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The Chemist and the Ship.

Collated by
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Introduction.

In so far as problems in shipbuilding and marine engineering are problems of materials they are also problems in applied chemistry. The business of the chemical industry—not alone but working in close collaboration with the other industries that surround it on all sides—is the development, production and continual improvement of materials whatever their origins and whatever their ultimate applications. The scope and interests of chemistry are far from being limited to what are commonly called "chemicals"; they extend directly, or still more often indirectly, to materials of every kind—natural or synthetic, mineral or vegetable, rare or plentiful. Nearly all other industries depend, in fact, on the chemical industry for some of the preconditions or their work and progress.

This being so, the object of the present paper is to bring together a series of pictures each drawn by a chemist able to speak with authority on his own branch, outlining on the one hand certain directions in which the chemical industry has brought forth notable fruits in recent years and, on the other hand, the directions in which these are of interest to shipbuilders and marine engineers. By reason of its authorship the picture is necessarily less complete on the latter side than on the former, but if its publication evokes discussion whereby the balance may be corrected so that the chemist can take the marine engineer's and shipbuilder's special needs into account when fixing his objectives for further research, its purpose will have been served.

The paper will be divided, accordingly, into the following sections:—

(1) Applications of rubber and rubber products.
(2) Applications of chlorine compounds.
(3) Applications of plastics.
(4) Paints and finishes.
(5) Defence against fire.
(6) Pest control.
(7) Metallurgical processes.
(8) Refrigeration and storage of perishables.

Two other branches of the chemical industry of interest to members of The Institute, namely boiler feed water treatments and non-ferrous metals, have been deemed sufficiently important to be made the subject of separate* papers already published.

*"Modern Boiler Feed Water Treatments and Suggestions for their Application to Marine Boilers", by P. Hamer and C. A. Stead. *Trans. of The Institute of Marine Engineers,* Vol. LI, June, 1939, pp. 167-83. "Copper and Copper Alloys—Their Properties and Applications", by Dr. H. W. Brownsdon. *Trans. of The Institute of Marine Engineers,* Vol. LI, October, 1939, pp. 277-89.

In concluding this introductory note the titular author wishes to make clear that his own part in producing the paper has been almost entirely editorial, and that whatever value it may possess is due to the work of his specialist colleagues in their respective fields.

(1) Applications of Rubber and Related Products.*

The rapid strides made by the rubber industry during the last few decades undoubtedly are intimately bound up with the rise of the automobile industry. At first rubber was used almost exclusively in tyres, but recently the automobile engineer has become "rubber-conscious" and in some cases as much rubber is used in the actual chassis and body construction of the motor car as in the tyres themselves.

It is felt that if naval architects and marine engineers were as "rubber-conscious" as their counterparts in the motor industry, they might find rubber and related products even more useful. For this reason it is proposed to discuss the properties of rubber and its related products and suggest ways in which the peculiar properties of such compounds might be usefully applied in ships.

The general properties of rubber are well known, in that it is a resilient, extensible and retractible material having a high tensile strength. The shortcomings of rubber are not so widely appreciated, and it is probably due to errors in application that rubber has not made more headway as an engineering material. A new material suitable for many purposes may be prejudiced by an initial mistake in its use. The most serious of the shortcomings of rubber are due to the deleterious effect of heat, light and oil. Rubber, when it encounters such conditions in severe degree, is likely to give unsatisfactory service, and it is unfortunate that in many if not most engineering applications one or more of these influences are present to some considerable extent.

At one time the poor heat resistance of vulcanised rubber was a great drawback, but the discovery of powerful anti-oxidants by the chemist and the development of low sulphur compounding by the technologist have gone a long way to overcome this difficulty. Even so, certain synthetic rubbers show definite advantages in resistance to heat, and in this connection it is interesting to note that synthetic products such as neoprene never revert like rubber, *i.e.* do not soften to an almost liquid condition but tend gradually to harden.

When we come to consider the effects of light, oxidation and oil, it has to be admitted that rubber, even when compounded according to the most modern developments, leaves much to be desired. It is under such conditions that the modern synthetic rubbers and their related products come into their own, and it will be convenient at this point to review the materials which are now available.

Synthetic Rubbers.

Synthetic rubbers may conveniently be divided into two classes :—

(*a*) Those closely related to natural rubber in chemical structure, *e.g.* poly-chloro-butadiene or neoprene, and poly-butadiene or Buna.

(*b*) Those having no chemical relationship with natural rubber, consisting mainly of a class of products known as "thioplasts", of which Vulcaplas, Thiokol and Perduren are important examples.

The members of class (*a*) have mechanical properties equal or superior to those of natural rubber together with far greater resistance to light, heat and oil, while those of class (*b*) are usually less resilient, and of lower tensile strength than natural rubber, but usually swell even less than materials of class (*a*) in oils and solvents. It is to be noted that a slight swelling in oil may in some circumstances be an advantage, since provided the mechanical properties of the rubber are not adversely affected by such slight swelling a tighter joint is obtained during service. This applies particularly to jointing rings, gaskets, oil-sealing tapes, etc.

Below is given a comparative table of properties of a typical vulcanised rubber and a comparable vulcanised synthetic rubber (neoprene).

Table I.

	Rubber.	*Neoprene.*
Hardness (Shore)	60	60
Tensile strength (Kgs./cm.^{2}) ...	216	224
Elongation per cent. at break ...	625	602
Resilience per cent.	63-65	63-65
Abrasion loss	0·110	0·110
Fatigue flexing...	268	over 1,000
Per cent. swelling at 70° C. in		
Diesel oil	480	58
Transformer oil	275	15
Mobiloil BB	104	4

The figures given above deal with two comparable mixings. It must be appreciated that both neoprene and rubber can be compounded by the rubber manufacturer to give products of widely varying hardness, tensile strength and resilience.

The ageing of rubber is usually assessed by determining the drop in tensile properties after varying periods of time in the oxygen bomb under 300lb. per sq. inch pressure at 70° C. or in the Geer oven in air at 70° C. The following table gives an indication of the comparative ageing figures of neoprene and natural rubber :—

*Contributed by B. J. Habgood, B.Sc., A.I.C., A.I.R.I.(Sc.).

TABLE II.

OXYGEN BOMB AGEING AT 70° C. AT 300LB. PER SQ. INCH OXYGEN PRESSURE.

	RUBBER.			NEOPRENE.		
	Tensile Kgs./cm.²	*Elongation per cent.*	*Hardness.*	*Tensile Kgs./cm.²*	*Elongation per cent.*	*Hardness.*
Unaged	216	625	60	224	602	68
6 days	86	366	64	167	448	72
12 days	34	132	83	157	378	74
18 days	perished	perished	100	132	313	77

TABLE III.

GEER OVEN AGEING IN AIR AT 70° C.

	RUBBER.			NEOPRENE.		
	Tensile Kgs./cm.²	*Elongation per cent.*	*Hardness.*	*Tensile Kgs./cm.²*	*Elongation per cent.*	*Hardness.*
Unaged	246	625	60	224	602	68
3 weeks	265	506	—	249	496	—
6 weeks	206	401	67	241	422	72
12 weeks	41	135	70	200	280	80

The resistance of neoprene to weathering, sunlight and ozone is very great as compared with natural rubber and the following photographs (Figs. 1, 2 and 3) show this very effectively.

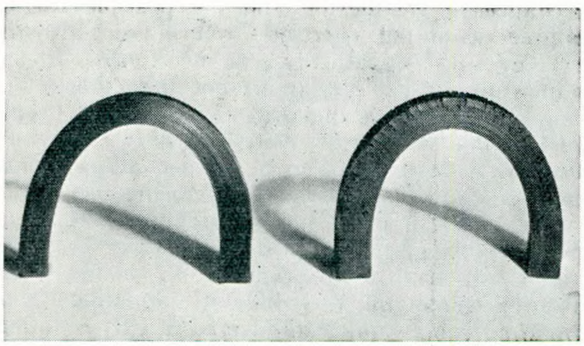


FIG. 1.—Effect of ozone upon neoprene (left) and natural rubber (right).

FIG. 2.—Neoprene compound after six months in bright sunlight (magnified three times).

Bonding to Metal.

In engineering applications the bonding of rubber and related compounds to various surfaces, and to metals in particular, is of great importance, and several methods are available, many of which depend upon the deposition of brass on to the metal to be bonded. The technique of bonding is dealt with in detail in a paper by B. J. Habgood in *Trans. Inst. Rubber Industry,* XIII, 2, 136, 1937, which also contains an extensive bibliography. Neoprene can be bonded directly to brass and to a variety of metals including iron and steel, nickel, chromium, lead, zinc and aluminium and its alloys, by the use of a chlorinated rubber interlayer (U.K. Pat. 493,139). Excellent adhesion is obtained equal to the strength of the neoprene itself.

Rubber is already being used as a protective covering for shafting, where its resilience and flexibility allows the covering to adjust itself to deformation without fracture. The protection of pipe lines carrying salt water, which is highly corrosive to nearly all metals, is a relatively new application and is proving highly successful, since not only is rubber very resistant to electrolytes—a fact adequately demonstrated by its successful utilization in the chemical industry—but being an insulator it prevents the development of electric currents through galvanic action, the cause of much trouble in the past.

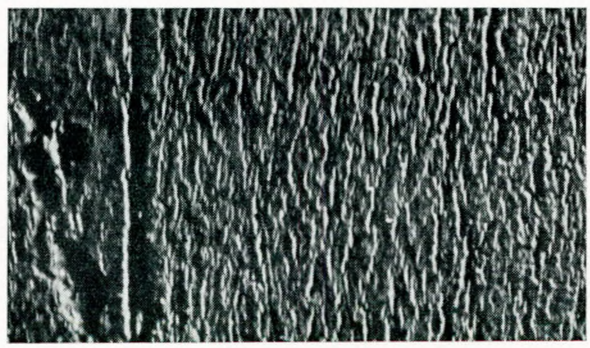


FIG. 3.—Natural rubber compound after six months in bright sunlight (magnified three times).

Shock and Vibration Absorption.

In the motor-car industry the use of rubber as a shock-resisting and vibration-damping suspension has come to stay. There would appear no reason why the same principle should not be applied with advantage aboard ships, not only to heavy reciprocating machinery but to electrical generators and other auxiliary gear tending to transmit noise and vibration through the hull. In submarines the efficient damping of noise would appear to be of paramount importance in lessening the risk of detection.

The superior oil resistance of neoprene enables resilient mountings to be employed under conditions where natural rubber would rapidly fail, and trials are in progress using neoprene suspensions for large marine Diesel engines and high-speed pumps. It is suggested that similar methods could be used for the prevention of hull vibration and metal fatigue in high-speed craft and for the alleviation of compressional strain developed in various circumstances. Under conditions where shock absorption, as distinct from vibration damping, becomes important, the higher hysteresis of neoprene makes it superior to rubber in applications such as gun-mountings and recoil mechanisms. The effective bonding of neoprene to metals renders possible the manufacture of laminated neoprene-metal sheets; these would be expected to show high shock-resisting properties and might find special applications in ship construction.

Neoprene Paint.

Before finally leaving the uses of bonded neoprene, reference must be made to a recent development which appears to be of great promise, namely, the application of neoprene solutions as protective coatings. Neoprene in its unvulcanised condition is considerably more soluble in organic solvents than is rubber; that is to say mobile solutions containing up to 30 per cent. of neoprene can be readily obtained which are capable of being brushed or sprayed on to various surfaces. One of the latest developments, which has been reported as being successful, is the lining of vortex chambers with neoprene paint. The heat encountered under service conditions vulcanises the material *in situ* with the result that corrosion troubles are stated to have been entirely overcome through the use of such coatings. Self-vulcanising solutions can be used if necessary, thus enabling the treatment of large areas which could not be vulcanised or stoved.

The investigation of neoprene paint as an anti-fouling composition would be of interest, and the production of non-slip deck coverings, having excellent ageing properties, would appear to hold great promise. It has been stated that "Empire Day" speedboat, the unofficial world record holder 400 Kg. class, piloted by E. Spurr in September, 1938, was equipped with a neoprene-coated hull as a protection against erosion and corrosion. It has further been reported that propellers which have been treated with neoprene paint have given excellent results, the scouring effect of sand and the pitting caused by cavitation being largely eliminated.

Another interesting application of neoprene solution lies in its application in the construction of radiators, oil coolers, intercoolers and the like in which neoprene replaces brazing and soldering, the resilient properties of the neoprene bond giving increased protection against the deleterious effects of vibration.

Oil-Resistant Products.

The resistance of neoprene to oil enables its successful use in a number of applications where rubber would fail, such as for oil seals and gaskets, including cork gaskets in which the cork granules are bonded together with neoprene, and for valve diaphragms. A good report has been received on the wearing qualities of neoprene air pump valves in resisting corrosion under oily conditions. The aeronautical industry has developed the use of neoprene strips for the caulking of joints where welding is inadmissible, and it is possible that a similar method may be of interest to the shipbuilder.

Large quantities of neoprene oil hose are at present being manufactured, the material being resistant not only to oil but also to weathering (a factor of particular prominence in the tropics) so that the problem of storing spares becomes much easier. The fact that neoprene hose can be manufactured with a smooth bore free from internal wiring is a further advantage, enabling higher flow rates to be obtained with a given diameter.

Electrical Equipment.

The superior ageing properties of neoprene render it suitable in a number of applications for which rubber is definitely unsuitable. The increased resistance to weathering and the possible use of neoprene as an anti-corrosive covering and also for deck covering have already been mentioned. Its use in unarmoured cable is at present attracting attention. At one time the greatest drawback to the V.I.R. cable lay in its relatively short life which meant that vessels had to be refitted at least once during their life, but the improvements secured of late years through the use of organic accelerators and anti-oxidants combined with strict scientific control of manufacture have gone a long way towards overcoming this difficulty, and the life of armoured cables and lead-covered V.I.R. is to-day of a high order. In the case of unarmoured and uncovered flexible cables, where the effect of light plays an important part and where the cables are working under high temperature conditions (*e.g.* in stokeholds, engine rooms, etc.) the use of neoprene as a sheathing is of interest. It has been suggested that a great saving in weight could be obtained through the replacement of lead armouring by neoprene or similar products, and the suggestion would appear worthy of trial.

The electrical properties of neoprene are somewhat inferior to those of natural rubber.

TABLE IV.
COMPARATIVE ELECTRICAL PROPERTIES OF RUBBER AND NEOPRENE.

	Vulcanised Rubber.	*Vulcanised Neoprene.*
Volume resistivity Ohms./cm.^{3}	$1{\cdot}35\times10^{15}$	1×10^{15}
Dielectric constant	2·3	5
Breakdown strength Kv/mm....	30	10
Power factor (radio frequency)	2·1	8

The above figures are indicative of the differences between rubber and neoprene, but the actual figures will vary to some extent with the compositions of the mixings employed. Notwithstanding the relatively poor electrical characteristics of neoprene, satisfactory results have been obtained when using it as an insulator for voltages up to about 250. With higher voltages a rubber insulation protected by neoprene sheaths is usually employed. The production of conducting rubber sheaths by the incorporation of carbon black, etc. has recently attracted attention since static electricity is largely eliminated in this way and the leakages which give rise to so much corrosion trouble are largely overcome. Sheathings made from neoprene by a similar method give even higher conductivities.

Before leaving the question of electrical equipment a passing reference will be made to the use of hard rubber ebonite for battery boxes. Ordinary ebonite has been so used for many years and, while satisfactory in its resistance to electrolytes, it suffers from one grave disadvantage in that it is somewhat brittle under impact. By the introduction of relatively small amounts of neoprene a material known as "flexible ebonite" is obtained which retains the anti-corrosive properties of ordinary ebonite whilst giving markedly improved shock resistance. Experiments are actively proceeding in the development of flexible ebonite battery containers which, if successful, should find use in ships, particularly in submarines.

The covering of light alloy battery boxes with neoprene and with flexible ebonite is also being investigated, but the trials are at present incomplete. It is hoped that a great saving in weight will be obtained in this way.

Flame Resistance.

Undoubtedly a great drawback of vulcanised rubber lies in its inflammable nature. The need for fireproof materials in ship furnishing has been only too well illustrated by the disastrous fires which have destroyed many ships in recent years, and in fighting ships the utilization of flame-resistant rubber becomes more important still. A great deal of work has been carried out recently on the subject of flame-resistant rubber and a survey of the subject is given in a paper by Dawson (*India Rubber Journal, 90,* 525, 1935).

In neoprene, however, we have a synthetic rubber which contains a relatively high percentage of chlorine—namely, about 40 per cent.—and after vulcanisation exhibits mechanical properties similar to those of natural rubber. Neoprene, therefore, is an excellent starting material for the production of flame-resistant and incombustible rubber articles, and neoprene mixings are readily obtainable which when held in a bunsen flame burn only with difficulty, and cease to burn immediately on removal from the flame.

Poly-vinyl chloride is another material of interest as a flame-resistant insulator for cables and similar purposes. This material contains approximately 50 per cent. of chlorine and its physical properties can be varied over a considerable range by the addition of plasticisers so as to obtain products varying from hard horny materials down to soft rubbery ones. Poly-vinyl chloride, however, has one disadvantage compared to neoprene in that it is thermoplastic and softens at about 70° C. and cannot be vulcanised. It does, however, exhibit excellent resistance to ozone, to oil and to weathering, and in cases where no high temperature conditions are likely to be met with in service, there is no doubt of its great potentialities.

It is hoped that the above summary of the properties of rubber and related products, and of their suggested applications, will interest and help naval architects and shipbuilders in the solution of some of their problems. It cannot be too highly stressed that close co-operation between the engineer and the rubber technologist is of paramount importance if the best results are to be obtained.

(2) Applications of Chlorine Compounds.

Thermal and Acoustic Insulation.

Chlorinated rubber sold under the name of "Alloprene" is produced in several stable forms which may play an important part in the equipment of ships. Hitherto it has been best known as a constituent of corrosion-resisting paints, for which purpose the powder form is used.

Two other forms of Alloprene possessing interesting thermal and sound insulating properties are attracting attention: these are porous block in which the cells are interconnecting, and sheet felt. These forms are non-inflammable, immune to mould attack, inert and particularly resistant to corrosive agents. They are also insoluble to water. The porous block will absorb moisture but the felt is exceptionally water resistant.

The Alloprene powder is available in commercial quantities but the porous block and felt are as yet only experimental. Laboratory measurements of the thermal conductivity of the porous block have been carried out and this is found to be lower than that of cork or similar materials. Porous block is recommended for trial as a thermal insulator for refrigeration systems, but because it decomposes at temperatures above 100° C. it cannot be used satisfactorily where high temperatures prevail.

With regard to sound insulation, chlorinated rubber felt may be worthy of consideration in applications where it is essential for the sound-proofing material to possess the additional desirable characteristics of non-inflammability and resistance to moisture.

Although these products are not yet standard manufactures, small samples are available for examination.

Flameproofing and Sealing of Electric Cables.

Chlorinated naphthalene (marketed under the name of Seekay Wax) is another material which offers considerable scope for usage in ships by virtue of its chemically inert nature and its flame-proofing, waterproofing, insulating, insect-resisting and fungus-resisting qualities. Perhaps the most important application is its use for the flameproofing of rubber-insulated fabric-braided cables, and this type of flameproof cable is readily available from cable makers. Recent work has shown that the product may also be successfully incorporated in rubber mixes designed for use in the manufacture of cables of "cabtyre sheath" type, but cable makers are not yet manufacturing C.T.S. cable flame-proofed in this way. In ships it is frequently necessary to fit equipment such as cable junction boxes in very cramped spaces where it would be difficult, if not impossible, to employ, as a sealing agent any material applied in the molten condition. In such circumstances the use of a plastic flame-resistant sealing agent based on chlorinated naphthalene, and capable of being applied by stemming in at ordinary or only slightly elevated temperature, is likely to present considerable advantages. Experimental work has indicated that a sealing medium of this type, which is marketed under the name of "Seelax", is very suitable for use under these conditions.

Water Sterilisation and Sanitation in Ships.

Government regulations require that all drinking water supplies must be "pure and wholesome". This wide description is generally interpreted to mean that drinking water must be palatable and free from pathogenic organisms. Natural gathering grounds rarely give water which will comply with these conditions and consequently a system of sterilisation must be adopted.

There are several methods of sterilising water but the cheapest and most reliable agent is chlorine, which has been successfully used since the 18th century. Chlorination has allowed the safe use of many water supplies which without treatment were unsuitable for use. It provides security against water-born diseases such as typhoid, cholera, dysentery, etc., reduces the necessity for long storage of polluted water, and stops the growth of algal slimes which develop in storage tanks.

The method of application may be either simple chlorination or chloramination. In the latter case ammonia and chlorine are added in certain proportions and form chloramines which are well-known sterilising compounds. The ammonia may be applied as gas or in the form of ammonium sulphate.

The sterilisation of water by chlorination can be carried out very simply by the use of a specially stabilised grade of bleaching powder containing 25 per cent. effective chlorine, which is very suitable for storing on ships working in tropical climates. A description of the powder is given in the Medical Scale for Merchant Shipping.

When bleaching powder is mixed with water in the proportion of 1lb. of powder to 25,000 gallons of water and storage of approximately one hour is allowed, complete destruction of all organisms harmful to man is obtained. For general sanitary purposes, another grade of stabilised bleaching powder, which contains 35 per cent. available chlorine, is very suitable for use in hot climates. It is of outstanding value as a disinfectant and deodorant, and is a convenient agent for adding to the water used for washing down decks, bulkheads and galleys.

Degreasing.

In many vessels, more especially those propelled by Diesel engines, repair work has to be carried out on machinery thick with oil; oil coolers and air coolers have also to be cleaned in order to restore the efficiency lost by coating-up with non-conductive deposits. In such cases degreasing with trichlorethylene is found to be effective and economic.

Where the parts can be dismantled they can be loaded into a "degreasing plant" and freed from oil in 15 minutes. Any remaining sediment can be removed by pressure hose. The overall time for cleaning was cut down in one case from one day for two men by the old methods to one hour with one man using trichlorethylene.

If coolers cannot be removed it is still possible to use trichlorethylene by employing the *in situ* process, whereby the solvent vapour is introduced into the cooler from any external still. The solvent condenses inside the cooler and washes out the oil and dirt.

(3) Applications of Plastics.*

Plastics have many properties which commend them for ships' use, notably freedom from rusting or corrosion, good electrical properties, low weight, and attractive appearance. Almost all plastics share these properties whilst many are, in addition, non-inflammable or have a low degree of inflammability. Each possesses characteristics which render it suitable for specialised applications: thus, the synthetic resin methyl methacrylate is distinguished by its optical clarity exceeding that of the best glass, whereas the flexible vinyl resins are chiefly of interest because they combine many of the useful characteristics of rubber with the additional valuable properties of non-inflammability and resistance to ageing influences and to oils.

Main Structure.

Plastics have as yet not entered into the main structure of ships, and it is unlikely that the materials at present available will do so. The principal reason is that, although certain of the plastics are actually stronger on a weight basis than

*This section is contributed by F. Heywood.

the established structural materials, their cost at present so far exceeds that of structural steel and wood as to render this circumstance relatively unimportant. A further consideration is that plastics cannot normally be fabricated with the same facility as steel and wood and usually require a high pressure moulding technique at some stage in their production or fabrication, the size of the units being consequently limited to that of the press equipment available. For these and other reasons, plastics can be usefully considered only for internal structure and decoration and for auxiliary equipment.

Urea-formaldehyde resins in an expanded form share some of the possibilities of use as structural insulating materials mentioned at the beginning of the preceding section.

Synthetic Resin Glues.

The introduction of synthetic resin glues has greatly widened the scope for plywood in the internal structure of ships. The two resins most commonly employed for this purpose are phenol-formaldehyde and urea-formaldehyde. The former is often used in the convenient form of a film in which the resin is supported on a thin paper base, whilst the urea-formaldehyde glue is commonly applied in liquid form. The particular merit of these glues is that they are converted, on hot pressing, to a chemically stable, insoluble form. Plywood so bonded is unaffected by temperature and humidity variations or by long immersion in water and the glue itself is immune from attack by moulds. Gaboon plywood bonded with synthetic resin glues of this type is now being used extensively for bulkheading, where the large unbroken surface is of advantage from the point of view of strength, consequent weight reduction, and the saving in erection cost. Moreover, the fire hazard is reduced by reason of the smaller volume of wood required as compared with tongued and grooved boarding and of the lower inflammability of plywood.

The use of urea-formaldehyde resin glue for fine veneering is rapidly extending. It is particularly suitable for this purpose as, in addition to providing a water and mould resistant bond, it does not cause staining of the veneers.

Laminated Plastics.

The urea-formaldehyde and phenol-formaldehyde resins find another important application in the production of decorative laminated materials, which have been used successfully for the panelling of public saloons, barbers' saloons, bathrooms and cocktail bars. The materials are available in almost any shade of plain colours, and in wood grain and tapestry effects and pictorial design. The chief attraction of the laminated decorative plastics is that they offer a new medium of mural decoration in which the design is protected by the hard surface of synthetic resin, very permanent in nature and easily cleaned. The laminated veneers are available in sizes up to 8ft. × 4ft. or larger, and are usually cemented to a backing of asbestos, plywood, fibreboard, or phenol-formaldehyde laminated paper.

The low moisture absorption of these laminated materials coupled with their hardness and good appearance has led to their extensive use for table tops; by incorporating a conducting layer below the surface, it is possible to produce materials which are not discoloured or blistered by hot utensils or even by a glowing cigarette.

Another well-established use for laminated materials is for signs, identification plates, and labels where the non-chipping, non-discolouring properties are of value.

The use of moulded accessories and fittings is so well known that there is little need to make more than passing reference to them. Telephones, door furniture, toilet seats, ashtrays, thermos jugs, desk lamps, switch plates, lamp brackets, lamp shades, coat hooks, and wash-basin accessories such as soap rack, water jug and towel rail are some of the items for which plastics are accepted materials. The earliest experience with some of these fittings was not always successful, a fact which emphasized the importance of selecting a plastic for its specific purpose with the same care as a metal would be chosen for a machine part. The characteristics of the various plastics are now so well known that when the operating conditions are also known no difficulty need be experienced in choosing the right material.

The clear transparent plastics, of which methyl methacrylate is a notable example, have for some time been extensively used in preference to glass in air and land transport and there is little doubt that they will receive increasing attention from naval architects. The extreme clarity of these materials, coupled with the ease with which they can be shaped when heated, high impact strength and flexibility renders them of interest for internal decoration and lighting schemes as well as for such uses as meter dials and glasses and instruments in the chart-room. Developments along these lines are, in fact, already taking place. Lightweight binoculars provide another example.

Engine Bearings.

Attention may be directed to recent developments in the use of plastics for heavy bearings in rolling mills and for slow and medium speed bearings and bushes in industrial plant where oil lubrication is objectionable or where abrasive dust is encountered.* Bearings of this type are lubricated with water or emulsified lubricants only; when correctly designed they cause only low frictional losses and give a long life even under shock loads. Rubber bearings are already being used successfully in small craft, and their high resistance to abrasion makes them especially valuable for use in coastal waters where a large amount of grit and sand is encountered; under such conditions a life four times as long as that of metallic bearings has

*General Discussion on Lubrication and Lubricants, Institution of Mechanical Engineers, Oct., 1937.

frequently been attained. There appears to be scope, also, for some of the laminated plastics and for resin-impregnated compressed wood for tail shaft bearings and thrust blocks in place of lignum vitæ and for bushes in auxiliary gear, where water lubrication can be arranged.

Electrical Applications.

Plastics are likely to find increasing use in electrical distribution systems for lighting, power, heating and cooking in ships. Here a range of conditions has to be met which includes high humidity, wide temperature variations, vibration, and exposure to fuel and lubricating oils. Meter cases, switch and fuse housings, bushings, lighting fittings, and other parts should be moulded in high resin content moulding materials which have very low water absorption and, in the case of some materials, it is advisable as an additional precaution to paint the surfaces of mouldings with a high grade of non-tracking varnish to guard against a type of breakdown liable to occur in moist atmospheres, especially where salt carried over by spray may also be present. The urea formaldehyde moulding materials are much less liable to the tracking type of breakdown and, as they are available in white and in light and dark colours, they are particularly suitable for marine electrical fittings.

It is anticipated that some of the plastics based on vinyl chloride as well as the synthetic rubbers will before long be employed for the sheathing and insulation of low voltage flexible cables for ships' use. The attraction of these materials lies in their relative non-inflammability, non-ageing properties, marked resistance to lubricating oils and, in the case of some of them, the fact that they can be made in a very wide range of colours, which is of importance in multi-core cables.

A small but important use for plastics is in connection with low power loss dielectrics such as are required in radio reception and transmission apparatus. Polythene and polystyrene are two of the newer plastics which are worthy of note for applications of this type.

(4) Paints and Finishes.

Paints for Protection against Corrosion and Decay.

The use of paint materials in ships gives rise in the first place to certain general problems of protection which are common to other constructions also, and secondly to a great number of special problems of localised or limited interest which there will not be space to examine here. An example of the latter is the problem of corrosion in oil cargo tanks on which Mr. H. S. Humphreys made some illuminating remarks on pages 7-8 of his paper "The Care and Maintenance of a Modern Diesel-Engined Tanker Fleet" (*Trans. Inst. Mar. Engrs.*, XLVIII, Jan., 1936).

In view of the references made below to decorative uses of paints it will be well to make clear, in first considering the use of paint for protective purposes, that the same paint may be both protective and decorative. The protection afforded by the film is due to the combined effects of the vehicle and pigment after air-drying or forced-drying, the degree of such protection depending to some extent upon the thickness of the film but mainly upon such of its properties as flexibility, resistance to heat, cold and wet.

The problems that arise in connection with the protection against corrosion and decay can be conveniently examined under the following heads :—

(*a*) Anti-fouling (below water line).

(*b*) Other protection (above water line).

Anti-fouling compositions are directed against the adhesion of barnacles to the ship's bottom. It has not so far proved possible to devise means of preventing such adhesion, but only to reduce the amount of adhesion and to facilitate removal by scaling-off such barnacles as have adhered. The importance of effective anti-fouling composition lies in the fact that barnacles provide resistance to the passage of the ship through the water. Effective anti-barnacle compositions thus increase speed and reduce fuel consumption, not merely in theory but quite substantially.

A further purpose of anti-fouling compositions is the important one of reducing the corrosion of the ship's bottom. In general, the ingredients used in such compositions to resist the barnacles are certain toxic metallic compounds which are intended to poison the barnacles and so cause them to drop off or to render their subsequent removal easier, and the ideal anti-fouling composition is one which poisons the barnacles and slowly "chalks" so as continually to present a toxic surface; in the absence of this chalking characteristic the anti-barnacle value of the composition becomes progressively weaker until the application is renewed. Consequently a high order of durability has not been found compatible with the most effective anti-fouling characteristics. Although some progress, along conventional lines, has been made by the relatively small number of manufacturers concerned in the manufacture of anti-fouling compositions, no revolutionary changes in formulation have been proposed and an important field of activity here awaits further attention by the chemist.

Other protective finishes are those applied to the hull, superstructure and miscellaneous surfaces. On passenger ships the hull paints employed are black, white or one of many intermediate shades. The instinct of the shipowners has been against high quality materials and they have in the main been content with orthodox oil paints, asking only that the paint should last for a reasonable period. The reason for this attitude, and for the consequent lack of application in ships of those developments which have latterly been realised through research on paints in general, may be found in the circumstance that the principal merit of improved finishes which has to be relied on to outweigh their slightly higher cost per gallon lies in their greater durability and appearance. Generally, their economy depends on the fact that labour costs are lower because the durability is greater; but where, as is so often the case on board ship, the crew do the exterior painting when they would otherwise be idle so that labour cost is not a separate factor, such saving is not necessarily realised.

In a few cases where a separate labour cost is thrown up savings have indeed been effected through the use of modern materials of a synthetic resin type and it is worthy of note that some of the largest United States liners are finished in synthetic resin hull paints. Superstructural painting. moreover, is usually undertaken by contract, and this gives an opportunity for superior paints to be evaluated and for lower labour costs to become clearly apparent.

In the case of both hull and superstructure paints the essential difficulties encountered are the same. In ships operating through wide variations of latitude the alternation of heat and cold affords one of the severest tests that any paint can be called upon to resist. Paint should provide essentially a flexible film; within limits this flexibility is a saving feature, but beyond those limits extreme heat alternating with extreme cold may easily lead to cracking. The company with which the author of this section is connected have been successful in developing modern synthetic finishes which stand up effectively to extreme cold or to extreme heat and which have withstood severe tests in both cold and hot climates; but where these extremes alternate on one and the same film it has to be admitted that an extremely difficult problem remains outstanding. To some extent this has been solved by the use of a synthetic vehicle and modern types of pigment.

Insofar as hull and superstructure paints undergo cleaning, this is normally done by simple washing down without any drying. The paints are, therefore, exposed to brine, in addition to which the pigment from which the colour is derived may be affected by hot sunshine active over long periods. In the case of hulls, bituminous compositions have been tried but without success; they tend, after several coats have been applied, to sag. It will be appreciated that hull paints are applied, coat after coat, without any intervening preparation of the surface as in the case of ordinary decorative painting; the protection is afforded not by one paint film but by the many which are superimposed on one another, until eventually all are stripped away together so that the process may begin over again. A normal paint system may vary between 4 and 10 thousandths of an inch in thickness and such a relatively thin film would offer little protection against the waves which pound against the side of the ship; hence the practice of building coat upon coat.

The method of application is an important factor in connection with protective paints and finishes. For the painting of the hull and superstructure there is no reason why spraying should not be used except for the considerable waste of material which would be involved when working under very exposed conditions. The commonest method of applying general protective paints to hull surfaces is still by the use of the Turk's head brush.

Every ship contains a large number of miscellaneous items of one type or another which require protective painting; canvas and cordage are examples on which tar and bituminous type paints have been found satisfactory. Again, a very general problem of construction and maintenance is the prevention of rust, a problem which, during the building of the ship on the stocks, is met to some extent by the use of a rust-inhibiting primer.

Paints for Internal Structure and Decoration.

The decorative effect achieved by paint arises from the pigment incorporated in it and from the gloss of the film. It is the pigment that provides the colour, and the progress made in the dyestuffs industry of this country, especially since the last war, has proved a material factor not merely in the achievement of new shades (such as the recent Monastral Blue) but also in securing greater stability in the colours. The type of surface is important in any complete scheme of decoration and may be used to throw up the general motif to advantage. The use of plastic materials in solid form has been mentioned in previous sections of this paper, and modern paints form yet another application of synthetic resins to the decorative side of shipbuilding and maintenance.

Science and art are no longer thought of as incongruous. The chemist's contribution is a scientific one, but is none the less artistic as well. This is especially true in the decoration of ships. where the chemist plays an essential though indirect part in æsthetic realization. Nor should this function be construed too narrowly in terms of the pleasure afforded to passengers alone; for, just as it has now been established that factory operatives react favourably to a bright environment, so there are signs of a disposition on the part of shipbuilders and shipowners to perceive that (subject to overriding economic considerations) the accommodation provided for ships' crews need not be so drab as has often been the case in the past. Owners, in providing the brighter atmosphere to which paint can so largely contribute, may not only give themselves pleasure as employers but are likely to influence helpfully the attitude of the crew to their several tasks. This applies to cargo vessels no less than to passenger ships. Here two sciences meet, for the chemist is helping to implement the work of the industrial psychologist.

The contribution made by the paint chemist to the decoration of the modern ship is best summarized by indicating the principal developments in paint formulation which have taken place in recent years. The basis of orthodox paints was always drying oil in which pigment was ground. Even before the revolutionary changes in composition which have occurred in recent years the contribution of the chemist was far from insignificant, for there are many grades of oil paint and the adjustments which can be made to ensure the complete suitability of the product for the particular purpose in view are the result of much patient investigation on his part. It would be unsound to assume, because new types of finish have in many instances displaced oil paints, that these have had their day or are incapable in appropriate circumstances of giving eminently satisfactory results. Here, as elsewhere, enthusiasm for technical advance needs to be tempered by a reluctance to identify the new with the invariably and necessarily better.

Chemical research, again, has been responsible for the development of methods of producing cellulose acetate and cellulose nitrate from vegetable material. Both in the United States and in this country it was realized that the products so available might, with suitable solvents, be used to provide a film for coating both metal and wood surfaces. The adaptation of nitrocotton to such peaceful purposes as the manufacture of finishes provides a notable example of the sword being beaten into a ploughshare. Faster drying and the possibility of spray application are two of the principal advantages derived from nitrocellulose finishes which have led to their use becoming all but universal in the mass production of motor cars and furniture. Still newer materials continue to be developed, offering, for particular purposes, still further advantages.

In their decorative applications cellulose finishes gained ground slowly, mainly owing to the difficulty, in the case of small jobs, of making the spray equipment available on the site, and also to that of masking in cases where only small areas are to be finished. As regards interior finishing of passenger ships there has been no difficulty at all, and cellulose has in fact made an important contribution to the interior decoration of the woodwork of modern vessels.

The latest and most revolutionary material in this field to become available through the work of the chemist is that resulting from his formulation of finishes with synthetic resin vehicles. These have provided paint films greatly superior in important respects, including those of durability and flexibility, to orthodox materials of the oil type, and also much superior in build to the best nitrocellulose finishes. Gloss is readily regulated by small adjustments in formulation and the materials are normally available in matt, eggshell and glossy types.

Another recent development, the applications of which are being studied and may well prove to be of special interest in marine work, is the incorporation in paints of the chlorinated rubber already mentioned in Section 2 of this paper. One of the special merits of this procedure lies in the proved possibility of thereby obtaining a paint which offers considerable resistance to flame and which can be used with advantage for the serving of electric cables and the covering of tanks for inflammable liquids. In addition it is highly resistant to corrosion, and experiments are being made to test its anti-fouling properties.

(5) Defence against Fire.

Fire being the most dreaded of disasters at sea and at the same time one of the commonest of all chemical phenomena is a subject particularly germane to this paper, whether from the point of view of provision for fighting fires when they have broken out or, what is much more important, that of preventing their outbreak and spread.

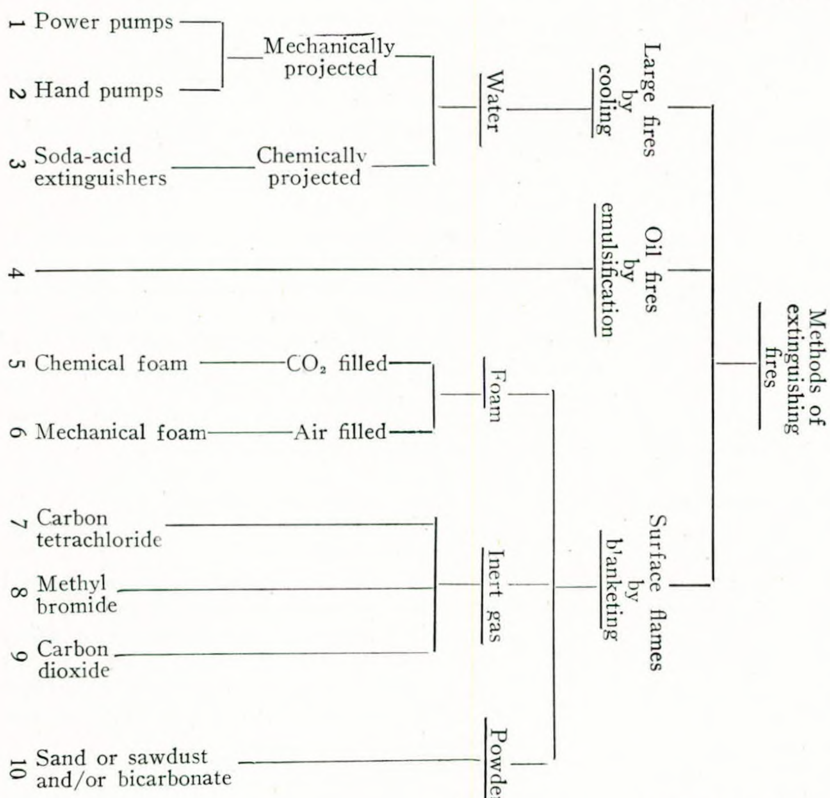
The idea of fire-resisting construction in ships is not, of course, by any means new, but has for many years been one of the chief items in the designer's list of desiderata, particularly for passenger vessels. In general, however, limitations in the choice of suitable materials of construction have forced him to confine his attention mainly to fire-resisting layout—*e.g.* the avoidance of "chimney" effects and the use of fireproof doors—and to methods of extinction, while continuing to use great quantities of the same combustible materials which earlier practice was apt to leave so hazardous.

So far as passenger vessels are concerned timber still forms one of the prime materials of construction for bulkheads between cabins and covers for steelwork, though since the last war its nature has changed appreciably. Plywood has tended increasingly to displace solid timber, very largely because it can be obtained in large unbroken surfaces with very little tendency to crack or warp; but there is still a large requirement of solid wood for frames, mouldings, edgings, etc., in addition to that required for decking. Some of the so-called "composition boards" which contain asbestos and are, therefore, more fire-resistant (though also much more expensive) than plywood are at present used to a limited extent. The cheaper types which do not contain asbestos are perhaps preferable to plywood for some purposes, since they are often lighter in weight and more sound and heat-proof, and as their use appears to be growing in popularity for construction on land it may further increase in ships. In general, however, all these materials suffer from the disadvantage that their resistance to fire is of a low order.

Several spectacular fires a few years ago seemed likely for a time to create a demand for less combustible materials in shipbuilding, but improvements in fire-resisting doors and bulkheads and particularly the successful adaptation of the sprinkler for use on board ship seem to have restored much of the vacillating confidence. Most fires are started by agencies which in the initial stages generate only a slow output of heat*. Thus, in London more than a quarter of the outbreaks are officially attributed to "lights thrown down" and the next most frequent causes are electrical failures, sparks and petrol. Statistics for fires at sea, if available, would probably disclose a similar state of affairs.

Fire Fighting.

As regards fire-fighting, it is important to distinguish between merely extinguishing surface flames and stopping the combustion of a large incandescent mass in which a great amount of heat has accumulated before the outbreak is discovered. In the former case all that may be necessary is to cut off the supply of oxygen by blanketing the fire and this can often be done with advantage by chemical means, but in the latter the application of water to remove the heat and so lower the temperature below the ignition point of the burning material is the only practical method, for even if the flames have been extinguished by blanketing they will break out again if the blanketing medium is blown away or otherwise lost. An ordinary water jet, however, is useless on oil fires. On these lines, methods of extinguishing fires may be classified as follows :—



1 and *2* are mechanical engineering problems in which the chemist is not concerned.

3. In the common "soda-acid" type of fire extinguisher sodium carbonate, or more usually bicarbonate, is made to react with sulphuric acid to generate CO_2 under pressure, and this is used to project a jet of water like that from a hand pump. The cooling action of the water is supplemented by a blanketing effect due to CO_2 dissolved therein and released at the burning surface, and by the salts in solution forming a protective coat. The risk of corrosion can be reduced by using a considerable excess of sodium bicarbonate in these extinguishers but, as the sodium sulphate formed is a good conductor, they are worse than useless for electrical fires.

4. A special method of extinguishing inflammable liquid fires should be mentioned in which the discharge of water takes place through specially designed projectors, converting the burning liquid into an emulsion which cannot burn.

5. Chemical foam (in appearance rather like a shaving lather) is generated by the interaction of aluminium sulphate and sodium bicarbonate, and consists of small tough bubbles of CO_2 enclosed in a film formed from a stabilising medium which is included in the mixture. This kind of foam is used a good deal for smothering oil fires and, as it adheres to any burning solid surface on which it is thrown and will stop combustion by completely excluding the air, extinguishers on this principle are frequently installed for more general use on board ship. The two solutions mentioned above may either be stored separately and fed through separate hoses to a common nozzle in which the foam-making reaction takes place, or the chemicals may be supplied as a dry powder which is mixed with water on the spot, making possible an uninterrupted flow.

6. Mechanical foam is a more recent development, consisting of bubbles filled not with CO_2 but with air or, in one form, with the exhaust gases from a petrol engine. The foam is generated in an apparatus which draws the requisite amounts of air or gas together with the stabilising medium into a stream of water and beats them up mechanically. Since the blanketing action depends on the stability of the walls—not the contents—of the bubbles, the constitution of these is the crux of the invention and rather special qualities are required. A suit-

*For a quantitative discussion of this point see the paper by J. Maruelle: "The Protection of Wood against Fire". *Rept. 14th Annual Meeting (1937), Inst. Fire Engrs., pp. 53-64.*

able medium for the purpose was first produced in Germany but another is now being manufactured in this country.

The main advantage of "mechanical" over "chemical" foam is the reduction in cost by about 90 per cent. owing to no chemicals being required to produce gas to fill the bubbles, and this renders the material cheap enough to be used for instructional purposes as well as on actual fires. It may, in fact, be regarded as a method of enabling the fireman, by the turn of a handle, to multiply the volume of the available water supply by something between five and ten, though at the cost of a corresponding loss in striking power.

7, *8* and *9* represent three methods of generating an inert gas to blanket the fire. Carbon tetrachloride is a volatile liquid which has to be squirted onto the fire by means of a hand pump (as in the type of extinguisher commonly fitted on motor cars) or by the action of CO_2 under pressure. Methyl bromide on the other hand generates its own pressure when the containing bottle is broken. Carbon dioxide kept in cylinders under pressure with piping to points where fire is liable to break out is now one of the commonest forms of fire-fighting installations in ships.

10. Sand, or alternatively sawdust (which rather surprisingly has been found better than sand for the purpose) are effective for smothering flames including those due to spilt petrol, but will not, of course, adhere to a vertical surface. Their effectiveness is sometimes increased by an admixture of bicarbonate of soda to generate CO_2; this may also be used alone, or with other materials such as kieselguhr.

Fire Prevention.

Instead of fighting fires it is better, of course, to prevent their outbreak, and this fundamentally means that heat must not be capable of penetrating into the material in question at such a rate that the temperature can rise to ignition point if it is a combustible material, or to the point at which the material loses its strength or other required structural properties if, like steel, it is non-combustible.

Timber, if sufficiently thick, acts automatically in this respect by charring on the surface, and it is of interest to note that in the U.S.A. the rates of insurance for mill buildings of heavy timber construction are in fact lower than those for steel construction. In a modern ship, however, the vast quantities of timber employed (probably of the order of two million square feet a year in this country) are nearly all in the form of plywood and relatively thin planking to which this does not apply, and if a protective skin to prevent internal rise in temperature is required it must be formed artificially. There are two ways of doing this :—

(a) By impregnating the wood with a chemical substance which when heated by the flames will undergo a reaction forming such a skin, and

(b) By applying the protective skin externally at the time of construction.

Protective Impregnation.

Wood can be made fire-resistant without materially affecting its other properties. So far as marine engineering is concerned, it was the British Admiralty that, in the latter years of the nineteenth century, first gave the chemist his chance by deciding to standardise chemically fireproofed wood. The result has been that out of a chaos of useful as well as of undesirable methods proposed and often patented, there have emerged some three or four reliable ones which have stood the test of time. All those in mind owe their value to the proofing value of ammonium salts, particularly to monammonium phosphate.

Such treatment operates in two ways. In the first place, when the wood is heated to a temperature just below that at which it decomposes the compound is broken up and gives off non-inflammable gases which mix with the inflammable gases from the wood substance to yield a non-inflammable mixture. The wood is by this means rendered flameproof and the layer of inert gas also insulates the wood to some extent from the attacking flame. Secondly, the fireproofing salt, on being heated, melts and produces a glaze which coats the surface of the charcoal, inhibits the entrance of oxygen, and prevents burning or glowing. The fireproofing of wood thus prevents flaming of the products of decomposition and renders the residue incapable of allowing the fire to spread.

These compounds are water-soluble and are in all cases applied as solutions. They may be partially removed by the action of water, and it is assumed that for external application the material treated will in all cases be protected by covering with some form of paint. On the other hand, shavings taken from wood proofed with the compounds and boiled repeatedly with water, still retain their fireproof nature to a very marked degree.

A monammonium phosphate compound is commercially available in three forms :—

(*a*) Suitable for general purposes and for proofing materials intended for interior construction; also for exterior construction in dry climates.

(*b*) Suitable for all exterior purposes and generally recommended for woodwork.

(*c*) Suitable for application by brush or spray treatment to erected timber (and also for such materials as thatch where surface treatment is sufficient or impregnation impossible).

The most effective way of using this product (or mixtures containing it) is quite a simple one very similar to creosoting, and it is perhaps not yet well-known that there are at least four timber-fireproofing firms operating in this country and a like number of timber merchants who have experience of fireproofing methods. Most timber merchants already possess most of the necessary plant which is, in essentials, the common creosoting plant, and there can be little doubt that supply could readily keep pace with demand however large.

It is interesting to note that independent authorities, notably the Forest Products Research Laboratory of U.S.A., have since 1930 singled out the ammonium phosphates as being foremost of the most effective single salts among over one hundred and forty preparations tested as fireproofers, and that modern large-scale chemical practice has put monammonium phosphate on the U.K. market at the low price of £19 per ton. The total cost of fireproofing and drying timber has thus been brought below 2s. per cubic foot. This figure does not include the price of the wood, which will vary according to type, an untreated common softwood costing a further 2s. to 2s. 6d. per cubic foot, and plywood about 12s. per cubic foot.

Timber, plywoods, wall-boards, etc. so fireproofed meet adequately the standard tests carried out under the conditions specified by the British Standards Institution.* The compounds are completely stable either as solids or in solution up to temperatures of 140°-150° C. Timber may be fireproofed in several ways. The choice depends on the type of material treated, the degree of protection required and the plant available.

Pressure Impregnation.

This process gives the best results and enables complete protection of thick baulks to be achieved. Special apparatus is required as the vessel must withstand pressures up to at least 150lb. per square inch. The ordinary creosoting cylinder is eminently suitable for this purpose, and anyone who is in possession of such equipment can undertake fireproofing.

Hot-and-Cold Steeping.

Where a pressure cylinder is not available, or perhaps not desirable because of the size and nature of the timber, effective protection of absorbent timbers and complete penetration of thin plywood and pulp board can be accomplished by soaking in an open tank.

Surface Treatment.

Where soaking is impossible, *e.g.* where the timber is already erected, brushing or spraying with a solution of compound (*a*) as mentioned before, gives definite protection against flames of comparatively brief duration.

Fireproofed wood may be planed and sawn as ordinary wood. The presence of salts hardens the surface slightly but not to any serious extent. It is recommended that wood to be fireproofed should be worked as nearly as possible to its final shape before the fireproofing treatment, since the highest concentration of the salts occurs in the surface layer. Glued joints can be made with the same facility as on ordinary dried timber.

Ordinary paints, varnishes and sizes may be used on fireproofed wood. Silicate fire-retardent paints should not be applied to it direct but an adequate insulating layer of mixed white and red oil primer should first be applied.

Protective Mineral Coating.

A mineral substance which may, with great efficacy, be applied to the surface of timber to provide protection against flames is obtainable from crushed rock anhydrite, suitably modified to give it the requisite setting properties and adhesive power when brushed or sprayed onto the woodwork. This recent invention shows great promise to which an impetus has been given by its applicability to air-raid precautions work in attics and other parts of buildings on land. The material is supplied as a powder which has to be mixed with water and stirred to the consistency of thick cream. Its covering power is approximately 600 sq. yards to the ton when applied in a thickness of about $\frac{1}{16}$in., and the efficacy of such a coating may be judged from the following comparative tests of small constructions of normal 1-in. wood planking and timber frames simulating attics of houses in which incendiary bombs were ignited:—

*B.S.S. 476-1932. Definitions for Fire-Resistance, Incombustibility and Non-Inflammability of Building Materials and Structures (Including Methods of Test).

No. of test.	*Type of Protection.*	*General Combustion.*	*Flames through roof.*	*Collapse of Structure.*	*Remarks.*
I	None	Immediate	About 5 mins.	About 20 mins.	Fierce combustion from start.
II	Two coats of limewash	30 sec.	About 5 mins.	About 20 mins.	Fire was retarded in early stages, but final destruction was complete.
III	Two coats of anhydrite	None	None	None	All flame out at 15 mins. The finish blistered in several places. Timber slightly scorched below these points, but structurally unaffected. A small hole was burned in the wood base.

The material is mentioned in the official Air-Raid Precautions Handbook No. 9 (First Edition, 1939) entitled "Incendiary Bombs and Fire Precautions". In ships its most important use would probably be found on the backs of the plywood lining which is separated by an air space from the sides of the hull and on the timber grounds to which these panels are attached, the cost of such coating in the thickness mentioned above being considerably less than that of the red lead paint which is now used as a protection against the effects of condensation—an additional requirement which the material prepared from anhydrite is particularly well adapted to fill by virtue of its capacity for absorbing and losing moisture so as to act as a kind of hygrometric governor. Its appearance, as applied for fireproofing, is rather like that of the cork paint used on the steelwork in ships' cabins to protect against condensation, and it might well also be used for this purpose. Experiments, not yet completed, give grounds for supposing that it will adhere excellently to steel which has been cement-washed, so affording a means of protecting steelwork against loss of strength in a fire which, as already mentioned before, may be as important as the protection of woodwork.

Chemically the material is the same as is used for hard-wall plasters in buildings; it may be used as a depth paint treatment, and like plaster, lends itself to decorative effects by ordinary painting or otherwise.

Fireproofing of Textiles.

Textiles (curtains, upholstery, awnings, etc.) are easily fireproofed by soaking in ammonium phosphate solutions and drying without rinsing, but they lose their fire-resistance if exposed to the leaching action of rain. If used out of doors they require a fixing treatment such as may be provided in the form of chlorinated rubber finish. In the textile field methods of fireproofing still leave much to be desired, but very active research work is being carried out both in this country and in the United States and there can be little doubt that simple yet wholly satisfactory methods will be ready as soon as a real demand develops.

(6) Pest Control.

On board ship as on shore there is increasing recognition of the necessity for controlling various pests either for reasons of public health or for economic reasons. On the public health side the rat menace is by far the most important because of the possibility of transmitting plague from an endemic centre to a fresh area. The acceptance by practically every country in the world of the regulations laid down by the International Sanitary Convention of Paris, 1926, has had a pronounced effect in reducing this possibility. For slight infestations trapping and the use of baits are frequently adequate, but for heavy infestations, or where there is evidence of dead or sickly rats, nothing but complete extermination of the vermin will suffice. This is carried out by fumigation, for which either hydrogen cyanide or sulphur dioxide are the most commonly used chemicals. There is little doubt that on technical grounds hydrogen cyanide is the preferable fumigant but on account of its extreme toxicity to humans it can only be used by specially trained operators, and this makes the fumigation more expensive than the burning of sulphur to produce sulphur dioxide which unfortunately is sometimes regarded as adequate without consideration of real efficiency.

Where passenger liners need to be fumigated the use of sulphur dioxide entails too great a risk of damage to fittings and furnishings, and under such conditions hydrogen cyanide is generally applied. In such ships, however, it is rare to find much rat infestation and there are obvious reasons, apart from measures of public health, why this should be so; but passengers are becoming more resentful of the presence of insects such as cockroaches and bed-bugs. While much may be done by general hygiene to reduce such infestations to the minimum, it is nevertheless quite impossible to guarantee that they will not develop. Fumigation by hydrogen cyanide is generally accepted as being the most reliable method of dealing with such infestations. Its high toxicity enables it to destroy insect life, including eggs, in the period usually required for rat control. Higher dosages are required for such work, and quotations will, therefore, be greater than for rat control work.

(7) Metallurgical Processes.

Heat Treatment of Steels.

The purpose of heat treatment of metals is to produce physical change. Alloy steels, for instance, are very difficult—if not impossible—to machine in the condition in which they are used in service; they are, therefore, annealed or softened to enable machining to be carried out and subsequently heat treated to develop the physical properties required in service. Unfortunately, during heat treatment oxidation may occur on the surface of the metal and so alter the composition. Since the analyses of modern alloys have been very carefully established in order to correspond with certain physical properties such changes are detrimental, and much successful ingenuity has been exercised by the chemist to minimize or prevent them. Sometimes, also, heat treatment is adopted to produce chemical change deliberately, as in carburising, nitriding and anodising, and in such cases it is obviously desirable to have the conditions and factors under complete control so as to obtain exactly the effect desired.

The prevention of oxidation during heat treatment of steel can be ensured either by the use of artificial furnace atmospheres or by the salt bath. Of these two methods the latter is generally admitted to be cheaper to install, simpler to operate and more definite in effect. These baths are mixtures of chlorides containing some compounds, such as sodium cyanide, which prevent the fused salt becoming an oxidising agent. Many parts of a ship's machinery are heat treated, but crankshafts, propeller shafts, turbine rotors, etc., are generally too large to be handled in the salt bath as at present used. There are, however, innumerable tools used in shipbuilding of which parts are heat treated from molten salts containing cyanide. Possibly the most familiar of these is the pneumatic riveter, whose moving parts are hardened in this way so as to ensure uniform and correct hardness and freedom from decarburisation which otherwise is a frequent cause of early fatigue failure. Derrick fittings and chain and anchor shackles are also heat treated in this way.

The cyanide bath is used very extensively for casehardening parts of ships' machinery. Such components as Diesel engine camshafts, pushrods and gudgeon pins, pump shafts and trip gear levers, are regularly casehardened in one of the cyanide-containing salts, the case depths varying from only 0·015in. in the case of pushrods up to 0·08in. for camshafts. There are also very delicate components, such as gyroscope parts, which require very exact control of case depth and which can be conveniently and accurately treated only by means of cyanide. None of the other methods permits the depth of case to be controlled to within 0·001in. while at the same time preserving the part from corrosion and scaling.

A soot-blower is casehardened only where the nozzle slides backwards and forwards in contact with the casing. This is cheaply and rapidly done in cyanide baths by suspending it so that only the part required hard is immersed in the liquid. Any of the other carburising processes would heat up the whole nozzle with consequent waste of time and fuel. Diesel engine pushrods require to be casehardened on the ends only and, as in the case of soot-blowers, only the portions to be hardened are immersed in the salt. Camshafts have to withstand very heavy loading and the larger ones are carburised as deeply as 0·08in. This depth of case is usually associated with the risk of forming a cementite network, a prolific source of cracking, and the cyanide bath has been chosen for this work as the degree of control it affords removes this danger. Progress is constantly being made and the time may not be distant when even the largest moving parts of ships' machinery may also be treated in the salt bath.

The hard wear-and-tear which modern machinery has to withstand demands that the metal used for its construction shall offer great resistance to abrasion and deformation. Certain alloy steels containing aluminium, chromium and other metals, whether cast or forged, receive an extremely hard "case" when they are heated, usually to between 475° C. and 625° C., in an atmosphere of ammonia gas. This great hardness—commonly over 1,000 Vickers Pyramid number—is due to metallic nitrides which are dispersed in the iron matrix, and it is much greater than that afforded by any other process. A noteworthy advantage over other methods is that the nitride hardness is retained at high temperatures. The danger of "seizing" of overheated moving parts is, therefore, small; a point of obvious importance in the development of high-speed internal combustion engines and in difficult lubrication problems.

These nitrided steels are also very resistant to the corrosive action of sea water, fresh water, steam and humid atmospheric conditions; corrosion-fatigue resistance in river water is also very high, the limit being about two-thirds of the normal fatigue value in air. The suggestion that resistance of this type should be of special value in solving problems connected with the corrosion of propeller shafts, centrifugal pumps, etc., may recommend itself to the marine engineer.

The process requires no subsequent quenching process so that this particular cause of cracking is eliminated; there is, moreover, little tendency to the formation of fatigue cracks, since the surfaces remain free from the imperfections which other processes may introduce.

Heat Treatment of Aluminium Alloys.

Light alloys of the duralumin type are rapidly coming into prominence for a great number of constructional and decorative purposes on land, and they are also already widely used in marine aircraft. Their possible application in ships is perhaps more limited, but, like the alloy steels, their number is increasing to supply various needs, and the marine engineer may yet find that some of them will solve difficulties which have at present to be circumvented without entire satisfaction. At the moment their susceptibility to chloride corrosion is still occasionally a source of worry, but it may be hoped that chemical treatments or metallurgical modifications will be found to eliminate this completely.

In order that these alloys may be used to best advantage all require thermal treatment at a temperature of 300°-500° C., depending on their composition, followed by quenching. The nitrate salt bath and muffle furnace methods are probably by now well-known, and are not likely to change greatly for some years to come. It is more likely, in fact, that alloys will be found which will not require special heat treatment.

Many of those now available (and this group includes the most useful) gradually recover their hardness within a few hours of heat treatment. It was known some years ago that their storage at sub-normal temperatures (about -20° F.) would suspend this age-hardening for long periods, but the lowest temperature normally available in a commercial refrigerator was hardly sufficiently low for the purpose.

With the production in this country of solid carbon dioxide, now well-known as a dry, snow-white solid with an evaporating temperature of -110° F., the chemist has presented the metallurgist and engineer with another useful technique in thermal treatment and it has now become easy, with readily available equipment of suitable design, to preserve these alloys in workable form for days. This method has eliminated much waste of time through repeated heat treatments and it does not in any way affect the normal course of the desirable recovery of hardness and high tensile strength at ordinary temperatures when fabrication is complete.

Shrink-fitting.

Mention of solidified carbon dioxide as a low temperature refrigerant recalls a new method of producing "shrink" fits. The practice of shrinking-in machine parts which are to be held firmly together by friction is employed largely on account of their superiority over forced fits, seeing that the use of force may be attended by abrasion.

Until recently, however, when very low temperatures became readily available at low cost, shrink-fitting was limited to parts which could be heated without distortion and in cases where some amount of scale could be tolerated. Thus, it could not be employed for putting the liners of steam-engine cylinders and valve chests in their places, as the casings were usually unwieldly and there was grave danger of distorting them if they were heated in a furnace.

It has now become possible, thanks to solid carbon dioxide, to cool a suitable liquid, such as alcohol or trichlorethylene, to about -100° F. and to "shrink-fit" by immersing in this the part which would formerly have had a very hot and much larger part shrunk round it. With the exception of pure tin, the strong cooling process has no adverse effects either on the crystal structure or the general characteristics of the common non-ferrous and ferrous metals, and the dangers of distortion and scaling are eliminated. The process is, of course, a sort of "through the looking-glass" adaptation of an old and well-known method, but its greater neatness will no doubt recommend it to engineers with widely different problems.

Bright Annealing.

Ammonia gas is finding increasing use also in another form. Consisting as it does of one part of nitrogen with three parts of hydrogen it can be split up into these two constituent gases by passage through a simple automatically-operated piece of apparatus known as a "cracker".

This "cracker" gas contains 75 per cent. hydrogen and is far more free from undesirable impurities than is the hydrogen obtained electrolytically or bought in cylinders. Moreover, at an average price of 16s. per 1,000 cubic feet it is cheaper than commercial hydrogen, and indeed provides an interesting and highly economic source of that material for many purposes.

It is, for example, finding useful application in the bright annealing of electrical resistor alloys, of specially pure irons, stainless steel, brass, bronze, phosphor bronze, nickel silvers, gold, silver and their alloys, in the form of wire, strip, tube, stampings, pressings, etc., in the bright-tempering of tools in autogenous welding and atomic hydrogen welding, and there are still many potential useful applications.

One of the great advantages of ammonia as a potential source of hydrogen in dockyards and workshops where mobility is required is its existence in the highly condensed form of a liquid in the containing cylinders.

The volume of liquid ammonia necessary to produce a given volume of hydrogen, at the pressure at which hydrogen would be released if it were obtained in cylinders, is only one-sixth as great as the volume of the hydrogen under pressure in the latter, or one-eighth the volume of the "cracker-gas" mixture released at the same pressure.

Lead-burning and Brazing.

In the past whenever it has been necessary to use a small hot flame in constructional metal work recourse has been had to either hydrogen or acetylene, either made in a generator or derived from cylinders together with a supply of oxygen gas. Recent work by the chemist in the oil-refining and oil-from-coal fields has afforded another interesting gas, butane, which for many purposes compares favourably with other fuel gases.

It is obtainable in highly condensed liquefied form in light-weight cylinders each of which, containing 28lb. of the product and costing 10s. 6d., will do the same work as 1,350 cubic feet of hydrogen (normally costing from £2 to £4 per 1,000 cubic feet) or 470 cubic feet of acetylene (normally costing from £2 10s. to £4 per 1,000 cubic feet). The amount of oxygen required at the same time is about the same as that which hydrogen requires, and about one-fifth more than acetylene requires. In general the equipment required is the same, but the size of jet used will need to be slightly increased when butane is used.

The temperature of the oxy-butane flame is approximately 2,800° C. which is considerably higher than those of the oxy-coal gas and oxy-hydrogen flames (about 2,300° C.), but lower than that of oxy-acetylene (about 3,100° C.). The oxy-butane flame is of value, therefore, for a multitude of purposes. Its most useful fields appear to be brazing and lead burning, and in the former oxy-butane is preferable to oxy-acetylene which is liable to cause the volatilization of zinc. It is not, however, applicable in steel welding. As regards portability, butane has the advantage that a 28lb. cylinder (of total weight 56lb.) will last as long as thirteen 100 cubic feet cylinders of hydrogen each weighing about 100lb., or as five such cylinders of acetylene.

It is of interest to note, also, the use of butane on small vessels as an alternative source of fuel to oil for heating and, in some instances, lighting.

(8) Refrigeration and the Storage of Perishables.*

Refrigerants.

Marine refrigeration may usefully, if roughly, be classified as applying to ships requiring preservation of food for their crew, to the larger passenger vessels, to refrigerated transport vessels and to ships of war. Each field presents its own problems.

It seems logical to suppose that the first of these types will develop along the lines followed by developments in domestic and other small refrigerating units on land. The second seems very like the refrigeration problem of the large hotel, except of course insofar as the safety requirements of the Home Office may, quite justifiably, not coincide with those of the Board of Trade. The third differs considerably from land practice in the choice of refrigerant, in the design of plant and in the handling of the refrigerated commodities. The fourth is the province of the naval constructor who will have to deal with food storage and with temperature control in magazines, etc., involving problems not encountered elsewhere.

Hitherto ammonia and carbon dioxide have been almost the only refrigerants used at sea, carbon dioxide predominating because its physiological effects and its effects on refrigerated products are so slight, though quite a large proportion of ammonia is still used in sea-going plant. A count made from Lloyd's Register for 1935-36 showed 781 refrigerated ships, 88 per cent. of which were using carbon dioxide and 11 per cent. ammonia.

The past seven of eight years has seen the discovery and gradual development in the U.S.A. and subsequently in this country of a new series of refrigerants, one at least of which has some very striking properties. This is Freon (F12)—or, to the chemist, dichlorodifluormethane. Comparing it with ammonia and carbon dioxide we may note the following points:—

Firstly, the choice of carbon dioxide for use in ocean-going refrigeration plants because of its lack of unpleasant characteristics has involved the engineer in the construction of very heavy plant with a large power consumption which is the result of high operating pressures. Freon has the advantage that its operating pressures are even less than those of ammonia, while, at the same time, it is even less toxic than is carbon dioxide. Whereas refrigeration with carbon dioxide consumes 1·84 h.p. per ton and involves a delivery pressure of about 1,030lb. per sq. inch, Freon requires only 0·96 h.p. per ton of refrigeration and a delivery pressure of about 95lb. per sq. inch.

Freon is almost as free from odour as is carbon dioxide; like the latter it is very stable, and it is non-inflammable. It has the advantage over both ammonia and carbon dioxide in that, when uncontaminated, it is without appreciable corrosive action on any metal normally used in refrigeration work, and it is not absorbed by and will not damage, or even taint, any refrigerated commodities —meat, fruit, vegetables, milk, etc.—with which it may have contact through leakage.

Food Transport.

For several years now there has been considerable activity in the improvement of methods of food preservation during transport on land and it seems highly probable that the future will see them adapted to transport by sea. In this field the chemist has joined forces with the biologist, and between them they have made striking progress in several directions by applying separately or conjointly the general principles of refrigeration, air-conditioning and antiseptic gas storage. The marine engineer who follows this progress will appreciate the important part his design work and construction will play in the adaptation of their findings to conditions on board ship. Let us examine their results more closely:—

(a) "Quick-Freezing".

One notable development is that of "quick-freezing" technique.

What are called "quick-freezing" methods depend for their action either on the rapid circulation of very cold air or other gas, direct immersion of the goods in very cold brine, direct spraying with brine, the use of fine sprays or fogs of cold brine, indirect immersion or spraying, contact with one or more heat-conductive cold plates, volatilization of liquids in direct or indirect contact with the product, or a variation or combination of these means. With their aid it has been made possible to preserve in excellent condition such perishable foodstuffs as fish, meat products, fruits and fruit juices and vegetables; in fact, a wide range of such products as by virtue of their availability in small or thin units, lend themselves to rapid freezing.

Some of the North European countries already have trawlers equipped for "quick-freezing" fish, but most of the "quick-frozen" commodities seen in this country are, as yet, frozen at fishing ports or land stations.

"Quick-freezing", however, is not alone sufficient to ensure the successful distribution of frozen perishables; most of them will have to be shipped long distances at very low temperatures if full advantage is to be taken of the opportunity the new technique affords of introducing out-of-season or even hitherto rare products to the consumer.

(b) Gas Storage of Perishables.

It has been found in recent years that the bacterial deterioration of meat which, as is well known, is retarded by chilling or freezing, is almost

*Contributed by A. C. Finch, B.Sc. (Hons.), M.Sc.

stopped by storing it in an atmosphere containing carbon dioxide gas. This is the familiar refrigerant used in a very different way. Carbon dioxide, it appears, although harmless to man, kills some meat bacteria and very materially decreases the rate at which others multiply.

To the authors of the present paper the history of this discovery is a source of gratification, being a case where research work initiated by their company has lead to the benefit of the shipping industry in a way which may not be generally appreciated. The matter originated in another of the investigations relating to the prospective uses of solid CO_2, the engineering and metallurgical applications of which have been mentioned a few pages back. Among these uses is the availability of the solid as a convenient source of gaseous CO_2, and experiments carried out at the instance of this company in using the latter as a means of checking bacterial growth on fish proved so promising that they were followed up by the Food Investigation Board of the Department of Scientific and Industrial Research in connection with meat. As an outcome of this, the first shipment of "gas-stored" chilled beef was made in 1933 from New Zealand at a temperature of 30° F. and in an atmosphere containing 10 per cent. of carbon dioxide. Since then a large number of ships have been fitted out for gas storage, and they are in regular service.

Atmospheres containing about 10 per cent. carbon dioxide and cooled to 41° F. have proved equally useful for the transport and preservation of apples for periods even of eight months. It should be noted that each strain of apple has its own idiosyncrasies and the research work necessary to afford all the information needed is still in progress.

Experiments in the United States have shown that sweet cherries, plums, peaches, Bartlett pears, raspberries, blackberries, figs, grapefruit and oranges respond excellently to the preservative effects of carbon dioxide, even without the use of refrigeration. Thus, in certain experiments the effect of storing the fresh fruit at ordinary temperature in an atmosphere containing carbon dioxide was quite equal to that of immediate storage at 32° F. Injury may occur if the carbon dioxide content rises above about 25 per cent.; normally 10-15 per cent., or even less, is quite sufficient. Carbon dioxide retards the ripening of tomatoes and the development of certain types of decay; too high a carbon dioxide content seems occasionally, however, to inhibit subsequent ripening altogether.

Cabbage, Chinese cabbage, broccoli, cauliflower, kohl-rabi, collards, spinach, turnips, beets, corn, iceberg lettuce, ripe bananas, avocados and papayas have all been kept in perfect condition, even with improvement in flavour for previously impossible periods of time by the adoption of the method, and the list is growing.

We may anticipate, also, the importation of flowers out of season or of varieties as yet generally unknown. Commercial trials carried out only during the past two or three years have shown that cut flowers, including iris, carnations, tulips, smilax, gladioli and peonies can be transported in firm and fresh condition over long rail journeys in England and by sea from the Channel Islands either in cold storage or carbon dioxide storage, or, better, in a combination of the two. In all cases the treated blooms reached market in better condition than did the untreated controls, and in many cases their life was appreciably lengthened.

Rabbits, poultry and game seem to show very much greater response to gas storage than to chilling and freezing. Fish, particularly dried fish which cannot be packed in ice or kept in a very damp atmosphere, can be kept very fresh for long periods if stored at 15° F. in atmospheres containing carbon dioxide; it is, in fact, recorded of early trials to the antipodes that the fish was "bad" on arrival and that subsequent investigation revealed the fact that what had been taken for a "bad" flavour was a "very fresh" flavour hitherto unknown in that market in connection with the fish in question.

So far, therefore, as these trends can be taken as indicating the lines of development in the near future, it would appear that carbon dioxide, hitherto well-known on board ship as a refrigerant only, will tend to become rather less used for that purpose and more and more used as a gaseous antiseptic. The course of this change seems likely to be marked by the design of lighter refrigerating equipment, probably using a refrigerant of the Freon type, and the construction of gas-tight holds in refrigerated merchant vessels. The changes will, of course, have also their influence on the training of those sea-going engineers who are responsible for the control of the conditions required. The rate of development remains to be seen, but, since the new ideas are already so well advanced in other parts of the world, it seems likely enough that appreciable progress may be noticed in Europe during the next few years.

In conclusion, the collator acknowledges as sources of the information contained in this paper, the contributions of specialists in various sections of Imperial Chemical Industries Limited.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Wednesday, 13th December, 1939.

Members.

Charles Chapman, 60, Arisaig Drive, Mosspark, Glasgow.

Thomas Stevenson Craggs, "Semiramis", St. Aidans Road, Wallsend-on-Tyne.

William Dempster Gardner, c/o Water Dept., P.W.D., Hong Kong.

John Edward Smith Kenningham, 100, Brampton Road, St. Albans, Herts.

Matthew Scott, c/o Water Dept., P.W.D., Hong Kong.

Thomas Spence, "Te Rangi", South Weald Road, Brentwood, Essex.

Associate Member.

John Hodgson Kirby, "Rosemount", Ribchester, nr. Preston, Lancs.

Associates.

John Munn Deheer, "Donna Nook", Kingsgate, Bridlington, Yorks.

John Lennox, 41, Tichfield Road, Troon, Ayrshire.

Albert Henry Swinburne, 30, Lord Street, New Silksworth, nr. Sunderland.

Richard Stuart McRae Harris, "Tremorden", 14, Green Lane, Purley, Surrey.

John Leslie Henderson, 12, Falkner Street, Liverpool 8.

Student.

John Joseph Hague, "The Smithy", Tarleton, near Preston, Lancs.

Probationer Students.

Edward Graham Sims, "Earlham", 51, Parkland Grove, Ashford, Middlesex.

Frank Parkin, 107, Humberstone Road, Grimsby, Lincs.

Transfer from Associate to Associate Member.

James Leask Sutherland, 2, Gainsborough Road, Malden Way, Kingston-By-Pass, Surrey.

Transfer from Student to Associate.

Thomas Dickerson, 47, Somerton Park, Antrim Road, Belfast.

John Hamilton, 53, Ferguson Avenue, Renfrew.

Edmund Heys, "Min-y-Don", Pensby Road, Thingwall, Birkenhead.

Walter James Hicks, 45, Rosemary Avenue, Finchley, N.3.

Donald Thomas Oxton, Nightingale Corner, Layer-de-la-Haye, nr. Colchester.

ADDITIONS TO THE LIBRARY.

Purchased.

Official Year-book of the Scientific and Learned Societies of Great Britain and Ireland. Charles Griffin & Co., Ltd.

Transactions of the Congrès International des Ingenieurs Navals, Liége.

The following British Standard Specifications:—

No. 329-1939. Round Strand Steel Wire Ropes for Lifts and Hoists.

No. 878-1939. Comparative Commercial Tests of Coal or Coke and Appliances in Small Steam Raising Plants.

No. 443-1939. The Testing of the Zinc Coating on Galvanised Wires.

No. 876-1939. Hand Hammers.

Specification No. 876 deals with joiners', engineers' smiths', stonebreakers' and boiler scaling hammers. The specification was prepared at the request of the Institution of Mechanical Engineers in close co-operation with the Edge Tools Manufacturers Association, and is intended to cover all the hand hammers in general use. Both form, dimensions and weight are dealt with and requirements are included governing the quality of the material used, together with practical tests on the hammer, etc.

9 sizes of joiners' hammers are specified between 4 and 20 ozs. in weight.

11 sizes of engineers' ball, cross and straight pein-hammers are dealt with between ¼ and 3lb. in weight.

12 sizes of sledge hammers—double face and cross pein—are included between 1 and 16lb. in weight.

6 smiths' and club hammers are included between 1½ and 4lb. in weight.

5 sizes of stonebreakers' hammers are included between 1 and 2lb. in weight.

3 sizes of boiler scaling hammers of 1, 1¼ and 1½lb. in weight.

2 pin hammers of 3½ and 4 ozs. in weight.

Munro's Engineer's Annual, 1940. James Munro & Co., Ltd., 159 pp., illus., 2s. 6d. net.

There will be found in the pages of this annual a variety of technical articles which should have an appeal to those whose interest lies on the marine side of engineering, *e.g.* "Cylinder Wear in Diesel Engines" by Gander, "A New Form of Ship Propulsion" by Sword, "After Parsons—Whom?" by Butler, and "Modern Welding and Its Relation to Marine Work" by Brett. For engineer officers who are interested in the Board of Trade Examinations, Messrs. Barr and Martin of MacGibbon's School, Glasgow, give much material data. The book is, of course, complete with the usual tables which have always been a feature of it.

Introduction to Electrical Machines. By A. W. Hirst, M.Sc. Blackie & Son, Ltd., 122 pp., illus., 5s. net.

This book is one of a series which, to use a well-worn phrase, meets a long-felt want. The publishers and author have realized that to many engineering students who are probably still serving their apprenticeship, 15s. upwards is a considerable sum of money. To quote the preface, "The object of the series is to provide, at a low price, a number of comparatively small volumes, each dealing with one particular section of electrical engineering". Thus the student can buy as he needs them individual volumes without putting too great a strain on his financial resources.

Professor W. M. Thornton, O.B.E., Past-President of The Institution of Electrical Engineers, once remarked that the whole of electrical engineering could be put on the back of a penny stamp. This was no doubt a poetic exaggeration, but his purpose was to impress on a number of students, of whom the reviewer was one, that the whole structure is built on the foundation of a comparatively small number of basic fundamental principles. The present volume is intended to cover those fundamental principles which must necessarily be common to several volumes, in order to avoid repetition and save space. The six chapters cover electromagnetism and electromagnetic induction; the magnetic circuit and magnetic calculations; the electromagnetic machine; insulation and insulating materials; losses, heating, and the ventilation of machines, and a final chapter on harmonic analysis.

The treatment is extremely lucid throughout, and a very useful feature is the full discussion of the general method of making magnetic calculations, the estimation of leakage coefficient and leakage reactance, the M.M.F. wave produced by polyphase windings, and the mathematical theorems underlying the usual methods of harmonic analysis. It is frequently found that many students find difficulty in carrying out correctly the magnetic calculations for electrical machines. One feels that it might have been an advantage if a specimen calculation had been given carried out in tabular form as is usually done in practice, rather than leave it in the stage of equating the M.M.F. to the total flux multiplied by the summation of the reluctances of the various parts of the magnetic circuit. Admittedly, the general procedure in practice is briefly outlined, but a concrete example would have clinched the matter, and would not have taken up much space. The few pages dealing with output coefficients are remarkably well presented.

In addition to the general excellence of the subject matter the book is most attractively laid out. The illustrations, which are ample, are in the form of clear line diagrams. One is in entire agreement with the opinion expressed that photographs are seldom as informative as a line drawing, and in any case are always available in the catalogues of the leading electrical manufacturers.

This book should prove of much value to Higher National Certificate and degree students. It should also prove a handy work of reference to many practising engineers, who occasionally wish to revise their fundamentals. Messrs. Blackie and Mr. Hirst are to be congratulated on this first volume. One awaits the other volumes of the series with interest.

Electrical Technology. By H. Cotton, M.B.E., D.Sc. Sir Isaac Pitman & Sons, Ltd., 541 pp., 435 illus., 4th edn., 12s. 6d. net.

Intended as a textbook for the National Certificate, City and Guilds, the Institution of Electrical Engineering and the B.Sc. degree examinations, this work now appears in its fourth edition and there is no doubt that its success is deserved.

Although the book is written primarily for examination purposes, the practical side has been kept in view, and it will therefore have appeal to practical engineers as well as to students. The fundamental principles of electrical technology, both direct and alternate working, are covered, as are also certain principles of design, but no detailed designs are worked out as these are beyond the scope of the book. The mathematical knowledge required of the reader is, on the whole, elementary, except in the chapter on electrical oscillations, in which differential equations are used of necessity. There is a large number of worked examples in the text, and most of the chapters have questions to be answered; these are mainly drawn from examination papers set by the London University and by the City and Guilds of London Institute.

In this new edition certain rearrangements have been carried out with the view to presenting the material in a more logical sequence. The direct-current section remains practically unchanged, but in the alternating-current section the theory of polyphase circuits now follows immediately after the single-phase circuit. In this way it is possible to treat the alternator and synchronous motor as polyphase machines instead of single-phase machines only, as in previous editions. Owing to the industrial importance of the polyphase commutator motor the fundamental principles of operation of this class of machine have been added to the chapter previously dealing with the single-phase motor only. The chapter on illumination has been removed from the direct-current section to a new section at the end of the book, and it has been enlarged slightly by the addition of a short description of the modern discharge lamp.

Practical Microscopical Metallography. By R. H. Greaves, D.Sc. and H. Wrighton, B.Met. Chapman & Hall, Ltd., 3rd edn., 272 pp., 331 illus., 18s. net.

The first edition of this book found a place on the shelves of most metallographers and also appealed to students generally. The new edition has advanced with the times and cannot fail to succeed. The authors' methods of presentation are beyond criticism. Within the limits of its title this is a highly desirable and fine work, probably the best of its kind.

The authors' tendency to plunge into practical metallurgy of indifferent quality is unexpected. For example, the chapter upon cast iron offers the well-worn and largely inaccurate platitudes concerning sulphur and manganese and, moreover, presents to the unwary the following picture—*cast iron has an ordinary silicon content of 2·5 per cent. being white with 1 per cent., its greatest tensile strength occurs with about 1·8 per cent. of silicon and 0·7 per cent. of combined carbon.*

The metallography of our metals of commerce would more than occupy the space now devoted to matter of the above kind and would contribute to the high standard of this otherwise excellent book.

Ripper's Heat Engines. Revised by A. T. J. Kersey, A.R.C.Sc. Longmans, Green & Co., 337 pp., 226 illus., 5s. net.

Much of the original work of Professor W. Ripper is retained both in the text and in the method of presentation in this new edition. The book has already gained a wide reputation as a comprehensive, introductory text book on steam, the steam engine, boilers, turbines and the internal combustion engine. The endeavour in the present revised edition has been to bring the subject matter up to date. Such a task necessarily involves a great deal of condensation if the book is to retain its original size and cost and in consequence, if criticism may be levelled, too much material is introduced in the small compass intended for an elementary treatise.

A new set of useful examples to be worked by the student has been supplied at the end of the book together with a complete set of answers. The edition has been well illustrated throughout with excellent diagrams and in its new form it should continue to be as popular as before. It is certainly worthy of an appointed place on the student's bookshelf if only on account of its inexpensive appeal.

JUNIOR SECTION.

Electricity Applied to Marine Engineering (Section 12).

By W. LAWS, M.Sc., A.M.I.E.E.

Alternating Current Motors.

The manner in which a magnetic field, approximately constant in magnitude and rotating in space, is produced when three-phase current is fed into a three-phase winding was described in Section 11. The speed of the field is given by

$$\text{r.p.m.} = \frac{\text{frequency} \times 60}{\text{pole pairs}}$$

It should be remembered that the field rotates relatively to the windings with which it is associated.

In this section we will consider how this rotating field is utilized in the operation of three-phase motors. There are two main types to be considered :—

(*a*) The Induction Motor.
(*b*) The Synchronous Motor.

(*a*) *The Induction Motor.*

Consider Fig. 109. Suppose *A* to be a stator core wound with a three-phase winding so that when three-phase current is supplied to it a rotating field is produced. The lines of force of the rotating field are

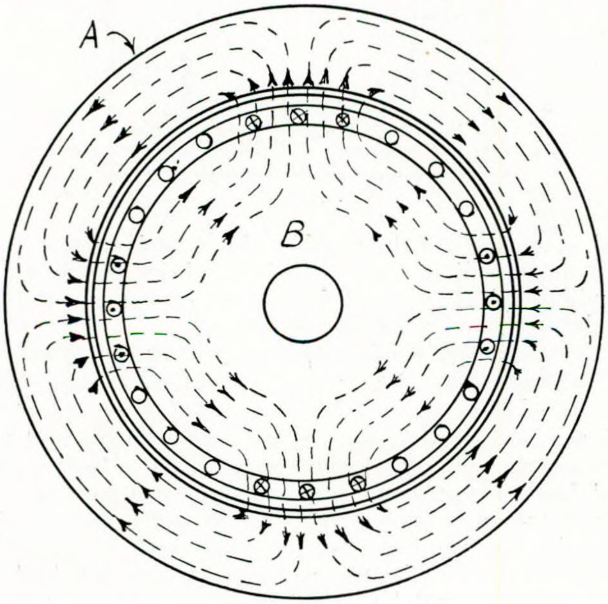


FIG. 109.

indicated by the dotted lines, and the field is supposed to be rotating about the centre in a clockwise direction. Let *B* represent a rotor core having copper bars lying in slots axially round the outer periphery, these bars being all short-circuited together at their ends by heavy rings of copper or brass or gunmetal. If the rotor is stationary and the supply be switched on to the stator, the rotating magnetic field due to the stator currents will sweep past the bars in the rotor in a clockwise direction. The electrical effect will be the same as though the magnetic field were held stationary in space and the rotor were rotated through it in a counter-clockwise direction. Remember, as was emphasized in another place, it is the *relative* motion of the two that matters. Relatively to the field, the rotor may be considered as rotating in a counter-clockwise direction. Because there is relative motion between the bars and the field, voltages will be induced in the bars, and because the bars and their short-circuiting end rings form a closed circuit, currents will flow in the bars. An application of Fleming's Right Hand Rule (see Section 3) shows that the currents will be flowing up out of the paper towards the reader in the bars lying under north poles and away from the reader down through the paper in the bars lying under south poles. Now the next step in our reasoning is of great importance. Once this current is flowing it *is* flowing. It is a *fait accompli.* It does not matter how or why it started flowing, it *is* flowing. One of the fundamental laws of nature is that if an electric current flows through a conductor lying in and at right-angles to a magnetic field, the conductor is acted on by a force tending to move it across the field. The mutual directions of current, field, and force are given by Flemings' Left Hand Rule (see Section 2).

Applying this rule to the conductors, we find that they are all acted on by a force tending to move them round in a clockwise direction, that is, in the same direction as the stator rotating field is travelling. The rotor therefore, being built on a shaft mounted in lubricated bearings turns round. What about its speed? If it were to run at the same speed as the stator rotating field, there would be no relative motion between the two and therefore no cutting of lines of force, no induced volts, no current, no force, and therefore no motion. It cannot therefore run at exactly the same speed as the rotating field. It must run at a slightly slower speed, so that *relatively* it is slowly moving through the flux in a counter-clockwise direction. If the mechanical load on such a motor be increased it naturally slows down a little, that is, it is moving faster through the flux in the opposite direction to the direction in which the field is travelling. Since the voltage induced in the bars depends on the rate of cutting magnetic flux, the voltage will be increased. Therefore the current will be increased. Therefore the force, which it will be remembered is proportional to the product of current and flux density will be increased. So the increased torque necessary to cope with the increased mechanical load will be produced.

Slip.

The difference between the speed of the rotating field and the speed of the rotor is called the "slip", and is usually expressed as a percentage.

Example.

A four-pole inductor motor is supplied with current at a frequency of 50 cycles per second. The speed of its rotor is 1,470 r.p.m. Calculate the percentage slip.

$$\text{Speed of rotating field} = \frac{\text{frequency} \times 60}{\text{pole pairs}} \text{ r.p.m.}$$
$$= \frac{50 \times 60}{2} \text{ r.p.m.}$$
$$= 1{,}500 \text{ r.p.m.}$$
$$\text{Slip revolutions} = 1{,}500 - 1{,}470.$$
$$= 30 \text{ r.p.m.}$$
$$\text{Percentage slip} = \frac{30}{1{,}500} \times 100.$$
$$= 2 \text{ per cent.}$$

The slip is expressed as a percentage of the synchronous speed, *i.e.* the speed of the rotating field, *not* as a percentage of the actual speed of the rotor. This is a mistake frequently made by students in examinations. The slip varies from about 0·7 per cent. on large-output fairly high speed motors up to 7 or 8 per cent. on very small motors, but is never more than a few per cent. under normal working conditions. About 2 per cent. is a fair average figure.

Starting.

If an induction motor is switched straight on to the supply it takes a current from the line of anything from about five times to eight times its normal full load current. Its starting torque may be anything from about one half normal full load torque to perhaps one-and-a-half times its normal full load torque depending on its design. It is impossible to lay down definite limits because there are many factors involved which are quite outside the scope of this article. If the rotor is of the type described above, *i.e.* a number of bars short-circuited by end rings it is known as a squirrel-cage, or simply a cage, rotor. An induction motor having such a rotor may be started in one of three ways as follows :—

(1) Switched direct on to the mains.
(2) Star-delta start.
(3) Auto-transformer start.

(1) This is self-explanatory.

(2) For a star-delta start the ends of the three stator phases are brought out to six terminals. These are connected to a special form of switch, illustrated diagrammatically in Fig. 110, in the first starting position

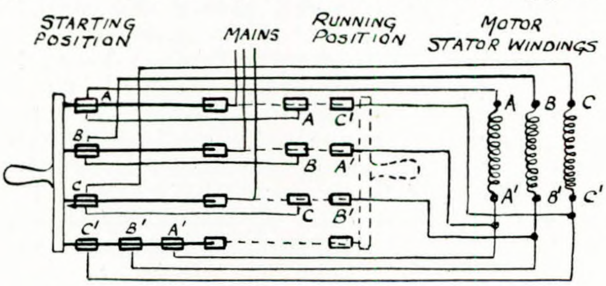


FIG. 110.

of which they are connected star, and after the rotor has attained full speed the switch is put over to its running position connecting the phases delta. The purpose of this is to reduce the voltage applied to the stator phases to $\frac{1}{\sqrt{3}}$ of the line voltage at start. If this is done, both the starting torque and the starting current are reduced to $\frac{1}{3}$rd what they would have been had the motor been switched straight on to the mains. For example, suppose a squirrel-cage motor were such that if switched straight on to the main it developed 90 per cent. of its normal full load torque and took six times its normal full load current from the mains. On star-delta start it would develop $\frac{90}{3}$ *i.e.* 30 per cent. of its normal full load torque, and take $\frac{6}{3}$ *i.e.* twice its normal full load current from the mains.

(3) Before describing the auto-transformer it will be as well to describe shortly the action of an ordinary double winding transformer. Consider Fig. 111. If an alternating current be passed through the primary winding P it will set up a magnetic flux, which will be itself alternating in the iron core. This flux as it grows from zero to a maximum, dies away to zero, grows to a maximum in the opposite direction, dies away to zero

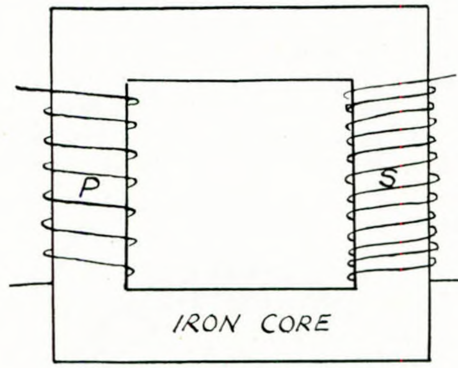


FIG. 111.

and so on, will cut the turns of the secondary winding S. A voltage will therefore be induced in the secondary winding and its size will depend on the number of turns in the secondary winding. In short :—

$$\frac{\text{voltage applied to primary}}{\text{voltage induced in secondary}} = \frac{\text{turns on primary}}{\text{turns on secondary}}.$$

It is therefore possible to supply electric power at a low voltage and high current to the primary and take very nearly the same amount of power at a high voltage and low current from the secondary. Obviously, we cannot take more power out than we put in, nor yet can we take the same amount of power out, because that would mean that the transformer was one hundred per cent. efficient, and high as transformer efficiencies are, we have not yet arrived at the desirable state of one hundred per cent. efficiency. Large transformers have been built with efficiencies of over ninety-nine per cent.; and transformer efficiencies are usually well up in the nineties. In passing it may be remarked that in practice transformers are not built with the primary winding on one leg and the secondary on the other because of magnetic leakage. They are built with both windings on both legs.

An auto-transformer consists of only one winding on an iron core, this winding being tapped at suitable proportions of its length to give corresponding proportions of the voltage across the whole winding. They are generally used when the transformation ratio is small, *e.g.* less than 2 : 1.

When used for starting squirrel-cage induction motors the full mains voltage is applied to the full winding and some suitable proportions tapped off for the motor stator windings. For a three-phase motor there will, of course, have to be three windings on the auto-transformer. In this case the starting current and starting torque are both reduced to (transformer tapping)^2 what they would have been had the motor been switched straight on to the mains. Supposing the motor mentioned above had been started by means of an auto-transformer on a 60 per cent. tapping, then the starting torque would have been $\frac{90}{100} \times \left(\frac{60}{100}\right)^2$ *i.e.* $\frac{32 \cdot 4}{100}$ or 32·4 per cent. of what it would have been if switched straight on, and the starting current would have been $\frac{600}{100} \times \left(\frac{60}{100}\right)^2$ *i.e.* $\frac{216}{100}$ or 216 per cent. of what it would have been if switched straight on.

Induction Motors with Slip Ring Rotors.

For induction motors of large output, the current demand from the mains at start would probably be excessively large if the motor were of the squirrel-cage type and started by any of the methods described. In such a case the rotor itself is wound with three phases connected either star or delta. The leads from the rotor windings are brought out to three slip rings mounted on the shaft, and by means of carbon brushes resting on these rings the rotor winding can be connected to a three-phase starting resistance, either liquid or metallic, which is gradually reduced and finally short-circuited as the motor runs up to speed. By this means it is possible to start the motor against the maximum torque of which it is ever capable, about one-and-three-quarters to two-and-a-half times normal full load torque, with a current demand of two to three times normal full load current. Alternatively, it can be started against normal full load torque with little more than normal full load current. The actual figures will, of course, depend on the actual circumstances, and on the design of the motor. Such a motor is called a slip-ring induction motor, or a wound rotor induction motor.

(b) The Synchronous Motor.

The operation of this type of motor is entirely different from that of the induction motor. Whereas the induction motor cannot run at one hundred per cent. synchronous speed, the synchronous motor cannot do anything else. Let us suppose that an alternator stator has been supplied with three-phase current producing the rotating field already described. If, with its d.c. field open-circuited (the d.c. field being the rotating element of the machine) the rotor is run up to the same speed as that at which the stator field is rotating, and the direct current excitation is then switched on, the poles of the rotor will become magnets, and there will be two rotating fields, one inside the other. One of the first things learnt in the study of elementary magnetism is that unlike poles attract each other. The stator and rotor are both wound for the same number of poles. The result is that each north pole of the stator attracts to itself the nearest south pole to it of the rotor field, and each south pole of the stator field attracts to itself the nearest north pole to it of the rotor field. The attraction is of course mutual. The two fields then lock together and the rotor continues to be dragged round by magnetic attraction at precisely the same speed at which the stator field is rotating. The machine is now running as a synchronous motor. Mechanical load can be put on the rotor and it will stand up to it up to a certain maximum, though it will slip back a little relative to the stator rotating field and then continue running at the same speed as the stator field. Under a uniform torque load, provided that the frequency of the supply remains constant, the rotor speed remains one hundred per cent. constant at the speed of the stator field. That is why it is called a synchronous motor. The process may be likened to some form of claw clutch. The two halves of the clutch can be made to engage when running, only if both are running at the same speed and if lined up together. The engaging of the two halves might be facilitated by chamfering off the edges of the claws, so that they might be rammed home together even if not quite truly lined up, and even perhaps if running at not quite exactly the same speed. But once they are engaged they must run at the same speed. There can be no question of any slipping as there is in a friction clutch. If load be put on the clutch, shearing stresses will be set up in the claws, and there will also be a microscopic strain. If load be put on the synchronous motor the magnetic field will be strained. Another mental picture of the operation which can be made is to think of two rings one inside the other and having a common centre. The two rings may be considered as connected together by thin strands of india-rubber. If the outer ring is rotated about its centre it will drag the inner ring round by means of the strands of rubber, there being a certain slight stretch in the rubber depending on the frictional resistances opposed to the motion of the inner ring. If these resistances be increased, the rubber will stretch some more. There will come a time when the increase in the resistance will snap the rubber strands. If we think of these rubber strands as magnetic lines of force we will get a very rough picture of how the synchronous motor works. Reverting to the claw clutch, it is conceivable that if we loaded the clutch up sufficiently we might shear off the claws. This corresponds to the rubber strands snapping, or to the magnetic pull of the lines of force not being strong enough to stand up to the stress put on them. Readers may remember that in the first section it was mentioned that in dealing with electrical matters it is very necessary to have some kind of mental picture of what is going on. Some highly competent mathematicians do not appear to require any mental picture of a physical happening; they visualise it all in terms of mathematical symbols. But it is a fairly safe bet that the illustrious Michael Faraday who was no mathematician—at least not as mathematicians understand the term "mathematician"—

had very clear pictures in his mind of what was going on when he was conducting his historic experiments, and what was good enough for him is probably good enough for us. It does not matter what the picture is so long as it works. That is the test. Are we able with the help of our pictures to foretell with reasonable accuracy what effects will follow certain causes, or to diagnose the cause of a given effect? This is what the late Professor Tyndall described as "the scientific use of the imagination".

It was mentioned that the synchronous motor must be first run up to approximately its correct working speed before both stator supply and rotor supply, *i.e.* the exciting current, may be switched on together. This running up may be done in several ways, three of which are as follows:—

Pony Motor Start.

This consists in having a small induction motor which is a self-starting machine mounted on an extension of the main synchronous motor shaft. The induction motor is usually wound for one pair of poles less than the synchronous motor, so that its synchronous speed is higher than that of the synchronous motor. A salient pole synchronous motor usually has a fairly high flywheel effect, so that it accelerates reasonably slowly. If then the set is run up to speed with the direct-current excitation switched on, the three-phase current can be switched on to the synchronous motor stator as its rotor is running through synchronous speed. It then pulls into step and the supply can then be cut off the pony motor.

A method which has been used by the B.T.H. Co. is illustrated in Fig. 112. The stator windings of the pony

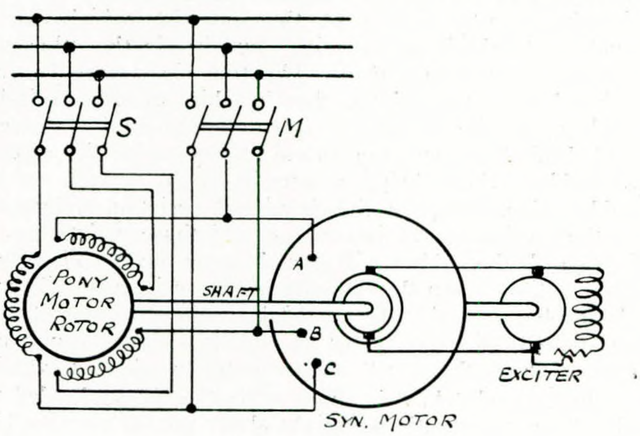


Fig. 112.

motor are connected in series with the stator windings of the synchronous motor. An exciter is mounted on the synchronous motor shaft so that as the speed rises the exciting current supplied to the poles of the synchronous motor is gradually increased. When the set has attained synchronous speed, the synchronous motor pulls itself into step. The switch *M* can then be closed and the switch *S* opened, thus putting the synchronous motor directly on to the mains and cutting the pony motor out of the circuit.

Starting by Exciter.

When a synchronous motor has its own exciter, and there is moreover an independent direct-current supply it can be started up using its exciter as a starting motor. The exciter is connected to the direct current supply and runs as a motor. It is accelerated to a speed above the synchronous speed of the synchronous motor and then taken off the direct-current supply. The set then starts to slow down, fairly slowly owing to its high flywheel effect, and of course it is now driving round the armature of the exciter. As it runs through its synchronous speed the exciter is switched on to the field of the main motor which then pulls into step, the three-phase supply having already been switched on to its stator.

Asynchronous-synchronous Start Using Damper Bars.

This method is of special interest to marine engineers because it is the method which has, up to the present, been used to start up the propulsion motors of ships with turbo-electric drive. In essence it consists of superimposing a squirrel-cage rotor on a salient-pole rotor. This is done by fixing stout copper bars in slots along the pole faces of the salient poles, the bars lying parallel with the shaft. The bars are short-circuited by rings running round the rotor periphery forming a squirrel cage.

The equipment consists of a steam turbine driving a turbo-alternator which is connected through appropriate switchgear to the propulsion motor. In a twin-screw vessel, one alternator may supply two propulsion motors; other arrangements are possible some of which will be indicated later. The sequence of operations when starting from rest is broadly as follows:—

(1) The turbine is run up to approximately $\frac{1}{8}$th speed without any excitation on alternator or motor.

(2) The direction switches are set for ahead or astern running as desired.

(3) The turbine is speeded up to about ^{1}th normal speed.

(4) The alternator is over-excited. This is to ensure a powerful starting torque on the motor. Being excited, the alternator generates a voltage which pumps current through the motor stator windings. The motor then starts to rotate *as an induction motor* because of the currents induced in the damper bars embedded in the pole faces. It accelerates to approximately $\frac{1}{5}$th of its normal speed, the difference between its actual speed and its synchronous speed, for the frequency being supplied at this stage by the alternator, being the slip already referred to. The alternator itself at this stage is supplying current at about $\frac{1}{5}$th normal working frequency.

(5) The motor salient pole field is now excited with direct current, causing the motor to pull into step as a synchronous motor.

(6) The alternator excitation is now reduced to normal.

(7) The turbine speed is adjusted to anything between ^{1}th full speed and full speed from the turbine governor.

(*Note.*—The speed control must be done from the prime mover end. The only way in which the speed of the synchronous motor can be varied is by adjusting the frequency of the supply. This means adjusting the alternator frequency which can only be done by altering its speed, and this can only be done by adjusting the prime mover's speed).

To Shut Down.

Throttle the turbine down to about $\frac{1}{5}$th speed and cut off all excitation.

To Reverse.

Go through the operations for shutting down, change over the direction switches and then start up again.

With regard to reversal, an alternating current motor, either synchronous or induction, has its direction of rotation reversed by changing over any two leads to the stator windings. Fig. 113 shows how reversal may

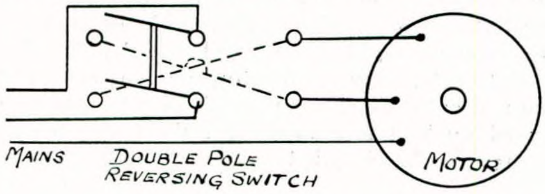


FIG. 113.

be accomplished using a very simple form of reversing switch.

With the turbo-electric equipment, gearing can be dispensed with because the speed reduction is inherent in the number of poles for which the alternator and motor respectively have been wound. For example, consider a two-pole turbo-alternator driven at 3,000 r.p.m. and a propulsion motor wound for 40 poles.

The frequency of the current supplied by the alternator is given by:—

$$\frac{\text{pole pair} \times \text{r.p.m.}}{60}$$

$$= \frac{1 \times 3{,}000}{60}$$

$$= 50 \text{ cycles per second.}$$

The synchronous speed of the motor is given by

$$\frac{\text{frequency} \times 60}{\text{pole pairs}}$$

$$= \frac{50 \times 60}{20}$$

$$= 150 \text{ r.p.m. propeller speed.}$$

That is, there is a speed reduction ratio of 20 : 1 inherent in the electrical machine windings.

In an actual equipment there are all sorts of interlocking devices making it impossible to carry out the operations in the wrong sequence.

It was mentioned above that various arrangements were possible. The "Viceroy of India" has two turbo sets and two propulsion motors. Either motor can be driven from either alternator or both motors can be driven from either alternator. With the latter arrangement a cruising speed of 16½ knots is obtained, while with both alternators and both motors working at full output a speed of 19 knots is obtained. In the "Monarch of Bermuda" there are two turbo alternator sets, and four propeller motors. Normally the starboard alternator set would drive the two starboard propeller motors and the port alternator set would drive the port propeller motors. By special switching arrangements it is possible to connect any one of the propulsion motors to either alternator.

With the turbo-electric equipment it is unnecessary to have a reversing turbine. If in the case of a twin-screw vessel each propulsion motor is working off its own alternator, assuming that there are two, then one motor can be going ahead and one astern at quite independent speeds for manœuvring purposes. If both motors are working off one alternator, then one motor can be going ahead while the other is going astern, but they must both be rotating at the same speed because they are both working at the same frequency. It is sometimes asked why synchronous motors are preferred to induction motors for propulsion purposes. The reason is two-fold. In the first place, a slow-speed induction motor would have what is called a poor power factor, which means shortly that for the same output its current input would need to be higher than that required for a synchronous motor. Broadly speaking this means a rather bigger motor and heavier cables, switchgear, etc. Another important point is that an induction motor must be built with as small a radial air gap between stator and rotor as one dare make consistent with reliability and safety. A synchronous motor can be built for a relatively large radial air gap which all makes for greater reliability.

This section completes the present series. The original intention was to provide a series of articles on electricity with special reference to its application to marine engineering, which should be helpful to the young engineer at sea who had the intention of going up for his Second-Class B.O.T. Certificate when he had completed his sea time. It was also intended that the articles should not attempt to do more than cover the Second-Class Certificate Electrotechnology, and Engineering Knowledge as regards electricity, syllabus. It is possible that occasionally they may have strayed a little further than that, but as the young engineer referred to will no doubt in due course be presenting himself for his First-Class Certificate, perhaps there is no great harm done.

The manner of presentation has been largely determined by questions asked the author over several years, and by difficulties which he knows from experience many marine engineering students find.

It may perhaps not be out of place to offer a word of advice to those students who have paid the author the compliment of having persevered up to this point. Some students are defeated before they start the subject of electricity because they have gained the idea that it is something very difficult and mysterious and requiring a large amount of mathematics. It is mysterious all right, insofar that we may know *how*, but do not know *why*. To quote Mr. J. Paley Yorke, O.B.E., "that is wrapped up in the first chapter of the Book of Genesis". And it is granted at once that one cannot see an electric current or a back e.m.f. as one can see a piston-rod moving in and out of its cylinder or a crank turning round; but the broad fundamental principles are comparatively few. Just as in mechanics one can go a very long way indeed on Newton's Law of Motion, so in electricity one can go a long way on the laws of electro-magnetic induction and Ohm's Law.

The author would particularly warn young students against learning parrot-fashion the method of solution of individual problems. With luck this might enable him to pass a written examination, though his bluff would probably be called in "verbals". In any case that will not make him an engineer in the best sense of the word. The thing to do is to master the few fundamentals, and then get practice in applying them to a wide variety of problems. When presented with a particular question you have probably several pieces of knowledge at your disposal. The thing to be able to do is to be able to recognise quickly which particular tool you want for the job. That is where experience comes in, and that can only be obtained by doing problems—lots of them.

One other point. There is a tremendous amount of "bunk" talked about the large amount of mathematics required in electricity, particularly in alternating current work. It would, of course, be idle to deny that a sound mathematical equipment is of the greatest help, and for what one might call the higher flights of electrical engineering, is indispensable; but for the ordinary everyday calculations it is not necessary. The author was a designer of alternating current machinery for upwards of eleven years, and in that period the number of times he needed to use anything more elaborate than a simple equation, with occasionally a quadratic or a little elementary trigonometry, could be numbered on the fingers of one hand. Admittedly, he used expressions for whose derivation the calculus had been required, but a man who grasped the physical principles involved, but who could not himself operate in the calculus, could have used the expressions equally intelligently.

In the next volume of the TRANSACTIONS it is hoped to contribute a few articles dealing with the slightly more difficult type of problem required for the B.O.T. First Class Certificate, some alternating current circuit theory and some alternating current problems. If space permits some work such as is required for the Extra-First Class Certificate may be included.

Abstracts of the Technical Press

Paddle Tugs with Producer Gas Engines for Service on U.S.S.R. Inland Waterways.

As the result of satisfactory experience with producer gas-engined river service tugs propelled by paddles, the Gorky Shipyard has prepared designs for such tugs with engines of 240 b.h.p., and arrangements for their construction are now stated to be in hand. The design provides for a steel hull for all-welded construction with an overall length of about 113ft., a moulded breadth of 19ft., a beam over paddle sponsons of about 43ft. 6in., and a moulded depth to the main deck of about 7ft. 9in. The maximum draught, with three days' fuel supply on board, will be 2ft. 6in., and the corresponding displacement 119 metric tons. The machinery is to consist of two sets of 120-b.h.p. producer gas engines having a total weight of 29 tons and designed to give the vessel a mean towing speed of 8 kilometres per hour (4·3 knots) with a useful pull 3·2 metric tons. The deckhouse will be of wood and there will be six transverse watertight bulkheads in the steel hull. There will be accommodation for a crew of 18. The fuel used will be wood and the bunker capacity of 18½ tons will correspond to three days' supply.—*V. I. Sergeiev and A. B. Karpov, "Soudostroienie", Vol. 9, No. 7/8, pp. 440-442.*

Firefloat for the Rhine Port at Basle.

A firefloat and salvage vessel built by Sulzer Bros., Winterthur, has recently been put into service at the Rhine port of Basle. The hull of the vessel, built of electrically-welded 5mm. steel plate, has a length of 70ft., a beam of 12ft. 6in., and a draught of about 3ft. 6in. The bow is raked to enable the ship to be used as an ice breaker. The propelling machinery consists of two Sulzer 2-stroke opposed-piston engines, each developing 125 b.h.p. at 1,500 r.p.m., coupled to the propeller shafts through 2:1 reducing gear. The blades of the propellers are adjustable, so that the engines may be run at full speed, if required, to work the pumps while driving the ship at any desired speed or keeping her stationary in any required position. The two self-priming 2-stage Sulzer medium-lift centrifugal fire pumps can be connected to the two main engines by means of clutch couplings. When working in parallel, each pump is capable of delivering 1,530 gall./min. against a head of 250ft., and when working in series 770 gall./mins. against a head of 500ft. The delivery pressure of the pumps should suffice to allow the firefloat to deal with fires in any riverside buildings of the town. The pumps can be used for salvage work on other vessels, if required, while the vessel itself is capable of undertaking light towing service. Electric power for the searchlight and for driving various auxiliaries is furnished by a 110-volt Diesel-electric generating set, while two dynamos driven by the main engines supply current at 24 volts for lighting purposes. The vessel was completed at Winterthur with all its machinery and equipment, and transported to the Rhine for launching by means of the special road vehicles of the Swiss Federal Railways recently put into service for the transport of large and heavy loads along the public highways.—*"Sulzer Technical Review", No. 2, 1939, p. 23.*

Electrically-controlled Automatic Stop Valve.

Under the New Factory Act control of the source of power must be available in any department or space where the power is used and this has resulted in a demand for equipment enabling such control to be effected. Amongst other devices of this nature, an automatic stop valve for shutting off the supply of steam to an engine, has been put on the market. The valve is of the automatic electrically-operated type and can be controlled by push-botton controls installed in various positions remote from the valve itself, either a.c. or d.c. electrical supply being suitable for the power required. No motor is employed, the action of a solenoid releasing a catch which holds the valve open. As soon as the catch is released a powerful spring comes into operation and instantly closes the valve. Resetting of the valve in the open position is effected by means of a wheel or remote control wiring from an a.c. or d.c. source of supply or by battery.—*"The Steam Engineer", Vol. VIII, No. 96, September, 1939, p. 525.*

Recent Technical Developments in the Swiss Engineering Industry.

An article by Prof. G. Eichelberg in the March issue of the Lausanne periodical *"Technique Suisse"* points out that although entirely separated from the sea, Switzerland has, since the evolution of the Sulzer two-cycle engine, become one of the greatest producers of marine oil engines. The author states that recent developments based on exhaustive experiments concerned with failure through heat stresses, fuel injection, scavenging, combustion, torsional vibration and failure through fatigue, have enabled the modern Diesel engine to attain a thermal efficiency of 41·5 per cent., the highest ever obtained from a heat engine. The application of two-point suspension to the Sarazin torsional vibration damper has led to increased reliability of oil engine operation. The author also refers to the Sulzer monotube steam generator in which the heating of the water, actual steam raising, and superheating are all effected successively in a single tube several thousand feet in length. The generator may be fired with oil, coal or pulverised fuel. The article is illustrated by photographs one of which shows a section through a Sulzer monotube generator for raising 37 tons of steam per hour at a pressure of 1,500lb./in.^{2}, while another shows an experimental Diesel engine with a cylinder 720mm. in diameter. —*"Sulzer Technical Review", No. 2, 1939, p. 4 (Supplement).*

Launch of a Dutch Light Cruiser.

The light cruiser "Jacob van Heemskerck" was launched at the Amsterdam yard of the Netherlands Shipbuilding Company on the 16th September, 1939, and is to be ready for service by June, 1940. The ship is primarily intended for service in the Dutch East Indies and has a displacement of 4,200 metric tons on a length of 435ft., a beam of 40ft. 9in., and a draught of about 15ft. 9in. The armament will comprise six 5·9-in. guns, eight 40-mm. anti-aircraft machine guns, four 12·7-mm. machine guns and two 20·8-in. triple torpedo tubes. A seaplane will be carried on a catapult amidships. Armour protection includes a light armoured deck and protection for vital parts of the vessel. The complement will number 309 officers and men. The propelling machinery will consist of two sets of geared turbines designed to develop 56,000 s.h.p. and supplied with steam by four water-tube boilers. The designed speed of the ship is 32½ knots. The whole of the main and auxiliary machinery, including the electrical installation, will be of Dutch manufacture.—*"Ship en Werf", Vol. 6, No. 20, 29th September, 1939, p. 306.*

Protective Linings for Ships' Fuel Tanks.

In September, 1937, the auxiliary fuel tanks of the tuna fishing vessel "Victoria" plying out of San Diego harbour, were coated with a new type of cold-applied plastic lining. This vessel is stated to be the largest and most modern tuna fishing boat afloat. She has a steel hull and, in addition to the main fuel tanks, has two auxiliary fuel tanks amidships which are used as such on the way out to the fishing grounds and as refrigerated storage for a portion of the catch on the way in. The vessel is generally absent from port for 5 or 6 weeks, so the cycle of fuel oil, refrigerated brine and back to fuel oil occurs at corresponding periods. The unlined steel tanks did not prove satisfactory and ordinary coating preparations proved unsuitable, the fish in these tanks becoming poisoned and unfit for sale. On her first trip with the auxiliary tanks lined with the new material, the "Victoria" brought in a record catch of tuna with practically no rejections for any cause. The new type of coating or lining is built up of 3 solutions derived from inert synthetic organic plastics. When in place, it forms a plastic sheet which adheres tightly to the surface to which it is applied and which follows the steel through thermal expansion and contraction changes and is unaffected by vibration. All 3 solutions are applied cold by hand-brushing or ordinary paint-spraying apparatus. The finished surface is semi-glossy, tasteless and odourless and is claimed to be unaffected by almost all commonly-used corrosive agents. In the "Victoria" the tanks were sand-blasted clean and primed with a special primer, a body coat $^1/_{64}$th-in. in thickness being sprayed on 8 hours later. The third solution or seal coat was sprayed on 48 hours later and after a further 24 hours a second seal coat was applied. These auxiliary fuel tanks contain high gravity Diesel oil on the outward voyage and when empty, they are washed down with lye, hot water and steam to remove all traces of oil. They are then filled with clean salt water and refrigerated to 28° F., being kept at that temperature until the catch is unloaded. —*"Marine Engineering and Shipping Review", Vol. XLIV, No. 9, September, 1939, pp. 437-438.*

The Robot Feed Regulator.

The Weir Robot feed regulator represents one of the latest developments in this type of apparatus and allows a steady continuous flow of water to enter the boiler at all rates of evaporation, maintaining a dead water level when the fires are banked. It is claimed to operate equally well with a direct-acting or a rotary feed pump. The essential feature is the automatic feed check valve, the movements of which are effected hydraulically and controlled by means of a float-operated needle valve. The whole apparatus form a single complete unit which can be installed readily on a marine boiler with very little change in existing arrangements. For any given rate of evaporation the valve floats in a position which allows feed water to flow into the boiler at the corresponding rate; when the rate of evaporation varies the valve instantly responds and increases or reduces the area for the flow of water, as necessary, to meet the changing rate of evaporation. The automatic feed check valve is similar to an ordinary non-return valve with a piston working in a cylinder formed in the check valve casing. This piston is larger in diameter than the check valve, and an easy fit in the cylinder. Referring to the part section, water from the feed pump discharge enters at (F) below the check valve and after passing through the latter, flows directly through (G) into the boiler. Water can flow from the feed pump discharge line into the piston

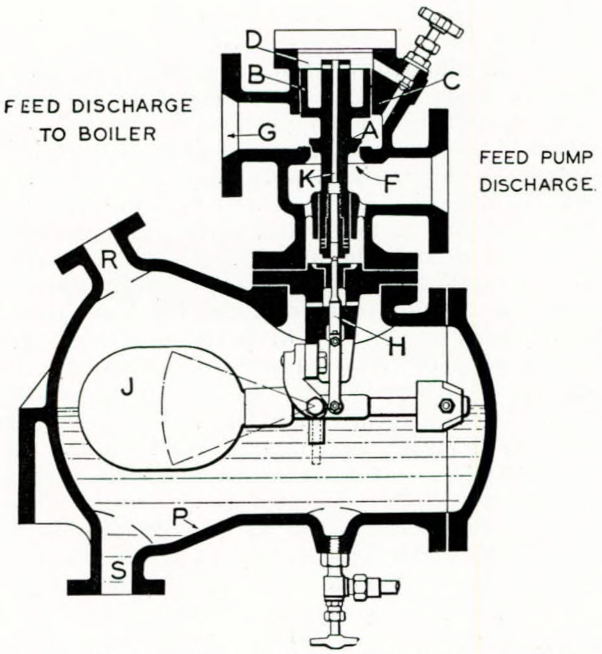


FIG. 2.—Part section of Weir "Robot" feed regulator.

chamber (D) through the passage provided for this purpose, the design being such that the feed discharge pressure acts on the bottom of the feed check valve while the boiler pressure acts on the top of this valve and on the underside of the piston. The top of the piston is subjected to a pressure which is intermediate between the feed pump discharge pressure and the boiler pressure, the pressure in the float chamber being controlled by a needle valve (H) which is actuated by the float and rises as the latter falls and *vice versa*. A by-pass cock is fitted from the piston chamber to the outlet side of the valve, so that the pressure may be broken down completely to allow the regulation valve to open fully, when the control can be taken on the main check valve by hand operation. This by-pass cock is normally closed when automatic feeding is in operation.—*"Engineering and Boiler House Review", Vol. 53, No. 4, October, 1939, pp. 235-236.*

Boiler Installation of the U.S. Liner "America".

The recently launched 30,000-ton liner "America's" two sets of double-reduction geared turbines will develop a total power of 34,000 s.h.p. at 128 r.p.m. of the propeller and will be supplied with steam at a pressure of 425lb./in.^{2} by six Babcock and Wilcox boilers arranged in two boiler rooms. The total steam capacity is to be 346,000lb./hr. at maximum operation, and the designed working pressure 500lb./in.^{2}. The steam temperature at the superheater outlets will be 725° F. when the boilers are supplied with feed water entering the drums at 300° F. Convection superheaters and horizontal tubular air heaters will be fitted, the boilers and air heaters being completely air cased. Each boiler will be fired by 6 Babcock and Wilcox Decagon mechanical-atomising oil burners operating with forced draught. Low-temperature steam for auxiliary purposes will be furnished by de-superheaters of the internal drum submerged type. The designed temperature of the flue gases in the uptakes is to be 300° F. with over 88 per cent. efficiency.—*"Marine Journal", Vol. 66, No. 9, 15th September, 1939, pp. 14-17.*

An Air-cooled Diesel Engine.

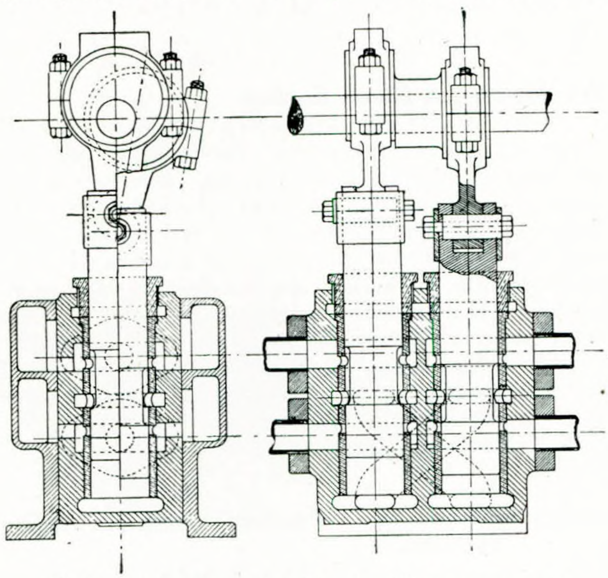
One of the exhibits which would have been seen—for the first time—at the Engineering and Marine Exhibition this autumn, was a single-cylinder air-cooled Diesel engine of 8/12 b.h.p., produced by a Midland firm of engine-builders. The engine is stated to have undergone a series of satisfactory tests, including operation in a hot room under tropical climatic conditions. Cold starting tests were also carried out, the engine starting readily after being all night in a refrigerated chamber in which it was subjected to several degrees of frost.—*"Gas and Oil Power", Vol. XXXIV, No. 408, September, 1939, p. 223.*

Improvements in Electric Ship-propulsion Systems.

A recently-accepted British patent concerns a system which is an improvement on the well-known form of installation in which a steam- or Diesel-driven alternator supplies a synchronous propulsion motor, speed control being effected by frequency control. In this system an increase of the load on the motor above normal full load may materially change the voltage of the alternator and stall the synchronous motor, and the invention is claimed to obviate this risk. An auxiliary exciter is coupled to the alternator shaft, while two independently-driven exciters supply the field windings of the alternator and of the synchronous motor, respectively, through separate regulators. Each of these main exciters has a field winding fed from a constant-voltage supply through separate regulators enabling the basic excitations of the alternator and motor to be varied independently of each other. The auxiliary exciter is excited from the same source, in addition to which each of the main exciters carries a field winding supplied by the auxiliary exciter through separate regulators. Any increase in prime-mover speed causes the auxiliary exciter to increase the excitation of the main exciters and so increase the motor and alternator excitations, but the rate of increase of the one can be regulated independently of that of the other. The auxiliary exciter is compounded, having a field winding fed from a current transformer in one of the leads to the motor through a rectifier. The compounding affects both the motor and the alternator and varies with the speed.—*"Engineering", Vol. 148, No. 3,846, 29th September, 1939, p. 374.*

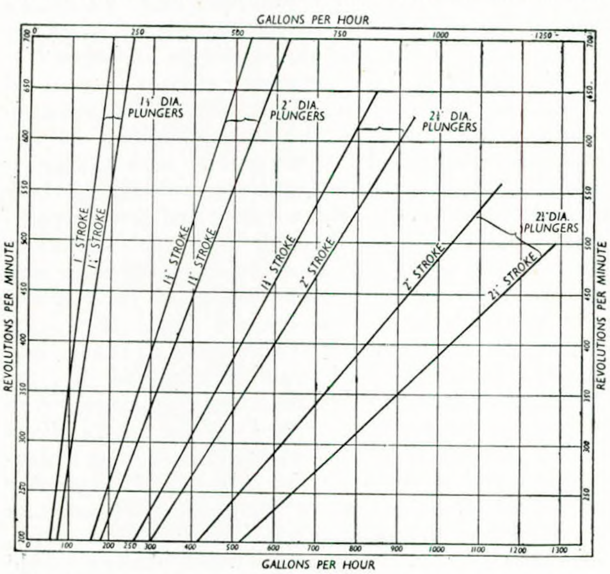
Something New in Pump Design.

The makers of the Brunton-Clark pump claim that it constitutes a considerable simplification on an earlier model inasmuch as the total number of aprts used in its construction has been reduced from 68 to 18. The essential feature of the new pump, which is of the plunger type, is that each plunger, in addition to its pumping duties, acts as



Sectional drawing of a Brunton-Clark pump unit.

a piston valve regulating the work of another plunger. Thus, the pump is always designed with two, or multiples of two, plungers. The arrangement of the valve mechanism is shown in the sec-



Graph showing the outputs, per plunger, of various sizes.

tional drawings. Two liners, each with three rows of ports, are fitted in the body of the pump, the recess behind the central ports communicating through a passage with the space at the bottom of the other barrel. The upper ring of ports of each liner is in communication with an inlet pipe, and the bottom rings are in communication with the delivery outlets. Each plunger is recessed peripherally after the fashion of a dumb-bell, and the length of the recessed portion is such that only one of the outer rows of ports is uncovered at the same time as the central ports. The cranks or eccentrics driving the plungers are set at an angle of 90°. When the right-hand plunger ascends, water is free to pass from the left-hand intake, through the upper ring of ports in the left-hand liner, round the recessed part of the plunger, out through the central ports and through the passage to the bottom of the right-hand barrel. On the downward stroke of the right-hand plunger, the water which has filled the space beneath it is expelled through the same passage in a reverse direction, to the central ports of the left-hand barrel, and thence to the bottom ring of ports, which are now in communication with it *via* the recessed part of the plunger. From this bottom ring of ports the water passes to the delivery outlet. A corresponding action is performed by the right-hand plunger, which thus controls the suction and delivery of the left-hand barrel. The suction and discharge from each cylinder are quite independent, so that the two plungers may be used to pump different fluids. Thus, for example, one plunger may be used as a circulating pump of a marine engine and the other as a bilge pump, this combination having been borne in mind by the designers of the pump. When the bilge pump plunger is not actually pumping fluid, it simply acts as a piston valve for the circulating pump, and the water which circulates round its recessed part serves to lubricate it. The absence of automatic valves makes it possible to deal with fluids containing solid impurities without risk of damage or of affecting the operation of the pump. Thick semi-liquids such as tar and heavy oil can be satisfactorily dealt with. The pump is stated to possess good self-priming properties and to be capable of an efficient performance at a fairly high speed. As the plungers have a clearance of only ·001in. in their barrels, the latter are not fitted with glands. A groove and small leak hole communicating with the inlet are provided to drain away any water which may find its way past the plunger. A two-plunger pump of this type measures 12in. by 10in. by 18¾in. high, the plungers having a diameter of 2in., and a stroke of 1½in. Such a pump will deliver 1,070 gallons per hour at a speed of 500 r.p.m. The performance curves for different sizes show a volumetric efficiency in the case of the smaller size, of 75 per cent., and for the larger units of 80 per cent., but it is stated that these efficiencies have been greatly exceeded on test. The plungers and liners are made of phosphor-bronze and the casing is of gunmetal. The simple design of the pump should enable it to be produced in quantities at a lower cost than that of the normal plunger type. The pump will be available in sizes suitable for use with propelling units of from 10 to 1,000 h.p. It has, of course, many other uses, such as for deck washing or general service. In such cases the two inlets and outlets can be connected so that the pump acts as a single unit.—*"The Motor Boat", Vol. LXXI, No. 1,839, 21st October, 1939, pp. 356-357.*

Refrigerating Plant in New German Ship.

The total refrigerated space in the Swedish-built motorship "Alsterufer" recently delivered to Hamburg owners, amounts to about 170,000 cu. ft. net bin capacity, in 12 compartments. These are cooled by four air-cooler batteries on the new Sabroe patent direct multi-temperature system with direct expansion of ammonia, which enables different temperatures to be maintained in the various cold chambers by means of a single compressor unit, and dispenses with any special "by-pass" arrangements for the current of air. The refrigerating plant is of Danish manufacture and comprises two vertical 3-cylinder, single-acting NH_3 compressors of the totally-enclosed type, with forced feed oil circulation, directly driven by two 92-h.p. motors at a speed which may be varied from 260 to 320 r.p.m. Only one compressor is required to maintain the insulated spaces at low temperature in the tropics, and when in colder climates, the power can be reduced down to 20 per cent. of the maximum, if necessary, by means of special capacity reduction arrangements fitted for the purpose. There are two multi-tube condensers with counter-current flow for the liquefaction of the ammonia, the sea-water circulating pumps being of the centrifugal type and driven by 6½-h.p. electric motors. Four air-cooler batteries of cross-blown type, with solid-drawn welded steel tubes, are fed with liquid NH_3 from the condensers; after having been expanded in the coolers, the ammonia passes back to the compressors in a gaseous state through the manifolds. Four powerful, reversible, stream-line propeller fans circulate the air over the batteries 50 times per hour through the holds by means of delivery and exhaust air-trunks along the ship's sides. A special arrangement is provided for the renewal of air which has been contaminated by CO_2 gas given off by the fruit. An electrical distance thermometer installation is fitted in the engine-room, with 24 point indicators, so that the engineer on watch can control the temperatures in the various compartments, as required. The entire plant is located within a ventilated airtight compartment in the main engine-room. For de-frosting the air-coolers steam heating coils are provided, which also serve to heat the fruit chambers during cold weather in northern regions when no refrigeration is required. A small independent NH_3 plant driven by a 4½-h.p. motor supplies refrigeration to a 300-cu. ft. meat and a vegetable room of similar capacity for passengers' and crew's provisions.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 34,832, 21st September, 1939, p. 7.*

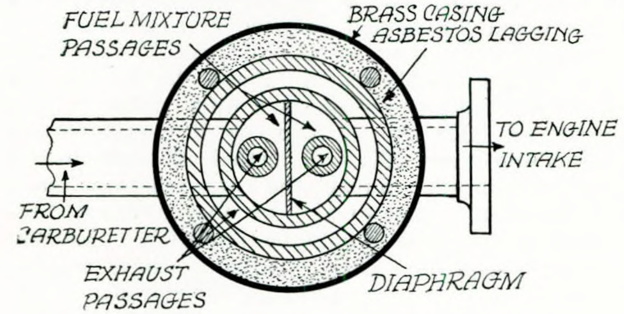
Some Notes on Modern Refrigerants.

Considerable attention has been paid in recent years to the development of refrigerants, and to ammonia, which once held the field unchallenged, must be added carbon dioxide, both liquid and solid, dichloromethane and dichloroethylene, freon, methyl chloride and sulphur dioxide. Anhydrous ammonia is still very widely used and is one of the purest chemical products. From time to time attention has occasionally been drawn to fires or explosions in refrigerating rooms in which serious leakage of ammonia has taken place. Numerous investigations by official organisations have collected fairly complete and consistent data regarding the explosive limits of ammonia-air mixtures and regarding the combustion of ammonia. From 13·1 to 26·77 per cent. of ammonia in mixtures with air appear to be the explosive limits of these mixtures. For all practical purposes ammonia is stable when exposed to pressure temperature and contact conditions that are usually met with in the normal working of a compressor. When abnormal conditions prevail, there is some dissociation of ammonia into its component gases. The presence of hydrogen in a compression system which has previously been free from it indicates that some decomposition is taking place and that the machine is not being operated properly. Ammonia is a strong alkali and will react as such when various textile, food, fabric, or fur products are exposed to it. It is very soluble in water. It is not corrosive to iron or steel, but readily attacks copper, brass, zinc, aluminium and many alloys, especially those containing copper. These metals should consequently be avoided in the construction of equipment which may become exposed to ammonia fumes or solutions. Contrary to a somewhat popular belief, ammonia is not poisonous. It is a powerful irritant to the mucous membranes of the eyes, nose, throat and lungs. Due to its solubility in water, it also irritates any skin surface where an accumulation of moisture or perspiration takes place. The physiological effect of ammonia is not cumulative, and workmen may develop a certain degree of immunity or tolerance towards exposure to ammonia in low concentrations. An atmosphere containing five volumes per thousand appears to be the maximum that may be inhaled without serious consequence, and as an atmosphere containing 1/25th volume per thousand imparts a strong odour to air, adequate warning is provided of conditions which may become dangerous. Ammonia acts as a powerful heart stimulant, both when inhaled in low concentrations and when taken internally in small doses. When anhydrous ammonia comes in contact with the skin, it causes a condition similar to frostbite or a burn, but the affected part responds to the usual treatment. Because of its odour and its characteristic chemical reactions, leaks in an ammonia system are easily detected. Anhydrous ammonia may be employed as refrigerant under an extremely wide range of conditions, and wide variations of temperature can also be covered down to −60° Fahr. Pressures employed in the normal working of ammonia compression machines are not excessive. They depend upon the quantity and temperature of condenser water used, and rarely exceed 250lb. per sq. in. Because carbon dioxide in fairly large quantities is not dangerous to plant or animal life, these systems are generally used in ships, hospitals, stores, etc., where slight traces of other refrigerants would be dangerous or disagreeable. The United States Navy now uses carbon dioxide exclusively in capital ships. The entire charge of carbon dioxide from the ordinary refrigerating plant can be safely emptied into the engine-room, as the amount can run up as high as 10 to 15 per cent. without danger, while 0·5 per cent. of other refrigerants in the air may be fatal. The fact that it is heavier than air keeps it in the engine-room, where it is not obnoxious, whereas other lighter-than-air refrigerants will escape through the upper part of the ship. Special safety devices, including outside vent pipes, are not required, as with other refrigerants. Carbon dioxide gas is inert and stable under all conditions. It never forms non-condensable gases which have to be vented from the system, nor can it form explosive mixtures, either inside the refrigerating system or around it. The use of copper coils in shell-type condensers is an advantage, as the amount of cooling surface is reduced, as well as the space needed for the apparatus. Any good grade of low, cold-test oil may be used in connection with carbon-dioxide refrigerating plants, because it has no chemical or emulsifying effects on oils. The life of the oil is therefore practically indefinite except that it picks up dirt and foreign matter in the course of operation. The main argument used against carbon dioxide has been the comparatively high working pressures. These range from 250lb. suction to 900lb. per sq. in. condenser pressures. While these are high as compared to steam engineering work, they are not excessive when compared to oil engine and liquid air practice. Since the critical temperature of carbon dioxide is 88·4° F., it is a common fallacy that there is practically no refrigerating effect with condenser temperatures above this. The fact is that carbon dioxide is not a perfect gas around the critical point, and there is no sudden change in properties in passing from 88 to 89° F. Authorities do not agree as to whether the refrigerating effect is due to the liquefying of part of the gas through the expansion of the balance or entirely to the effect of the high specific heat of the gas at this point. The efficiency and capacity of the system are considerably higher than for a dense-air machine under similar conditions. Refrigeration as applied to air conditioning presents a distinctly different set of conditions from those met elsewhere, because the product of the process must be free from impurities, and every effort in design must be directed towards making everything connected with it safe beyond any possible question. This consideration has led to the investigation of refrigerating systems and to the development of what is at least a unique type of refrigerant and machine adapted for use with it. The refrigerants, dichloroethylene (Dieline) and dichloromethane (Carrene), differ from the usual commercial cooling media in being liquid at ordinary temperatures and pressures, and the machine in which they are used is unique in operating always at pressures below atmospheric. Unlike most other refrigeration applications, air conditioning is characterised by great variations in the load factor, amounting to as much as from 100 per cent. to zero load in a matter of a few hours with an ordinary change in weather. In addition to the ordinary changes in outside weather conditions, the variation in internal as distinguished from external, or weather-variation, load, represented by the departure of an audience from a large room, may bring about an equally large variation in the work to be done by the refrigerating plant. These variations must be quickly and accurately followed by the machine if efficient operation is to result and conditions are to be kept at the optimum. No manual operator can possibly possess the alertness and dexterity necessary for such control. Automatic control is therefore highly desirable. The ability to meet these conditions is inherent in a centrifugal compressor through its full flexibility and ability to float with the load demands. Obviously these two refrigerants are satisfactory in possessing high thermo-dynamic efficiencies and capable of working within the range required. Furthermore, at least dichloromethane meets all safety requirements. However it is evident that a positive displacement compressor for use with either is out of the question from the standpoint of practicability, since the volumes of vapour to be handled are relatively large. These characteristics led to their adoption for use with centrifugal-compression machines. As the characteristics of the centrifugal compressor were found, upon analysis, to be ideal for air-conditioning loads, the availability of these chemicals as refrigerants made possible a refrigerating system which is unique in its field. Freon is dichlorodifluoromethane (CCl_2F_2) and was developed in a deliberate attempt to produce, by chemical arrangement, a refrigerant from which risks are eliminated and which still has properties especially favourable to economic operation. Freon is adaptable for use in all compression types of refrigerating systems, and tests have shown that it closely approaches the ideal refrigerant. Freon or dichlorodifluoromethane is a colourless, almost odourless gas, boiling point-29·8° C. at 760mm. (-21·7° F.

at 29·92in. absolute). It is non-toxic, non-corrosive, non-irritating, and non-inflammable. It is generally prepared by replacing chlorine in carbon tetrachloride with fluorine. Chemically it is inert at ordinary temperatures and thermally stable up to 550° C. (1,022° F.). Pressures required to liquify the refrigerant vapours affect the design of the apparatus; the specific volume per pound of the refrigerant vapour from the evaporator determines the piston displacement of the compressor; and the latent heat of vaporisation and density of the refrigerant affect the quantity of liquid refrigerant to be circulated through the regulating valve and expanded. While Freon has a relatively low latent heat value, this is not considered a disadvantage, as it merely means that more of the refrigerant must be circulated to produce the desired amount of refrigeration. It is a decided advantage in small refrigerating machines, because the larger quantity of liquid circulated will permit the use of less sensitive, more accurate, and more positive operating and regulating mechanisms. Freon works at low but positive head and back pressures and high volumetric efficiency. It permits light compressor construction, simplicity of design, great flexibility of application, high efficiency, quietness of operation, low manufacturing cost, and low installation and service costs. Furthermore, the low but positive pressure prevents moisture-laden air from entering the system which might cause the following adverse conditions; reduction of the coefficient or performance (ratio of indicated horsepower to refrigeration per minute); air lodging in the condenser and resulting in high head pressure; and moisture freezing interfering with the normal operation of the regulating valve. A Freon leak may be detected by a torch burning alcohol, which, under normal conditions, produces a colourless flame. A tube fastened to the base of the burner is used to conduct the air suspected of containing Freon vapour through the flame and over metallic copper. Owing to the breaking down of the refrigerant in the flame, a volatile copper halide is formed, and the flame colour changes from the normal colourless to bright green if the air contains as much as 0·01 per cent. of Freon. A leak from a refrigerating system of 0·06 pound (27·7 grams) or more per month is easily detected by halide lamps now available. Such a leak would be equivalent to the escape of one ounce per month, or 0·75 pound (340 grams) per year. Freon-air mixtures are non-explosive, and it has been impossible to obtain flame propagation in vapour-air mixtures when tested at ordinary or even elevated temperatures, up to 1,382° F. (750° C.) by the application of either electric spark or gas flame. It is a stable compound of undergoing, without decomposition, the physical changes to which a refrigerant is commonly subjected, involving repeated evaporations, compressions, condensations, and heat absorptions. Methyl chloride, discovered in 1835, is used in the French Navy as the safest refrigerant for marine work, and it was required wherever refrigeration was installed in submarines. Methyl chloride is entirely without action on any metals normally used in the construction of refrigerating systems. A point of great importance with methyl chloride lies in the fact that, while in a pure state it is wholly without action on any metals, small amounts of moisture if accidentally introduced into the system do not produce corrosive effects with the methyl chloride used as the refrigerant. The moisture may be absorbed by causing the refrigerant to pass through a tube filled with calcium oxide or other suitable drying agent. Methyl chloride has a low explosive risk. One report gives the explosive range when mixed with air as between 8·1 and 17·2 per cent. by volume of methyl chloride. One pound of methyl chloride at ordinary room temperatures and pressures will form 7·5 cub. ft. of gas. This could render about 92 cu. ft. of a methyl chloride-air mixture inflammable. In a room of 1,000 cub. ft. capacity it would require something over 10lb. of methyl chloride to be liberated in order to reach the lower explosive limit; if the usual change of air, due to ventilation, took place, much more would be required. Various specifications have been written to cover sulphur dioxide that is to be used as a refrigerant. These usually state that the sulphur dioxide shall be water-white in colour and shall leave no residue on the evaporation of 100 c.c. A clean dry glass vessel in which a sample is evaporated should be just as clean and dry after the liquid sample has evaporated as it was before the sample was placed in it. Refrigeration-grade sulphur dioxide does not attack metals used in refrigeration machines. Sulphur dioxide containing water above some small amount does attack metals. What amount of water there must be in the liquid sulphur dioxide before i begins to attack metals depends on several factors. Some few years ago the sulphur dioxide shipped in steel containers held from 0·2 to 0·3 per cent. water (2,000 to 3,000 p.p.m.), and little or no action on the cylinders occurred. Yet if a piece of bright steel is placed in liquid sulphur dioxide containing more than 50 p.p.m. of water (0·006 per cent.) and allowed to remain in it until the liquid has entirely evaporated, the steel will show that it has been acted upon. If sulphur dioxide escapes from a refrigeration system because of a leak in that system, its irritating effect makes its presence immediately known. If for any reasons it is breathed, only temporary discomfort is experienced, and exposure to very strong concentrations of sulphur dioxide rarely results in any permanent injury or serious after-effects. Liquid sulphur dioxide is a very inexpensive refrigerant. It is made not only for this industry, but the commercial grade finds use in a rather wide field.—*"The Journal of Commerce" "Shipbuilding and Engineering Edition), No. 34,831, 14th September, 1939, pp. 1 and 3.*

The Gaines Paraffin Vaporizer.

The restriction of petrol supplies for boats is causing attention to be paid to the possibility of using paraffin as a fuel and a device for this purpose is the Gaines vaporizer illustrated in the accompanying diagram. There is an outer tube of wrought iron, fitted with end covers arranged with an inlet and outlet for the exhaust gas from the engine, together with an inner tube with inlet and outlet pipes through which the fuel mixture is conveyed from the carburettor to the engine. The tube is closed by end plates with machined seatings, held in position by two smaller central tubes through which a portion of the exhaust gases passes. A diaphragm of thin sheet steel is fixed longitudinally



Cross-sectional diagram of Gaines vaporizer.

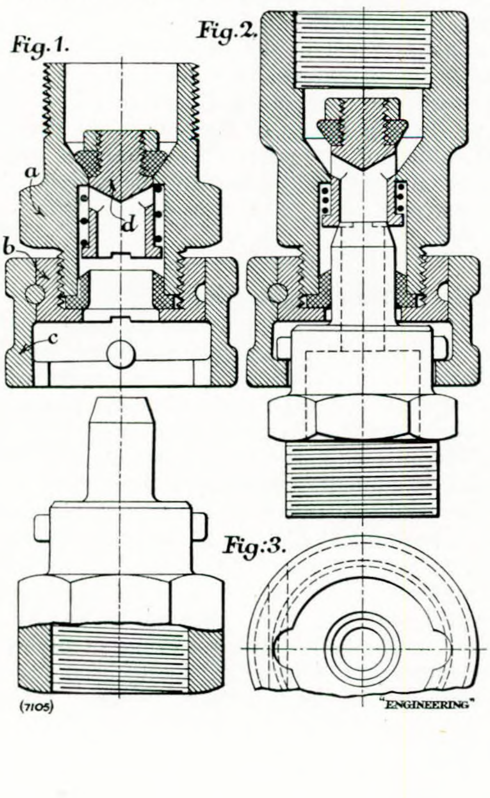
in the main inner tube between the two small tubes and extends for most of its length, but a space is left at one end. The mixture inlet and outlet are so arranged that the mixture has to travel along one side of the inner tube and back along the other on its passage from the carburettor to the intake, being heated both externally from the annular space between the outer and inner tubes, and internally from the two small central tubes. The end plates, which are tapped to take the exhaust pipe, are secured in position by four through bolts and nuts. The small central exhaust tubes have one end enlarged and the other threaded to take the nuts by which they are secured. The inlet and outlet tubes for the mixture may be arranged at right angles or opposite each other, as required. Asbestos lagging is provided for the outer tube, and the whole is cased in a cylindrical brass cover. It is claimed that when this vaporizer is used petrol is not needed for starting. If the vaporizer is heated by a blow-lamp for a few minutes, the engine can be started directly on paraffin. The Gaines paraffin vaporizer is made in several sizes, the smallest of which is suitable for engines up to 10 h.p.—*"The Motor Boat", Vol. LXXI, No. 1,842, 11th November, 1939, pp. 410-411.*

French Engineer's Automatic Boiler Firing System.

A French heating engineer has developed a novel system of stoking which allows a boiler to be fired either automatically or by hand in the usual way. His method utilises an ordinary furnace and grate, and requires no special system of draughts; it can be used with any type of coal or coke, and if properly regulated, produces practically smokeless combustion. The system comprises a hopper fitted to the furnace front, just above the ordinary furnace door, which is filled from a storage bunker or by means of a travelling crane. A metal feed cylinder is provided below the hopper, with a series of eight projecting ribs extending along one-eighth of the length of the cylinder, the successive ribs around its periphery being arranged at successive eighths of the length. As the cylinder revolves, the ribs catch and move along a certain quantity of the coal in the hopper, the amount depending on the angle of the hopper floor at the point where it approaches the feed cylinder, and on the width of the rib. This coal, moved out of the bottom of the hopper by the feed cylinder, slides down a chute to the projection cylinder which, like the former, is a perfectly plain cylinder with a series of eight ribs. These ribs, however, run the full length of the cylinder which turns more rapidly than the feed cylinder (the latter being geared to turn about one revolution in two minutes) and catches the coal as it falls, throwing it violently into the combustion chamber of the furnace. The speed of this cylinder is controlled by a handwheel operating a control rheostat on the driving motor. The speed is regulated on the assumption that no coal, however carefully screened, has all the lumps of one size. The impulse given to all the lumps by the projection cylinder is the same, but the variation in size or weight per lump, which is practically infinite within certain limits, will cause the lumps to fall fairly evenly over an area within a certain range of distances from the projection cylinder. If this cylinder moves very rapidly, the impulse given the lumps will be greater and they will tend to fall at the back of the combustion chamber. The regulation of the speed must be such that the range of distances within which the lumps can fall will coincide with the distance from the front to the back of the combustion chamber. This speed can only be determined by experiment, *i.e.*, by watching the distribution through the door of the furnace. Once the speed has been found, it can always be obtained for a given installation very rapidly, by merely setting the rheostat in the appropriate position. The arrangement of the ribs on the feed cylinder-cover causes the coal to be supplied to the projection cylinder in a series of waves, the first lumps being delivered at one end, and the delivery moving slowly towards the other, only to begin over again in a second wave as soon as the first is completed. The same effect could, of course, be obtained by providing the feed cylinder with a single spiral rib of a pitch equal to the length of the cylinder. This arrangement means that the coal is not piled on any given spot on the grate continuously, nor in large quantity. Each eighth of the width of the grate receives a light sprinkling of coal once every two minutes, *i.e.,* once in each revolution of the feed cylinder. This ensures that every part of the grate is covered with only a very little coal in a state which makes it possible for the coal to give off volatile substances and these being produced in small quantity at any given point, suitable aeration of the fire permits their combustion as rapidly as they are formed, thereby avoiding any risk of smoke, even when firing with fairly soft coal. This system is, of course, lacking in one of the characteristics of a fully automatic mechanical stoker, inasmuch as it is necessary to shake the ash down by hand. This operation, however, need only be carried out by the boiler attendant once every hour or two at most.—*"Industrial Power", Vol. XV, No. 168, September, 1939, p. 280.*

Hose Coupling with Automatic Cut-off Valve.

A device known as the "Instantair" hose coupling, developed by a well-known firm of air compressor manufacturers, is designed for use in pneumatic-tool air-lines and embodies a cut-off valve which automatically stops the air supply as soon as the coupling is disconnected. The new coupling is made either rigid or swivelling, the latter form enabling the hose to be twisted without kinking. The construction of this type of "Instantair" coupling is shown in the accompanying drawings (which are not to scale). Referring to Fig. 1, it will be noted that the coupling consists of a plug at the bottom and a socket at the top, the socket itself being made up of a body *a*, an inner sleeve *b*, and an outer sleeve *c*. The sleeve *b* is screwed firmly on the body and serves to retain in place a



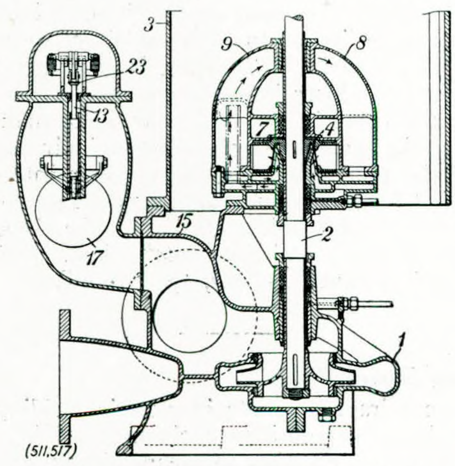
hat leather which forms a seal for the spigot on the plug. A peripheral groove is turned in this sleeve in which groove lies, tangentially, a pin passing through the outer sleeve *c*, as shown in Fig. 3. This arrangement allows the outer sleeve to rotate on the inner one and, as the plug is coupled to the former, an unopposed swivelling action is obtained. The automatic cut-off valve is carried in the body *a* and is indicated at *d*. It is of the port piston type and, when the plug is not in place, the rubber ring which forms its seating face is held tightly against a conical seat by a compression spring. As the plug is not in place in Fig. 1, the valve is closed, but in Fig. 2, where the two lengths of hose are connected, the valve is held open against the compression of the spring by the spigot of the plug, the latter being held in place by a pair of projecting pins, held against a flange in the outer sleeve by the valve spring, as shown in Fig. 2. When coupling the two parts, the pins pass through the semi-circular notches in the edge of the flange seen in Fig. 3. The sleeve is then given a quarter turn and the pins slip into notches on the inner face of the flange formed by drilling a hole right through the outer sleeve in the position shown in Fig. 1. The lock thus formed is sufficiently positive to prevent any twisting of the hose from causing accidental disconnection of the coupling, which may be done, when required, by turning the outer sleeve by hand, its periphery being knurled on the two end rings. The rigid type of coupling is only used for ¼-in. hose, the plug and socket being locked together by a bayonet joint as in an electric lampholder. The swivelling socket is made in two sizes, to suit ⅜-in. and ½-in. hose, respectively, and is available with either male or female screwed ends, or both. As shown in Fig. 1, the plug has a female end and the socket a male end, these conditions being reversed in Fig. 2. These variations in construction enable the coupling to be used in a pipe line or to be fitted direct to a pneumatic tool. Clearly, as the valve is held open by the plug spigot, it closes immediately the plug is withdrawn, and there is no loss of air when making or breaking the joint. Any leakage of air past the seat of the plug spigot on the valve is intercepted by the hat leather round the spigot. The coupling is light in weight and is claimed to be completely air-tight in use.—*"Engineering", Vol. 148, No. 3,854, 24th November, 1939, pp. 596-597.*

Welding Steam Pipes.

Recent improvements in electric welding have led to almost revolutionary changes in the design and methods of erection of steam piping, and have enabled some new methods of construction to be used in steel drums for high-pressure boilers. By employing the shield-arc process of welding combined with X-ray examination, it is now easily possible to join steam pipes end to end, make all kinds of special bends, elbows, branches and other connections of a type that could only be made by welding, fabricate superheaters and monotube generators and accessories, and weld boiler drums to operate at pressures of up to 1,000lb./in.^{2} with total steam temperatures of 1,000° F. One well-known firm of welding engineers claim to be able to make wire electrodes to an accuracy of within 0·001in. of the required diameter, of the same steel or other metal as the parent metal, *i.e.*, as the pipes or other components to be welded, these electrodes having a homogenous cement-like outer coating which is extruded and baked. On connecting up to a suitable a.c. or d.c. source of electric supply, the electrodes on touching an earthed metal surface liberate an enormous amount of heat by the passage of the current, the metals of both the parent metal and of the electrode becoming molten locally, and thereby enabling the weld to be made. In the shield-arc system the coating decomposes by the heat as the metals melt, liberating a highly de-oxidising gas which protects or shields the weld from the atmosphere. Consequently, no oxides and nitrides are present and bubbles of gas cannot be found when an X-ray examination is carried out, indicating that the weld is stronger than the original metal. —*"Boiler House Review", Vol. 53, No. 3, September, 1939, p. 188.*

Self-priming Centrifugal Pump.

A British patent recently granted to the makers of Worthington-Simpson pumps concerns improvements in the priming arrangements of centrifugal pumps. The drawing shows a vertical-shaft bilge-pump unit designed to operate either unsubmerged or submerged, with variable suction heads. The centrifugal pump (1) forms the base of the unit and the motor driving the shaft is above it. The



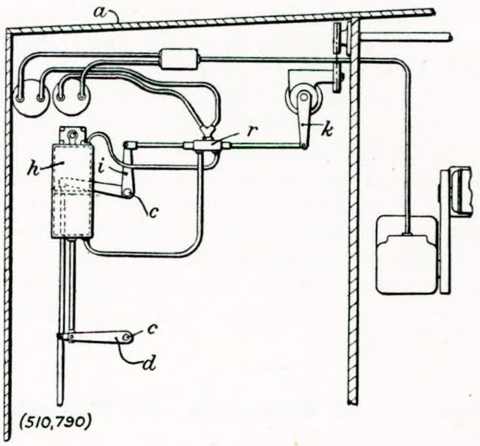
casing enclosing the motor extends downwards at (3) to form an air bell which entraps air and prevents water from entering the motor casing when the unit is submerged. Between the pump and the motor is the rotor (4) of the water-ring priming pump, which is unloaded automatically when the centrifugal pump is fully primed. Its casing has double walls which enclose an annular make-up reservoir (7) with a pair of limbs (8) and (9) forming an arch and communicating at their upper ends through passages on each side of the bearing which they support. These arched members constitute an air bell above the make-up reservoir. The loading and unloading of the priming pump is controlled by a valve (13) housed in a float chamber mounted on a branch of the main pump suction, with which it is connected, a float (17) operating the valve with a snap action. The valve consists of two pistons on a common rod for controlling the various ports and of a mushroom valve (23) at the top of the rod, which, when closed, isolates the priming pump from the float chamber. The unit operates as follows: Assuming that air is present in the suction of the centrifugal pump and the unit is started up, the valve (13) is in the position shown, the float chamber being filled with air. The make-up reservoir is then in communication with the priming pump, thus supplying water to form the sealing ring, and the unloading port is closed. The suction of the priming pump is in communication with the float chamber through the mushroom valve (23), and the pump therefore evacuates the suction of the centrifugal pump. The evacuated air is discharged into the limbs (8) and (9), any excess escaping into the skirting bell (3). As soon as the pump is primed, the water rises in the float chamber and operates the valve (13). The priming pump is cut off from the float chamber by the valve (23) and the suction side is connected to the junction of the limbs (8) and (9), while at the same time the sealing water is discharged by centrifugal force and returns to the make-up reservoir, being replaced by the air trapped in the limbs, thus obviating the necessity of an external air supply. The priming-pump rotor now revolves freely in air until such time as there is a loss of suction in the centrifugal pump sufficient to cause the water in the float chamber to fall and operate the valve (13).—*"Engineering", Vol. 148, No. 3,854, 24th November, 1939, p. 598.*

Steels in Marine Engineering.

Generally speaking, between 50 and 60 per cent. of the total weight of a ship's machinery and boiler installation is made up of various grades of steel, including low and high carbon steels, and low and high alloy steels, a large proportion of the plates, bars, forgings and castings being made of steel of low carbon content. Standard boiler steels for both fire-tube and water-tube boilers, are low carbon steels containing 0·22 to 0·32 per cent. carbon and having a tensile strength of 28 to 35 tons/in.^{2}, and an elongation of 20 per cent. Bars for rivets and plates for flanging are specified to be 26 to 30 tons/in.^{2}, such steels, having a range in any one case of not more than 4 tons/in.^{2} being used for plates, girders, butt straps, staybars, drums, tubes and wrapper plates. Where boiler pressure exceeds about 250lb./in.^{2}, higher carbon steels of 26 to 42 tons/in.^{2} tensile strength or 3½ per cent. nickel steel, are used for these components, and recently alloy steel boiler tubes have been introduced, containing 0·25 to 0·5 per cent. copper and 0·25 to 0·5 per cent. molybdenum. Alloy steels are not ordinarily employed for marine boiler work except for superheater supports and baffle plates exposed to flame temperatures, when non-scaling, heat-resisting steels are utilised. Steels of the 18/8 type with silicon, titanium, or tungsten, 28/18 or 35/12 nickel-chromium steel, or 30 per cent. chromium steel, give satisfactory service when used for such parts. Certain studs, bolts and nuts are also made from alloy steels. Carbon steels used in the form of normalised forgings or bars are usually classified, according to their strength, as 28 to 32, 31 to 35, or 34 to 38 tons/in.^{2} carbon steels. The first class is used for crankshafts, crank webs, connecting rods, piston rods, bolts, valve and pump parts, shafting and propellers in reciprocating and oil engines, and for primary wheels, claw pieces, and the main shafting of turbines. The second class is used for similar parts—crankshafts excepted—in reciprocating and oil engines, where greater strength is required, and for main wheel rims, gearwheel shafts and discs in turbines. The third class is employed for higher strength crankshafts and webs, connecting rod bolts and shafting in such engines, and for rotor shafts, rotor wheels, rotor drums, coupling sleeves, and main shafting in turbines. Steels of over 40 tons/in.^{2} tensile oil-hardened and tempered, are sometimes used for connecting rods, crossheads, and fuel valve and pump parts in oil engines, and case-hardened mild steel for gudgeon pins, cams, rollers, and fuel valve and pump parts in similar engines. Annealed cast steels of 31 to 35 tons/in.^{2} are used for turbine casings for steam temperatures between 450° and 760° F. Where higher temperatures are involved, a low-molybdenum cast steel gives satisfactory results, due to its higher yield point and greater resistance to creep. Crank webs are sometimes made of 28 to 35 tons/in.^{2} cast steel, and the same steel is used for cylinder covers, while a higher tensile cast steel of 35 to 40 tons/in.^{2} is suitable for piston heads. Low alloy steels of nickel (3½ per cent.), nickel-chromium, or nickel-chromium-molybdenum, oil-hardened and tempered, are used in turbine construction for such parts as pinions, while in high-speed turbines, stainless steel is used in quantity for H.P. and L.P. reaction blades, and 32/12 nickel-chromium steel containing tungsten, for H.P. impulse and astern blades. The latter steel and 18/8 steel containing titanium, is also suitable for partition plates and nozzles. In addition to the above, large quantities of steel are, of course, employed for the valves, steampipes, pumps, steering gear and auxiliary machinery of ships.—*"Metallurgia", Vol. 20, No. 119, September, 1939, p. 165.*

Servo Steering Gear.

A recently-published British patent concerns an invention consisting of a quick-acting servo-operated steering gear for boats, which incorporates a mechanical standby to guard against failure of the servo-motor. Referring to the accompanying diagram, the boat has three rudders mounted on separate vertical spindles *c*, the tiller arms being set at slightly divergent angles and linked together by a bar. The centre rudder is extended above its tiller and fitted with a master-tiller arm *d* coupled to the piston of a servomotor cylinder *h* lying athwart the boat. This cylinder is double-acting and oscillates to allow for the radial motion of the master tiller arm. An arm *i* secured to the port rudder spindle is connected to the drop arm *k* of a motor-car steering gear by a connecting rod which is divided at the control valve, one half being connected to the circumferentially-grooved piston and



the other half to the cylinder *r* of the valve. The relative movement of the piston and cylinder is limited, and controlled by springs tending to maintain the piston in mid-position. The cylinder is connected by flexible pipes to an exhauster, and other pipes lead from the valve cylinder to the respective ports of the servomotor cylinder *h*. Upon rotation of the hand steering wheel, and during a free initial movement determined by the strength of the springs in the control valve cylinder *r*, the control valve piston opens the suction to one end of the cylinder *h* so that the piston operates the rudders; the travel of the piston is directly controlled by the handwheel, the piston coming to rest as soon as the control valve resumes its normal position. Movement of the rudders independently of the handwheel, and sufficient to produce additional compression of one of the control valve springs, moves the control valve so that power is applied to restore the rudders to the position corresponding to that of the handwheel. In the event of failure of the servo-motor, the handwheel transmitting mechanism remains operative.—*"Engineering", Vol. 148, No. 3,851, 3rd November, 1939, p. 516.*

Hull and Machinery Efficiency.

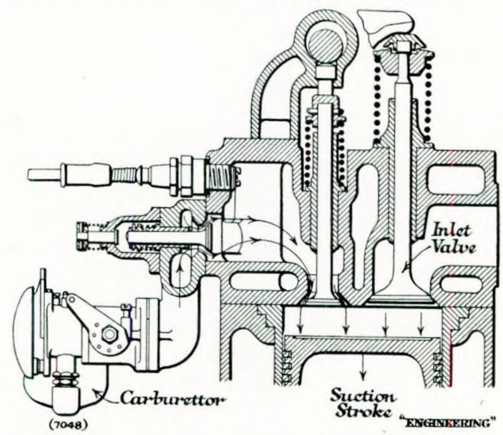
An article on the horse-power and fuel consumption of marine engines contributed by the chairman and managing director of a well-known firm of Scottish shipbuilders to a recent issue of the *"Shipbroker"*, deals with the methods adopted to assess the efficiency of the hull and machinery as a whole. The author—who is an acknowledged authority on the subject of the powering of cargo vessels—points out that when the fuel consumption results for some particular ship are not wholly satisfactory, it is necessary to determine the separate efficiency of the hull and the machinery, in order to find out which is at fault. This is not always an easy thing to do, since the basis of comparison for both cases is the horse-power developed by the engines. It is suggested that in order to make the fuel consumption per horse-power appear favourable, there is a tendency among engineers to log horse-power values on the high side. The greater the horse-power is for a given speed, the poorer is the performance of the hull. The result is that a lack of efficiency which is really attributable to the propelling machinery is often imputed to the hull. The only remedy for this state of affairs is either to ensure that the horse-powers taken are accurate, and to reduce them to a standard by means of a correction based on the average revolutions per minute for the duration of the voyage, or by a slightly more complicated method, to base the horse-power on the observed propeller slip.—*"Fairplay", Vol. CLII, No. 2,941, 21st September, 1939, p. 454.*

Relative Cost of Motorships and Steamships.

Tenders from 14 U.S. shipyards on the Atlantic and Pacific coasts for the construction of the Maritime Commission's C1 Design cargo vessels, vary from $1,512,000 to $2,630,000 per ship. The maximum difference in the estimated cost of a steamship and a motorship is 8·64 per cent., but one firm quoted the same price ($1,980,000) for either, while another quoted $8,000 (=0·378 per cent.) less for a Diesel-engined ship than for a steamship. The difference in first cost of the motor vessels over the steamships is, in each case, substantially less than it would be in European countries. The C1 cargo vessels will be 413ft. in overall length, with a moulded breadth of 60ft., a moulded depth to shelter deck of 37ft. 6in., and a deep load draught of 23ft. 6in. The normal power of the propelling machinery is to be 4,000 s.h.p. and the designed speed 14 knots. The ships will be of the shelter-deck type with raked stem and cruiser stern, and two complete steel decks. A third deck will extend below the second deck from the stem to the forward machinery space bulkhead, and a flat will be provided below the second deck at the level of the top of the shaft tunnel abaft the machinery space. Each vessel will have accommodation for eight passengers and will be manned by a crew of 43.—*"Motorship and Diesel Boating", Vol. XXIV, No. 9, September, 1939, p. 476.*

Petrol Starting Device for Diesel Engines.

A somewhat unusual petrol hand-starting device for a Diesel engined tractor of German manufacture is illustrated in the accompanying drawing. Actually, the makers produce two models, one with this petrol hand-starting device and the other with an electric starting arrangement. The compression ratio of the Diesel engine in question is 16 to 1, and it is necessary to reduce this ratio considerably for operating on petrol by connecting the combustion space proper to a subsidiary chamber located on the left-hand side of the cylinder-head (as seen in the drawing), the passage between the two chambers being fitted with a spring-loaded mushroom valve. When the engine is operating normally on Diesel oil this valve remains closed throughout the cycle. When it is desired to start up on petrol, a shaft



carrying an eccentric is rotated by means of a hand lever until a valve tappet in contact with this eccentric lifts the spring-loaded mushroom valve off its seat. The valve then remains open until it is desired to change over to Diesel oil, the compression ratio with the valve open being 4·5 to 1. When running on petrol the engine functions as a normal petrol engine, the only difference from modern practice being that the inlet valve is of the automatic type. Such valves were, of course, at one time universal in petrol engines, and are entirely satisfactory at low speeds. The valve is shown mounted horizontally in the illustration, with the carburettor below it, the latter being a small model of only sufficient capacity to operate the engine when idling, so that the operator cannot run the engine on petrol on load. When working on petrol, ignition is effected by a sparking plug of normal type located in the subsidiary chamber and supplied with the necessary current by a magneto.—*"Engineering", Vol. 148, No. 3,853, 17th November, 1939, p. 569.*

Air-puff Soot Blowers.

In a description of a high-efficiency tanker which has recently been completed in America, it is stated that the boilers—which are of a well-known design, also manufactured in this country—are fitted with what are termed "air-puff" soot blowers. Although no details are given, it would seem that air is used instead of steam as the means for removing the deposit of soot. Such a procedure possesses certain advantages, more especially in the case of oil-fired boilers (as in the present instance) since, if the oil contains a definite percentage of sulphur, then the oxides formed during combustion must tend to form either sulphurous or sulphuric acid in contact with steam from the blowers, with very deleterious results. On the other hand, a supply of compressed air is not usually available in a steamship.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 12, 21st September, 1939, p. 327.*

Whale-catcher Converted for Carriage of Explosives.

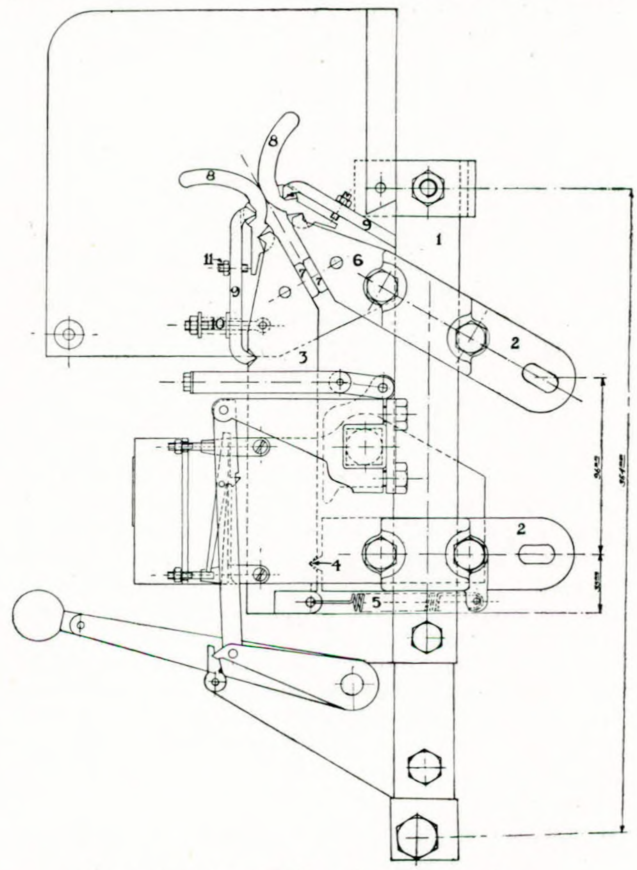
The Norwegian whaler "Busen 2", recently purchased by the Dampskibs A/S Partagas, has been adapted by the Kristiansands Mek. Verksted for the special purpose of carrying explosives. The conversion work involved included the lengthening of the hull by 16ft. and the installation of a new boiler. The entire work took 12 weeks to complete, the appearance of the ship being radically altered. She has now been re-named "Nobel". The loading capacity is about 200 deadweight tons, corresponding to a useful cargo space of approximately 12,000 cu. ft.—*"The Journal of Commerce", (Shipbuilding and Engineering Edition), No. 34,832, 21st September, 1939, p. 7.*

Oil in Feed Water.

Apart from the natural impurities present in all kinds of boiler feed water, there is always the risk of the feed water being contaminated with oil, particularly in the case of reciprocating-engined steamships, although auxiliary machinery of the reciprocating type in turbine-driven vessels may also be responsible for some of the lubricating oil finding its way into the feed water. This may ultimately reach the boilers, where its presence, in the form of a film floating on the surface of the water, results in excessive priming. If such a film becomes deposited on the heating surface, the high resistance which it offers to the passage of heat may lead to overheating and a consequent collapse of the furnace crowns or bursting of the tubes. It is not generally known that if in addition to the soda ash which is used for preventing the formation of scale, a solution of alumino-ferric is allowed to flow into the feed as a separate stream, a flocculent precipitate of alumina is formed. This serves to entrap all the particles of oil suspended in the water and forms a coagulation of oil and alumina which can be removed in the ordinary way from the feed water during its passage through the feed water filter.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 12, 21st September, 1939, p. 327.*

A New Marine Circuit-breaker.

The Gardy electrical circuit-breaker was primarily designed to meet the requirements of the French Navy and is claimed to be a robust piece of mechanism in which all the parts are accessible from the front, and in which replacements can be effected very quickly. The circuit-breaker is made up of a series of self-contained units, one for each phase or pole of the circuit to be controlled. Referring to the diagram, each unit is mounted on a pair of duralumin bars (1) suitably insulated from the rest of the apparatus. The connections are made at the back to flat bars (2) to which cable end lugs can be bolted, the cable running either up or down, or laterally from the breaker, as may be required. The moving arm (3) is made up of a number of copper knife-blade bars, the number depending on the capacity required. A triangular notch is cut in the bars near the lower end, into which the knife blade (4) projecting from the lower connection, fits. This forms the contact between the connection and the arm. Each element of the latter is held in con-



Layout of the new French circuit breaker.

tact with the knife-blade by the spring (5), both the knife blade and the interior of the notches in the blades of the breaker arm being heavily silver-plated to ensure good contact. The moving arm (3) and the fixed arm (6) are maintained in contact by means of the two large silver contact blocks (7). The pressure between these two blocks is regulated by a spring in the frame (8) which presses the arm (3) against the fixed contact (6). The contacts are made of pure silver, which is soft enough to be slightly compressed under the pressure of the spring arms when they close, thereby ensuring perfect contact at all times. In order to prevent arcing, each of the arms, *i.e.*, the fixed arm (6) and the moving arm (3)—is provided at the end with a horn (8) of the special shape shown in the drawing. Bars (9) hold these horns in position, the contact against the arm and the horn being by knife-blade contacts in a groove, as shown. A pivoted rod (10) holds the bar on the arm, with a sliding spring to press the bar into position. A setscrew (11) forms a stop limiting the travel of the horn. The operation of the device is as follows: When the moving arm opens, the current first passes through the horns of the two contacts, maintaining the flow until a clean separation of the silver contacts has taken place (which is made possible by the double knife-edge hinging of the horns). When the end of the horn touches the setscrew (11) the horn is also drawn away, and any arcing takes place between the horns, not the contacts. In case there should be the beginning of a fusion between the contacting horns, the pressure of the moving bar causes the lower end of the bar (9) to lift and the horns then roll against each other and break the weld by "torsion", whereupon the horns separate cleanly. The opening and closing of the system is effected by means of a relay which has a moving arm connected with the breaker control arm, and is accessible from the front. The control is by a system of levers and trips arranged to connect with the operating handle, the whole of the mechanism being shock- and vibration-proof.—*"The Marine Engineer", Vol. 62, No. 748, November, 1939, pp. 322 and 336.*

Norwegian Fruit Carrier Launched in Denmark.

The motorship "Mosdale", recently launched at the Burmeister & Wain Shipyard, Copenhagen, for Norwegian owners, is specially designed for the carriage of fresh fruit in refrigerated and air-conditioned holds. The ship is 315ft. long, with a beam of 45ft. 6in., a depth of 28ft. 10in., and a deadweight capacity of about 2,250 tons. The insulated holds have a capacity of approximately 163,000 cu. ft., and can be maintained at a temperature not exceeding 32° F. in the tropics by a Sabroe NH_3 refrigerating installation. The propelling machinery consists of a 9-cylinder B. & W. single-acting 2-stroke Diesel engine designed to develop 3,700 i.h.p. at about 160 r.p.m. The service speed of the ship will be 13 knots and the fuel consumption for all purposes at that speed is expected to be about 13 tons per 24 hours. Electric current will be provided by three Diesel-driven generators, their power units being 180-b.h.p. single-acting 2-stroke B. & W. engines running at 400 r.p.m., which are also coupled to air compressors by clutches. The steering gear is of the all-electric type and the cargo-handling equipment includes eight 4-ton derricks.—*"Journal de la Marine Marchande", Vol. 21, No. 1,067, 13th September, 1939, pp. 1297-1298.*

Welded Buoys.

One of the great advantages of welding over riveting lies in the fact that it yields a perfectly watertight joint, for which reason a channel buoy of all-welded construction should prove particularly serviceable, since there can be no loss of buoyancy due to the leakage of water into its structure. An illustrated description recently appeared in a technical periodical, of a light-carrying buoy, 10ft. in diameter and 7ft. 6in. in overall length, which has been built on the all-welded principle. The float chamber is formed of $\frac{3}{16}$-in. mild steel plates and is divided into four watertight compartments. It carries a cast-iron ballast ring weighing $1\frac{1}{2}$ tons, which is suspended by tee bars welded to the lower deck of the float, but bolted to the ring, light stays welded in place being used for bracing. The mooring lug is also welded to the bottom of the float chamber. There are no lugs or projections of any kind and the total weight of the all-welded buoy is 17 cwt. less than that of the buoy it has replaced, notwithstanding its more robust construction.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 12, 21st September, 1939, p. 327.*

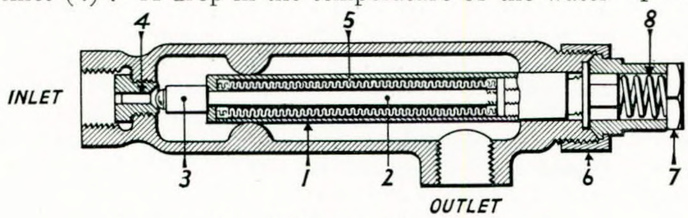
A Self-unloading Vessel.

A contract has been placed in the U.S.A. with the Bethlehem Shipbuilding Company for the conversion of a collier into a self-unloading ship with a capacity for 10,000 tons of coal or an equivalent volume of coke, stone, gravel or similar material. The hold will comprise a series of hoppers having about 80 gates through which the material will pass on to a pair of belt conveyers 42in. wide and about 286ft. long, each of which has a capacity of 700 tons an hour. At the bow of the ship these conveyers transfer the material on to short transverse conveyers. These transverse conveyors unload into the boot of a chain and bucket elevator running up through the deck and delivering to the lower end of a boom conveyer 54in. wide and 162ft. long. This boom conveyer, which handles over 1,400 tons an hour, may be raised, lowered, or swung out over either side of the vessel.—*"The Engineer", Vol. CLXVII, No. 4,366, 15th September, 1939, p. 279.*

Hot Water in Crew Accommodation.

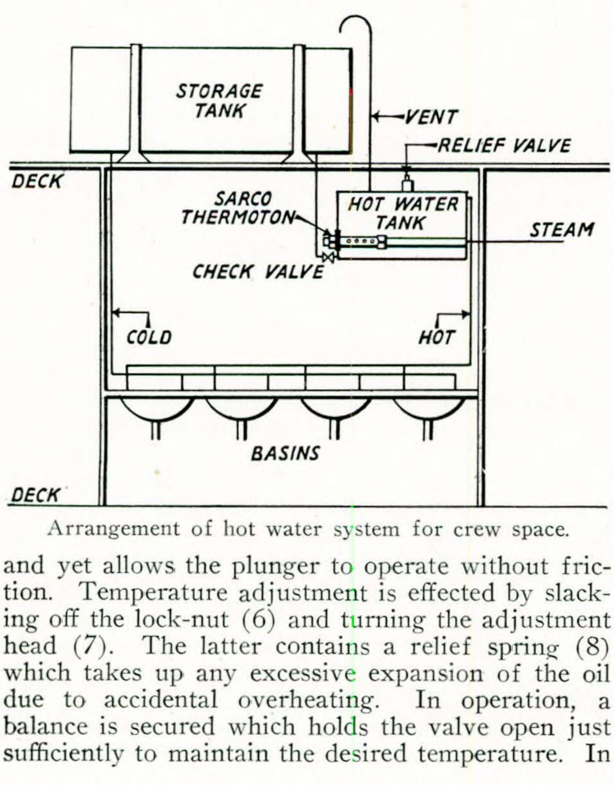
Recent recommendations of the Board of

Trade concerning the supply of hot water in crew accommodation has led to the development of a compact form of thermostatically-controlled steam water-heater which combines efficiency and economy. The installation consists of a small tank fitted with a thermostatic steam injector and provided with a steam connection. Cold feed is obtained from an overhead tank and the heated water is led to the wash-basins as shown in the diagram. Referring to the cross-section of the thermostatic control device, the thermostatic element (1) is filled with special mineral oil and hermetically sealed, the body casting being provided with a number of holes to allow the water to circulate around the element. When the water reaches the set temperature, expansion of the oil pushes the plunger (2) forward and the valve head (3) attached to the plunger, closes the steam inlet (4) . A drop in the temperature of the water



Cross-section of thermostatic control.

causes the oil to contract, allowing the plunger to recede and open the steam valve. The plunger works in a packingless gland (5) formed of spiral bellows tubing, which seals the oil in the element



Arrangement of hot water system for crew space.

and yet allows the plunger to operate without friction. Temperature adjustment is effected by slacking off the lock-nut (6) and turning the adjustment head (7). The latter contains a relief spring (8) which takes up any excessive expansion of the oil due to accidental overheating. In operation, a balance is secured which holds the valve open just sufficiently to maintain the desired temperature. In this manner, only that amount of steam is used which is necessary to maintain the required temperature in the tank without any wastage of steam. The increased volume of water from condensation can be returned to the storage tank, or if this is not desirable, it can be led into a condensate drain. Where there is danger of the vent pipe freezing, a relief valve may be filled to the top of the tank. This thermostat unit has been fitted in a number of ships and apart from its uses for the temperature control of hot water, the unit has several other marine applications.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 18, 2nd November, 1939, p. 482.*

Vibration of a Turbo Generator.

A 2,000-kW. turbo-generator developed a peculiar form of vibration twice a day, between 9 and 10 a.m. and 2 and 3 p.m., and this vibration was sometimes severe enough to trip the emergency valve. On opening up the turbine casing it was found that everything was in good condition. The regularity with which the vibration occurred led to the suspicion that heating and cooling of the turbine parts was causing the trouble, and this surmise proved to be correct. An examination revealed that the steam-pipe supports buckled through expansion and exercised a twisting effect on the turbine-valve casing. The vibration of the turbine gradually worked the pipe through its supports to free the valve casing, whereupon the vibration would cease. When the turbine was shut down at noon and night, contraction of the pipe and turbine pulled the former through its supports again, so that it was ready to distort the valve casing when the turbine was started again. The vibration was entirely stopped by releasing all the anchors on the pipe and supporting it on rollers.—*"Mechanical World", Vol. CVI, No. 2,750, 15th September, 1939, p. 261.*

New Range of Vertical Oil Engines.

A new range of medium-speed cold-starting vertical oil engines introduced by Ruston & Hornsby, Ltd., to replace their present VR series, comprises 21 sizes, varying from 90 to 1,040 b.h.p., and having from 3 to 8 cylinders. The engines work on the 4-stroke cycle at from 750 to 375 r.p.m., and are suitable for stationary purposes or for use as marine auxiliaries. The main differences between these new engines and the series which they are intended to replace, are an "open" type of combustion chamber with overhead valves, and a new fuel-injection equipment including a separate fuel pump for each cylinder mounted alongside the cylinder it serves, together with the recently introduced Ruston Mark 37 atomiser. Other differences are of a comparatively minor nature. The same makers have also produced an improved series of pressure-charged engines based upon the larger sizes of the new range. The Büchi type of exhaust-driven turbo-blower is used and the power developed varies from 415 b.h.p. in a 6-cylinder engine of this type to 1,560 b.h.p. in an 8-cylinder unit, there being 8 intermediate sizes. These powers are about 50 per cent. higher than those developed in the non-pressure charged engines of similar cylinder size.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 34,820, 7th September, 1939, p. 7.*

American Excursion Steamer Converted to Diesel Drive.

The Sound Steamship Lines' excursion steamer "Calvert" was built in 1902 for passenger service and was then fitted with steam engines of 1,800 h.p. The "Calvert" is 180ft. long, with a beam of 40ft., a depth of 10·3ft., and a gross tonnage of 889 tons. There are two continuous passenger decks, the main deck being completely sheltered and providing large space for cargo, if required. When the ship was re-engined with a 600-h.p. Atlas Imperial unit, it was found possible to accommodate the latter, together with all the auxiliary machinery, fuel, air and water tanks, in the original engine room, leaving the boiler room empty. This Atlas Diesel engine has 6 cylinders with a 15-in. bore and 19-in. stroke, and works on the 4-stroke cycle. It is rated at 600 b.h.p. at 300 r.p.m., is direct-reversing and fitted with fresh-water cooling. The salt water circulating pump is pulley-driven from the propeller shaft, as is also a 25-kW. 110-volt d.c. generator which supplies electric power while under way. For harbour use there is a similar generator driven by a Hercules Diesel engine. An air compressor driven by the main engine supplies air for the whistle and for manœuvring purposes, a Curtiss 2-stage auxiliary compressor driven by a 10-h.p. electric motor being fitted in addition. The former boiler room has been divided into upper and lower compartments by extending the main deck, and provides extra passenger and cargo space. The anchor winch and steering gear are electrically-operated. The "Calvert" carried out acceptance trials after conversion on the 10th August, when the engine, driving a 3-bladed propeller, 84in. diameter by 48in. pitch, ran at 282 r.p.m. with an exhaust temperature of 750° F., and a fuel pressure of 4,000lb./in.^{2}, giving the ship a speed of over 11 knots.—*"Motorship and Diesel Boating", Vol. XXIV, No. 9, September, 1939, pp. 470-471.*

Large Tugs for the U.S. Navy.

The U.S.S. "Navajo", the first of three ocean-going tugs under construction for the U.S. Navy, was launched at Staten Island on the 17th August. The tugs are of unusual size, being 205ft. 3in. long, with a beam of 38ft. 6in., a depth of 22ft., and a draught of 14ft. They will be equipped with Diesel-electric propulsion, four main generator engines with a total power of 3,000 h.p. being installed. High-speed motors, operating through a reduction gear, will drive the propeller at 140 r.p.m., giving a speed of 16¼ knots. Each tug is to be fitted with an electrically-operated automatic towing winch and will provide accommodation for 96 persons. The tugs are intended to work with the fleet and will be specially equipped for such service.—*"Motorship and Diesel Boating", Vol. XXIV, No. 9, September, 1939, p. 479.*

Mercantile Shipbuilding in Italy.

The passenger and cargo vessel "Calino", recently launched at Trieste, and building to the order of the Societa Anonyma di Navigazioni, is intended for service in the Eastern Mediterranean. She is a vessel of 2,500 tons d.w. capacity and is to have accommodation for 209 passengers in single, double, and three-berthed cabins. The ship has a length of about 355ft., and will draw about 19ft. The propelling machinery is to consist of two sets of 8-cylinder C.R.D.A. oil engines each developing 2,400 h.p. at 180 r.p.m. and designed to give the ship a speed of 18 knots. The Cantieri Navali of Fiume have begun the construction of the first of three 4,200-ton cargo vessels for the Tirrenia Company's service between Italian ports and London. All three ships are expected to be in service towards the end of 1940. The Cantieri Riuniti dell'Adriatico have launched the cargo motorship "Grenanger", the second of two sister ships ordered by Norwegian shipowners, who recently took delivery of the first, the cargo motorship "Siranger", a vessel with dimensions of 402ft. × 55ft. 10in. × 33ft. 6in., and a deadweight capacity of 8,600 tons on a draught of 27ft., with accommodation for 12 passengers. The propelling machinery consists of a 6-cylinder, single-acting 2-stroke Sulzer Diesel engine developing 3,400 h.p. at 125 r.p.m., and designed to give the ship a speed of 13 knots. The "Siranger" is, however, stated to have attained a speed of 14½ knots on her trials. Both these ships are intended for service between Norway and Vancouver, B.C.—*"Journal de la Marine Marchande", Vol. 21, No. 1,068, 21st September, 1939, p. 1,320.*

Self-lubricating Bronze Bearings.

The bronze used in such bearings manufactured by a British firm in the Eastern Counties, contains 89-90 per cent. copper and 11-12 per cent. tin, but by special processes the metal is produced in a micro-cellular condition, having all the interconnecting cells charged with a good-quality lubricating oil. This amounts to between 25 and 40 per cent. of the volume of the bearing, and when subjected to pressure or heat, the oil is exuded at the bearing surface. The bearing is, therefore, self-lubricating, a film of oil being always present. The amount of oil in this film is increased automatically as the pressure or temperature in the bearing is raised. The film is stated to be absolutely uniform and to give lubrication of an efficiency impossible to attain by the addition of oil to bearings of the conventional type. Running is almost noiseless and self-lubricating bronze bearings are claimed to be practically equal to ball bearings as regards reduction of friction. The original amount of oil in the metal will suffice for several years' service (corresponding to over 750 million revolutions) and there should, therefore, be an appreciable saving in respect of oil consumption. Micro-cellular bearings of this type are for most purposes little inferior to ordinary bearings as regards strength, and will operate up to a pressure of about 4,000lb./in.^{2}, a load appreciably higher than is called for in general engineering practice. The bearings are supplied by the makers ready for use without any subsequent machining or adjustment, being manufactured to a tolerance of half-a-thousandth of an inch inside and outside diameter, up to 1in. bore and of 0·0006in. for 1 to 1¾in., no oil holes or grooves being necessary. Nearly 200 standard sizes, from ⅛in. to 2½in. bore, are produced by the makers.—*"The Sheepbridge Stokes Magazine", No. 18, September, 1939, p. 11.*

Diaphragm Valves.

A type of valve which is claimed to possess many advantages regarding tightness and simplicity of construction has been developed by a well-known British firm. The main feature of this valve is the replacement of metal closing contacts by the flexing of a reinforced rubber diaphragm. The flow is arrested at a given point by the descent of the diaphragm on to a weir in the body of the valve to provide a perfect seal. An important point in the design is the separation of the working parts of the valve from the fluid passed. By replacing the usual troublesome gland with a resilient diaphragm the risk of leakage is eliminated, ease of operation is obtained and there are no pockets to collect solids and prevent perfect closure, in fact, the rubber diaphragm closes over any small solids trapped. Absence of metal faces means that seizing cannot take place and maintenance costs are reduced, since the damage which is frequently caused by the passage of particles of grit, etc., to both the valve and the seating in the usual type of stop valve, cannot occur with this form of construction.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 13, 28th September, 1939, p. 351.*

New American Dredger.

The dredger "Chester Harding", built at Wilmington, Delaware, for the U.S. Engineer Department, is 308ft. long, with a beam of 56ft., a load draught of 20ft., and a hopper capacity of 2,500 cu. yards, her load displacement being 7,000 tons. The propelling machinery comprises two sets of 8-cylinder Busch-Sulzer 4-stroke Diesel engines each developing 1,000 s.h.p. The auxiliary machinery includes two 6-cylinder non--reversing Diesel engines, each of 650 s.h.p., coupled to two large centrifugal pumps, running at 250 r.p.m., with a total capacity of 17 cu. yds. per min. of solid matter. The pump outlets have a diameter of 20in., whereas the inlets are 22in. in diameter. Electric current is furnished by a 400-kW. generator driven at 450 r.p.m. by an 8-cylinder 600-b.h.p. Diesel engine, the supply being at 250 volts. All the Diesel machinery is cooled on the closed circulating water system, with heat exchangers capable of a heat transfer of over 5½ million B.Th.U. per hour. The engine-room auxiliaries include three centrifugal fresh-water pumps driven by 10-h.p. motors. The deck winches, steering gear and windlass are also of the electric type. The two main suction pumps discharge into a trough which runs fore and aft over the hoppers, down the centre of the ship. As one stream comes up on the port side and the other on the starboard, they mutually offset each other's force and avoid a strain on the ship at that point. As the sludge goes down this trough it runs off into hoppers on each side. In the ship's bottom are 8 cast-steel hopper doors, 4 forward of the machinery space and 4 aft. Each gate is opened and shut by a hydraulic pressure mechanism working at a pressure of 300lb./in.^{2}, the doors being individually controlled by a hand-wheel accessible from the catwalk over the hoppers.—*"The Shipping World", Vol. CI, No. 2,415, 27th September, 1939, p. 346.*

Boiler Safety Valves.

An improved type of safety valve has recently been patented by a British engineering firm, in which a small spring-loaded valve is incorporated which permits steam to pass to the underside of a piston at the desired blow-off pressure. The upward movement of this piston gives an increased lift to the main valve and enables the steam from the boiler to escape at the same high rate at which it is generated. The auxiliary valve chamber is directly connected to the inlet branch of the main safety valve and both valves are set to blow off at the same pressure. After blow off, when the pressure is sufficiently reduced to permit the main and auxiliary valves to close, a small passage is uncovered which allows the steam on the underside of the piston to escape so that the piston drops to its normal position and does not impede the closing of the main valve.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 13, 28th September, 1939, p. 351.*

Variable Capacity Burners.

Notwithstanding the high degree of efficiency attained in the design of the oil fuel burning installations in ships, many of these still include burners which can deal with only a limited amount of oil per hour. At the upper and lower limits of capacity, efficiency is seriously impaired, either through high pump pressure on the one hand or poor atomisation on the other, which can only be remedied by changing the burner nozzles when variations in steam requirements are indicated. In order to obviate this disadvantage and at the same time supply a fitting with fine quality atomisation at a moderate cost, a variable capacity atomiser operating at a constant oil discharge pressure was recently introduced by an American firm. This burner is similar in many respects to the ordinary design already supplied by the same makers, but includes a device through which oil surplus to requirements is returned to the pump suction. The quality of atomisation for this variable capacity burner is constant over the entire range obtainable, all the oil passing through the sprayer nozzle (including the amount by-passed) being given the energy required to proper atomisation. Tests conducted with this type of burner have shown that the capacity range is very large, an atomiser with a maximum capacity of 1,300lb. of oil per hour having been operated continuously and satisfactorily at 17lb. per hour.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 13, 28th September, 1939, pp. 351-352.*

Diesel-engined Firefloat for Stavanger Municipality.

The motor firefloat "Nøkk" recently delivered to the Stavanger municipality by A/S Rosenbergs Mek. Verksteds, Stavanger, is a steel-built vessel 95ft. 2in. in overall length, with a beam of 18ft. 4½in. and a draught of 6ft. 10½in. She is propelled by two sets of 8-cylinder 160-b.h.p. Gleniffer Diesel engines driving the propellers through 2:1 reduction gearing. Wet exhausts are led to the stern, with water injection silencers and a combination of armoured rubber and alloy exhaust pipes. The main engines are fitted with wheelhouse control. The pumping units comprise two 12-cylinder Gleniffer V-type Diesel engines, each of 240 b.h.p. coupled to two pumps each having a normal output of 1,540 gallons per minute against a head of 145lb./in.^{2} and capable of maintaining pressures up to 210lb./in.^{2}. The pump engines are fitted with exhaust arrangements similar to those of the main propelling engines. For fire fighting, 3 monitors with worm operating gear for both slewing and elevating are fitted on the main deck, in addition to two hose manifolds, each with 6 connections, provided on the after deck and a 3-connection manifold arranged on the forward deck. For salvage work, a suction manifold is provided on the starboard side and a towing hook and horse are also fitted for salvage purposes. Electric current is supplied by two 115-volt dynamos, each driven by a 2-cylinder 14-h.p. Lister Diesel engine. One of these is also coupled to an air compressor and the other to a general service pump. In order to keep the hull cool when working in close proximity to a fire, perforated small-bore pipes are led along the gunwales, thus allowing streams of water to play on the ship's sides. Deck machinery includes a hand capstan aft and a double hand winch forward. A double bottom tank under the engine room holds 10 tons of oil fuel. On trials the "Nøkk" developed a speed of 11½ knots.—*"Shipbuilding and Shipping Record", Vol. LIV, No. 13, 28th September, 1939, pp. 356-358.*

New Japanese Motorship at New York.

Having sailed from Yokohama on her maiden voyage on the 31st August, the Mitsui Line's motorship "Awazisan Maru" arrived at New York—*via* the Panama Canal—late in September. Constructed by the Tama Shipbuilding Co., Ltd., she is a vessel of 9,794 tons gross, 511 by 64 by 20ft., with a draught of only 14ft. The propelling machinery consists of a set of Japanese-built B. & W. 2-stroke double-acting Diesel engines developing 9,600 b.h.p. and giving the ship a speed of 20 knots, the service speed being 18 knots. In addition to a silk room, the vessel has refrigerated space for special cargoes and accommodation for 12 passengers in five double and two single staterooms.—*"The Nautical Gazette", Vol. 129, No. 20, 7th October, 1939, p. 23.*

New Self-trimming British Colliers.

Two 4,350-ton colliers now completing at the Burntisland Shipyard for Messrs. Wm. Cory & Son, Ltd., were launched 72 days after the laying of their keels. The new ships have 5 self-trimming type holds, 4 steel derricks being provided for cargo handling. The holds are designed on the hopper principle, to facilitate the coal flowing by gravity to within the immediate range of the discharging grabs. The deck machinery includes a steam windlass, telemotor-control steering gear, 4 cargo winches, and a warping winch. The propelling machinery consists of a set of triple-expansion engines in which the I.P. and L.P. cylinders are fitted with cam-operated poppet valves designed for use with superheated steam. Two cylindrical boilers with Howden's forced draught provide steam at a pressure of 220lb./in.^{2} and a superheat temperature of 620° F. The auxiliary machinery includes an emergency Diesel-driven dynamo for use in port when steam is not available.—*"The Burntisland Shipyard Journal", Vol. 16, No. 4, October, 1939, pp. 64-65.*

Main Engine Friction Clutch Control Arrangements in Oil-engined Paddle Tugs.

Diesel engined paddle tugs with two sets of engines working on a common paddle shaft drive the latter through helical gearing and hydraulic or friction couplings. Some of the new motor tugs designed for service on the Volga are fitted with pneumatically-controlled twin-plate friction clutches. A drop in the pressure of the air in a clutch of this type causes the springs pressing against the back of its plate to bring the face of the latter into engagement with that attached to the paddle shaft gearing, thereby connecting the engine with the gearing and paddle wheels. A rise in the air pressure within the clutch causes it to disengage and disconnects the engine from the gearing and paddle wheel. When manœuvring a tug it is frequently necessary to go ahead on one paddle wheel and astern on the other, the vessel being reversed by means of either engine. Under these circumstances it becomes necessary to guard against the possibility of having both engines in gear while they are running in opposite directions, as such a mishap might cause extensive damage to the machinery and—more especially—to the friction clutches. An adequate safeguard against such accidents is provided by interconnecting the controls of the friction clutches with those of the main engines. This makes it necessary for both engines to be run in the same direction before they can be coupled to the common paddle shaft. A control system of this kind, designed by the author, has been fitted in the second group of the 1,200-h.p. Volga motor tugs built by the Sormovo Works to the order of the People's Commissariat of Water Transport. The system comprises two pneumatic control valves—one for each engine—a distributor and two emergency shut-off cocks connected by a pneumatic pipe line. The system is operated by compressed air supplied by a bottle through a reducing valve to an air reservoir of about 8·8 cu. ft. capacity in which the air is stored at a pressure of about 75lb./in.^{2}. This reservoir is fitted to prevent an excessive drop of pressure in the system due to sudden declutching, which might occur through a delayed action of the reducing valve. The pneumatic control valves are fitted at the front of each main engine and each consists of two valves operated by the levers employed for starting and stopping the main engines. The latter can only be put in gear when the levers are in the "running" or "stop" position, being thrown out of gear when the levers are moved over to the "starting" or "idling" position. The distribution is located at the main engine control position and may be of two different types, both of which operate in the same manner. Type *A* comprises a cast-iron valve box with 6 gunmetal rubber disc valves controlled by a camshaft and handwheel. Type *B* employs a single cylindrical slide valve with an appropriate system of passages and ports instead of the 6 disc valves, the valve box being provided with indicators showing the connection made. Type *A* has the advantage of giving ready access to the valves for repairs or renewals, while Type *B* provides greater ease of operation of the valve spindle owing to the absence of valve spring resistance. On the other hand, the cylindrical slide valve is less readily accessible for repairs in the event of damage. A final choice of the type of distributor to be adopted in new tugs will be made when further running experience has been obtained. The distributor has four working positions, *viz.* (*a*) Both engines de-clutched; (*b*) both engines in gear—for which purpose they must both be running in the same direction; (*c*) and (*d*) either engine in gear and running ahead or astern, the other engine being disconnected. The emergency shut-off cocks fitted to each of the main engines operates simultaneously and automatically declutch both engines if their controls on the distributor are set to a position putting them into gear when they are running in opposite directions. The emergency shut-off cocks are of gunmetal, with cast-iron bodies, and are fitted at the front of each engine. These cocks are operated when the engines are reversed, by means of pinions on the vertical reversing shafts which move through an angle of 270° when reversing and are geared 1 :3 with toothed quadrants mounted on the emergency shut-off cock spindles, so that the latter are turned through 90° when the engines are reversed. The cocks are provided with indicators showing the direction of rotation of the engines. The control system is extremely simple in operation, as apart from the manœuvring levers on the main engines and the fuel valve controls, the handwheel on the distributor is the only control which need be operated by the engineer on watch when manœuvring. In order to reverse both engines the distributor valves are set to the "both declutched" position by means of the handwheel, while if only one engine is required to be reversed—as, *e.g.*, in readiness for manœuvring—and the other is to be kept running on the paddle wheels, the distributor indicator must show "starboard connected" or "port connected" as the case may be. A series of trials conducted in tugs fitted with such a system of controls showed that in the tug "Uralneft" the time taken to engage the clutches of both engines was from 5 to 6 seconds, a similar time being required for engaging the clutch of either engine when manœuvring; while in the tug "Andreev" 6 to 7 seconds were required to engage both engine clutches and only 3 to 4 seconds to engage either clutch when manœuvring the engines. In both cases an air pressure of about 66lb./in.^{2} was maintained in the control system. The article is illustrated by 6 descriptive diagrams showing the control connections under various conditions.—*V. E. Gubanov, "Soudostroienie", Vol. 9, No. 10, October, 1939, pp. 578-580.*

Electrical Equipment of Ships.

A third edition of the Institution of Electrical Engineers' *Regulations for the Electrical Equipment of Ships* has now been published. These regulations, which enumerate the main requirements and precautions for ensuring satisfactory results, including safety from fire and shock, relate to the generation, storage and distribution of electrical energy for all purposes in sea-going ships of all descriptions except ships of war. They are not intended to take the place of a detailed specification or to instruct untrained persons. Various methods of accomplishing the electrical equipment of ships are provided for, and in order to guard against the risk of fire and shock the method selected should be suitable for the voltage, the atmospheric conditions, and the size of the installation. Only existing proved materials, appliances, and methods are considered. It is not intended, however, to discourage invention or to exclude other materials, appliances, and methods, which may be developed in the future. The Institution of Electrical Engineers may make appropriate additions or modifications to the regulations when, in their opinion, such modifications are necessary, in order to provide for the use of methods, materials, or appliances, for which provision is not at present made in the regulations and which are shown to the satisfaction of the Institution to be not less safe than those covered by the existing regulations.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 34,868, 2nd November, 1939, p. 3.*

Mitigating Noise and Vibration on Board Motorship.

In the case of the cross-Channel passenger vessel "Prince Baudouin", the main problem was the reduction of the noise at its source and in order to effect this the interior of the main and auxiliary engine-rooms were lagged with cork slabs of about 20in. by 20in. with a thickness of 2in., fitted on 2-in. wooden battens. The suction casings of the turbo-blowers were lined with a 2-in. thickness of felt protected by wire-netting. Extensive use was made of celotex for lagging ceilings in the passenger accommodation, the general results being fairly satisfactory in view of the relatively low cost involved. The main engine silencers were designed on the theory of acoustic filters, and after eliminating noise due to an inadequately-stiffened partition plate separating the two resonance chambers forming the main portion of each silencer, the results are reported to be excellent. Initial vibration of the engines and propellers due to imperfect balancing has since been overcome by local stiffening of the hull at the spots where such vibration was most apparent. The machinery installation of the "Prins Albert" is similar to that of the "Prince Baudouin", except for the fact that independent rotary blowers for scavenging are provided in lieu of reciprocating pumps driven by the main engines. This has resulted in a substantial reduction of noise. Improvements were made in the design of the main and auxiliary engine silencers, including the provision of acoustic filter plates permitting free passage of the gases. The results are reported to be highly satisfactory, the system appearing to possess the efficiency of a low-frequency filter. Vibrations, especially in the vertical plane, occur at service speed, but in a different way to those noted in the "Prince Baudouin". The third harmonic of the engine revolutions (due to the 3-bladed propellers) is only felt in the after part of the ship. Throughout the forward and midship sections natural amplitudes preponderate and these tend to increase towards the lower part of the hull. The origin of these vibrations was assumed to be the insufficiently rigid full bottom, since the double bottom extends only under the machinery spaces. Additional stiffening has now been provided. It is considered that the natural frequencies of certain portions of the structure have been influenced by the method of assembly adopted, giving rise to differences found to exist between practically identical ships. The engine rooms of the passenger liner "Baudouinville" were lagged externally with sound- and heat-insulating material, in accordance with the original design. This large ship is singularly free from noise as compared to the cross-Channel motorships, the ratio $\frac{\text{b.h.p.}}{\text{tonnage}}$ being only one-tenth of the latter, in which it is $\frac{16{,}000 \text{ b.h.p.}}{2{,}800 \text{ tons}} = 5{\cdot}35$, whereas in the "Baudouiville" it is $\frac{9{,}000 \text{ b.h.p.}}{17{,}100 \text{ tons}} = 0{\cdot}53$. The main and auxiliary engine exhaust silencers of the vessel are fitted with acoustic filters and the general result is excellent. The Diesel-electric propelling machinery installations of the surveying ships "De-Paul" and "Paster-Pype" include fairly high-speed engines running at constant speed. The resultant vibration is below the troublesome limit for hydrographic work. The exhausts, fitted with silencers, are led aft and discharge above the waterline.—*Paper read by Jean Bosquet at the Congrés International des Ingénieurs Navals at Liége, summarised in 'The Motor Ship", Vol. XX, No. 237, October, 1939, p. 243.*

Corrugated Furnaces in Boilers.

Notwithstanding modern improvements in the material and methods of manufacture of corrugated furnaces in marine boilers, these furnaces are liable to develop defects in service, the chief of which is a tendency to "come down". Another common defect is wastage along the line of the fire bars, which, however, can usually be remedied by building up the part with electric welding. As regards the liability of the furnace to collapse in a vertical direction, it has been suggested that furnaces should be constructed with the vertical measurement about $\frac{1}{8}$in. more than the horizontal one, in order to counteract this tendency. Where new furnaces are fitted in old boilers, new leaks are often started and old ones enlarged, but proper care in the fitting of the new furnaces should, nevertheless, produce satisfactory results.—*"Fairplay", Vol. CLIII, No. 2,945, 19th October, 1939, p. 90.*

Extracts.

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

Steam Traps for Marine Installations.

By Obering. Hans Richter—Hamburg VDI.

"Shipbuilding and Shipping Record", 3rd August, 1939.

The reliable and economical operation of a ship's steam generating plant depends to a great extent upon the correct and timely removal of water formed by the condensation of steam. A considerable quantity of condensate is produced by the extended pipe lines leading to the steering gear, windlass, and winches, as well as the engine-room auxiliaries and heating apparatus. In the case of other apparatus, such as cooking vessels, laundry machines, radiators, and heating coils, however, the steam is supposed to condense and transmit its heat content to the walls of the appliance. If this condensate is not removed in time, *i.e.,* if the steam is not continuously freed from water, dangerous water shock will ensue which may result in the bursting of pipes and fittings and rattling in the heating system. In addition to those disadvantages, the calorific efficiency of the heating and cooking equipment decreases very much when the steam is not freed from water. Fig. 1 shows the large influence of accumulated condensate upon the efficiency of the heating surface, for it indicates clearly that the transmission of heat in the presence of condensate is only 1/20 of the heat transmission of condensing steam; in other words, the entire heating surface covered by the condensate is practically out of commission.

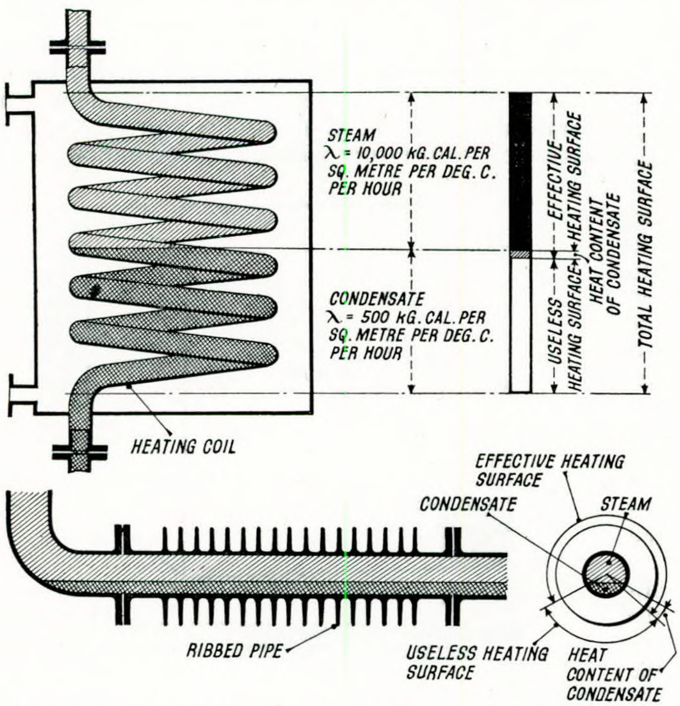


Fig. 1.—Loss of heating surface due to stemmed condensate.

Large steam losses are often caused by leakage and breakdown of the steam traps. Unfortunately this fact is often not considered important enough to warrant investigation, though it is of greatest importance for economical working. A leak having an area of only 1/25 sq. in. will, at a pressure of 150lb. per sq. in., cause a loss of 140lb. of steam per hour. Under actual working conditions, these leaks with their steam losses are considerably larger. For instance, if a valve sticks on account of dirty levers or links or the float is rendered inoperative for the same reason, then the steam passage is wide open and steam will escape at the rate of 8,000lb. per 24 hours, assuming the bore of the valve to be ¼in. and the pressure 150lb. ner sq. in.

Removal of the condensate in a ship is even more important than in an industrial works, for the vessel is subjected to heavy pitching and rolling, which causes the condensate to be hurled to and fro in the pipe lines, thereby increasing the danger of water hammer. Moreover, the operation of the steam trap is unfavourably affected by this rolling, for which reason types generally used on land cannot be installed aboard ship. The float, for instance, is a freely moving unit guided by joints and possessing great inertia, in consequence of which the steam trap (slide or valve type) is not controlled by the level of the water of condensation, but very often only by the rolling motion which the steam trap is naturally forced to follow. The danger is therefore present that either the condensate is stemmed or that the steam will blow through unchecked, depending on how the ship's motion affects the float.

Fig. 2 shows the pitching curves of the motorship "San Franzisko" (*Rundschau Deutscher Technik 7, July, 1938*), and below them the corresponding movement of the steam trap. The diagram shows that on account of the movement of the ship the float is temporarily prevented from closing the discharge unit, though the actual valve is not covered with water at all and steam can flow through unchecked. These conditions will of course obtain no matter how the steam trap is mounted, for the ship is subjected not only to pitching, but also to rolling motion. In addition, considerable acceleration is imparted by the ship's motion which according to measurements on board the aforementioned

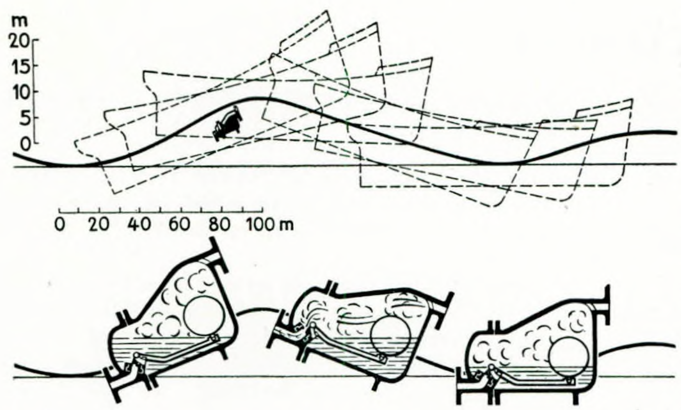


FIG. 2.—Ineffective operation of float-type steam trap due to pitching (exaggerated for the sake of clearness).

boat can amount to about 8½ft. per sq. second. It is evident that such violent acceleration will cause the condensate to be strongly agitated in the pipe lines and is also going to influence the float so that the moving parts are bound to stick.

Experiments to compensate the ship's rolling motion by shortening the float lever of the steam trap are also doomed to failure, for the lever must always be of such design that the float can fully open the discharge valve. If the float lever, therefore, is short, the ratio between lift and valve or slide motion respectively has to be correspondingly large with the result that the apparent advantage of the short lever is not only annulled but may even turn out to be a disadvantage, for the ship's pitching is in the end just as damaging to the steam trap with short levers as to those with longer levers.

When considering the suitability of steam traps for marine installations it should not be overlooked that float type steam traps are easily subjected to breakdowns by the accumulation of air in the float chamber. It is unavoidable that air and other kinds of gases (*e.g.*, carbon dioxide) enter the condensate; for air and carbon dioxide are precipitated from the water on evaporation of the feed water in the boiler, and together with steam will pass into the condensate and thence into the steam trap. Even a very small volume of air, just sufficient to fill the float chamber is capable of putting a steam trap out of commission. Automatic removal of this air volume is not a simple affair, for air escape valves which usually operate with an expansion mechanism, easily break down, as this device either weakens in the course of time or develops leaks. A regular venting by means of hand-actuated devices on board ship, however, is absolutely out of the question.

In contrast to float type steam traps, those with expansion mechanisms operate independently of the ship's rolling motion and breakdowns due to air accumulation can occur. On the other hand, the expansion mechanism is very sensitive and weakens quickly due to frequent expansion and contraction, or it will develop leaks, preventing its closing and causing steam to escape. Besides this, an expansion device operates very slowly, *i.e.*, it does not always pass the condensate at once. If, however, the trap is constructed in such a manner that condensate will pass quickly there is the possibility that the expansion unit may respond too slowly to the temperature of steam and will close too late and cause the loss of steam.

In designing a steam trap for use in ships, the following points should be observed :—

(1) Operation independent of the ship's rolling and pitching motion.

(2) Automatic discharge of air from the condensate.

(3) Operation without any moving parts, so that neither weakening nor breakdown is possible.

By employing newly discovered scientific principles (see *Wochenblatt für Papierfabrikation, 1937, No. 19, pages 254 to 357*) it has been possible to actually meet these demands. The baffle plate steam trap passes the condensate not by means of moving parts such as floats or expansion devices, but by employing a specially constructed labyrinth channel system. The efficiency of this system is based upon the utilisation of the re-evaporation phenomena of the flow of the hot condensate when pressure is decreasing. Everyone knows that although a boiler water gauge glass shows water at a certain level, when a test cock below this level is opened, a jet of steam becomes visible. This is due to the water in the boiler being under high pressure and therefore high temperature (about 360° F. at 150lb. per sq. in. As soon as the hot boiler water expands at the point of discharge it is highly superheated, for water can have only a maximum temperature of 212° F. at atmospheric pressure. The excess of temperature will cause evaporation of the

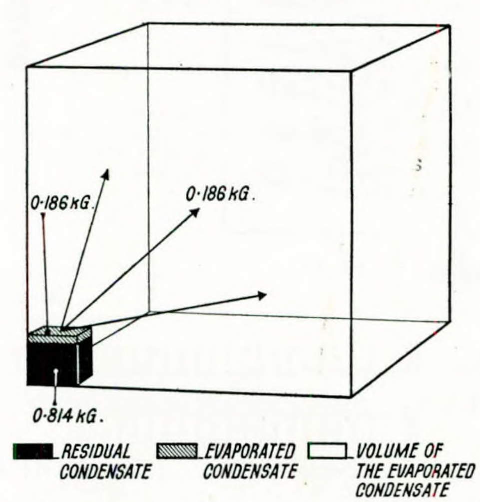


FIG. 3.—Increase of volume due to re-evaporation of condensate.

water by converting the heat of liquid into heat of evaporation. This conversion of heat will at the same time cause a cooling of the rest of water down to 212° F. (Fig. 3).

On account of the steam generated by the expansion of the hot condensate, the effective sections of the channels of the labyrinth system of the baffle plate steam trap (shown in section in Fig. 4) are automatically constricted or enlarged. For instance, if large quantities of condensate are flowing, and are therefore not in contact with steam, no re-evaporation will take place and the channel-sections can be fully utilised for the flow of condensate. If, however, only a small quantity of condensate is flowing, it is in continuous contact with steam. It has, therefore, the temperature of steam and is superheated when expanding, so that steam is generated in the labyrinth channels. This steam constricts the channels on account of its high specific volume, allowing only a small quantity of condensate to pass. In this manner the steam trap operates without any moving parts and adapts itself automatically to the quantity of condensate to be passed.

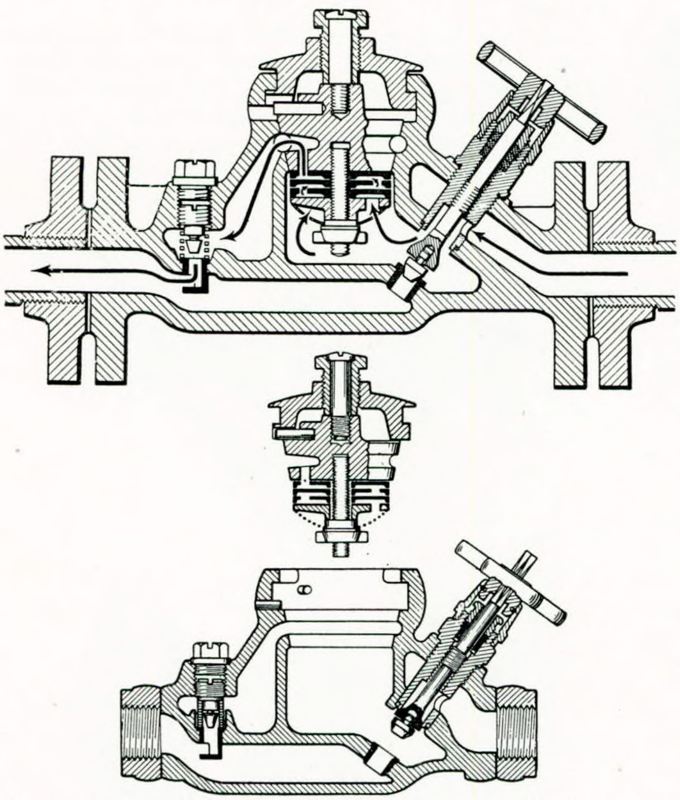


Fig. 4.—Section through baffle plate steam trap showing, above, operating condition and, below, by-pass valve closed and interior removed for inspection.

In contrast to steam traps with mechanically slow-operating expansion devices the baffle plate steam trap responds at once and is not subjected to breakdown. The extent to which such a steam trap can adapt itself is shown in Fig. 5. It should be noted in connection with this diagram that on account of the labyrinth, steam cannot pass when no condensate is being discharged. In such cases the steam expands in the alternately narrow and wide channels to such a degree that it becomes nebulous and can only issue in very small quantities. Such a minute issue of steam which may occur on rare occasions is less than the quantities of steam which are continuously escaping on account of the radiation of the large float type steam traps. The effect in such a case is similar to the action of a labyrinth box of the steam turbine, where the steam can only pass in minute quantities, although the passages of the box are open. A baffle plate steam trap, therefore, has not only the advantage of working without moving parts, but also with great economy.

Of cardinal importance is the fact that air and gas (*e.g.*, carbon dioxide) are also automatically discharged by the labyrinth system, thus preventing a breakdown through an accumulation of air. For this reason the baffle plate steam trap is well suited to intermittent working, such as occurs in the operation of windlasses, winches, and steering gear.

It should be a rule aboard ship that arrangements can be made to disconnect a steam trap from the condensate discharge line at any time and inspect it without causing a breakdown of service. Float type steam traps, therefore, must be fitted with stop and by-pass valves.

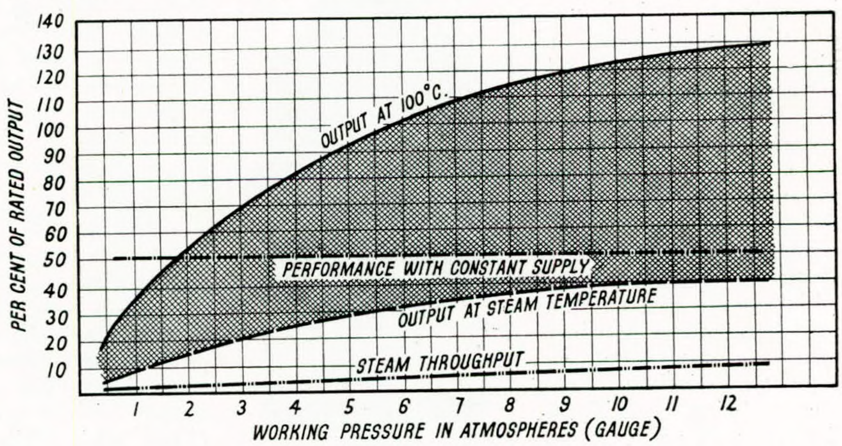


Fig. 5.—Operating diagram of baffle plate steam trap with labyrinth channels, showing adaptability to condensate fluctuations.

The construction of the baffle plate steam trap, however, is such that the stop valve together with the by-pass arrangement is incorporated in the trap. The latter, in addition, is designed in such a way that it can be opened, inspected, and replaced again

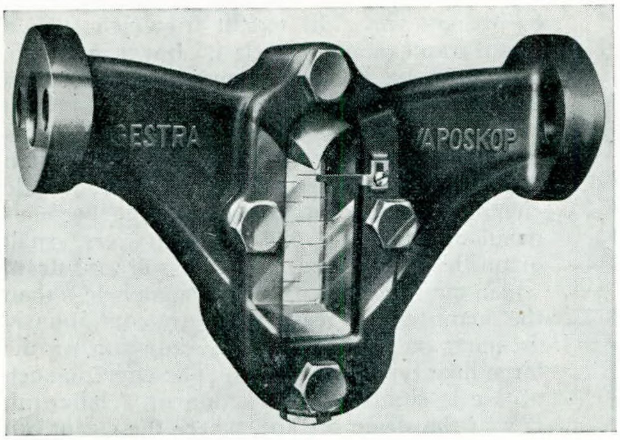


Fig. 6.—Vaposcope steam trap control apparatus for horizontal mounting.

within a few minutes by means of a bayonet catch.

The by-pass device incorporated in the baffle plate steam trap has the great advantage that the condensate can be quickly discharged and warming up speedily effected, which is of importance after a stay in port or after long intervals in the operation of winches.

It is not amiss to call attention to the fact that every steam trap needs continuous supervision; this applies especially to steam traps operating with moving parts. The condensate nearly always contains impurities (dirt and scum, loose packing particles, etc.) which stick in the mechanism and cause trouble.

Figs. 6 and 7 show a control device (Vaposcope) which operates according to entirely new scientific principles and gives a very clear and rigorous control of steam traps of all types. This control apparatus consists of a housing with two strong observation windows opposite each other. A triangular-shaped tongue below which steam and condensate must pass, projects into the space between these two windows. The steam being specifically lighter, will pass on top just below the tongue, whereas water flows

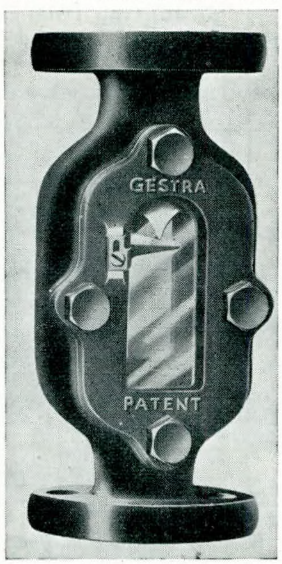


Fig. 7.—Control device for vertical mounting.

below. As long as no steam is being lost the observation windows show only water. But as soon as steam escapes it will pass below the tongue and visibly depress the water level (Fig. 8). Such a device, therefore, indicates not only whether steam is escaping, but also whether its quantity be large or small.

It must be pointed out that the control of steam traps is not possible by mounting the control device in the *outlet* pipe of the trap. On account of the re-evaporation of hot condensate, steam is always produced in the outlet pipe of the steam trap, provided the latter works reliably. If therefore, a control device mounted behind the steam trap should

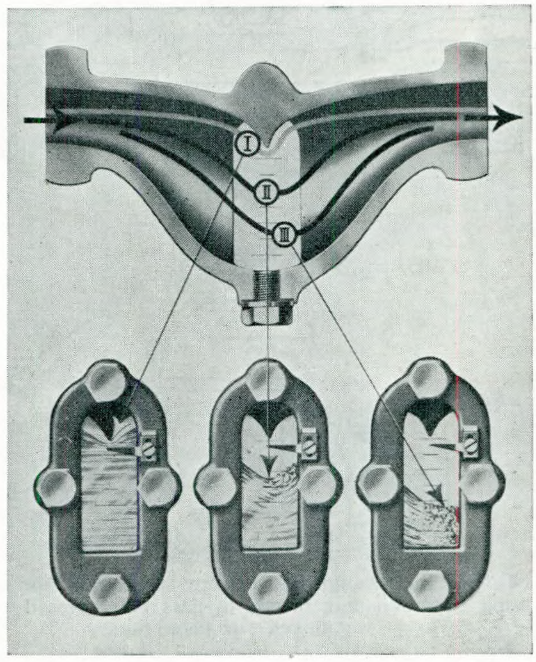


Fig. 8.—Operation of steam trap control apparatus.

indicate steam it would be impossible to determine whether it be live steam, *i.e.*, actually waste steam, or re-evaporated condensate which naturally cannot be considered a loss. It is a proviso for every steam trap control apparatus that it be installed in front of the trap, *i.e.*, into the condensate discharge pipe which is under pressure and where re-evaporation is impossible.

Furthermore, steam trap control possesses the great advantage that it enables the by-pass valve to be correctly operated. Only such a control apparatus is capable of indicating whether—the by-pass valve being in an open position—an excess quantity of condensate is discharged, *i.e.*, when live steam is flowing. The control device, therefore, indicates visibly when the by-pass valve should be closed again. Up to the present time this was not possible, resulting in wrong manipulations of by-pass valves, especially in return pipe lines which make observation of the condensate impossible.

A ship's boiler easily tends to frothing over and priming, due to the great heating surface load and to the rolling and pitching the boiler is subjected to. Sludge and foam are consequently carried along by the steam and enter the main engine, the auxiliary engines, and finally the exhaust pipes. By means of the control apparatus shown in Fig. 6 it is now a very simple matter to examine at any time the degree of purity of the condensate and, therefore, the cleanliness of the steam pipe. This control device has already revealed many surprising conditions which so far were unknown. It goes without saying that a timely removal of sludge is very important, for sludge and foam not only dirty the steam pipes and particularly the superheater, but subject main engine and auxiliary engines to wear and tear. The blades of the turbine become covered with impurities which may come through and cause the gap between the blades to become clogged. The efficiency of the turbine is, therefore, decreased. It is a well-known fact in shipping circles that the turbine blades are often very much incrustated when being inspected. The Vaposcope will detect these impurities at once.

The foregoing notes show that, independent of the ship's heavy rolling and pitching, it is possible to solve the problem of condensate removal in an efficient manner, and to reveal breakdowns and impurities in time. How great an effect the influence of such precautionary measures have upon the economical operation of ships has already been stated.

War Risks and Single Deck Cargo Ships.

Structural Modifications to Raise Standard of Safety.

By a SPECIAL CORRESPONDENT.

"The Journal of Commerce" (Shipbuilding and Engineering Edition), 23rd November, 1939.

Several interesting contributions dealing with the subject of open shelter deck type ships have recently appeared in technical journals, which outline simple and, at the same time, practical measures designed to make effective the large potential reserves of buoyancy inherent in this type of hull. It would, therefore, appear timely to consider ships included in that large percentage of cargo carrying tonnage, variously described as "poop, bridge and forecastle" or "three-island type"—ships having two wells—and the related types having a single well deck and a combination of erections.

At the outset it cannot be too clearly stressed that any criticism as regards slight losses in efficiency, whether due to (1) loss of deadweight or (2) restrictions in stowage, must be considered in the light of war conditions, and if the desired results outlined hereunder are achieved, as alternatives to the complete loss of the ship and cargo, not to mention valuable trained crews, who are increasingly difficult to replace, then the measures suggested should be carefully examined.

The types under review, which, very generally, provide a one compartment basis of floodability, are obviously much more vulnerable to attack than shelter deck ships with continuous erections. If extensive damage be inflicted by repeated attack over a longitudinal range of hull, or a lucky hit registered affecting two compartments, further measures to secure reserve buoyancy to a two compartment standard of safety must be investigated.

In the ultimate analysis, where it may be argued that despite the adoption of such measures, sinking is inevitable, any delay will allow the crew better chances of escape and by complicating the task of the enemy submarine or surface craft, give our defence forces more time to arrive on the scene.

As an example may be taken the familiar single deck three-island type of general trader, portrayed in Figs. 1 to 4, having the following basic particulars:—

Length b.p. ...	...	370ft. 0in.
Breadth moulded	...	53ft. 0in.
Depth moulded	...	28ft. 6in.
Draught B.K. ...	...	23ft. 7in.
Block coefficient	...	0·78
Sheer, forward	...	9ft. 9in.
Sheer, aft ...	...	4ft. 10in.
Erections ...	...	50 per cent. L.B.P.

Assuming these dimensions and optimum volume of machinery space and tunnel to ensure the propelling power deduction from gross tonnage, it is at once evident that to secure even a one compartment standard of safety the following modifications to normal arrangements are essential:—

1. Where a wood bulkhead is fitted, subdividing the usual large No. 2 hold to give a reserve coal bunker (No. 2A) adjacent to the boiler-room, this bulkhead must be replaced by a watertight bulkhead and where so fitted the coaling doors in boiler-room bulkhead should be blanked off. Reserve coal would then be transferred to deck and re-trimmed via bunker hatches into permanent bunkers.

This method is suggested as an alternative to bridge-controlled hydraulically or electrically operated watertight doors, as being free from mechanical or electrical defects as might be experienced during an attack and from considerations of cost.

2. Height of hatch coamings should be increased above the minimum determined by current normal requirements, and there would appear to be no practical reason why coamings should not extend well above height of bulwarks or rails, together with any air escapes, small access hatches and, where necessary, ventilator coamings.

3. All erections should be permanently enclosed, end bulkheads being intact, with access only from deck over. Where ships are chartered on the basis of gross tonnage the resulting increase in tonnage would not operate to the disadvantage of the shipowner, whilst if this problem is a serious desideratum, plate closures on the usual lines with

hook bolts or any approved alternatives would be satisfactory, provided steps were taken by constant examination and attention to secure reasonable efficiency.

Calculations based on the typical ship already described would appear to confirm that the recommended precautions as to structural modifications should suffice for a one-compartment standard.

The water lines resulting from the successive floodings of the various single compartments indicated closely approach the deck edge, and a reserve of buoyancy in the erections is therefore a vital

Diagram No. 4 is included to show that with tunnel access door open, the tunnel, together with the engine and boiler room, may be flooded, the position as to immersion being slightly better than with the after hold flooded.

Calculations are based on the fully loaded ship, the holds being filled with cargo having a permeability of 60 per cent. Permeability of engine and boiler room is taken at 80 per cent. and tunnel 100 per cent.

The comparative ease with which the shelter deck type can be converted to a two-compartment

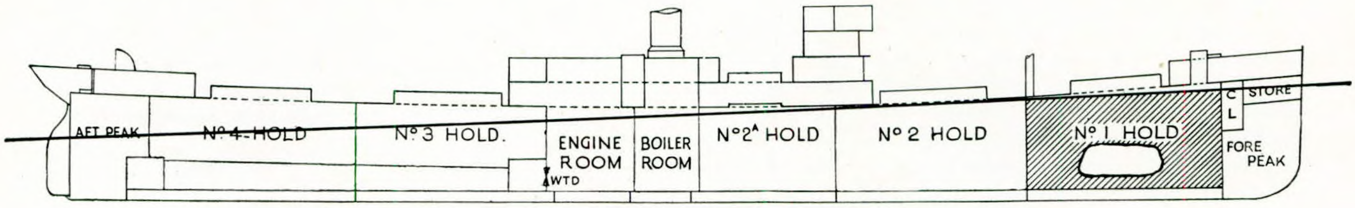


FIG. 1.

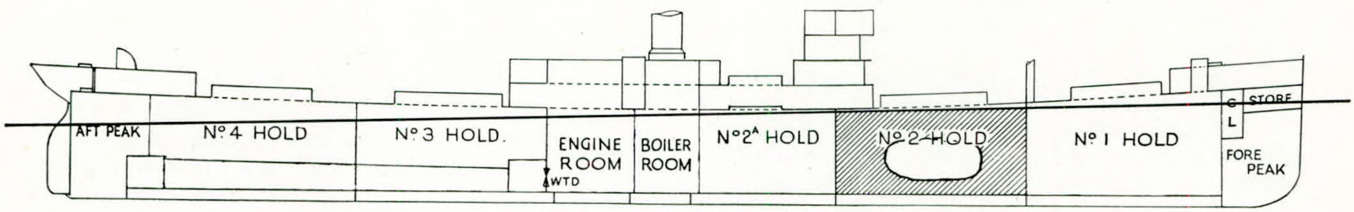


FIG. 2.

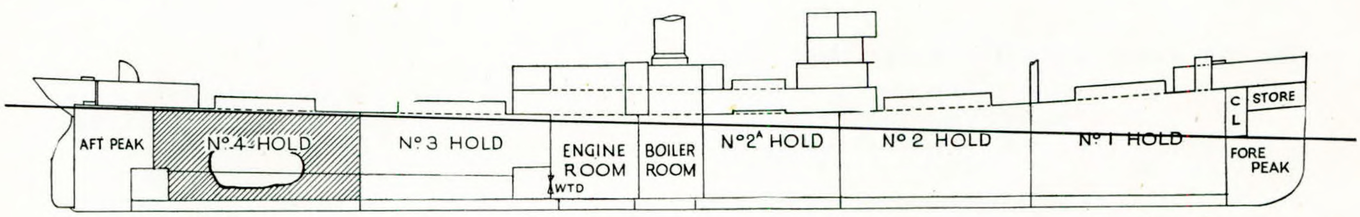


FIG. 3.

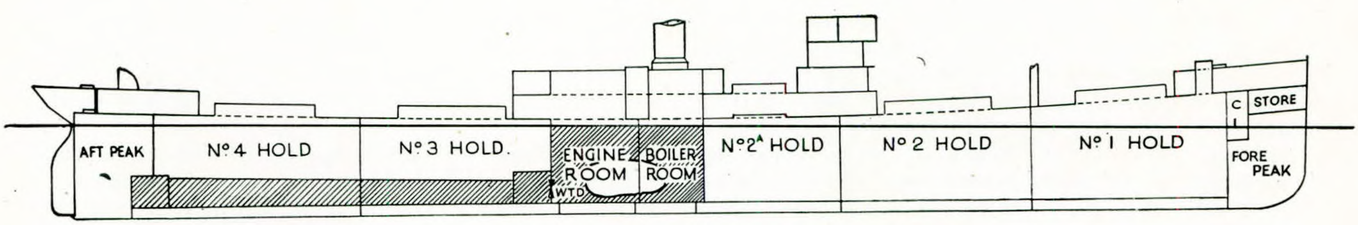


FIG. 4.

necessity if foundering is to be obviated in any but smooth water. The raising of hatch coamings will reduce the danger of further flooding through the hatch covers of the adjacent holds.

The diagrams illustrate the position of the water line relative to deck edge, from which it will be observed the real danger of sinking is coupled with excessive trim. For this reason only, the worst cases of flooding, Figs. 1, 2, and 3, are portrayed.

standard of floodability is unfortunately not applicable to the ship under discussion. If such a standard be found necessary, due to the incidence of heavy losses, more costly measures must necessarily be examined.

An examination under the headings of (1) fitting of buoyant non-inflammable material secured under deck, particularly over the end compartments, designed to retain the necessary reserves of buoyancy and prevent if possible spread of fire due to attack by incendiary projectiles, and (2) steel air-tight hatched covers, reveals in the case of (1) that the resulting decrease in deadweight coupled with a large and not proportionate loss in actual carrying capacity would be entirely uneconomic, whilst (2) may be dismissed on the grounds that with a full hold, and therefore little volume of free air to absorb concussion, an explosion would immediately destroy the air seal on the hatch coamings.

In summing up the case for a two-compartment standard, it is inevitable to refer back to the shelter-deck type. At the risk of reviving the old controversy of the comparative merits of one type or the other, it would appear that the logical solution of the problems under review, as applied to the single-deck ship, would be to fill in the wells without further question and carry up the main bulkheads to the uppermost deck. The usual tonnage well and tonnage openings in divisional bulkheads with plate closures would, of course, be obligatory if it be desired to retain the original tonnages.

Some increase in draught would thereby be available to offset increased weight of structure, such increase in draught depending to a greater or a lesser degree on the initial proportions L/D of the hull under consideration, whilst the increased cargo capacity for light stowage thus obtaining would be an immediate and very valuable gain.

On a strictly geometrical basis and assuming strength considerations could satisfactorily and economically be disposed of, the ship in question would be entitled to a maximum draught of about 25ft. 7in., or 24in. more than previously obtaining. In a fully stowed condition, with the original deadweight, the only cargo which need be carried in the new erections would be of a light nature, as surplus to that normally carried in the main holds, i.e., where the density in the main holds was less than the optimum necessary to immerse the ship to her load line.

In this respect the hull, as modified in respect of a continuous erection would, therefore, be a better proposition as regards ability to stow a more varied nature of cargo, whilst still retaining minimum tonnage and maximum reserve buoyancy. The considerable general strengthening which would be necessary to enable full advantage to be taken of the possible maximum draught as a result of the improved geometrical properties is, of course, not advocated on grounds of cost and delay in reconstruction.

Confining the alterations to filling in the wells with materials having scantlings approximately to the adjacent structures and carrying up the main bulkheads is, however, not without practical consideration. In order to preserve the original deadweight, consideration might be given, if only as a war-time measure, to the suggestion that since the only addition to load draught need be the few inches required (some 4/5) to offset the weight involved in the recommended local structural modifications, considerations of general longitudinal strength and local pillar and girder support alike might well be waived.

Rudder Shafts on Roller Bearings.

"The Marine Engineer", November, 1939.

Further interesting applications of roller bearings on shipboard are dealt with in this article. Fig.

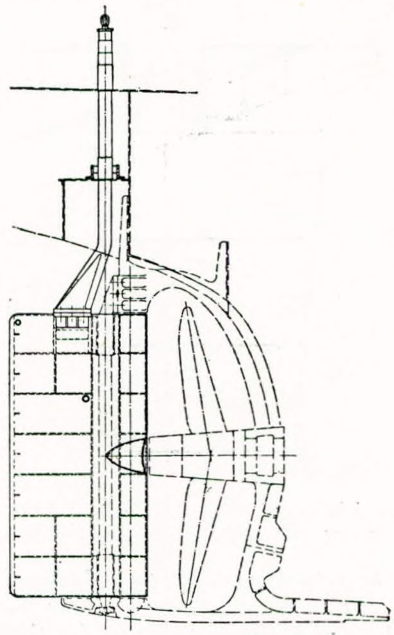


FIG. 1.—Normal single-screw cargo ship rudder of modern type.

1 shows an ordinary cargo ship rudder and Fig. 2 a typical roller bearing for such an application. Felt rings protect the bearing from the ingress of water and dirt. Lubrication is by grease, which

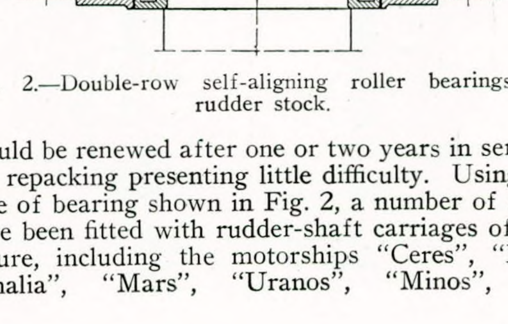


FIG. 2.—Double-row self-aligning roller bearings for rudder stock.

should be renewed after one or two years in service, the repacking presenting little difficulty. Using the type of bearing shown in Fig. 2, a number of ships have been fitted with rudder-shaft carriages of this nature, including the motorships "Ceres", "Iris", "Thalia", "Mars", "Uranos", "Minos", and

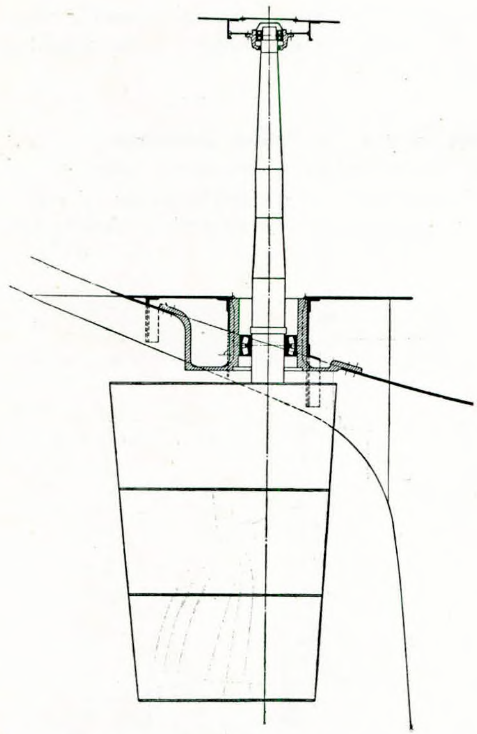


FIG. 3.—Semi-balanced overhung rudder with upper and lower self-aligning roller bearings.

"Luna"; all are owned by the Neptune Shipping Company, of Bremen. Seven other vessels now building for the same owners and for the Hamburg America Line are to be similarly equipped.

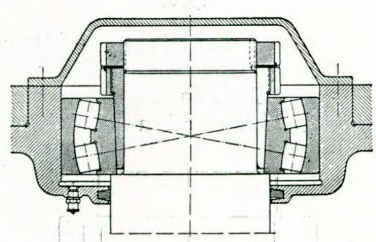


FIG. 4.—Upper double-row self-aligning bearing for the rudder shown in Fig. 3.

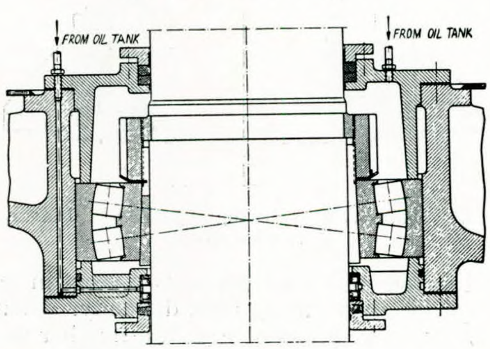


FIG. 5.—Lower roller-type rudder stock bearing for the rudder shown in Fig. 3.

For the overhung type of rudder shown in Fig. 3 the problem is much more difficult. Figs. 4 and 5 show suitable bearings for the upper and lower supports of such a rudder. In Fig. 5 it will be noticed that, to avoid putting a thread on the rudder stock itself, a spring collar is used. The oil tank feeding the packing is sufficiently high to give a pressure greater than that of the outside water and also affords a check on the tightness of the packing. The bearing itself can be either grease or oil lubricated, but the latter is to be preferred because a second overhead tank can be arranged lower than the other one and cleaning out the bearing can be done by simply draining out the oil when in dock.—Dr. Ing. Robt. Mundt, *Werft Reederei, Hafen,* June 15th.

Coal-fired Steamers.

"The Journal of Commerce" (Shipbuilding and Engineering Edition), 16th November, 1939.

It is interesting to reflect what type of machinery would be adopted if our supplies of oil fuel were to be restricted to a point where its use became impossible in merchant ships. Practically every ton of oil used has to be bought and imported from abroad, yet during the past 20 years motorship tonnage has increased by leaps and bounds, with the result that apart from the actual cost of the oil and its transport great expense is, during the present international situation, incurred in safeguarding that transport, the storage stations and in regulating distribution.

Little effort has been made in this country to adopt or develop mechanical methods of firing, and the cargo shipowner openly expresses his distaste for water-tube boilers. It is therefore safe to assume that if there was a reversion to steam machinery, there would be no departure from Scotch boilers and hand firing if the inclination of owners was to be followed, but such a situation would create possibilities.

For instance, it would be worth while subsidising those willing to instal pulverised fuel-burning plant to let our merchant fleet get the "feel" of it. If a scheme were drawn up to ensure an adequate number of ships being so fitted, pulverisation could be done ashore at the principal coaling stations. Bunkering under these circumstances would be clean and as rapid as with liquid fuel.

If such a scheme came to maturity several important results would be accomplished. Our shipping would be independent of foreign fuel supplies, our coal mines would benefit, an important step would have been taken towards using instead of wasting the heat in the fuel, and loading and stoking, the biggest drawbacks to the use of solid fuel, would be eliminated.

So far as machinery is concerned, the choice has reached such magnitude at the present time that no general solution is possible. It has been estimated that taking fuels, boilers, main propelling machinery types and auxiliaries into consideration, there are over 300 possible combinations of elements, the main factors normally being decided by the particular trade upon which the ship is to be engaged and lesser details being a matter of cost or personal preference. The elimination of oil would naturally reduce the main alternatives more or less to a choice between smoke or water-tube boilers and reciprocating or turbine engines, with such secondaries as turbo-electric drive.

The efficiency of the geared turbine is beyond dispute, but this prime mover must be run continuously at full designed power if the efficiency is to be maintained. Furthermore, it is generally agreed that 2,000 s.h.p. (about 2,400 i.h.p.) is about the lowest power for which it is advisable to instal this type of machinery, and if a return to steam took place it is probable that, as has been the custom up to the present, turbines would be used mainly for passenger and large cargo vessels on regular routes, while the reciprocating engine would fill the requirements of all others.

Due to the general scramble towards the easy fuelling and low consumption of the oil engine occurring just before a world trade depression, it can be said that the reciprocating engine was given no chance to show what it could do against its new competitor. No effort was expended towards improvement of design until sheer necessity arose, this in spite of the fact that cylinder ratios were invariably too large and boiler heating surface insufficient, for the efficiency of a boiler is highest at low rates of evaporation. Since thought was directed to the problem, there is now also a consensus of opinion that higher referred mean pressures tend towards greater economy, and this fact is utilised in most modern designs.

There are to-day double compound and three-cylinder compound engines, uniflow cylinders, cam-driven slide valves, and poppet valves. By installing any of the modern reciprocating types in conjunction with high superheat, the performance of the triple-expansion engine can be improved upon by as much as 10 per cent. with little or no increase in first cost. By adding an exhaust turbine economy would be further increased by about 20 per cent., or a total saving of between 25 and 30 per cent. over the plain triple-expansion engine, or alternatively, a smaller size of engine could be installed to produce the same power.

There has at no time been any inclination to increase steam pressures beyond 250lb. per sq. in. in cargo-ship practice, and when it is considered that heat is the medium from which the energy is obtained, and steam merely the fluid which conveys it, it can be seen that there is greater scope for economy by raising the degree of superheat than by increasing the pressure.

This is, in fact, the theory behind what may seem a retrograde step in returning to compound engines, in favour of triple expansion; if saturated steam was used, a three-cylinder compound would show no advantage over a triple-expansion engine and would probably require more steam, but there are many other aspects to be considered.

Superheated steam can be treated as a gas, and losses through heat exchange between the steam and the cylinder walls are therefore very low; by adopting the uniflow principle as far as possible this loss is still further reduced, since the walls remain at an almost constant temperature, and by eliminating the large piston and slide valves a great deal of space is saved.

There is no doubt that if only a small amount of the energy and money spent in research on oil engines had been devoted to the development of the steam engine, its appearance and performance would have altered considerably many years ago instead of only in the last few. To-day, there are on the market efficient and compact engines, also boiler designs and devices unlimited, and it is obviously towards the fuel problem that we of this country should direct our energies.

BOARD OF TRADE EXAMINATIONS.

List of Candidates who are reported as having passed examinations for certificates of competency as Sea-Going Engineers under the provisions of the Merchant Shipping Acts.

Name.	Grade.	Port of Examination.
For week ended 26th October, 1939:—		
Triggs, Robert R.	2.C.	Hull
Dalgleish, William C. McL.	2.C.M.	Leith
Dickson, David B.	2.C.M.	"
Mouat, Hugh F.	2.C.M.	London
Eastabrook, Boyd J. ...	2.C.	Liverpool
Keith, Hugh	2.C.	"
Knight, Alfred	2.C.	"
Linklater, James D.	2.C.	"
Mackintosh, John	2.C.	"
Jones, Thomas E.	2.C.M.	"
Newby, Edgar Jas.	2.C.M.	"
Dickerson, Thomas	2.C.M.	Belfast
Dodds, Robert	2.C.	Glasgow
McNaughton, Archie McK.	2.C.M.	"
Cockburn, Tom	2.C.	Newcastle-on-Tyne
Wallace, Leslie	2.C.	"
Dryden, Ronald	2.C.M.	"
Taylor, Cedric B.	2.C.S.M.	"
Palmer, Harold E.	2.C.S.E.	"
For week ended 2nd November, 1939:—		
Sexton, John Q.	1.C.	Cardiff
Cheape, Henry R.	1.C.	Glasgow
Day, Richard J.	1.C.	"
Johnston, Jas.	1.C.	"
Lennox, John	1.C.	"
Peddie, George	1.C.	"
Hayes, John A.	1.C.M.	"
Renfrew, William	1.C.M.	"
Wood, Finlay	1.C.S.M.	"
Hamilton, William L. ...	1.C.M.E.	"
Bottomley, William	1.C.S.E.	Hull
Walker, Arthur E.	1.C.	"
Roy, Lessels	1.C.	Leith
Dunne, John R.	1.C.	London
Turner, Archibald S. ...	1.C.	"
Williams, Owen M.	1.C.	"
Driscoll, Arthur J.	1.C.M.	"
Feickert, Harold J.	1.C.M.	"

Name.	Grade.	Port of Examination.
Matthews, Edward J. ...	1.C.S.M.	London
Wallace, William D. ...	1.C.S.M.	,,
Allan, Thomas H.	1.C.M.E.	,,
Martin, Charles M.	1.C.M.E.	,,
Sutcliffe, Frederic N. ...	1.C.M.E.	,,
Todd, Robert	1.C.M.E.	,,
Cowley, Norman	1.C.	Liverpool
Colwell, John McM. ...	1.C.M.	,,
Davies, Frank T.	1.C.M.	,,
Thompson, George F. ...	1.C.M.	,,
Duckworth, Arnold H. ...	1.C.S.M.	,,
Gibbs, Edward J. K. ...	1.C.S.M.	,,
Hulse, Thomas P.	1.C.S.M.	,,
Spence, Thomas	1.C.M.E.	,,
Jameson, James E.	1.C.	Newcastle
Lawson, Gilbert Y.	1.C.	,,
McCormack, Thomas F. ...	1.C.	,,
Thornton, Joseph L. ...	1.C.	,,
Jones, Ernest M.	1.C.M.	,,
Martinson, Walmar G. ...	1.C.M.	,,
Rae, William A.	1.C.M.	,,
Cooper, Harold	1.C.M.E.	,,
Mack, John J.	1.C.M.E.	,,
McKaine, William L. ...	1.C.M.E.	,,
Squire, Alfred D.	1.C.M.E.	,,
For week ended 16th November, 1939 :—		
Bell, Thomas	Ex.1.C.	
Kirby, John Hodgson ...	Ex.1.C.	
Greaves, Richard George ...	2.C.	
Norgate, Albert Roy ...	2.C.	
Weir, William McKendrick	2.C.M.	
Harris, Richard Stuart McRae	2.C.	
Luck, Percy Charles ...	2.C.	
Francis, William Faulkner...	2.C.	
Smith, Douglas Leonard ...	2.C.	
Anderson, Samuel	2.C.	
Shields, Thomas William ...	2.C.	
For week ended 30th November, 1939 :—		
Anderson, Cecil E.	2.C.S.	Glasgow
Hunter, Carnegie	2.C.S.	,,
Thomson, Robert	2.C.S.	,,
Fleming, John	2.C.M.	,,
McKerron, Frederick J. ...	2.C.M.	,,
Pearse, Kenneth D. ...	2.C.M.	Hull
McDougall, Robert C. ...	2.C.S.	Leith
Marr, James	2.C.S.	,,
Prain, William L. McK. ...	2.C.S.	,,
Hunter, Francis M.... ...	2.C.M.	,,
Holt, William M.	2.C.S.	Liverpool
Morley, William A. ...	2.C.S.	,,
Christensen, Niels C. ...	2.C.M.	,,
Gerrard, Harry	2.C.M.	,,
Tippett, Frederick	2.C.S.	London
Burgess, Arthur G.	2.C.M.	,,
Edmonds, Henry G. ...	2.C.M.	,,
Schwersenski, Justus ...	2.C.M.	,,
Bennett, Alfred	2.C.S.	Newcastle
Dagg, John G.	2.C.S.	,,
Dunn, Robert P.	2.C.S.	,,
Jacques, Stanley	2.C.S.	,,

Name.	Grade.	Port of Examination.
Nash, Norman	2.C.S.	Newcastle
Little, Cecil E.	2.C.M.	,,
For week ended 7th December, 1939 :—		
Foster, James Henderson ...	1.C.E.	Belfast
Thompson, James Cecil ...	1.C.E.	,,
Miles, Edwin	1.C.S.E.	Cardiff
McAulay, James I. S. ...	1.C.E.	Glasgow
Robertson, Norman Ritchie	1.C.E.	,,
Urquhart, Robert King ...	1.C.E.	,,
Carlyle, Malcolm Nicoll ...	1.C.M.E.	,,
Kidd, Alexander Crawford	1.C.M.E.	,,
Morton, Hugh	1.C.M.E.	,,
Kemp, Arthur William ...	1.C.E.	Hull
Hendry, George	1.C.E.	Liverpool
Jones, Leonard	1.C.E.	,,
Leslie, Paton Lumsden ...	1.C.M.E.	,,
Miller, Alexander	1.C.M.E.	,,
Smith, Alexander Anderson	1.C.M.E.	,,
Coey, Thomas	1.C.E.	London
Thompson, Douglas Blacow	1.C.M.	,,
Teare, Leonard W.... ...	1.C.S.E.	,,
Ahern, Thomas	1.C.M.E.	,,
Darrock, Reginald R. ...	1.C.M.E.	,,
Kerr, Gilbert Armstrong ...	1.C.M.E.	,,
Richard, George Alexander	1.C.M.E.	,,
Sunners, Brian P.	1.C.M.E.	,,
Berry, Albert Thompson ...	1.C.E.	Newcastle
Finch, James Sexton ...	1.C.E.	,,
Taylor, Gilbert Basil ...	1.C.E.	,,
Tweddle, George Anthony	1.C.E.	,,
Ferguson, Thomas	1.C.M.	,,
Forster, Richard L. ...	1.C.M.	,,
Howden, John	1.C.M.	,,
Johnson, Donald	1.C.M.	,,
Richardson, Edward Henry	1.C.M.	,,
Slater, Michael Salkeld ...	1.C.M.	,,
Stobbs, Arnold H.	1.C.M.	,,
Svenson, Alexander Henry	1.C.M.	,,
Wright, Leonard H. W. ...	1.C.M.	,,
Arnold, William	1.C.M.E.	,,
Bridges, John C.	1.C.M.E.	,,
Ridley, Arthur	1.C.M.E.	,,
For week ended 14th December, 1939 :—		
Osborne, Thomas E. ...	1.C.M.E.	Belfast
Steele, George Wyllie ...	2.C.	Glasgow
Baikie, John George ...	2.C.M.	,,
Stewart, James G.	2.C.M.	,,
Lawson, Albert	2.C.	Newcastle
Ramsay, William G. C. ...	2.C.	,,
Watson, John W.	2.C.	,,
For week ended 21st December, 1939 :—		
Williams, John W. ...	1.C.M.E.	Liverpool
Brodie, William McI. ...	1.C.M.	Glasgow
Lamb, Richard W.	1.C.	Liverpool
Twist, William J.	1.C.	,,
Cain, William L.	1.C.M.E.	,,
Smith, Arthur I.	1.C.M.E.	,,

Institute Luncheon.

Following the Annual General Meeting on Friday, March 15th, 1940, a Luncheon was held at Connaught Rooms, Great Queen Street, London, W.C.2. The cancellation of The Institute's normal social functions and meetings due to the War made this opportunity for re-union particularly welcome, and as a consequence some 270 members and guests assembled for the Luncheon.

The President (Sir Percy Bates, Bt., G.B.E.) was in the Chair, supported by a number of eminent guests including the Rt. Hon. Sir John Gilmour, Bt., G.C.V.O., D.S.O., M.P. (Minister of Shipping), Admiral Sir Charles J. C. Little, K.C.B. (Second Sea Lord), Sir Amos L. Ayre (Director of Merchant Shipbuilding and Repairs), Eng. Vice-Admiral Sir George Preece, K.C.B. (Engineer-in-Chief of the Fleet), Sir Westcott Abell, K.B.E. (Past-President), Sir E. Julian Foley, C.B. (Past-President) and Sir Stephen J. Pigott, D.Sc. (Past-President).

The Rt. Hon. Sir John Gilmour (Minister of Shipping) after the Loyal Toasts had been proposed by the President and duly honoured, submitted the toast of "The Institute of Marine Engineers". He was glad of the opportunity to say how much the Government, and indeed all the people of this country, were grateful to the profession which The Institute represented. He was one who might be termed a politician, having been for over 30 years in the House of Commons, and yet the things he looked back upon with special interest were voyages in distant seas. He was two years of age when he first crossed the Atlantic to his partial homeland of Canada. Those were the days of fine lines and billowing sails, before the marine engineering profession flourished. To-day we lived in a mechanised age, and whether it was at sea, on land or in the air, it was the skill of the engineer which counted. Since he had taken over the office which he had the honour to hold, he had realized that it was the practical man who counted, and he hoped they realized that it was the object of the Government to get the very best advice which the marine engineering profession could give.

War was a brutal thing, and those who had experienced previous wars were loth to take part in another, but now we all realized that it was only by standing for the things that mattered that a halt could be called, and it was because of that that war had come. They had had six months of war and the strain and anxiety suffered by the marine engineer were such that he deserved everything the landsman could give him. Those who worked in the bowels of the ships, only occasionally hearing things, had to retain their courage and their skill at times in circumstances which were immensely difficult.

It was fortunate that however much democracy might be criticized, one felt that in democratic countries, whatever the object, one could work with honest purpose and there was always a comrade to help if mistakes were made. Mistakes could be made in the Government, and the Government relied upon the public to keep it right and give support to its aims.

He noticed many famous names in the list of Past-Presidents of The Institute, to which the name of Sir Percy Bates would be a notable addition. In giving the toast of "The Institute of Marine Engineers" he congratulated Sir Percy on the passage of the "Queen Elizabeth" across the Atlantic without any trials and without those opportunities for testing which in the ordinary course of events would have taken place. It was all to the credit of those who designed and built this great ship. He hoped that peace would come quickly, thereby enabling this great ship to carry out the duties for which she was built.

Sir Percy Bates (President of The Institute), in responding to the toast, made some complimentary references to Sir John Gilmour's long family association with the shipping industry. Sir John had said that this was a mechanised age, and so it was, but machines and men needed the same treatment—rest, overhaul and lubrication. He assured Sir John, on behalf of the marine engineers, that as long as he provided these—particularly the last two—needs, there was not the slightest fear that their side of the job would fail. Sir Percy then paid a tribute to the guests, and mentioned that it was very appropriate that among them were included Sir John Gilmour, who as Minister of Shipping was the largest user of marine horse power in the world, the Royal Navy, represented by Sir Charles Little and Sir George Preece, being probably next. Co-operation between the two services to-day was such that essential technical information obtained from their experience was freely and gratefully interchanged. The ships of the Navy had to work in different conditions from those in which merchant ships operated. The former were built for extremes of short duration, but he had noted with satisfaction the First Lord's recent statement that they had been standing up to their job in a way which was surprising. That showed that naval and mercantile practice were coming closer together. In the Mercantile Marine they erred in the other direction by thinking not in terms of speed but of reliability of service. Continuing, Sir Percy mentioned some of the problems associated with the "Queen Elizabeth's" crossing of the Atlantic, and referred to the record previously put up by the "Aquitania" for the number of round voyages in six months. It had been hoped that the two new "Queens" would exceed that record, running week by week like a shuttle of goodwill between this country and the United States. This hope, however, had been impossible of fulfilment under present conditions. Nevertheless, he firmly believed that that record would yet be attained, and that it would be due to the combined knowledge and experience of the naval and mercantile marine engineers and constructors.

Admiral Sir Charles Little (Second Sea Lord), responding for the guests, referred to the benefit which the engineering branch of the Royal Navy obtained from the papers which were read at The Institute's meetings and published in its TRANSACTIONS.

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