ships under construction do not include any sea-going tankers.—*"Journal de la Marine Marchande", Vol. 22, No. 1,099, 25th April, 1940, p. 465.*

A Magnetic Oil Filter.

A system of magnetic oil filtration has been developed by a well-known electrical manufacturing firm in this country. It employs a permanent magnet enclosed in a cylindrical aluminium housing, arranged so that the oil to be filtered must pass within a distance of 2 mm. from the permanent magnet. The system is not intended to carry out the first gross decontamination of the oil, being designed to supplement other filtration systems installed for that purpose. The magnetic cleansing system is stated to be particularly useful for installation in lubricating-oil outlets from reduction-gear boxes, etc., as if allowed to pass through such gear trains repeatedly the grinding effect reduces the metal particles in the oil to such minute dimensions as to make their complete elimination impossible by any other means. The smallest size of magnetic filter produced by the manufacturers has a capacity of 120 gall./hr., and is designed to operate with oil pressures of up to 75lb./in.^{2}, but in most cases it is preferable to fit the filter on the suction side of the pump in order to give the latter the maximum benefit of its effect. The interior trapping surface will deal with approximately 5,000 mg. of particles (under unfavourable circumstances, such as thick oil and very minute particles, rising to 11,000 mg., as filter circumstances become more favourable) before saturation occurs, when the filter ceases to function, although even under these conditions clogging cannot take place as the space still available for oil flow in the filter interior is greatly in excess of the ½-in. inlet and outlet orifices. For larger capacities these filters can be connected in parallel and where frequent cleaning is necessary such an arrangement is advantageous, as by an appropriate system of cocks individual filters can be cut out of circuit for cleaning without affecting the oil circulation. The makers of these filters are reported to be developing other sizes with capacities ranging from 1,600 to 5,000 gall./hr.—*"Practical Engineering", Vol. I, No. 13, 20th April, 1940, pp. 523-524.*

Lack of Welding Facilities in British Shipyards.

The employment of electric welding instead of riveting in the construction of tankers and small craft enables a saving in weight of 16 to 25 per cent. to be achieved in addition to a substantial saving in the necessary labour. Apart from the economy of material and labour, there are other advantages to be gained by the adoption of welding in oil tankers as it enables many of the projections on the bulkheads, such as rivet heads and plate edges, to be eliminated. This allows the tanks to be cleaned more easily and reduces corrosion. Minor leaks which often develop in riveted ships after heavy weather are also obviated. Despite these advantages the use of welding in the construction of British-built tankers is unlikely to be extended at the present time owing to the lack of facilities for welding on a large scale in the shipbuilding industry and the scarcity of skilled welders. Many of the older yards are congested enough without adding to their difficulties by the introduction of welding plant and—most important of all—the technique of welding large portions of a ship's structure can only be learned through experience. Although the troubles now being encountered by our shipbuilding industry are nothing like as great as those of the last war, one of the most important lessons which can be gained from that experience is the desirability of adhering to well-tried methods. Experiments must be rigorously excluded from shipbuilding under present conditions, and welding on a large scale must be regarded as an experiment.—*"Fairplay", Vol. CLIV, No. 2,972, 25th April, 1940, pp. 627-628.*

Mass Production of Ships.

The annual report for last year of the Ship Constructors' and Shipwrights' Association states that the present-day building programme of this country is the nearest thing to mass production that the industry has ever known. In a few weeks' time cargo vessels in shipyards all over the country will be taking shape on the stocks faster than our ships can be sunk. Each yard is building one type of ship only, and that type is the one which can be constructed most rapidly and economically. The ships are termed "emergency" vessels, but although the labour involved is reduced to a minimum, they are being built to last and will not suffer the fate of the "standard" ships of the last war, many of which had to be scrapped. The vessels which have been under construction during the past few months, the report continues, are being added to the launching output, so that before the year 1940 is far advanced there will be an exceptionally heavy demand on the fitting-out basins, notwithstanding the fact that many of the new ships are likely to be launched in an advanced state of completion in order to reduce the fitting-out period. The Government's decision to order a large number of tramp vessels of simple type is, of course, the backbone of the yards' activity, and these orders are enabling the shipyards to build economically.—*"The Engineer", Vol. CLXIX, No. 4,396, 12th April, 1940, p. 341.*

Geared Diesel Lighthouse Tenders of U.S. Coast Guard Service.

The American Lightouse Service was amalgamated with the U.S. Coast Guard Service on the 1st July, 1939, on which date the latter assumed charge of the 64 lighthouse tenders belonging to the first named organization. The duties of these vessels include the distribution of provisions, fuel and stores to lighthouses and lightships; the fuelling, repair and adjustment of an ever-increasing number of automatic or unattended lights; the replacement at intervals of mark buoys by reconditioned units; plus a multitude of miscellaneous jobs too numerous to mention. Of these 64 tenders 40 are steam driven, 12 have direct Diesel drive, 4 have Diesel-electric drive and 6 have geared Diesel engines. Among the special features of the tenders are (1) a high degree of stability for hoisting buoys over the side; (2) shallow draught to enable them to approach shoals and obstructions; (3) an adequate cargo-carrying capacity; (4) a sufficiently high speed for emergency purposes; (5) low running costs, and (6) ice-breaking ability. The most recent additions to the fleet of lighthouse tenders are the 120-ft. geared-Diesel "Narcissus", "Zinnia" and "Maple", completed six months ago. The hulls of these vessels are of steel, the shell plating being riveted, but all the internal frames, bulkheads, longitudinal stiffeners and decks welded to save weight. About 40 per cent. of the hull structure is welded, with a saving in weight of nearly 14 tons or about 2¼in. of draught. The hull of each ship is divided into six watertight compartments and is fireproof throughout. A flat-plate keel saves 5in. of draught and the shell plating is welded instead of riveted to what is virtually an inner stem. To facilitate dry-docking and painting a 1in.×6in. flat steel bar is welded flatwise below the keel plate to provide hull clearance from the blocks. A steel tripod mast forward of the wheelhouse serves to support a 10-ton derrick hinged forward of the mast. The propelling machinery of each vessel consists of two 200-h.p. Diesel engines running at 600 r.p.m. and driving the twin propellers at 280 r.p.m. through reduction gears. The whole of the auxiliary machinery is electrically driven, current being supplied by two Diesel generator sets of 7½ and 10 kW., respectively. Each ship is manned by a crew of four officers and eighteen men.—*"The Nautical Magazine", Vol. 130, No. 4, 1940, pp. 16-17 and 43.*

Extracts.

The Council are indebted to the respective Journals for permission to reprint the following extracts and for the loan of the various blocks.

Scale Prevention in Oil Engines.

By F. J. Matthews, B.Sc.

"Gas and Oil Power", December, 1939.

The successful operation of explosion engines calls for efficient circulation of adequate supplies of cooling water, but unfortunately natural sources of water supply are commonly contaminated with mineral impurities of an encrusting character. Accordingly, scale formation at the cooling surfaces is widely experienced in the jackets of oil engines. The insulating effect of scale deposition reduces the cooling and increases the risks of piston seizures and heat stress fractures, a danger aggravated by the fact that frequently precipitates partially choke water passages and piping and so reduce the supply of water delivered to the cooling surfaces. Cooling systems operating on a gravity flow from an overhead tank, or on the thermo-syphon principle, are of course particularly susceptible to such restriction of water passages in view of the small forces available for overcoming resistance to water flow. Sometimes a cooler is incorporated in the circuit, and it should not be overlooked that scaling at such a unit will gradually arise, leading to reduced cooling and therefore a gradual increase in the temperature of the cooling supply to the engines. Since temperature is a big feature in determining the amount of deposition, it is evident that scaling increases progressively. Measures for minimising scaling are therefore of extreme practical importance, and attention may be drawn to a new treatment of cooling water which has been developed in the past year or so and is now being widely applied with marked success on all kinds of industrial cooling systems. Furthermore, the treatment is both cheap and simple to apply.

The need for an effective water treatment is emphasised by the fact that even where circulation is maintained for 20 minutes or so after each engine stoppage, the cooling water character is often such that scale gradually accumulates on the surfaces. An enclosed circuit has to allow compensation for leakage or evaporation by admission of make-up *via* a ball valve, and accordingly gradual concentration of impurities and their decomposition to scale deposits takes place. Scale removal at intervals is therefore necessary. To avoid difficulties in removing liners, chipping scale, etc., removal of scale is often effected by treatment with a solvent acid; this method is sometimes essential due to poor design increasing difficulties of examining and cleaning water-cooled surfaces. To prevent attack on the metal, which is particularly virulent on cast iron, the acid has to be treated with an organic inhibitor which delays the reaction with the metal while the solvent attack on the lime deposition is unimpaired. Careful doping of acid is therefore essential, and at the end of the treatment the water passages have to be carefully flushed with a weak alkali to neutralise any residual traces of acid, since the increased temperature of operation would reduce the effect of the inhibitor and corrosion would take place. In addition to these features, one has the expense of idle engines during the de-scaling operation. All these problems are avoided by the new treatment, since the deposition of carbonate scale is prevented.

The treatment deals particularly with carbonate scale rather than sulphate scale, but the latter is rarely experienced in cooling systems. Scale deposition in oil engine jackets and the like is due to the thermal decomposition of the bicarbonates in the water, calcium carbonate of much lower solubility being produced. The modest increase in temperature arising in such engine cooling has little influence on sulphate impurities, and therefore such salts do not deposit. This is illustrated by the following analyses of scale from engine jackets:—

Calcium carbonate	94·2	88·6 per cent.
Magnesium carbonate	2·7	5·3 " "
Sulphates	0·8	2·2 " "
Iron oxide	2·1	0·8 " "
Silica	0·2	0·6 " "
Organic matter	—	2·5 " "

Iron oxide is found due to chippings from liners, etc.; sometimes organic matter is present, due to contamination of the water with organic growths, slime, etc.

The formation of such carbonate deposits can be prevented by the addition to the cooling water of sodium metaphosphate, the very small amount of only one or two parts per million (that is, only 1 or 2lb. per 100,000 gallons) being required for effective treatment. It has been found that this reagent, even in such small amount, possesses the remarkable property of holding up the precipitation of carbonate at normal cooling water temperatures, until a very much higher concentration of the impurity has built up in the water by evaporation effects, etc. Recent experience on power plant condensers, compressors, Diesel and gas engines, etc., at a variety of works such as power stations, distilleries, oil refineries, chemical works, collieries, etc., has shown that not only is the carbonate deposition prevented, but old carbonate scale deposits are gradually removed during the treatment.

Deposit and Water Hardness.

The extent to which deposition is prevented is given by the figures in the table. These show the percentage of carbonate deposited from waters of varying mineral contents, the waters being heated at the temperature concerned for a full hour.

Cooling Water. Bicarbonate Concentration, grains per gallon. [Degrees temporary hardness].	Percentage Carbonate Depositin at Water Temperature of									
	104° F.		122° F.		140° F.		158° F.		176° F.	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
14	Nil	Nil	Nil	Nil	4	Nil	8	Nil	20	Nil
28	6	Nil	18	Nil	22	Nil	30	Nil	36	1
42	23	Nil	27	Nil	32	Nil	44	3	47	8
56	50	Nil	Not determined	1	Not determined	1½	Not determined	9	Not determined	17
70	Not determined	1	Not determined	1	Not determined	6½	Not determined			

Figures are compared for untreated water and water treated with two parts per million of metaphosphate, and data cover the normal range of oil engine exit water temperatures (100° F. to 140° F.), with two higher temperatures in addition:—

The protection afforded by the reagent is illustrated graphically in Figs. 1 and 2, which shows results at 104° F. and 140° F. respectively. The marked preventive influence of the reagent is evident from these graphs and figures, since even where data

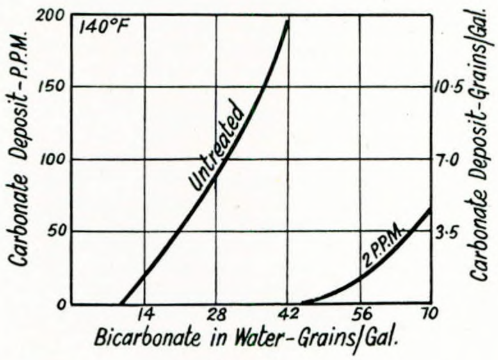


FIG. 1.

are incomplete the rapid increase in precipitation in earlier figures indicate that the "unknown" depositions are very high in the case of untreated waters. It will be noted that even at a temperature approaching boiling point (actually, 176° F.) the treated water gave little deposition until the mineral content was very high.

These figures are confirmed by a variety of successful applications. For instance, a large colliery saved around £2,000 per annum by a treatment of 1½ p.p.m. in a re-circulating condenser system, where scaling is essentially the same carbonate problem. In another instance, compressor jackets were freed from deposition. Indirect benefits may also be gained. Improved heat transfer and cooling means improved engine operation, and may be accompanied by a reduced demand for cooling water due to more effective cooling. In two instances, savings under this head amounted to 40 per cent. and one-third of the former water consumption respectively. It should not be overlooked, too, that since the metaphosphate allows a higher concentration of minerals to be carried in the cooling water, other sources of cooling supplies may become usable and financial savings may result from these being cheaper. Another point is that metaphosphate is a slightly alkaline reagent, and will therefore afford

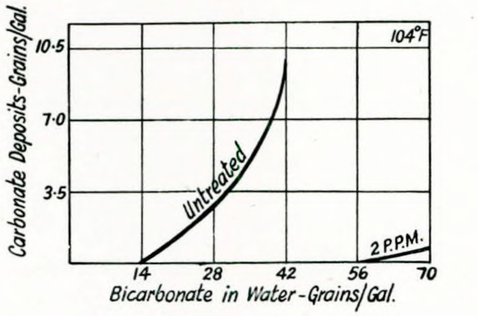


FIG. 2.

engines some protection against any corrosive influences which may accidentally reach the cooling supplies. In addition, of course, there are savings of costs of de-scaling operations, with idle engines, etc.

The treatment is quite simple to apply, the reagent being added as a gravity feed from a stock dilute solution. It is not even necessary to have accurate proportioning gear, since the reagent is effective over a range of concentration. Local factors, such as temperatures, character of water supply, details of cooling systems, etc., influence the precise amount of treatment to give. Normally, however, an amount of the order of 0·5 to 2 p.p.m., or ½ to 2lb. per 100,000 gallons of water is sufficient. It may be desirable to use a little more (up to 5 p.p.m.) initially to get rid of old deposits more quickly, but such an increase is purely temporary. In recirculating cooling systems, it is often advisable to limit the concentration of bicarbonate (where this is increasing due to leakage and evaporation effects, etc.) by a periodical purge of a portion of the water. Excessive mineral concentrations are thus avoided, economising in the necessary treatment. Where water passes once through the system, lower mineral concentrations are usual and less treatment is accordingly satisfactory.

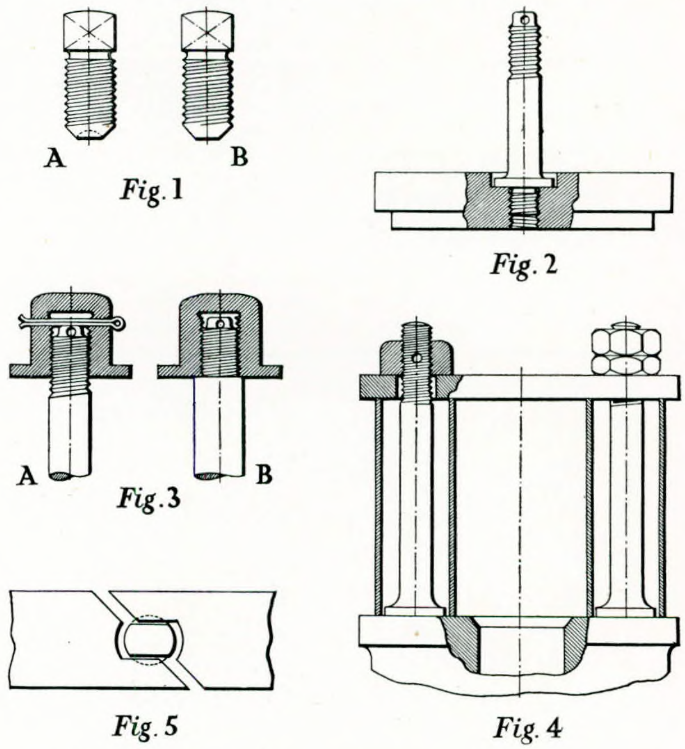
Locking Devices.

By L. J. HOLMAN, M.I.Mar.E.

"Shipbuilding and Shipping Record", 18th January, 1940.

Attention to detail in the design and periodical overhaul of machinery is no more forcibly emphasised than by the efficiency or otherwise of the locking devices attached to its moving parts. Faulty design in this direction, as well as careless maintenance work, is responsible for many minor breakdowns and an occasional major one. In design work where locking devices are concerned practical experience in maintenance is most necessary, for however efficient the device chosen, difficulties encountered in fitting can do much to nullify its value. The following notes and sketches illustrate a few errors which have come under the writer's notice.

Commencing with the ordinary grub screw, the form shown at A in Fig. 1 is seldom encountered, that depicted at B with a plain end being much more usual. Yet the former, with the sharp edges of the recessed point, is far more efficient in providing an adequate safeguard, and the extra cost is negligible. The measure of protection afforded by split pins is sometimes reduced by lack of attention in maintenance work. For instance, wear and adjustment of bearings normally has the effect of



FIGS. 1-5.—*Various devices for securing machinery components.*

increasing the distance between the nut and the split pin fitted at the end of the bearing bolt or stud. Possibly, in some cases, the point is of no great importance, yet in others a good deal of damage would be done long before the nut reached the split pin should it become slack. Where such a hazard exists, wear should be compensated by fitting washers under the nut, in order to maintain its correct position relative to the split pin.

Securing Valve Guards.

Fig. 2 depicts a valve seat with central stud for securing the valve guard. It will be noted that the stud is provided with a split pin hole, and this is another instance of the importance of keeping the nut as close as practicable to the split pin. Should this point not receive attention, the guard itself commences to beat up and down if the nut becomes slack. Considerable damage would eventually be caused by the hammering of a heavy guard in this fashion. The stud itself is not locked in the seat however, and the possibility exists that vibration might slacken it. Such studs should be screwed through the seat and lightly riveted over, or, if their removal is necessary during overhauls, a lock nut and pin should be fitted under the seat.

"Blind" nuts on valve spindles have caused more than one accident in the writer's experience. As shown at A in Fig. 3, the split pin is inserted *across the top* of the stem instead of through the hole. At B the spindle is shown slightly larger in diameter, and the nut screws down on a shoulder. With such *visual* guidance the possibility of the foregoing error during assembly is eliminated.

In order to prevent tampering with the safety valves of small boilers, it is sometimes the practice to drill a hole through nut and pillar for the reception of a split pin, as shown at the left in the sketch Fig. 4. In one case which came to the writer's notice the pillars were of muntz metal $\frac{5}{8}$in. in diameter and the split pin holes $\frac{1}{8}$in. The pillars were thus dangerously weakened in a vital position, and one was actually found to be fractured through the split pin hole. As this procedure is devised mainly with the object of deterring a semi-skilled boiler attendant from tampering with the valve, a similar purpose is served by the arrangement depicted on the right hand pillar. This consists merely of a thin lock nut next to the compression plate, necessitating the use of a special thin spanner for unlocking.

Pegging piston rings against the tendency to rotate in their grooves is a practice which has suffered severe criticism following damage to pistons and cylinders due to the pegs coming adrift. Investigation of a number of such breakdowns revealed that in every case the pegs were of round section screwed into the piston. Naturally, such parts could not be locked against slacking back. They could be made self-locking, however, by taking the form shown in Fig. 5.

Piston rod nuts are sometimes secured under the crosshead block by means of a locking plate as shown at A in Fig. 6. This arrangement as originally fitted constitutes an efficient lock, but is open to the objection that it entails considerable extra maintenance work. On replacing the nut after an overhaul, with the same force exerted in tightening up, it will be found to advance slightly from its former position, due principally to stretch in the threads. Thus the locking plate will require refitting, which is by no means an easy operation. So much so in fact, that, especially when the work is being carried out hurriedly, a great temptation exists to leave the nut in the original position, or, in other words, not to harden it up quite so tightly. Furthermore, after a few such alterations the original locking plate will be found to be useless, and a new one must be fitted.

The arrangement shown at B, Fig. 6, is rather more complicated, but would not require so much fitting on re-assembly, and neither would the locking plate ever require renewal. Briefly, as may be seen from the sketches B and C, the locking plate has radial slotted holes and, in effect, moves *with* the nut. The spaces in these slotted holes at each side of the studs are fitted with special filling-up pieces, and these would, of course, require re-fitting at each fresh position of the nut. This operation would not, however, be nearly so lengthy or difficult as re-fitting the locking plate shown at A.

It should be noted that both the above arrangements lock the nut only. Where the end of the rod is parallel, a snug must be fitted as indicated at D, Fig. 6, engaging with a corresponding slot in the crosshead block. Otherwise the possibility exists that the rod and piston may screw out of the nut. This may appear self-evident, yet the writer has noted the omission of these snugs on more than one occasion.

A fuel valve torque shaft is illustrated at A in Fig. 7. It has a semi-rotary motion, and a considerable force exists in the direction of the arrow. In order to prevent wear on the end of the bush *b*, a thrust washer *c* is interposed between it and another washer *d*. The parts are shown separated in the sketch for sake of clearness, but actually the bush *a*, the shaft, and the washer *d* are all tightened solidly together, and oscillate in unison. Washer *c* is prevented from turning by the pegs shown, which it is impossible to lock, and in practice they were found to become slack and shear off.

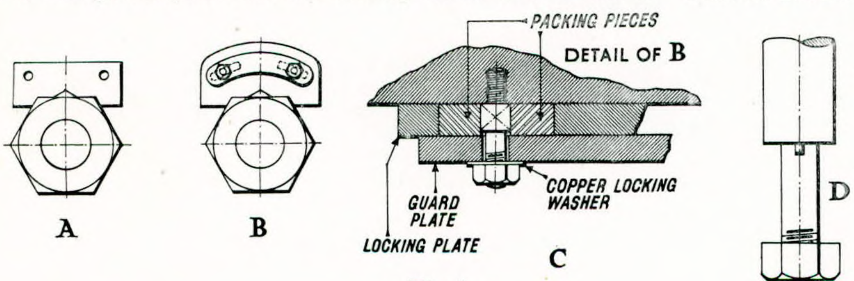


Fig. 6

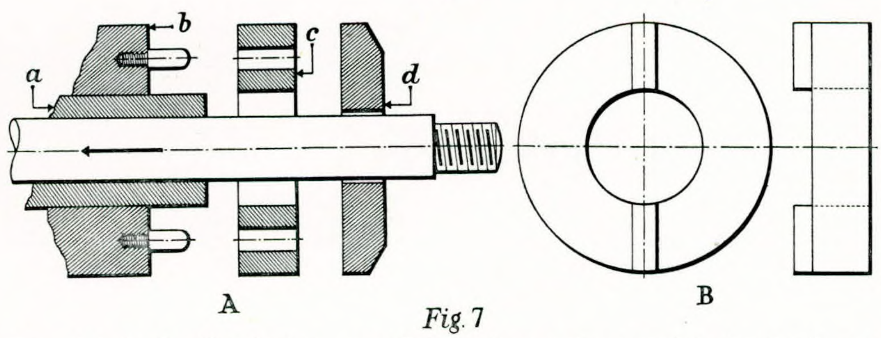


Fig. 7

FIGS. 6 & 7.—*Locking devices as applied to piston rod nuts and fuel valve torque shafts.*

Poor Design.

This is an instance of poor design work, and a cure could only be effected by the type of thrust washer shown at B in Fig. 7. This was milled out of the solid with the keys indicated, and the bush *b* drawn in order to cut corresponding slots across its face in place of the tapped holes for the pegs.

Another type of locking device is the stop fitted behind a key in order to prevent it working out of place unnoticed. In such positions as overhead electric cranes, the provision of efficient stops to prevent the working out of keys in gearwheels should not be overlooked. Such parts unfortunately often receive the minimum of attention, and apart from possible serious breakdown when the crane is handling a load, a small gearwheel falling from a height might cause severe injury.

No discussion on locking devices would be complete without at least passing reference to the allied problem of vibration.

Even if parts are stationary, the possible effects of vibrations on pipe joints, nuts, and other fastenings should be taken into account, and efficient means sought to counteract any tendency for such parts to become slack. Particularly is this the case with pipes and fittings in enclosed crankcases which are not readily kept under close observation, and which should be provided with carefully fitted clips.

Diesel Engines in German Motor Torpedo Boats.

Translated from "La Marine Marchande", 14th March, 1940.

Some interesting information concerning German motor torpedo boats is contained in two descriptive articles which appeared in recent issues of *Le Génie Civil.*

The earliest craft of this type were those of the LM class, built about 1925, which only displaced between 6 and 7 tons, with a length of 52ft. 6in. and a beam of 7ft. 10½in.; they had triple screws driven by petrol engines of 630/720 h.p. and were capable of doing from 28 to 30 knots. Their radius of action was between 150 and 200 miles and they were armed with one 37mm. or 47mm. gun, a machine gun and an 18-in. torpedo tube.

In 1926 a number of boats of the K class were constructed, these having a length of 57ft., with engines of 1,060 h.p. and a speed of 40 knots.

At about the same time several much larger boats of 26 tons displacement and a length of 69ft. 6in. were built; these craft were primarily intended for service as submarine chasers and could only do 29 knots.

The motor torpedo boats built after 1933 differed radically from the earlier craft. German technical experts were of opinion that boats with rounded-section hulls were more seaworthy than those with stepped bows or flat bottoms and the German naval authorities thereupon evolved designs with rounded-section hulls and relatively large displacements, to which they have since adhered. They also substituted lightweight heavy-oil engines for the petrol engines formerly used, as these were considered to be unsafe under service conditions.

The motor boats R1 to R16, built between 1930 and 1935, are craft with a displacement of 45 tons and a length of 85ft. 6in., propelled by two M.A.N. engines of 600 h.p., each and having a speed of 18 knots. They are armed with an A.A. gun and carry a crew of 15.

The motor boats R17 to R40, built between 1935 and 1937, have a displacement of 90 tons, a length of 92ft. and a speed of 18 knots, with two M.A.N. engines developing a total of 1,800 h.p. They carry two A.A. guns and a complement of 17 officers and men.

An improved type of motor torpedo boat was also produced during these years and is represented by the boats numbered S6 to S37, built between 1933 and 1939, having a displacement of 62 tons, a length of just over 93ft. and equipped with two double-acting two-stroke M.A.N. engines or Daimler-Benz engines, of 2,400 h.p., giving them a speed of 30 to 36 knots. They carry an A.A. gun and two 19·7-in. torpedo tubes, with a complement of 17.

The hulls of the majority of these boats are of wood and were built in the Lürsen-Vegesack Shipyard, which recently constructed eight similar craft for the Yugoslav Navy. These have a displacement of 60 tons, a length of 92ft., a beam of 14ft. 1in. and a draught of 5ft. They are equipped with three Daimler-Benz type BF.2 engines each rated at 1,000 h.p., with a small auxiliary engine for cruising purposes. The armament consists of a 47mm. gun, a machine gun and two 18-in. torpedo tubes, while the complement numbers 12 officers and men. These large Diesel-engined boats have, of course, a very extensive radius of action and can do about 1,680 miles at cruising speed, whereas that of the usual type of small petrol-engined boat (of some 20 tons) does not exceed 500 to 600 miles.

The Diesel engines fitted in German motor torpedo boats are of a type developed by several firms—under government supervision—for use in Zeppelins. These engines were subjected to extremely rigorous tests and those manufactured by Daimler-Benz were utilised for the Zeppelins employed on the North Atlantic air service. Similar engines installed in motor torpedo boats are rated at 1,350 h.p. and have 16 cylinders arranged in two banks forming a V of 50°. The cylinders have a bore of 175mm. and piston stroke of 230mm. The net weight of the engine is about 4,400lb., which is just over 3lb. per h.p.

The M.A.N. engines develop 1,200 h.p. at 1,200 r.p.m., although their normal rating is 900/1,000 h.p. The weight is just under 2·7lb. per h.p. and there are seven cylinders of 190mm. diameter and 300mm stroke.

The auxiliaries required for these double-acting two-stroke engines comprise a centrifugal scavenge blower, an oil pump for piston cooling, a lubricating-oil pump and a centrifugal cooling-water pump, all of which are engine-driven and absorb approximately 20 per cent. of the power developed. The fuel-oil consumption is reported to be under 0·39lb./h.p.-hr., which indicates that the processes of scavenging and combustion must be highly efficient. The net weight of the engine is 3,610lb.

It is significant that the German naval authorities should have prohibited the sale of this type of engine and that the publication of any technical descriptions concerning their construction and performance should likewise be forbidden.

Paving Slabs for the Protection of Fishing Craft.

"Shipbuilding and Shipping Record", 25th April, 1940.

The cost of sandbags used to protect a wheelhouse of a trawler at the beginning of the war was about £120 and the weight some 200 tons. The Ministry of Shipping are now reported to be contemplating the employment of concrete paving slabs. The latter are stated to be easier to fit, less bulky and lighter in weight than sandbags, and ample stocks are available in every port in the country. The slabs are made to B.S. specification like those used for street paving and have a minimum thickness of 2½in. which is sufficient to withstand bullets. A wheelhouse can be adequately protected by placing the slabs flat against the structure and securing them in place by wood or steel channels. Alternatively, they can be held in position by cover plates where the slab butts join. In vessels with open wheelhouses the slabs are erected and held in place by means of a strutted framework. The windows, which are 12in. deep by about 18in. or 24in. wide, can be closed at a moment's notice by lowering steel shutters, while the doors are protected in a similar manner or preferably by auxiliary doors made of paving slabs carried in a special frame.

Trials of the Soviet Passenger Liner "Viacheslav Molotov".

"The Journal of Commerce", 9th May, 1940.

Successful trials have been run on the North Sea Canal of the 7,500-ton turbo-electric passenger and cargo ship "Viacheslav Molotov", built at the Amsterdam yard of the Netherlands Shipbuilding Company, and engined by Gebr. Stork & Co., Hengelo, for the Government of the U.S.S.R. Like her sister ship, the "Iosif Stalin", which completed her trials last December, the new vessel has an overall length of 443ft., a beam of about 60ft., and a depth of 31ft., with a loaded draught of 21ft. Accommodation is provided for 48 first-, 164 second- and 296 third-class passengers, the crew numbering 102. The cargo-handling equipment comprises six 5-ton, two 3-ton and one 15-ton derricks, worked by eight electric winches. The propelling machinery consists of two sets of Stork-Parsons turbines each of 6,400 s.h.p., coupled to electric generators for supplying current to two propulsion motors which drive the twin propellers through 14 to 1 reduction gearing. Steam is supplied by four Stork-Babcock and Wilcox oil-fired water-tube boilers with an output of 68 tons/hr. at a pressure of 470lb./in.^{2} and 700° F. superheat. The normal full speed of the ship with both turbo-generators and four boilers in use, is about 20 knots, but an average speed of 16 knots can be maintained with two boilers and one turbo-generator in operation. Current for the all-electric auxiliaries and general service of the ship is furnished by three 425-kW. generators running at 1,000 r.p.m. and driven through mechanical gearing by steam turbines running at 7,000 r.p.m. There are also two 75-kW. Diesel-generator sets for use in port.

Remote Control Device for Main Engines.

"The Marine Engineer", May, 1940.

A simple device intended primarily for stopping a ship's main engines from any remote part of the deck in the event of an emergency necessitating the launching of lifeboats, has been developed by the makers of the Aspinall marine engine governor. The device is in the form of an independent fitting consisting of a cylinder containing a spring-loaded plunger which is normally restrained against the pressure of its spring by a small locking pin held in its locking position by a lever to which is attached a thin wire cable led to the deck level. When the wire is pulled the lever revolves around its fulcrum, presenting a hole to the end of the locking pin which instantly jumps out of engagement with the plunger under the influence of a small but powerful spring. The plunger then forces the governor weight up into its shutting position and retains it there. The fitting is secured to a pump lever of a reciprocating steam engine or to the special governor lever where fitted (as in a motorship) in such a manner that when the plunger is held in the "off" position, the head of the latter is just clear of the underside of the governor weight.

Gravity Lubrication in New American Cargo Ships.

"The Journal of Commerce", 2nd May, 1940.

The main turbines, gears and thrust bearings of the U.S. Maritime Commission's C-3 class cargo steamships are lubricated by gravity. The system comprises two-motor-driven De Laval oil pumps, one hand pump, one centrifuge, two oil coolers, two gravity tanks, one settling tank, one storage tank, one sump or drain tank, strainers, gauges, thermometers, indicators, relief and other valves and other essential equipment. The lubricating oil pumps draw oil from the sump tank under the reduction gear and discharge through filters and oil coolers to the gravity tanks, from which the oil flows to the bearings of the turbines, gears and thrust, and thence drains to the sump tank. The two gravity tanks are located at such a height as to maintain a minimum oil pressure of 10lb./in.^{2} at the highest bearing. The purifying piping is so arranged that both continuous and batch purification can be carried out. When continuous purification is used the oil is drawn from the sump tank through the purifiers and returned to the sump tank, whereas when batch purification is employed the oil is drawn from the sump tank and discharged to the settling tank. After settling the oil is pumped through the purifier and discharged either to the sump tank or to the storage tank.

Lubrication of Electric Motors on Marine Service.

"Journal of Commerce", 18th January, 1940.

Protection of bearings and windings of electric motors when called upon to work in the presence of excessive water, as when the motors are exposed to weather, or where coal or other abrasive dust is present, has received much attention from motor designers in recent years. The employment of the unit drive in power transmission to virtually every phase of marine and dockside operation has been largely responsible for this study, because once installed the motor must function dependably and often continuously. Any failure of bearings due to impaired lubrication or contact of the windings with water or dust may swell repair costs.

At first sight this appears to be a problem which concerns the designer only. This is true as far as protective external housings are concerned. Bearings and lubricant seals, however, are the concern not only of the motor designer but also of the specialist in lubrication. It has, of course, long been possible to obtain bearings of most accurate design and bearing metals of a very high degree of service efficiency. Under normal industrial conditions motor bearings can be lubricated without much difficulty, but where the motor is exposed to salt spray, water or abrasive dust, a special set of circumstances must be considered.

The probable life of any motor bearing, irrespective of type or design, can be estimated only after due consideration of the provisions for sealing to prevent leakage of lubricant and entry of abrasive dust, water, or corrosive acids or alkalies. Dependent upon the service, a variety of seals has been developed, including felt and cork washers or gaskets, metallic slingers, dust collars, expanding rawhide devices.

Sealed housings are, however, but one way of securing long bearing life. That of keeping the bearing surfaces thoroughly lubricated at all times is of even greater importance. Other factors, such as the use of the proper grade of oil, occasional inspection and regular renewal of oil, are also essential.

When sealing methods were first developed, felt and leather washers and grease-proof seals proved their value and were comparatively inexpensive, as well as simple in design. Other types of seal have, however, come into use, including metallic rings similar to piston rings, mercury baths in connection with vertical installations, and metallic springs for the purpose of maintaining the adjustment of felt, leather, rawhide and cork, with respect to the rotating element. Composition rings have also proved valuable as oil seals.

Any bearing seal, to be effective, must show almost no wear in service. Washer-type seals are sometimes unsatisfactory in this respect, although the rate of wear depends upon the quality of the material. This is one reason why adjusting springs are used to-day in connection with washer or leather cup seals, to keep the material in close contact with the shaft or journal surface, and thereby compensate for wear.

Leakage of lighter lubricants under normal temperature conditions can often be prevented by grease seals, which are comparatively easily and cheaply made. On the other hand, they require periodical attention to renew the sealing grease. If this is not done, possible glazing of the surface where it makes contact with the rotating shaft might result in enough clearance to allow leakage. Heavy-bodied greases of high melting point can be used as grease seals provided they show no tendency to separate oil from soap and contain no matter which might be abrasive to the shaft surface. Grease grooves can also be used in conjunction with felt washers for some types of service, though this sometimes means extension of the bearing housing length.

Many claims are made from time to time for the spring-adjusted seal on the ground that it will ensure the most uniform contact with and conformation to the surface of the rotor shaft. It is extensively applied to rawhide or cup leather seals when positive sealing is necessary and where initial cost is of secondary importance. This type of seal is suitable for ball and roller bearings, where the minimum housing space is advantageous. It is particularly good in the presence of moisture, also where abrasive dust must be kept out of the bearing.

The effect of higher motor speeds is to increase windage and the possible drawing in of abrasive materials through both the bearings and the ventilating apertures. High shaft speeds also place a severe load on the lubricant in its protection of the bearings by reason of the development of higher temperatures. As temperatures rise, it is obvious that the lubricant used must be more resistant to break-down and the formation of gummy, resinous or carbonaceous deposits. In the sleeve-type bearing these would tend to accumulate in the oil grooves and to interfere with the proper circulation of the lubricant. In a ball and roller bearing they would gather in the raceways or cages to impose a braking action on the free rotation of the rolling elements.

More recently, with the introduction of the geared motors, it has been necessary to consider the effect of windage and dust contamination on the gear lubricant. The geared motor is a particularly valuable means of combining the driving and speed-reducing elements in one compact housing, which can be effectively designed to withstand the entry of foreign matter. It is valuable where space is at a premium.

Interchangeability of either sleeve-type or anti-friction bearings can be more readily obtained by providing for this when the motor is designed, although it is feasible to make the changes later, especially when new bearings are being considered. In any event, it is important to remember that certain types of bearing seals may require an increase in the length of the housing. This may in part offset one of the advantages claimed, particularly for the ball bearing, that overall length is reduced, and yet protection of bearing elements against undue wear by more positive lubrication is of far more importance.

In the sleeve-type bearing provided for oil lubrication by ring oilers, a sealed vapour and spray chamber at each end of the bearing will function to retain oil vapour and spray which may be thrown off by the oil rings. Due provision to return this oil to the reservoir in the base of the bearing is arranged for.

In some types of sleeve bearing where oil is thrown directly on to the walls of the housing more or less leakage will obviously occur, for some oil will always creep along the shaft to work its way out through any seal which may be provided. If such bearings are grease-lubricated, a collar of greases penetrating from the bearing around the shaft has often been regarded as an indication of adequate lubrication. Further, it will often prevent dust, dirt or foreign matter from working into the bearing clearance space. Any lubricant present elsewhere than in the lubricating system may very easily lead to a dangerous or sloppy state of affairs which is detrimental.

In view of the fact that the lubrication of any motor bearing can only be as satisfactory as the purity of the lubricant used, there must be adequate provision for draining and flushing the bearing at regular intervals and suitable venting during working to relieve back pressure on the lubricant. It can be realised that continued churning of abrasive foreign matter with oil or grease in any bearing, and its passage through plain bearing clearance spaces or in intimate contact with highly polished balls, rollers or raceways, will lead to abnormal wear, noise, misalignment, and often the necessity for costly repairs.

With increased preference for the ball bearing in certain types of motors of low to medium power, the necessity for draining and flushing is often a subject of discussion. Where bearings are fitted with a seal which will definitely prevent the entry of foreign matter, cleaning periods can be extended. Under comparatively clean conditions, it is reasonable to assume that some motor bearings will work for years without flushing.

On the other hand, to set any hard-and-fast rule, even with the best of seals, would be unwise, due to the wide variety of service to which motors must be subjected, particularly in marine or dockside operation. For this reason suitable provision is usually made for the drainage of the lubricant and flushing oil by placing an outlet in the base of each bearing.

Normally, a suitable plug which can be securely screwed into a drilled and tapped hole will serve the purpose and will prevent leakage during working. This can often be elaborated upon where oil is employed for lubrication by an arrangement of nipples and pipe fittings terminating in a sight-gauge glass. This facilitates not only cleaning, but also observation of the oil level in the bearing.

Maximum protection of a ball or roller bearing requires positive assurance that the lubricating system is as free from foreign matter as possible. In coal handling or grain elevator service, this may be especially serious. In the application of anti-friction bearing seals, as well as provision for cleaning, there is always a possibility of entry of non-lubricating abrasive impurities where motor bearings are not properly sealed. The detrimental results which develop in the form of scored bearing elements are obvious.

Ring oiling systems will in general require more frequent attention than ball or roller bearings due to the fact that their housings are usually less tight. With the former, cleaning may be necessary or advisable every two weeks to every several months. In normal ball and roller bearings with proper seals continued good working may be almost indefinite unless the working conditions are particularly dirty.

On the other hand, ring oiling systems possess natural advantages in that the flood of oil which is constantly passing through the bearings tends to wash out any grit, dirt, dust or metallic particles which may have gained entry. As a result, wear is reduced to the minimum just as long as the oil in the system does not become so highly contaminated as to be unable to precipitate such foreign matter during its period of so-called rest.

Pump Lubrication.

"Journal of Commerce", 4th April, 1940.

Pump design, and the lubrication requirements of the standard types must be carefully studied, the more so because lubricants may often be called upon to function in the presence of excess moisture, which might seriously impair their lubricating ability. In the opinion of many leading authorities the small high-speed centrifugal or rotary type of pump is more adaptable to modern practice than the larger more cumbersome reciprocating units, so familiar to boiler-room operators.

Unit control by electric power is more flexible and regarded by many as more economical. It is certainly easier and less wasteful to lubricate the bearings of an electric motor and centrifugal pump than the steam cylinders and external mechanism of the average reciprocating pump. The centrifugal pump is also an all-service machine, being capable of handling hot or cold water and liquids of any temperature with equal efficiency.

Knowledge of the motive power is of importance only to the extent to which it may involve cylinder lubrication. The electric motor as adapted to the centrifugal or rotary pump will only mean additional bearings to be lubricated. Lubrication of the steam pump, on the other hand, presents the problems of steam cylinder lubrication, which will often be so in contrast to the requirements of the other pump mechanism as to involve considerable opportunity for faulty operation, if lubricants are changed or applied in a careless manner.

Reciprocating piston and plunger pumps are extremely flexible in regard to speed, pumping capacity and head. They furthermore show a relatively uniform efficiency curve under wide variations in the above conditions. They are, therefore, adapted for heavy duty, or service under adverse conditions. The operation of reciprocating pumps involves sliding friction between the essential operating parts.

For the lubrication of reciprocating steam pumps two basic types of lubricants are necessary, *i.e.,* one to serve the internal parts such as steam cylinders and valves, the other to serve the external wearing mechanisms such as rocker bearings, guides and rod connections. For steam cylinder lubrication the steam pressure is the salient factor, assuming 150lb. pressure as the dividing line in the choice of oils. Saturated steam will predominate, so the discussion is based on this assumption.

Above 150lb., for example, an oil of somewhat higher viscosity would be required than for lower pressure conditions. In addition, a little less fixed or fatty compound will be required, because there will probably be less moisture in the steam and less chance of washing action affecting the lubricating film once it is formed.

External bearing lubrication can be effected by oil or grease according to the lubricating devices installed. In general plain babbitted bearings will predominate. Where oil is required a medium viscosity straight mineral product of from 200 to 300 seconds Saybolt at 100° F. will generally be satisfactory. For grease lubrication a medium consistency grease will be best in compression grease cups, although a somewhat more fluid product may be advisable for pin type cups.

Of the several types of pistonless pumps which are used to transfer fluids by rotary motion, the centrifugal or rotary type are perhaps the most generally used. The principle of rotary pumping such as embodied in the screw pump, cycloidal, centrifugal, or other impeller device, etc., is distinctive in that it involves no valves, springs, or other small parts to wear out and become inoperative. Further, there are no internal parts which require lubrication.

Although pumps of this character will need essentially only the lubrication of bearings, these latter may vary in design and involve specific problems according to the working conditions and the fluids being pumped. As a result, they require serious consideration and cannot be passed over as mere instances of ring oilers, ball bearings, etc., or plain babbitted bearings served by oil or grease cups.

For general all-round service on horizontal pumps the ring oiler is preferred by many, due to its comparative simplicity, cleanliness, the extent to which it brings about automatic lubrication, the small amount of attention which it requires, its economy, and the uniformity and regularity of oil distribution.

In construction the ring oiler comprises a bearing housing which is built with a reservoir and a slot of sufficient width and depth to permit one or more rings suspended from the shaft to revolve therein. As a result, with the revolution of the shaft, these rings being subjected to rotation, will carry a certain amount of oil to the top of the shaft from whence it is able to flow into the bearing oil grooves and clearance space to be ultimately distributed to the entire wearing surface.

As a rule, oil after being passed through the bearing, will flow out to the end or ends of the shaft through a suitable return chamber which is part of the bearing housing, back to the oil reservoir below. Ring oilers, however, are not usually recommended for bearings below 2in. in diameter, especially where high speeds are involved, due to occurrence of excessive slipping of the rings, and the possibility of foaming arising in the oil where reservoir capacities are limited.

Ring oiling is regarded by many as the simplest adaptation of the most efficient method of lubrication whereby the bearings are flooded with a considerable excess of oil over the amount that would theoretically be necessary to furnish the requisite oil film. By flooding the bearing with oil, the latter serves not only as a lubricant, but also as a cooling medium to carry away part of the frictional heat developed, thereby reducing the temperature of operation.

If the oil reservoir in the base of the bearing has been propely designed and is of sufficient capacity, this overheated oil will have ample opportunity to become sufficiently cooled after each circulation by contact with the reservoir walls, particularly if the radiation of the latter is not interfered with. Lubricating systems of this nature possess natural advantages in that the flood of oil which is constantly passing through the bearings tends to wash out any grit, dirt, dust or metallic particles that may have gained entry, as a result, reducing wear to the minimum.

On account of this washing action the reservoir will gradually tend to accumulate a certain amount of sedimentary deposits. Therefore, it should be flushed out and cleaned at intervals, old oil being replaced with new or purified oil. This is especially important when such a system is new, and sand, etc., may be present.

It is evident that flood lubrication works on the opposite theory to that of supplying a bearing with just sufficient oil to furnish the necessary lubrication film. In fact, to-day in many types of machinery flood lubrication is the only method allowed by the manufacturer. On the other hand, there are many arguments in favour of regulated lubrication such as embodied by the drip cup or automatic force-feed lubricator.

Ball or roller bearings are, however, preferred on certain of such types of pumps. They are advantageous in that they supplant sliding motion with rolling motion, thereby theoretically reducing the resultant friction where properly lubricated. Ball bearings involve point contact, whereas roller bearings involve line contact.

In the lubrication of either type, however, one of the chief functions of the lubricant is to prevent corrosion of the highly polished surfaces. As a result, wherever possible the housings should be oil-tight, for thereby the body of the lubricant can be reduced, and in consequence the internal friction that will be developed during operation.

Where leakage may develop, a grease should be used which will have just enough body to cause it to remain in the bearing housing. Lubricating attachments may or may not be used on such bearings irrespective of their use. However, it is necessary to change or fill the housing and raceways periodically with the proper grade or lubricant through a suitable orifice or fitting which can be effectively sealed or plugged during subsequent operation to prevent the lubricant form flowing out.

In general, one charge of oil to a roller or ball bearing equipped with an oil-tight housing should last for a period of several months. Where grease is required, however, it should be renewed once a month, or more often, according to the extent of seal which is maintained.

Sydney Harbour Ferry-boat with Diesel-electric Propulsion.
By A. C. HARDY, B.Sc.
"The Journal of Commerce", 2nd May, 1940.

The double-ended ferry-boat "Bellubera" was converted from steam drive to Diesel-electric propulsion a few years ago, being fitted with Harland-B. & W. 2-stroke engines and B.T.H. electrical equipment. The vessel had a propeller at each end, but the shafting was not of the straight-through type, while the fact that it was parallel to the keel made it impossible to have a short-raked shafting with a double-armature propulsion motor direct-coupled as in American Diesel-electric ferry practice. It was necessary instead to have two small diameter fast-running motors geared to the shaft, the motors being ranged in tandem in order to save 'thwartship space, just as they were geared to the propeller to save vertical space. There were four main generating sets each comprising a 5-cylinder 2-stroke oil engine direct-coupled to a 320-kW. d.c. generator running at 600 r.p.m. The total output of the propelling machinery was 2,064 s.h.p. The four generator sets were mounted athwartships, two of them having their engines and exciters towards the port side and two towards the starboard side, the arrangement being a staggered one. There were two engine rooms, one containing the four Diesel generator sets, a pair of propulsion motors, their gears and thrust block, together with two oil fuel tanks and a motor generator for the steering gear; the other contained two auxiliary generator sets, a pair of motors and the main switchboard. The whole of the machinery was well below the main deck, so that the passenger spaces were not cut up by large hot and cumbersome uptakes of the kind found in steam-driven vessels of this type. It is to be regretted that the "Bellubera" has been destroyed by fire.

Defects in Riveted Seams of Pressure Vessels.
"The Steam Engineer", May, 1940.

One of the great advantages of the riveted seam is that before failure warning is usually given by the presence of persistent leakage from the joint. If such leakage cannot be stopped by light and efficient caulking, expert examination of the trouble should be arranged for. On no account should welding be resorted to, as welding around the rivet heads or along the lap edges of the plates or butt straps in any major seam, only conceals the evidence of cracks of what may be a very serious internal leakage. When the cause of the leakage has been ascertained and found not to be due to any serious defect, such welding may be permitted in minor seams, as, *e.g.*, about the rivets or lap edges of the firehole ring of a vertical boiler. Heavy caulking should also be avoided, as this only tends to spring the plates apart and thus make any leakage worse. Care should be taken to prevent the caulking tool from undercutting or forming a sharp nick in the adjacent plate edge, as such a condition forms an ideal source of stress concentration, and subsequent extension of the defect in the form of a fracture extending through the plate often takes place. Heavy caulking is also frequently the cause of cracks in the plate about the rivet holes and the breaking off of rivet heads. Rivet heads are a common source of trouble. The rivet is always a highly stressed member, as even when the vessel is free from pressure the plates are still being gripped together by the compressive stresses between the rivet heads originally set up by the cooling of the elongated heated rivet. Apart from the danger of caustic embrittlement, rivet heads often snap off due to the initial stress and fatigue. This need cause no particular concern provided the rivet shank is firmly embedded in the component plates, as, *e.g.*, with the rivets securing the gusset plates and angles of a pressure vessel or in the case of the rivets of the furnace seams of a vertical boiler. If, however, the headless rivet is part of a major seam or is exposed to internal pressure which might blow it out of position, it should be replaced at once.

Swedish Motor Tanker of Welded Construction.
"Shipbuilding and Shipping Record", May, 1940.

The small motor tanker "Soya VI", built by the Eriksbergs Engineering Works, Gothenburg, for Stockholm owners, was launched early in April. The vessel, which is designed for the carriage of oil in bulk, has a raked stem and cruiser stern, one continuous deck, forecastle and poop. The hull, which is specially strengthened for navigation in ice, is of practically all-welded construction. The length, b.p., is 240ft., the moulded breadth 38ft., the moulded depth 16ft., and the load draught 15ft., the d.w. tonnage being 1,650. The machinery compartment is aft with a cross-bunker forward of it. There is a dry cargo hold abaft the fore peak and the pump room is arranged amidships. The cargo oil tanks comprise four centre tanks and eight wing tanks, there being two continuous longitudinal oiltight bulkheads. Between each centre and side tank and forward of the cross-bunker and aft of the dry cargo hold transverse cofferdams are arranged. The double bottom extends under the centre oil tanks. The total capacity of the cargo oil tanks is about 2,050 tons, which is dealt with by two 150-ton duplex steam pumps. The deck machinery is steam driven and consists of a windlass, a 3-ton winch at the foremast, steering gear and an after capstan. The propelling machinery consists of a four-cylinder single-acting 2-stroke Diesel engine developing 1,500 i.h.p. and estimated to give the ship a speed of 12 knots fully loaded. The auxiliary machinery includes two generator-compressor sets, one being driven by a 30-h.p. Diesel engine and the other by a 50-h.p. steam engine. There are two steam boilers, each with a heating surface of 820ft.^{2}.

A Suction Gas-engined Tin Dredge.

"Gas and Oil Power", April, 1940.

A new dredge for recovering alluvial tin in the mangrove swamps of Lower Burma was recently shipped from this country to Rangoon in the form of plates and angles for assembly locally. The dredge has a length of 138ft., a breadth of 50ft., and a depth of 9ft. 7in., the draught being about 7ft. under working conditions. Buckets, each of 9 cu. ft. capacity, raise the tin-bearing gravel and these can be lowered to dig 40ft. below water level at 50°, if desired. The gravel is dropped down a chute into a revolving screw in which powerful jets of water pulverise it and force it through perforated screen plates. Boulders, etc., pass right through the screen and are dropped over the stern of the dredge, while the screened gravel is passed over jigs on which is a thin layer of hæmatite lying on bronze screens, to resist the scouring action of the gravel. The jigs are filled with water up to the level of the screens and this water is given a pulsating action by reciprocating paddles. In passing over the hæmatite bed, the tin in the gravel, being heavier, is deposited and drawn through the bed, while the gravel—or "tailings"—is carried on and dropped over the stern of the dredge. The tin, or more rightly "concentrate", is then collected and pumped over another jig called the "clean-up" in which the concentrate undergoes further cleaning prior to hand-washing for the removal of residual sand, this latter operation being carried out ashore by Chinese who are exceptionally skilful at this class of work. In the final process the tin is dried in ovens, bagged, and shipped away for smelting. The dredge is operated throughout by electricity, alternating current being generated on board by two 250-kVA., 420-volt alternators directly driven by two 294-b.h.p. National suction-gas engines, the gas being generated from charcoal, in suction producers at the stern of the dredge. Dredging proceeds night and day, so that the vessel has to be well lighted, and a searchlight used to illuminate the areas in front. Lighting current is normally taken from the main a.c. supply, but there is also an auxiliary power unit on board, comprising a National single-cylinder Diesel engine directly-coupled to a 5-kW. d.c. generator and air compressor. The compressor is used for starting the main engines and for suppling pneumatic power for drills, etc., on board. A well-equipped workshop, with modern machine tools and electric and oxy-acetylene welding plants, is provided on board. When the main engines are shut down the workshop machinery can be driven by a small National Diesel engine installed for the purpose. This engine also serves as a stand-by for the ballast and bilge pumps. The main engine cooling system is of the enclosed type with radiators for cooling purposes. The dredge has no propulsive power, but is manœuvred by a powerful winch which operates two stern lines, two bow lines, and a headline for holding the dredge against the working face. The bow and stern lines are used to traverse the vessel across the latter. In service, the dredge works in a tidal creek with a rise and fall of some 17ft., and when the ebb tide is supplemented by storm water and a high wind is prevalent, it is no easy matter for the dredge master to ensure that the vessel does not sit on its own "tailings". The main engines and motors are operated from the control room, from which all such operations as starting, stopping and reversing the buckets, raising and lowering the ladder and actuating the winch lines, are carried out. The control room contains variable speed controllers, contactor panels, and resistances. "Stop" push buttons are placed at vital points to enable the buckets and screen to be stopped in case of emergency, and a system of electrical interlocks is fitted between the controllers and main circuit breakers so that in the event of a motor stopping due to overload or push-button operation, the main breaker cannot be closed until the controller is placed in the "off" position. Although the power plant of the dredge is being operated by a staff which has had no previous experience with this type of engine, the results are reported to be highly satisfactory. The ground now being dredged is of low tin value and teething troubles have not yet been wholly eradicated, but over a 7-day run with three shifts working the dredge 77 per cent. of possible hours, 190 cu. yds. per hour are being dredged, while the recovery of concentrates has improved progressively to 92 per cent. of the bore-hole values.

Turbine Design.

"Electrical Review", 26th April, 1940.

In order to study blade vibration in turbines under working conditions by optical means, the American Westinghouse organisation made use of a single 25-in. diameter wheel with 1½-in. Curtis blades, taking steam at a pressure of 400lb./in.^{2} and temperature of 700° F. A beam of light was projected through the shaft, up to the blade periphery and back again to an oscillograph viewing screen or camera. Pictures taken at the rate of two per second each recorded the vibration during one or more revolutions, with widely variable blade loading, speed and acceleration. Further observations are to be carried out with an experimental 10,000-kW. turbo-generator taking steam at 1,250lb./in.^{2} and 900° F. now under construction. An 81,500-kVA Westinghouse turbo-generator set is being installed in the Waterside power station of New York. It is claimed to be the largest superposed machine ever made and will run at 3,600 r.p.m. Its exciter will be exceptionally large for direct connection at that speed and will produce 260 kW. at 250 volts. This machine will be one of four superposed turbines in the Waterside station, aggregating 250,000 kW. and bringing the total power of the station up to 500,000 kW. It is said to be the first to be commercially built with a flexibly-mounted stator core, to counter the tendency of the 2-pole field to distort the stator into an ellipse. Such a distorting force rotates in synchronism with the field, thereby transmitting a 120-cycle vibration to the turbine bed. The active element of the stator will rest on two sets of steel bars, one set being attached to the stator sides and free to move slightly in one plane, while the second set will be arranged horizontally at the bottom to permit movement in another plane at right angles to the other. In this way the tendency to move will not be restrained; but the amplitude of the vibrations and noise level will be substantially reduced.

Dutch-built Motorship for Rhine Service.

"Lloyd's List and Shipping Gazette", 8th May, 1940.

The Rhine motorship "Rex Rheni", built by the Vahali Shipyard and Engineering Works, Gendt, near Nijmegen, for Rotterdam owners, has run trials on the Meuse. The vessel, which is intended for the cargo traffic between Rotterdam and Basle, has a d.w. carrying capacity of about 675 tons, the main dimensions being 201ft. 8in. × 23ft. 2in. × 8ft. 6in. The propelling machinery consists of a 375-b.h.p. 6-cylinder 4-stroke Brons engine designed to give the ship a loaded speed of 9·7 knots and about 11·5 knots when light. A novel feature of the vessel is an arrangement for lowering the wheelhouse by about 3ft. for passing under bridges. In light condition the ship's maximum height above the waterline will be only 13ft. 1½in.