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VOLUME XLI.

The Design and Construction of Electrical Auxiliaries for Marine Service.

BY G. J. SCOTT, B.SC., M.I.E.E.,

Read by MAJOR GLENDENNING on behalf of Capt. Scott,

On Tuesday, February 12, at 6.30 p.m.

CHAIRMAN: W. E. FARENDEN (Member).

The CHAIRMAN: Capt. Scott, who was to have been with us this evening, is unfortunately ill, but we have Mr. Glendenning of Messrs. Laurence Scott and Company's Works at Norwich with us who has read the paper in his stead, and he has also undertaken to answer any questions which may be raised during the discussion.

IT is now generally realised by ship engineers that the ordinary electric motor and control gear designed and made for use on land is not suitable for ships.

The extremely onerous conditions in which electrical machinery has to work on board ship render it imperative to instal only motors and control gear which have been specially designed and manufactured for this especial purpose.

The principal reason why it is only in recent years that electric power has been extensively applied to merchant ships is that the necessity for specialised design was not at first realised by ship designers and engineers, with the result that there were many cases of breakdown, which prejudiced ship owners against the use of electrically-driven auxiliaries.

The pioneers of the use of electrical machinery on ships were the British Admiralty, and it is the experience gained by the Admiralty in pre-war years of sea conditions as applied to electrical machinery that has been of immense value during the years since the war, when ship engineers became convinced of the great advantage of electric drive over steam drive.

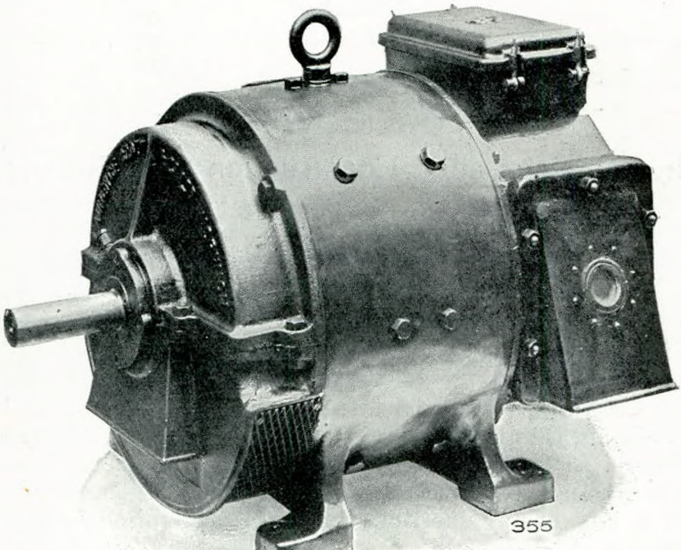

Fig 1.—A Drip-proof and Splash-proof Motor. Designed for Ships' Engine Rooms.

There are very few positions on land where electric motors have to withstand such severe conditions as on board ship. In the engine-room the presence of oily vapour, frequently high air temperature, very humid or steamy atmosphere, condensed water dripping from the roof, water leakages, vibration, and other adverse conditions, make it imperative that only motors and control gear specially designed for ships' engine rooms should be installed. See fig. 1.

On the deck, great extremes of heat and cold, sea-water spray, and often actual immersion in sea-water, again make it

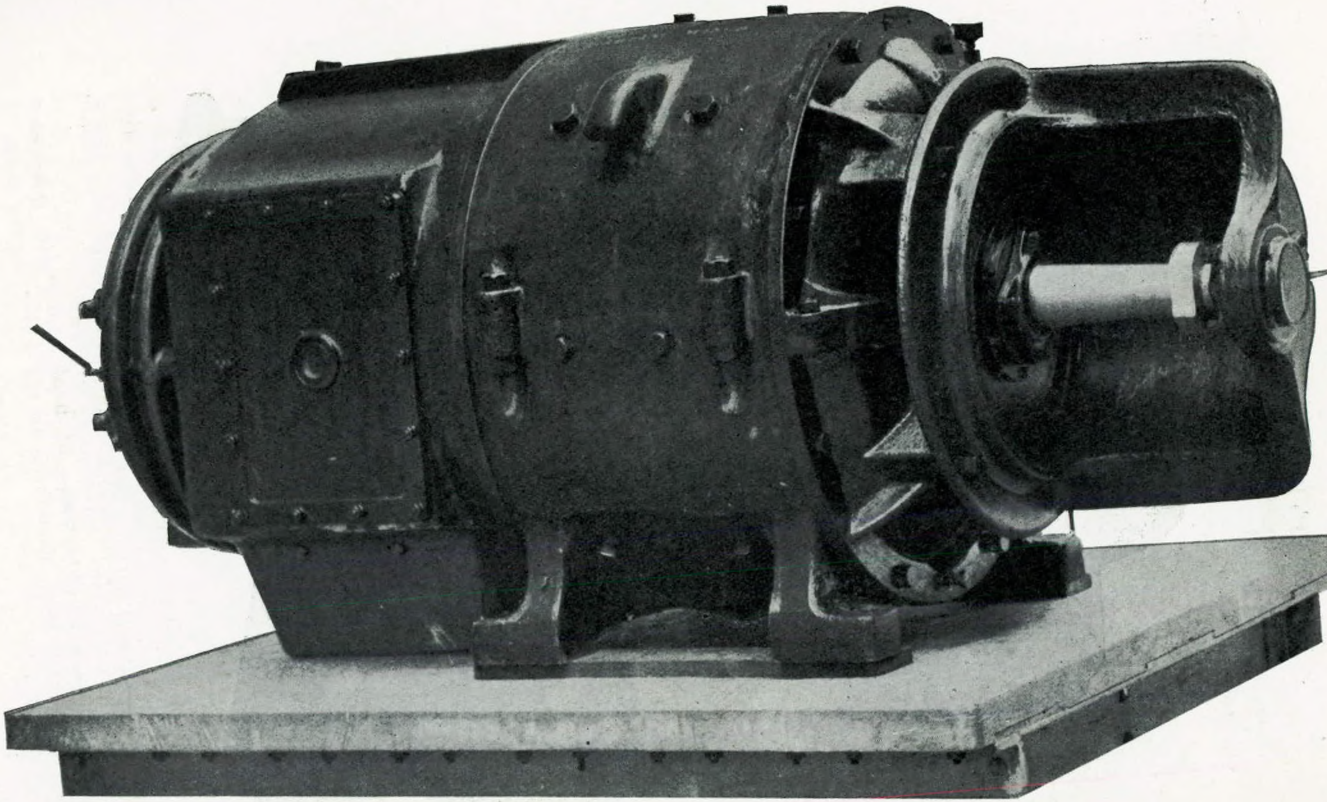

Fig. 2.—A totally-enclosed and Watertight Motor. Designed for use on deck.

necessary to instal only motors and control gear suitably designed. See fig. 2.

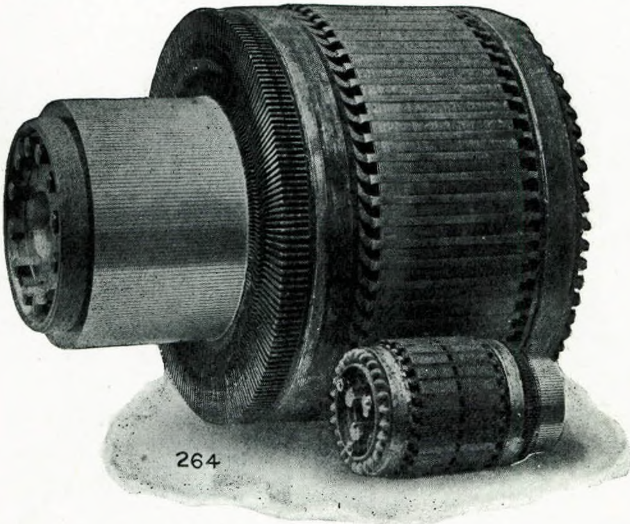

Fig. 3.—Armatures of Ship Motors.

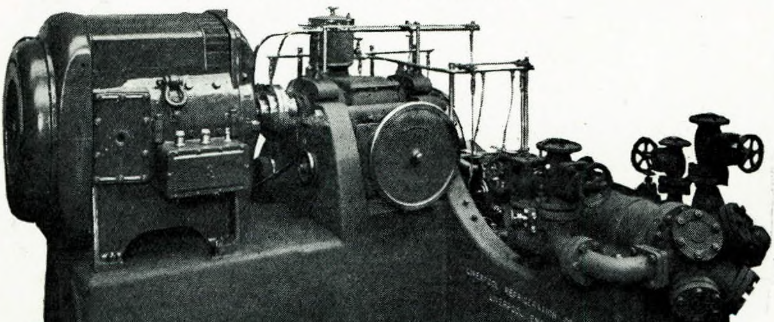

Fig. 4.—Totally-enclosed Motor ("Emcol" type) Driving Refrigerating Machinery.

The advantages of direct current electric motors over steam engines for driving ships' auxiliaries are now so obvious that it is almost unnecessary to enumerate them. I will, however, mention a few:—

(1) The direct current electric motor has an extremely large overload capacity for short periods. For winches, windlasses, capstans, steering gear, etc., this quality is invaluable. The steam engine has practically no overload capacity.

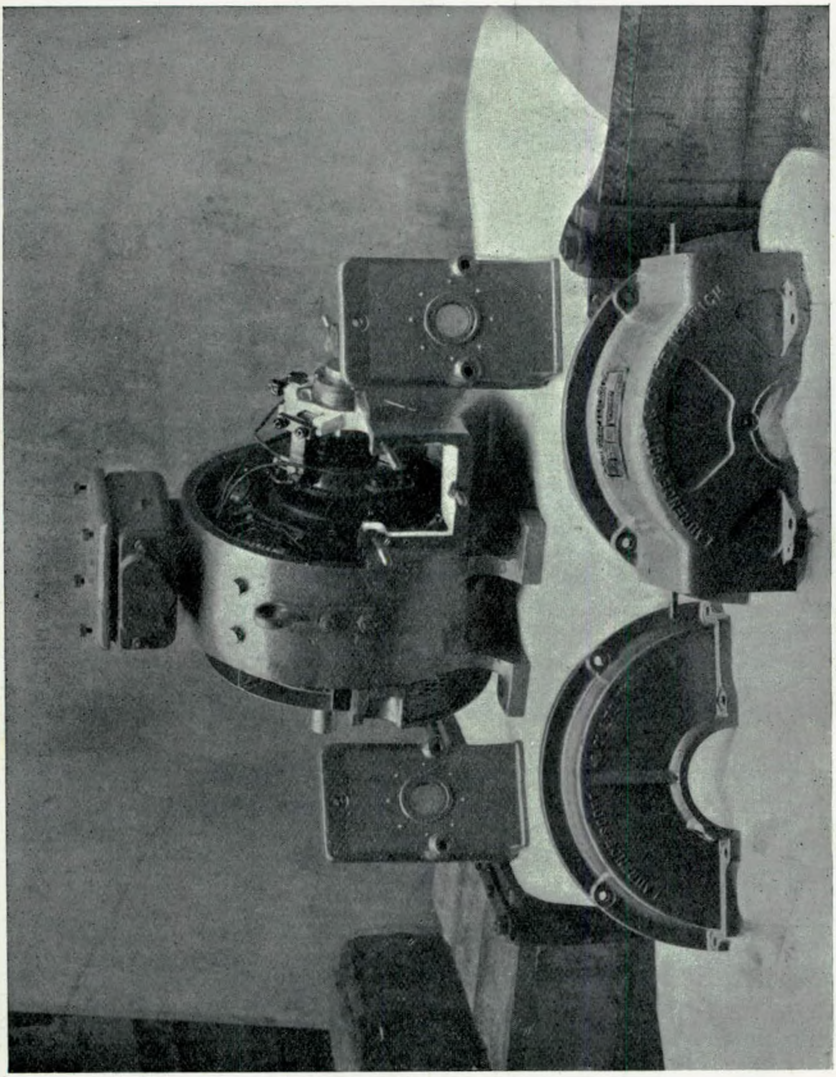

Fig. 5.—"Deluge" Type Motor, with top half of end bracket removed.

(2) The electric motor is always ready to run at full load, or even overload, at a few seconds' notice; the steam engine only if steam is kept in the feed pipes, in which case there is an enormous loss of power by condensation.

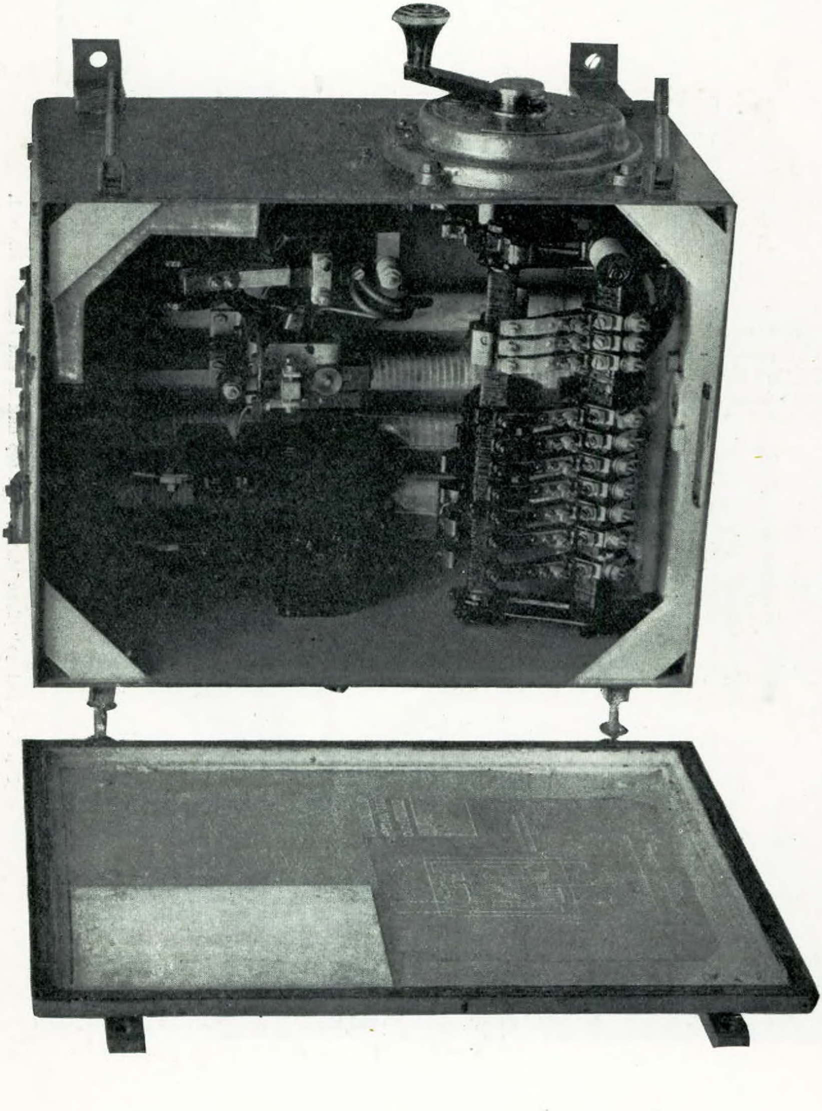

Fig. 6.—Typical Starter for Engine-room Motors.

(3) An electric motor specially designed for ship work is extremely reliable, and mechanically very simple. There is only one rotating part, and the number of wearing parts very small compared with those of a steam engine. The renewals, therefore, are very much less after a few years' running, compared with steam engines.

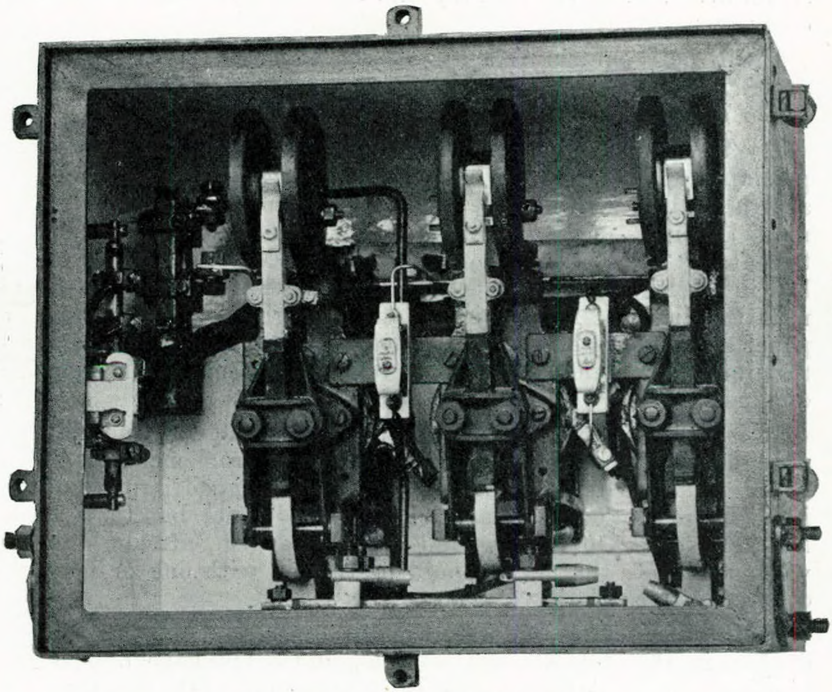

Fig. 7.—Fan Controller for remote control.

(4) The labour required for maintenance on an electrically-equipped ship (again only if properly designed motors and control gears are used) is very much less than that for a steam-equipped ship.

(5) Although the first cost of installation of electrical ships' auxiliaries is considerably higher than that of steam auxiliaries, the running cost has been proved to be very much lower, particularly in the case of intermittent running machines such as winches, windlasses, capstans, steering gear, etc. In

recent years two independent investigators have proved that the running cost in fuel alone of electric winches is one-seventh that of steam winches.

(6) Electric winch, windlass and steering gear design has been brought to such a high standard of performance that the electric drive is now as flexible, reliable and fool-proof as a steam drive, while the running and maintenance cost is enormously less.

I will here enumerate a few of the principal points in the design of electrical gear for ships which are of paramount importance on board ship:—

(1) The insulation of the machines must be of the highest possible standard. It has been found that micanite and mica are the only really reliable insulating materials, and a minimum thickness of 20 mils of micanite or mica is essential between all "live" conductors and earth. Micanite, however, has in itself very little mechanical strength, and from 15/30 mils thickness of leatheroid or other tough, non-hygroscopic paper should be used to form a packing or cushioning material to protect the micanite and prevent movement of the conductors.

It is also extremely important that all armatures and coils after being wound should be entirely freed from moisture by baking, and impregnated in vacuo with some good impregnating varnish, followed by a further baking of not less than 24 hours, in order to oxydise and set the varnish, after which, when still hot, the parts should be treated with one or more coats of best carriage varnish.

(2) Binding wires on the armature core to hold the conductors in the slots are not reliable, and a breakage of such binding wire is liable to cause serious damage to the machine. Hard wood wedges suitably impregnated should be employed instead. See fig 3.

(3) For motors and dynamos on board ship the very minimum amount of sheet iron in the form of covers should be used, as even when painted it is found that they corrode after a few years. Thick cast iron commutator covers, with ventilation openings well below the centre line and pointing downwards, with similar inlet openings, have been found to be the best for engine-room motors (see Fig. 1). The internal fan used for ventilating the motor must be of sheet iron, but should be hot-galvanised to prevent corrosion.

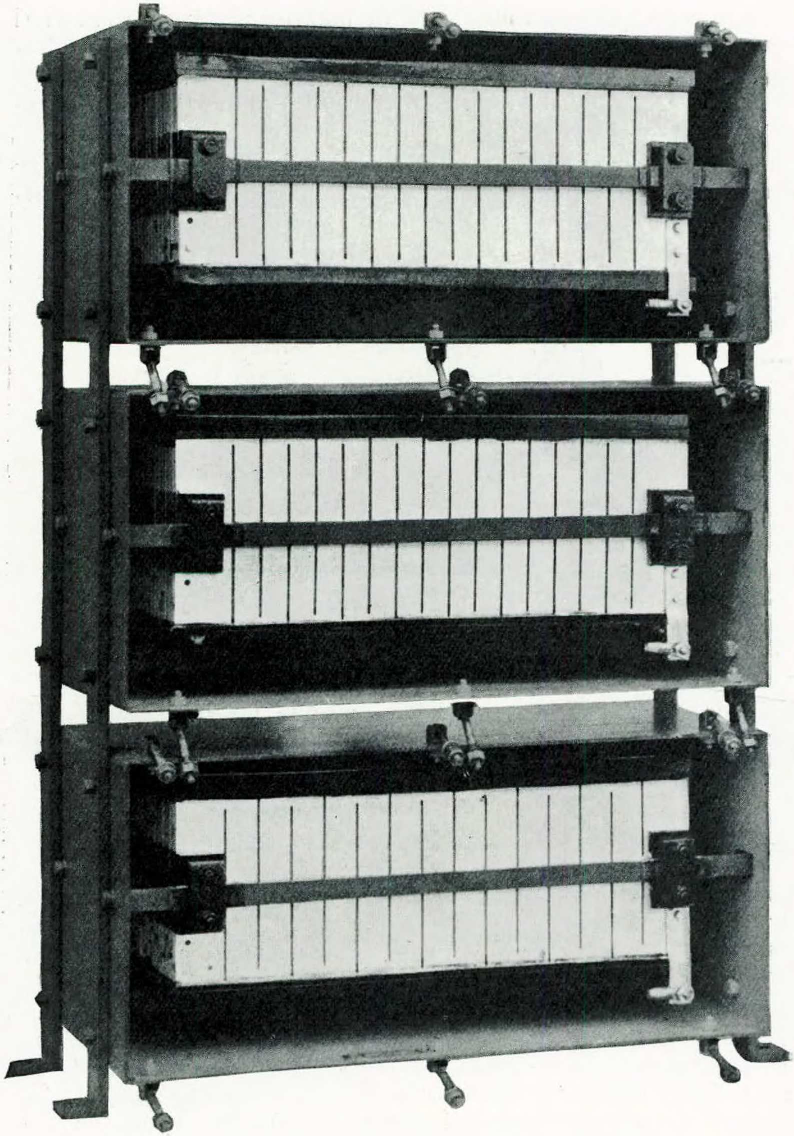

Fig. 8.—Frame of Watertight Resistance Banks for deck use.

All studs, bolts and nuts used in making internal or external connections or holding on covers, or parts which may be frequently removed, must be made of non-ferrous metal, or, if made of steel, must be zinc or cadmium-plated by an electrolytic process.

I do not consider that totally enclosed motors are necessary below deck, as long as ventilated motors are designed as out-

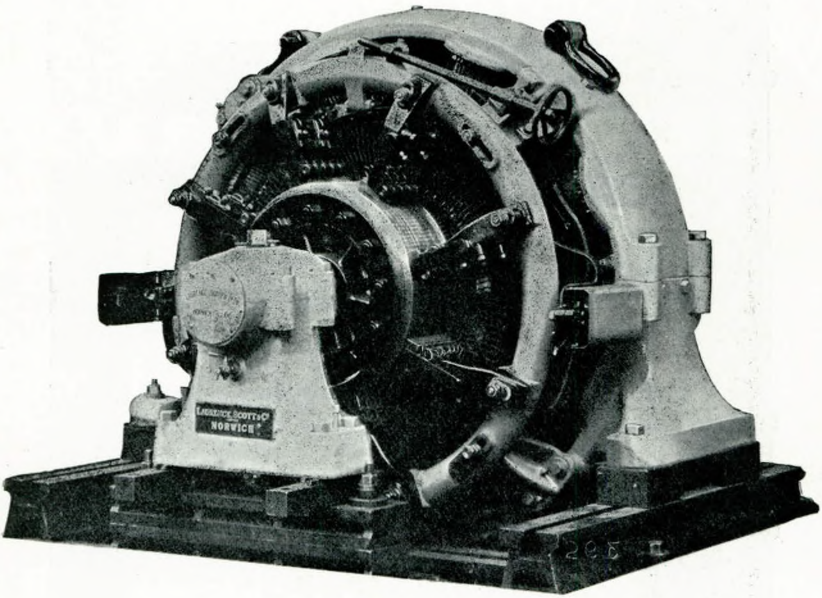

Fig. 9.—Eight-pole Open-type Generator.

lined in the foregoing remarks, except in special positions, where, for instance, chloride fumes may be present, as near refrigerating machinery, or where the air may be impregnated with coal dust, such as in or near boiler rooms. See fig. 4.

For obvious reasons, which I need not enumerate, accessibility of electrical machinery in ships' engine rooms is of the greatest importance. Even if motors are installed which are so reliable that a breakdown is a very rare occurrence, the occasional general overhaul which is advisable is very much more easily performed if the motors are designed so as to allow the interior to be inspected, cleaned, and re-varnished if necessary, with the greatest ease and the least disturbance to other machinery. It is advisable therefore to specify that all ship motors should have separate bearing housings and that both end brackets should be split horizontally. See fig 5.

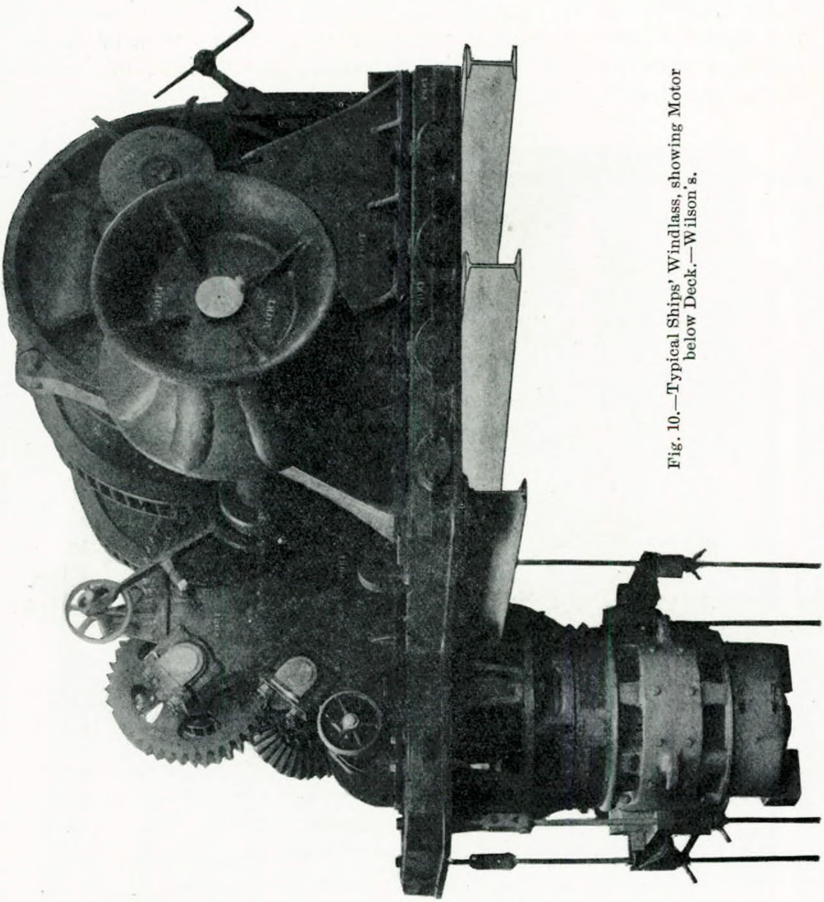

Fig. 10.—Typical Ships' Windlass, showing Motor below Deck.—Wilson's.

Ball bearings have now proved themselves so reliable that they are becoming universal on ship motors. Oil-ring bearings require frequent attention, and the filling up with oil is liable to be forgotten and is sometimes difficult owing to the position of the motor. Ball bearings to be reliable, however, must be made a very careful fit on the shaft, and as therefore removal of the ball bearing from the shaft is to be avoided, it is essential that bearing housings should be made separate from the end bracket, so that the armature may be removed and replaced with its bearings untouched.

All motors of over 20 b.h.p. should be split horizontally throughout—that is to say, the magnet frame as well as both end brackets, should be split, to reduce the weight of parts to be handled during cleaning and overhaul.

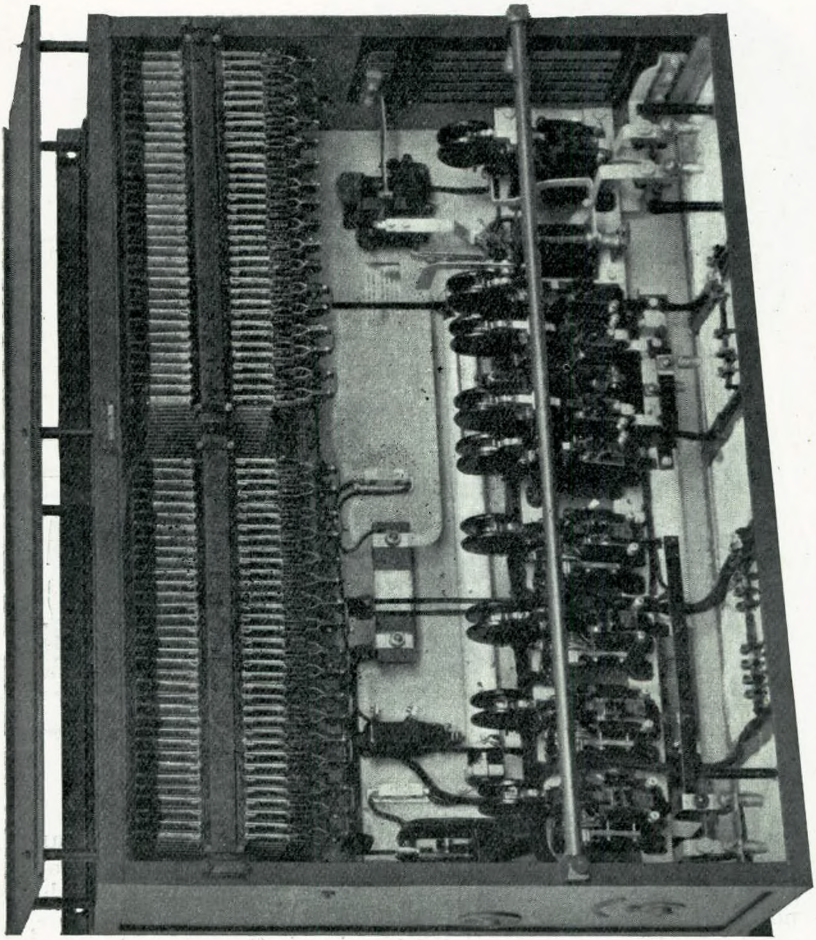

Fig. 11.—Reversing Contactor Controller for Windlass (with grid resistances).

Terminal boxes should be larger than on land machines, to cope with lead-covered or armoured cable and glands, and should be in such a position that wiring up is easily accomplished.

Starters.—Most of the control gear used below deck is in the form of starters for motors of various kinds, and these

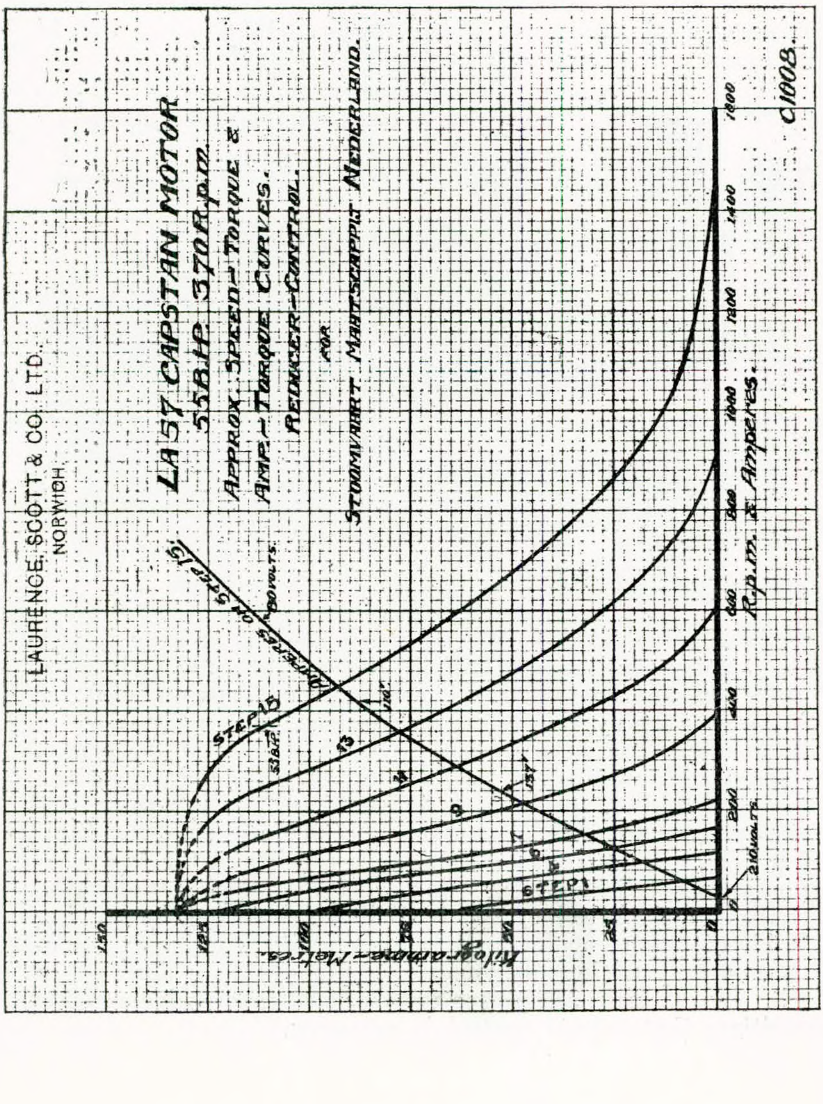

Fig. 12.—Speed-Torque Curves, Motor-generator type Capstan.

starters are mostly of the barrel type, the contactor type being only required for motors of larger horse-power, such as those driving refrigerating machinery, compressors, etc. Here again mica is the most reliable form of insulating material, and it should be hot-moulded on to iron bars, with all contacts and connections clamped on to the micanite, sufficient leakage path being always provided. It is very advisable to have all connections in the front of the starter. All contacts should be large, well spaced apart, and with renewable tips.

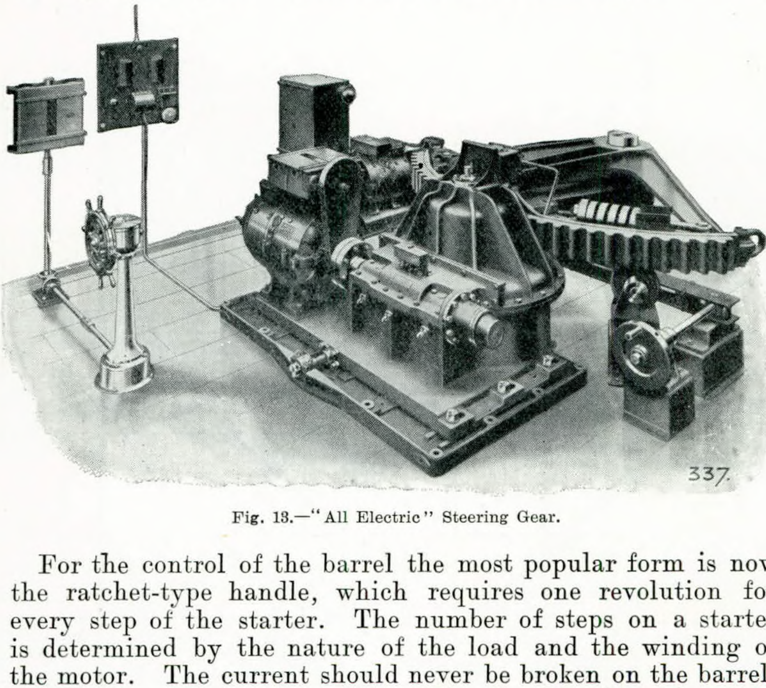

Fig. 13.—"All Electric" Steering Gear.

For the control of the barrel the most popular form is now the ratchet-type handle, which requires one revolution for every step of the starter. The number of steps on a starter is determined by the nature of the load and the winding of the motor. The current should never be broken on the barrel, but on a separate contactor—see Fig. 6. The formula given in the B.E.S.A. specification is less than that generally considered good practice. For some special duties, like ventilating fans, a small contactor starter is considered the best, employing what is known as "flux control"—that is to say, the control of the speed of the fan motor is effected by putting in circuit from one to three separate series windings by contactors operated by very small regulators at a distance. (See Fig. 7). These fans and motors are often in such inaccessible positions that remote control is necessary.

Other forms of control gear, usually of the contactor type, I will deal with later when describing windlasses, capstans and winches.

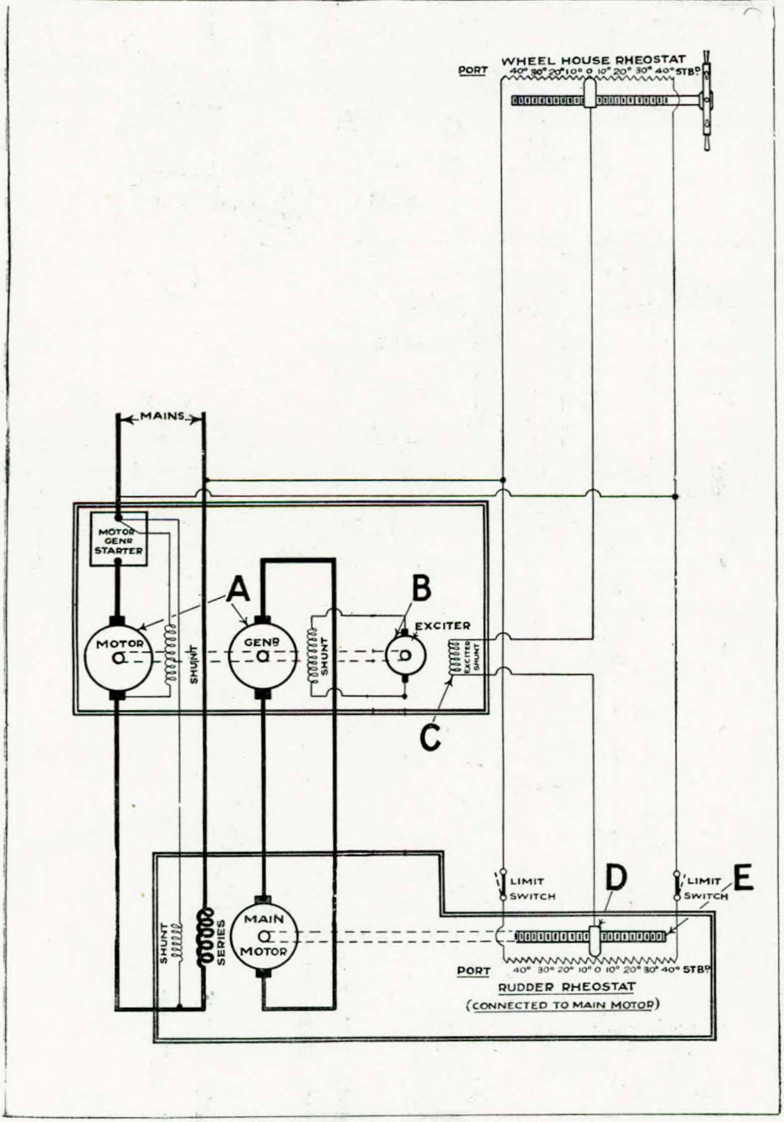

Fig. 14.—Key Diagram of All-electric Steering Gear.

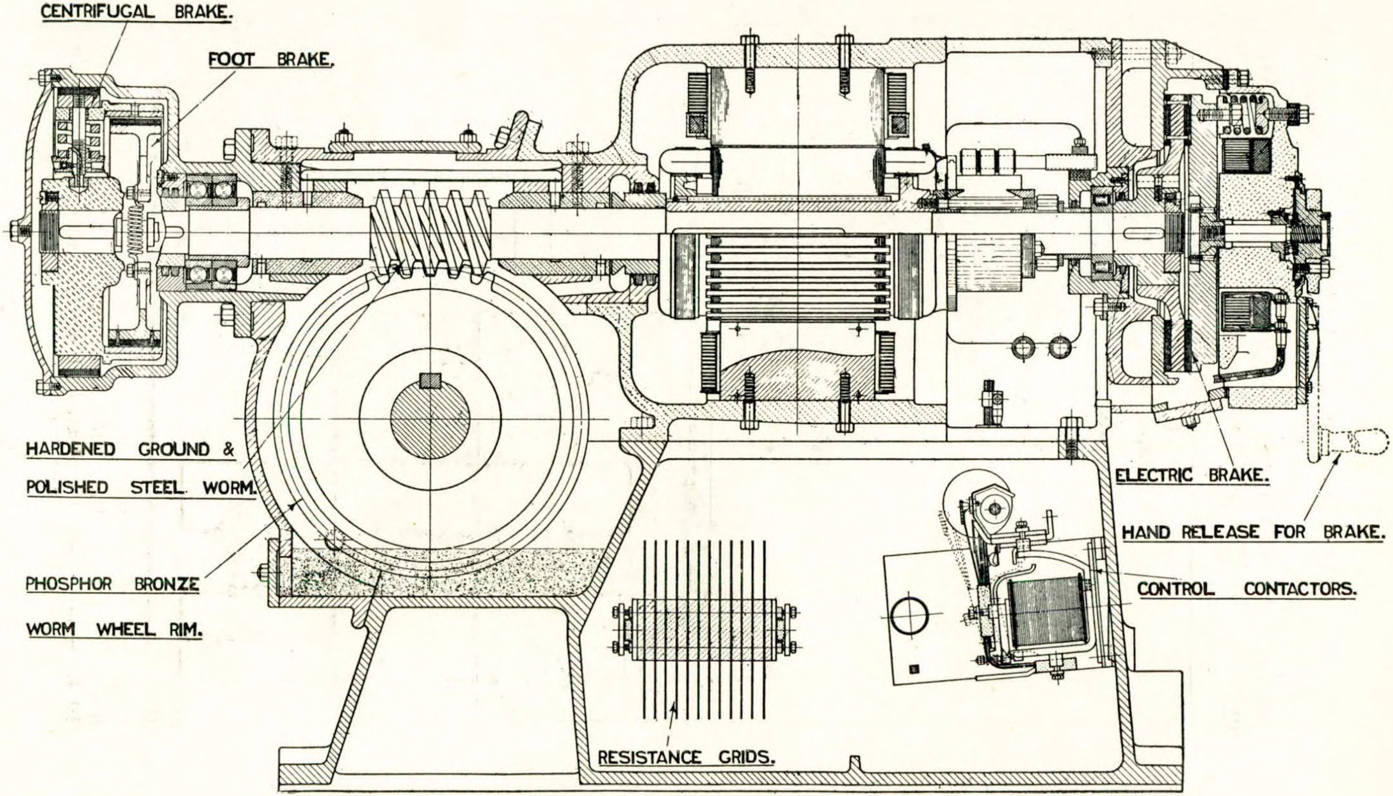

Fig. 15.—Sectional Arrangement of Deck Winch.

Resistances in starters are now generally made of a special stalloy iron which is practically unbreakable and should be always electrolytically zinc or cadmium-plated (See fig. 8.)

Amongst machinery below deck, dynamos must be considered. Here the most important detail of design is the commutator and brushgear. Assuming the electrical design is

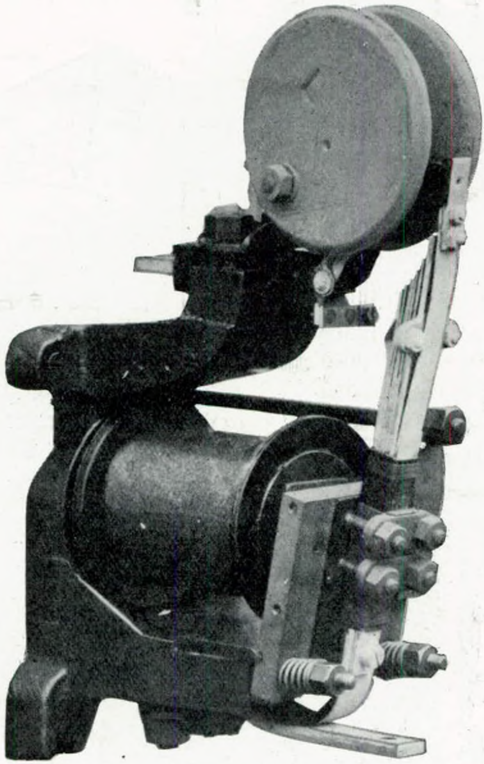

Fig. 16—Clapper type Contactor.

such that the electrical sparking limits are kept low, there should be an entire absence of sparking at all loads unless the commutator becomes distorted or one or more bars of the commutator rise up slightly above the others, which might cause sparking due to mechanical causes, such as jumping of the brushes. To avoid this, the commutators of large dynamos should be very carefully designed and should be subjected to what is known as " heat treatment " during manufacture, to take out before the machine is installed any preliminary distortion which may take place due to heating. Care should also

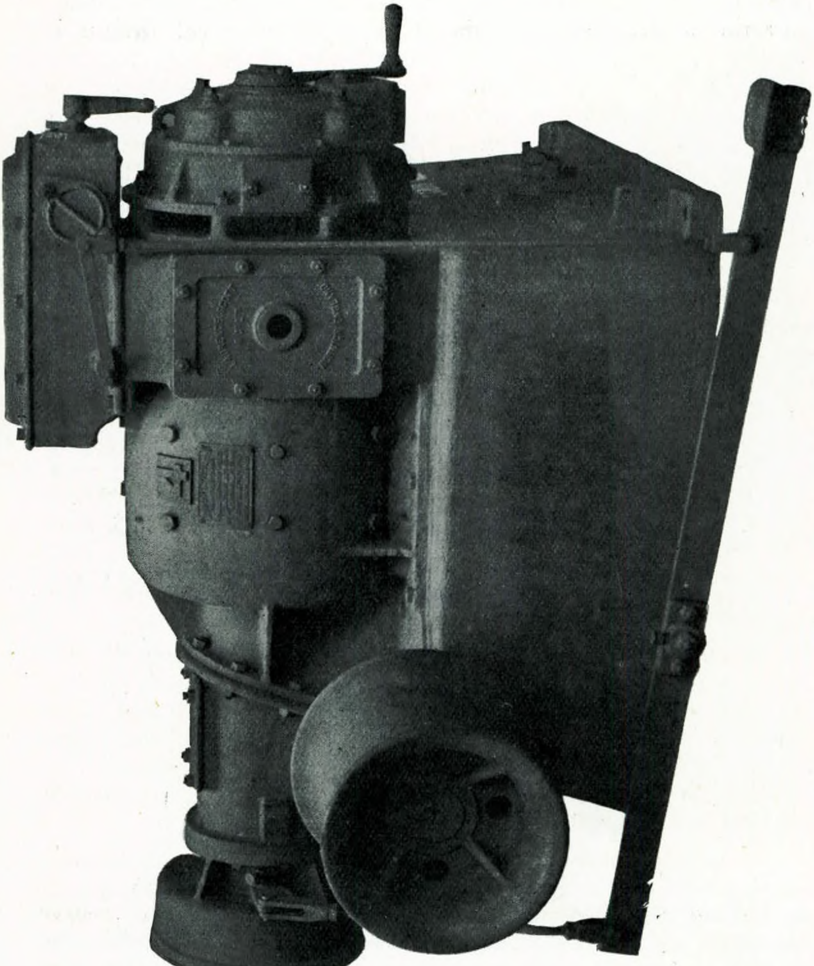

Fig. 17.—" Scott Patent Self-contained Winch.

be taken in the design that the maximum temperature rise of the commutator is well below the limits specified, for it is much more affected by heat than other parts of the machine.

The brushgear should be of very substantial construction, and should never be carried off the nose of the pedestal bearing, but on strong cast iron brackets fixed to the magnet frame. (See Fig. 9).

In specifying the maximum temperature rise of continuously-running electrical machinery on ships, the average temperature of the air surrounding the motor or dynamo should be taken into account, and it is now becoming usual, at least for ships which travel in tropical climates, to specify a maximum rise of temperature at full load of 63° F. after six hours' run at full load.

Electric Windlasses, Capstans, Winches and Boat Hoists installed above deck are usually now driven by motors fitted as part of the equipment on the deck and therefore exposed to all weathers. Such motors must therefore be totally enclosed and watertight and capable of withstanding heavy seas. The precautions to prevent corrosion already described for engine-room motors are even more necessary with deck motors. The work required of motors driving deck machinery, being of an intermittent nature, and the speed and load varying very greatly, these motors are usually series wound in contrast to the constant running machines below deck, which are generally shunt wound.

I will now describe deck electrical machinery in detail, beginning with *Windlasses*.

I am of opinion that windlass motors, when properly designed are perfectly reliable fitted on the windlass bedplate, and it is not necessary to fit them below deck, which adds considerably to the cost, both to the manufacturer and the shipbuilder. The control gear, however, is usually placed below deck, as it is necessarily rather large, operated by a master controller fitted on the deck.

A windlass motor is required to exert very heavy momentary overloads when breaking anchor, during which the speed should be low, followed by sudden reduction of load, when the speed should be very much higher. This necessitates, in all but very small windlasses, the use of a contactor controller which is capable of controlling the speed of the motor over a considerable range. As the anchor approaches the hawser holes the controller must be capable of reducing the speed although the load is very much reduced, so that the anchor may be stowed snugly without damage to the gear. The

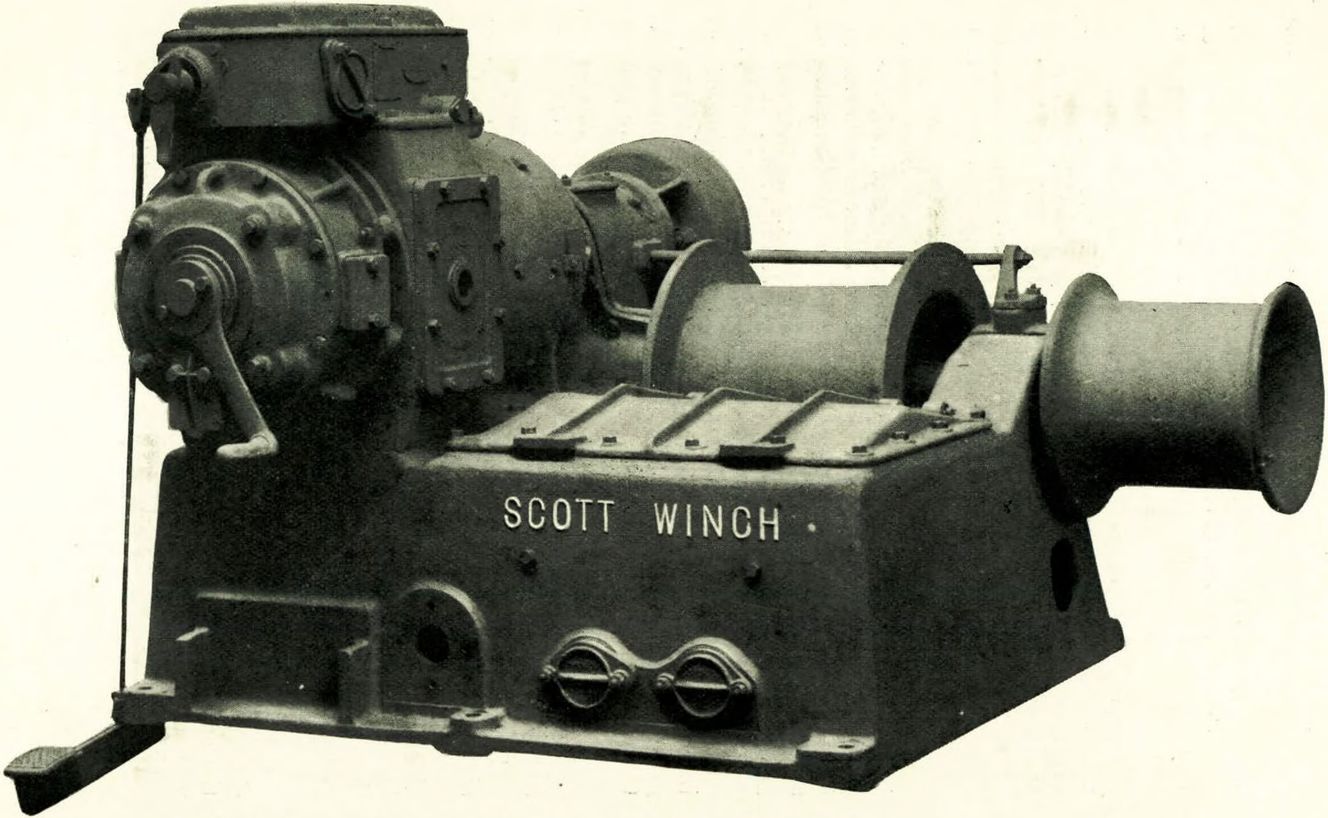

Fig. 18.—"Scott" Patent Self-contained Winch.

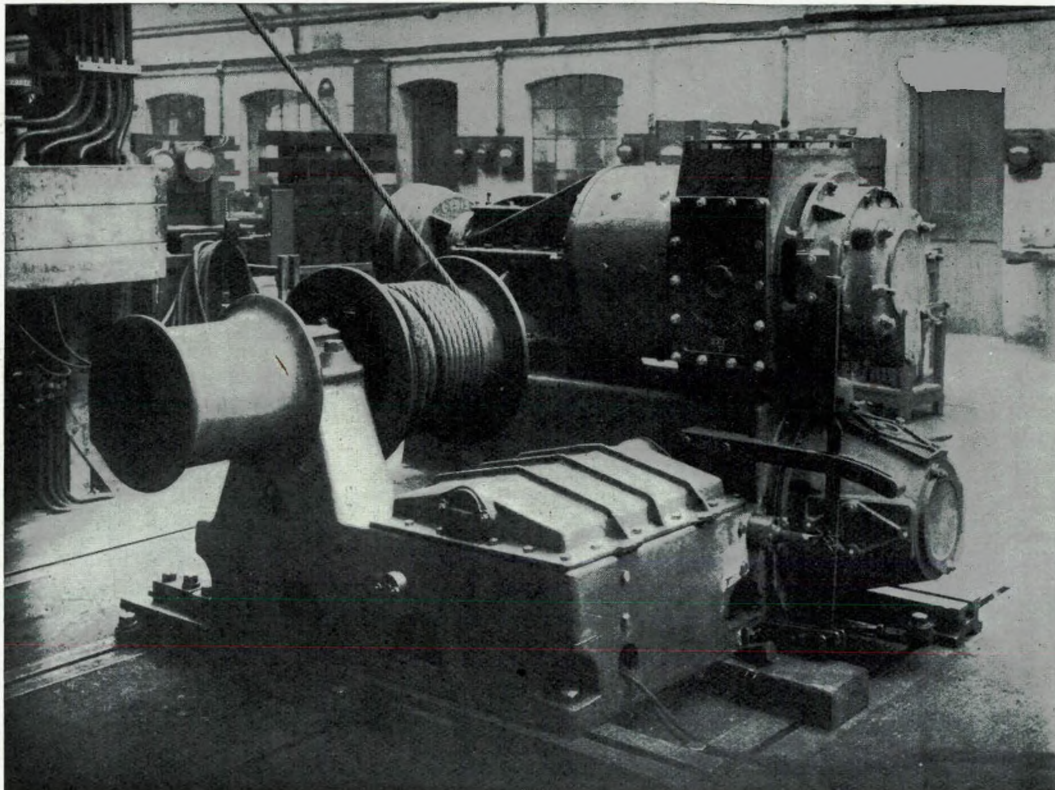

Fig. 19.—Deck Winch, No. D3. (Motor Reducer Type.)

inertia of the armature of the motor, which might be running at a high speed if the operator is not careful at the moment when the anchor enters the hawser pipe, might shear the teeth of the windlass gearing unless a slipping clutch is fitted.

A contactor controller, however, is not an ideal method of controlling a windlass, and in the last two years a motor-generator type of control has been developed which has certain advantages, and a number of ships have now been fitted with such windlass gear. In place of the elaborate contactor controller, a motor-generator or motor-reducer is employed, consisting of two machines below deck, coupled together, running at a constant speed, the control being effected by a very simple regulator fitted on the windlass which varies the voltage given by the generator of the motor-generator in such a way as to allow complete control of the speed of the windlass at all loads. See fig. 12.

As the controller has only to deal with small shunt currents, a large number of controlling steps are possible, giving very fine speed control.

The field winding of the generator is specially designed to automatically "stall" the motor at the pre-determined overload without allowing sufficient current to pass as to damage the motor by overheating within a reasonable time.

The motor-generator need only be started up just before the windlass is required to be used, and can be shut down after the anchor is stowed.

The foregoing remarks apply generally to *Capstans* also, which are now being extensively fitted with motor-reducer control.

The motor automatically "stalls" when the strain on the rope is somewhat above the rated full load of the motor, and a constant strain can be maintained for a reasonable time, the speed automatically picking up when the strain is removed, thus keeping the rope taut.

Steering Gear.—The motor-generator system of control has been applied to ships' steering gear for many years, the first vessel so equipped being the S.S. *Mississippi* (Atlantic Transport Line) in 1914. To distinguish this system from the electro-hydraulic it is known as the "all-electric steering gear."

The same principle as with capstans and windlasses is used, viz., a constant running motor-generator, the control being

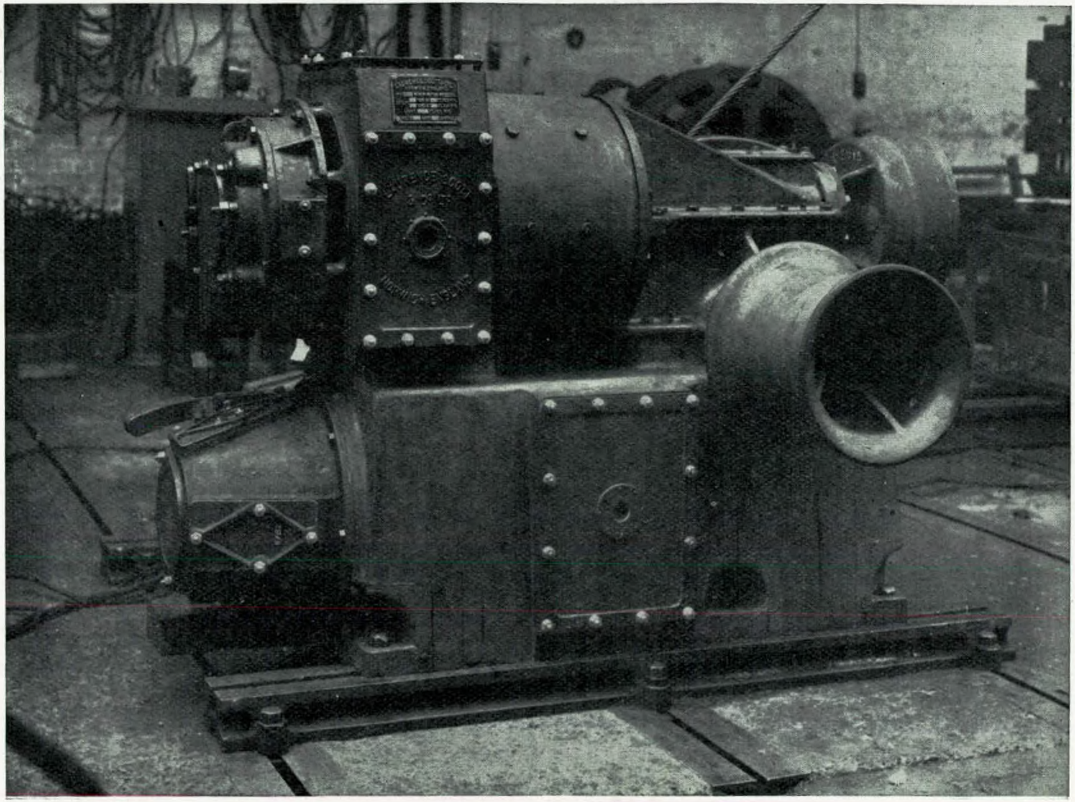

Fig. 20.—Deck Winch, No. D3. (Motor Reducer Type.)

effected by varying the strength and direction of the generator field, thus varying the flow of current in the permanently-closed circuit of the steering gear, the latter itself driving the rudder-stock through worm and quadrant gear.

This system has proved itself to be extremely reliable. It is unaffected by weather conditions, and it is very flexible, thus preventing heavy strains on the ships' plates when the rudder is struck by heavy seas.

The greatest advance in electrical machinery for ships has been made in *Electric Winches.*

The type of winch now usually adopted, even on cargo boats, is worm-geared, such gearing having been found to be more reliable, stronger, and more long-lived, besides being silent, than spur gearing, while owing to the much higher gear ratio possible, a change-speed gear is not required, the necessary change in speed being effected by having a motor with a high speed range

The worm gearing on a ships' cargo winch is a very important part of its design, and what are known as "soft" worms should not be accepted. It should be specified that the worms should be forged from the best grade of low-carbon case-hardened steel. They should be annealed before and after cutting the thread, then case-hardened, and then ground, and polished after hardening, in order to obtain a perfect tooth-form. The wheel rim must be of the best quality phosphor-bronze.

The best designs of winches are fitted with three separate brakes—a magnetic brake, foot-brake, and centrifugal brake—all being totally enclosed and watertight.

The control gear must be of the contactor type, and to give high speeds at medium loads some automatic device for raising the speed, such as a load discriminator, should be fitted.

If well-designed contactors are used it is my opinion that a self-contained winch, with the contactor control gear fitted in the bedplate of the winch, is very reliable and presents many advantages. The cost of fitting the winch on the ship is then very small, the only requirements being two cables from the mains, brought through the deck into the base of the winch.

In order to ensure the utmost reliability in contactor control gear fitted on board ship, especially that fitted in the bedplate of a winch, it must be specially designed. Both the positive and negative poles of the contactor should be insulated from the frame by moulded micanite, so that the frame itself is "dead." All the ferrous metal parts must be electrolytically zinc-plated, including all springs, nuts, bolts and washers. Separate easily-renewable sparking contacts are essential, and

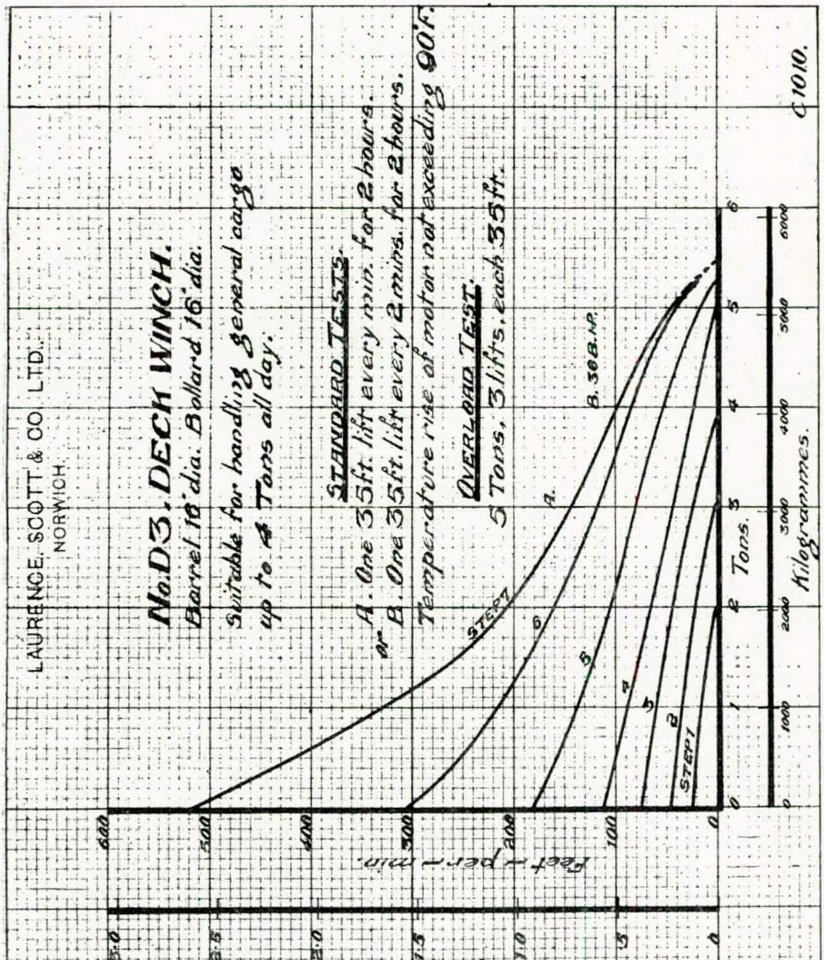

Fig. 21.—Speed-load Curves, D3 Deck Winch. (Motor Reducer Type.)

all connections must be readily accessible. A reliable timing element between the contactors should be used, which is unaffected by changes in temperature or by damp atmosphere.

It is essential that the control should be so arranged that a large range of speed is available, say from 100 feet per min. on the rope at full load to 450 feet per min. on light hook, and that this change of speed should be given automatically by the winch according to the load lifted, but also that the speed at any load should be under the control of the operator. For instance, although the winch may be designed to give automatically a high speed with no load on the rope, yet there are times when a very slow creeping speed is necessary with slack rope, as when hauling cargo from under hatches.

The best way of doing this with contactor-controlled winches is to interlock the foot-brake with the controller so that when the foot-brake is depressed the controller is automatically brought to the first step, whatever the position of the controller handle, thus putting the maximum resistance in the circuit. Further pressure on the foot-brake puts an artificial load on the motor, bringing the speed down to a creeping speed if required. The provision of such a creeping speed with slack rope is also very useful when weaving the rope on to the barrel.

The winch should be designed so that any load can be lowered at a high speed, and the maximum load stopped at will within two feet, and lowered very gently to the deck. This is usually accomplished by releasing the magnetic brake, thus allowing the load to drop by its own weight, the speed being controlled by varying the pressure on the brake.

An electric winch must be designed so that it is not only easily controlled, but is fool-proof, and even rogue-proof; that is to say, it should be very difficult to deliberately put it out of action, and should be capable of being worked without damage to cargo by the roughest of labour. It should also be so designed that it automatically gives the highest speed commensurate with the available power at all loads, and that the stevedore should feel such confidence in it that he can work it always at the highest speed for which it is designed to run. For this reason, in addition to the foot-brake and magnetic brake, it is very advisable to fit a separate centrifugal brake, as then the stevedore can, when lowering a load, "let it rip" without fear of damage to the winch. Otherwise, it is found that the operator is apt to lower very slowly.

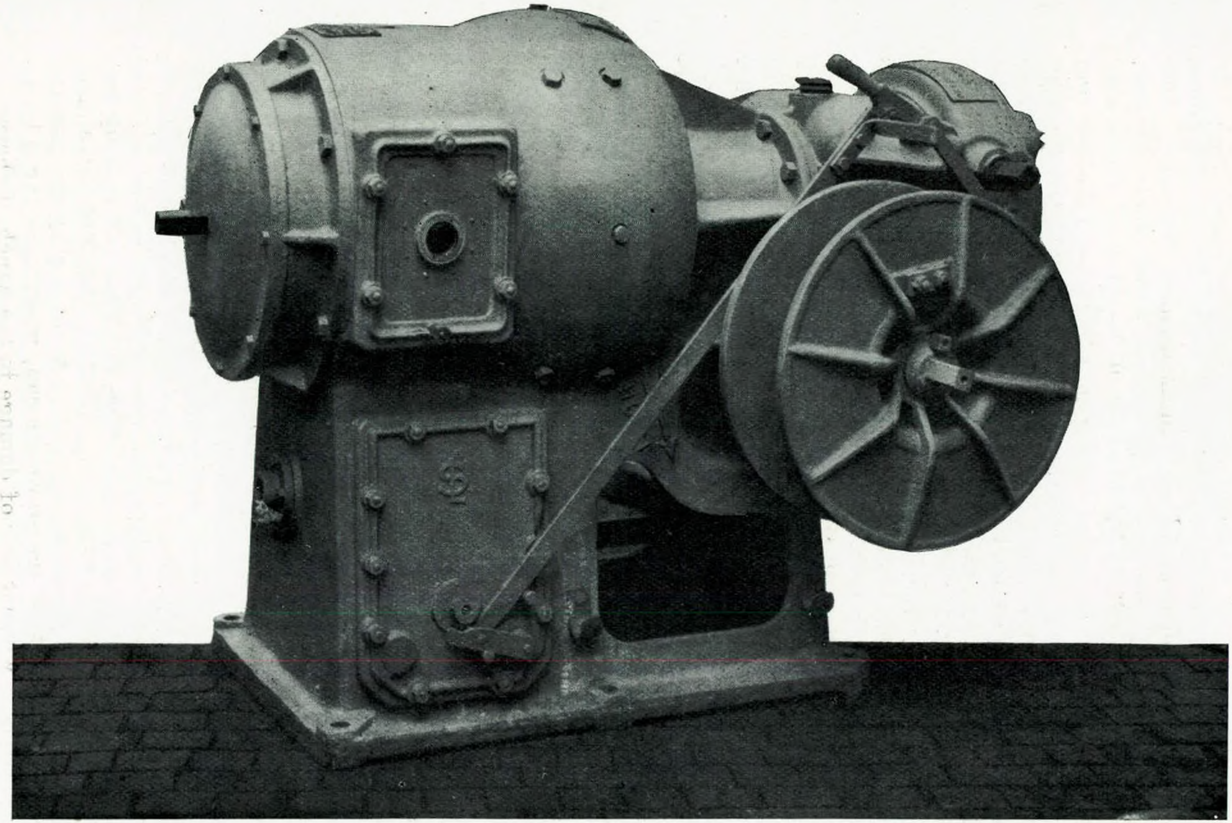

Fig. 22.—Boat Winch.

I have already described the application of motor-generator or Motor-reducer control in windlasses and capstans. This type of control is also now being applied to the electric winch, the motor-generator being fitted on the bedplate of the winch. A lifting speed range of 4 or 5 to 1 between full load and light hook is just as essential in this type of winch, and creeping speeds at light hook can be obtained without having to put on an artificial load by an interlocked foot-brake. This is done by reducing the voltage given by the generator of the motor-generator.

Fig. 21 shows the speed-load curves obtainable on the D.3 winch illustrated above. It will be seen that the speed is automatically inversely proportional to the load at all loads, in contrast to the ordinary electric winch, in which the speed is automatically increased in one step at about half load.

The use of contactors is here reduced to a minimum, as in the case of windlasses and capstans, the control being effected by a shunt regulator varying the field of the motor-reducer.

The winch motor also automatically stalls at a pre-determined overload, and resistances are not required.

Electric Boat Hoists are now being fitted on large liners, which have to pass very stringent Board of Trade tests. They must have the same qualities of reliability and watertightness as a cargo winch. See fig. 22.

The load on winch, windlass and capstan motors being intermittent, the rating specified varies according to the work required of them. In the case of windlasses and capstans it is usually 90° F. after one hour's run at full load. In the case of cargo winches or boat winches, however, it is becoming more usual to specify that the winch should lift the full load so many times an hour for a given period, after which the temperature rise of the motor should not be more than 90° F.

It is essential that all electrical machinery for use on board ship should be very carefully tested before despatch from the manufacturers' works, and service conditions should be imitated as nearly as possible, as, unlike electrical machinery on land, not only do motors have to withstand very much more onerous conditions, but generally speaking any single motor on board ship is a more essential unit than in (say) a factory. The earnings of the vessel, and even its safety, may be dependent on any one electrical machine installed, and all shipowners should insist on a stringent specification being worked to by the manufacturers.

DISCUSSION.

Major S. E. GLENDENNING: The writer of the paper has asked me to express his sincere regret for absence to-night. He has rather a severe attack of the prevalent malady and he has remained at home under the strict orders of his doctor. I must ask your kind indulgence under the circumstances, but I will do my best on Capt. Scott's behalf. He will, I understand, have the opportunity of making a considered reply in your proceedings. I must thank you on behalf of the writer of the paper and myself for the courtesy you have extended to us. Many of the statements in the paper may be controversial, but I know that Mr. Scott wrote the paper with the discussion in view, and I hope there will be a good discussion. As far as opportunity offers I shall be pleased to answer any questions which arise.

The CHAIRMAN: The paper bristles with information, and is now open for discussion.

Mr. R. H. MACKILLICAN: Reference is made to the advantage of the large overload capacity of the D.C. motor, particularly in relation to winches, windlasses, etc, but no figures are given. In the British Engineering Standards (1923) the following overloads are specified:—

Sustained Overloads: for motors with continuous rating, 25% overload for two hours for sizes of 4 B.H.P. and upwards. For generators with continuous rating, 25% overload for two hours for sizes of 3 K.W. if D.C., K.V.A. if A.C., and upwards.

Momentary Overloads: for motors with continuous rating (not totally enclosed) 50% for 1 minute, 100% for 15 seconds, and less if totally enclosed.

Are these figures applicable to the equipment under discussion?

I note that the motor-generator system is now being applied to electric winches, as well as to windlasess, capstans and steering gear. I presume that this involves a considerable increase in cost, compared with a motor supplied direct from main generating set and contactor controlled.

I should like to make a few remarks and suggestions on behalf of the sea-going engineer. During the discussion of a previous paper on this same subject about four years ago, one speaker remarked about the " intensive course of instruction " in Electrical Engineering, to which members of the Institute were being subjected. I gathered that it was in the nature of a protest. Now, it has to be remembered that the vast majority of our members are men who have had little or no training in Electrical Engineering, and I think the Institute can do no work which would be more appreciated by this vast majority than to arrange for further papers on this subject, and I suggest that the treatment be made as elementary as possible. Although the percentage of members able to attend the lectures is small, the others, that is, the sea-going engineers, have the benefit of verbatim reports in the Transactions.

The importance that electrical machinery for marine purposes is now attaining, presents a task of no mean order to the marine engineer, at any rate to those who wish to be conversant with all branches of the profession; and I think one may say that marine engineers who are members of this Institute are mostly men possessing the desire for knowledge. I find that in matters electrical, more than in any others, the marine engineer has difficulty in understanding principles. I therefore submit that the "intensified course" be resumed.

Mr. W. A. Cobb: The author states that binding wires for holding conductors in the slots of armatures are not reliable and that hard wood wedges suitably impregnated should be used instead.

Is there not a tendency for wood wedges to shrink in excessive heat, becoming loose and allowing movement of the conductors, leading to breakdown of the insulation between the conductors and the armature core?

In a case which I have in mind where hornbeam wedges were in use investigation following a breakdown showed that the wedges had shrunk and movement had taken place; the insulation was perforated in many places, allowing leakage to the armature core.

The use of binding wires was in this case a safeguard against more serious trouble; would the author say whether the use of wires in addition to wedges is not generally more satisfactory than sole dependence upon "suitably impregnated" wedges.

The Chairman: I notice from a statement on page 7 of the advance Copy, that it is now becoming usual, for ships which travel in tropical climates to specify 63°F. maximum rise in temperature after six hours' run at full load. That means a reduction of the temperature rise by about 7°F. I presume that this will not increase the cost of the motors to any great extent? I think it is a step in the right direction. It is most important that electrical machinery should be specially designed for ship work. It is quite different from electrical machinery for land work. Any breakdown occurring is a very serious matter. This is a point which should be very carefully considered, otherwise the shipowners will be opposed to electrical machinery. All electrical machinery should be specially designed and built to withstand the severe conditions likely to be met with at sea.

Mr. T. Golding (Visitor): I should like to say that I am in agreement with Mr. Scott's paper as read, but I think that much of the most interesting matter is that which was given in the description of the slides The great amount of attention now being given to details is, as has been pointed out in the paper, a factor making for popularity and reliability of electrical machinery on board ship, but I think there is a tendency for cumbersome details to be added which are apt sometimes to aggravate the trouble which they set out to cure. For example, the use of ratchet type starting devices for motors is an application which although desirable on starters for large motors is in my opinion unnecessary and undesirable for small machines, the usual automatic no-voltage and overload release protecting devices embodied in the controller providing sufficient protection against too rapid starting. I think the aim of designers should be to cut out "frills" as far as possible and to provide the desired results in the most simple and straightforward manner. Generally speaking, these "frills" mean unmechanical gear—the more simple the apparatus, the more robust and mechanical can it be made.

The rating of electrical machinery is a subject which has been much more carefully considered during recent years and the low temperature rise provided in machinery of reputable makers is all in the right direction. Unfortunately it is difficult sometimes to obtain prices which are consistent with the large amount of material that has to be provided in order to maintain these low temperatures and the manufacturers of these higher grades of electrical machinery are frequently not compensated for the value of supply.

In the maintenance of machinery on board ship I think that cleanliness is of prime importance and those in charge should be encouraged to keep the gear as clean as possible. For this reason accessibility is of first importance, as well as the provision of smooth surfaces which can be wiped down without the insulation being damaged. I am inclined to think the stressing of micanite insulations as the *only* insulation, is going rather too far because there are other materials, particularly Bakelite products, which offer a smooth surface and can be easily cleaned without any fraying or flaking of the insulation which is liable to occur when micanite alone is used. In referring to Bakelite products I would emphasise the fact that it is essential that none but the highest grades should be used and that these should be properly applied, large creepage surfaces being allowed, all holes properly bushed and the edges of the cut material being sealed against the ingress of moisture. The material should not be used in any position where arcing is likely to occur owing to the tracking effects which may be obtained as a result of burning, but in such positions as the insulation of brush gear of dynamos where no arcing is likely to occur and where large creepage surfaces can be provided it is an excellent material, as in addition to the advantages mentioned above it is virtually incompressible and is a good mechanical insulation.

I was interested in a previous speaker's remarks about binding wires, and agree with him that condemnation of this method of retaining armature coils in their slots is not justified. I can speak from experience of thousands of motors fitted with binding wires which have given almost universal satisfaction. Of course there have been failures but the percentage of them is very small and in practically every case that has come under my notice this trouble has been due to abnormal conditions or badly fitted bands. Wooden wedges for retaining armature coils have a very definite use on large machines, but this method of retaining the coils in the slots is only satisfactory when it it properly applied, and badly fitted wedges or wedges made from wood which is not properly seasoned and impregnated are a real source of danger. To-day some manufacturers are replacing wooden wedges by wedges made from Bakelite fabric or grey fibre, but in my opinion where wedges have to be used, well seasoned and impregnated wood is as good as anything obtainable. One objection to the use of wedges on small armatures is that that part of the coil which is subject to greatest heating, *i.e.*, the part of the coils which is embodied in the slot portion of the machine, is much more enclosed with a wooden wedge than when the coil is retained in the slot by means of bands and consequently there is a danger of the internal temperature of the armature coil being much hotter than any part of which the temperature can be measured by thermometer.

I notice the author suggests that motors of 20 h.p. and upwards should be split on the horizontal diameter. Although I fully agree that motors of moderate and larger sizes should be split, I think that using the h.p. as the determining factor is wrong since a high speed motor developing 20 h.p. might be very small and light weight whereas a 10 h.p. low speed motor might be very heavy. I think it is better to specify that the splitting of motors should be carried out on all machines having armatures above say 11in. diameter.

Mr. S. N. Kent: I notice that the author says that " in the engine room the presence of oily vapour, frequently high air temperature, very humid or steamy atmosphere, condensed water dripping from the roof, water leakages, vibration, and other adverse conditions make it imperative that only motors and control gear specially designed for ships' engine rooms should be installed." Would it not be better to put totally enclosed motors in ships' engine rooms? There are ships which are trading all over the world, and which have many motors on the engine platform with cables leading downwards, underneath the platform. They are out of the way where they are never seen until something happens. Are there any definite objections to this method?

With regard to Bakelite, it is as likely to get wet or damp as any other parts and allow leakage of current. If there is a breakdown it takes hours to find the cause and perhaps only a few minutes to put it right. Again, with electrical installations, motors run satisfactorily, but control gears and their accessories are sources of trouble. We get one piece of copper coming in contact with another bit which has to do all the work, which is often the cause of the motor getting out of gear. I think it usually takes far more time and trouble to find such a defect than to put it right.

As regards binding wires, I also am inclined to think that the wooden wedges are just as cumbersome, and it should be possible to obtain wire which could be welded or fastened in some other way. We should have overcome such a difficulty by now.

The author states that " all studs, bolts and nuts used in making internal or external connections or holding on covers, or parts which may be frequently removed, must be made of non-ferrous metal. . . .," but why? If that is so, the same restrictions should be applied to the parts of the contactor gear, which suffer in the same way. The little things such as contactors, switches, etc., are together responsible for a lot of trouble.

I do not quite understand the author's remarks about temperature rise. Supposing that you are testing a motor where the temperature is just 100°, are you going to allow it to go up to 163°? Is that not too large a limit?

Mr. A. Jobling: It would be interesting to learn from a shipowner's point of view, what is gained by the adoption of electrical winches, capstans, steering gear, etc., in preference to steam auxiliaries.

In some cases it is perhaps understandable that electrical auxiliaries are more conducive to appearance and general economy, but at what cost? The difference is sufficiently big to cause grave consideration when estimating the price of a vessel.

Another important item is the intricacy of electrical machinery; it has to be constantly attended to, and by a staff that is already overburdened with work.

Therefore one naturally asks, what does the shipowner gain by adopting electrical gear throughout his ship.

Mr. S. N. Kent: Would not winches of the varying voltage type be as satisfactory as the type alluded to in the paper?

Mr. J. Thom: It is clear that the author has given a very good description of electrical auxiliaries for ships. There is no question that they would be more expensive than other types of winches, etc., but the author has told us definitely that while they are more expensive to instal they cost less in the running and in consumption of fuel. It would have been clearer if he had given in the ordinary way some comparative figures showing in tons of fuel the difference in consumption.

I do not agree with the author's remarks about binding wires. Some wires are quite satisfactory to-day. There have been accidents but not necessarily because of the wire. Wood has to be properly treated for a considerable period before it can be used for the same purpose. Other materials now coming to the fore will replace these and assist in preventing moisture getting into the coils.

With regard to temperature rise, the test limit is given as 63°, but the author does not mention the temperature of the surrounding air of the test room. When these machines are intended for use in very warm places such as engine rooms and stokeholds, they should be tested under similar conditions. I think that possibly the safety rise should not be so much as 63° on board ship.

As regards the splitting of small motors, I do not think there is any necessity for that. You take off one end plate and there is no need for any further division. The extra cost involved would not be compensated for by any advantage obtained. The operation is as easy as drawing a piston out of a cylinder.

With regard to the use of motor generators for altering the speed of capstans and other machines where it is difficult to gauge the loads put on them, I think that is a very excellent arrangement which should eliminate the difficulties. If contactors are made properly, they give no trouble; occasionally they have to be re-set, but that is not difficult. If it is possible to make a contactor starter to start a train on the electric railway with very variable loads, surely a starter can be made for marine purposes. The contactor starter is the most satisfactory arrangement you can have for varying loads and varying temperatures.

I think the paper indicates the great possibilities of electrical auxiliaries on board ship, especially in reducing the amount of fuel consumed for these services and increasing the speed.

Mr. W. A. Christianson: The question of cleanliness of the atmosphere in which electrical plant is required to work has been referred to, and I should like to ask to what extent, if any, air filtration systems have been made use of, apart from closed air circuit systems, one of which has been described by the author.

A paper of this description cannot be considered complete without reference to the Austin system. This, I understand, is a "series" system, for dealing with the deck auxiliaries, in which a single motor generator supplies a number of auxiliaries arranged in series, at constant current, but with voltage varying with the demand. This has the advantage of doing away with control gear on the auxiliary motors affected, and reduces the number of motor generator units which would otherwise be necessary. These advantages may be offset by disadvantages, and it would be interesting to have the author's remarks on this system.

Mr. G. R. Hutchinson: I have noticed on a number of two-stroke cycle-engined motorships where independent scavenging is used that the motor for driving the scavenging blower is invariably of foreign make. I know there are problems associated with the production of a high-speed, high-powered D.C. motor, and I think it would be interesting if the author could tell us why British manufacturers have not got into this market. I believe the author's firm have done a certain amount of research work on this subject, because I recall seeing such a motor of their make running experimentally some time ago.

I support Mr. Christianson's remarks on the Austin system. It has good points, and possibly a few " snags " as well, but as it has been fitted in a few important ships perhaps the author could tell us more about it. I also agree that we should have more papers on electrical matters. We, in this Institute, of all people, should be *au fait* with all aspects of electrical engineering development as it affects marine matters, because it is patent that electricity is going to play a more important part at sea in the future than it has hitherto. Mr. Scott is deserving of our best thanks for his interesting paper.

Major S. E. Glendenning (for the Author): I have very much appreciated the discussion. A number of speakers defended the binding wires, but I should have thought that mechanical people would be the first to recognise anyway one disadvantage. If you lay an armature down and nick the wire slightly, the binder may be weakened very much. A wood wedge armature on the other hand can be rolled about without much fear of injury.

Another trouble is that binders on the armature core are in the magnetic field and must not be soldered up too solid or there will be overheating due to eddy currents. There should be no shifting of the conductors underneath the wedge, but if in addition to the micanite there is leatheroid as a mechanical protection, any slight movement will not break up the insulation. I do not remember, from before the war onward, any failures due to the wood. One usually uses lance-wood or some other tough and fairly hard well-seasoned timber. It is roughed out and further seasoned by gentle kiln-drying and then finally trued to size so that it is a very tight fit. It is impregnated with the armature so that it does not subsequently take up moisture. The use of fibre is to be deprecated, as most fibres shrink.

Bakelite referred to in this and other connections, is a rather treacherous material. It consists in general of a synthetic resin given mechanical strength by a paper or canvas base, but the makers seem to find it difficult to impregnate the fibrous material thoroughly. It must be remembered that the cut edges are somewhat absorbent, especially in canvas-base Bakelite, and trouble may result in moist atmosphere. Also, should a flash-over occur across a Bakelite surface (due perhaps to coal dust, etc.) the material is carbonised and has to be dug out. It is possible to write one's own name in bold characters by drawing out a glowing carbon track between two terminals connected to a 440 volt supply, the effect being known as "tracking." There are experiments going on at present with other materials which are supposed to be non-"tracking." They are of the Bakelite family, but not such as we ordinarily buy in this country.

My firm have kept clear of Bakelite as far as possible, while many people who started very enthusiastically with this material a few years ago are now much more cautious. It originated in the U.S.A. where the standard of electrical practice is not up to the British. I do not want to condemn Bakelite as a whole, and there are situations where its mechanical properties justify its use, but it is "not in the same street" as micanite for marine work. If micanite is served over with silk tape and varnished it is as easy to clean down as Bakelite.

With reference to overload capacity, the B.E.S.A. specifications are all right as a general guide, but if you know the exact nature of the job and the overloads to be encountered, the machinery can be designed for those particular conditions. In some cases the B.E.S.A. overloads allowed are too generous, in others not enough. It would obviously be silly, for example, to specify an overload heating test on an anchor windlass at an increased torque which the cable itself would not safely stand.

With regard to the training of engineers for service on board ship, I quite agree with one or more of the speakers. When one remembers the early Diesel ships, the electrician was usually a wireman with a pair of pliers, taken from one of the shipbuilding yards. The proper course is to employ qualified men who are engineers as well as electricians, capable of discovering defects and putting them right before troubles occur. Such a man realises when carbon brushes or sparking contacts will require renewing shortly, and knows from the nature of any failure where to look for the cause. If he understands his diagram and is accustomed to seeing and hearing his gear in operation, he knows what a contactor or " gadget " should be doing at a particular time, and will detect immediately if anything unusual is happening.

The success of electric auxiliaries all depend on the maintenance electrician doing his job as well as the mechanical engineer has done his in years past.

The Chairman is very optimistic in hoping for lower temperature rise at the same price. The lower the temperature rise required the more difficult it is to get it. In boiler rooms you sometimes have a forced draft fan surrounded by a temperature of 120°F. It is a question then whether the motor is in the right place at all, and if you could not find a better situation, *e.g.*, by putting it on a different flat or the other side of a bulkhead. The total temperature (air + rise) should not exceed 180°F., because after that cotton insulation in course of time chars. It is possible to insulate machines by means of asbestos, but it is a question whether it is a practical proposition.

I quite agree with Mr. Golding's suggestions regarding the elimination of troublesome details, such as ratchet starting devices for small machines. In avoiding one trouble one may get another instead. You usually have a competent man to start up, and " fool-proof " devices may be more nuisance than use. In the Java trade, natives are used who are difficult to train in mechanical skill and such devices may be justified. I personally like a good, stiff, plain star-wheel which gives a steady click-click.

With regard to the splitting of motors, it is true that it is not the horse-power which counts, it is the size of the machines, with a view to man-handling in a crowded engine room.

In reply to Mr. Kent's question concerning oil vapour, the answer is micanite. It does not justify totally enclosed motors usually, because the machine is larger and heavier. Also a totally enclosed motor " sweats " badly, for example, in the Atlantic, with great variations of air temperature and humidity. Consequently it is essential anyway to have good insulation which will not suffer from damp and sweating, and you might just as well go to a semi-enclosed design.

On the subject of Controllers he has hit me very hard. He suggests that they are always going wrong. Well, they require maintenance just as a steam engine, and they want the attention of a man who knows them. They look complicated when they are not.

Micanite insulation, accessibility from the front, and sound engineering construction are important factors in maintenance.

The first cost of electric auxiliaries tends to be higher, but on the other hand installation costs are lower, and there is no need to interfere with passenger accommodation. Fuel consumption is much lower, and you can in port, for example, cut out one or more boilers. Standby losses are much lower, and so are maintenance costs, in the absence of such things as leaky glands.

Several speakers referred to the Austin system. It is a rather big subject, but there are several points of criticism which I may mention. One is the very heavy cables taken round the ship, another is the special generator for a group of winches, and another the low-voltage contacts and exciter commutator to keep clean on each winch. For all practical purposes I suggest that a straight winch is cheaper and quite as effective.

With regard to high speed motors for turbo blowers, there is no doubt that the Germans and Swiss got ahead of the British makers because, I think, they were prepared to take more risk, and design for lower factors of safety. The situation is different now, and when there is a demand we can make the motors for it.

I thank you very much for your kind reception. I have quite enjoyed myself and hope you have also.

Engineer Lieut.-Comdr. A. J. Elderton, S.R., R.N. (By correspondence): Mr. Scott's paper is both interesting and instructive. There is no question nowadays about the reliability of electrical machinery for marine work, and it does not hold the mysteries with which it was formerly regarded; it is commonplace knowledge following and constructing complicated wireless layouts. The installation of electrical machinery for every purpose depends largely on the type of machinery used for main propulsion and the amount of auxiliary load together with the number of points where application is required. The hindrance to its more general adoption is the question of first cost; electrical machinery to be reliable cannot be built cheaply. If the auxiliary load is large enough this is more than compensated by the fuel economy obtained.

The author states that the running cost in fuel alone of electric winches is one-seventh that of steam winches. I think this is rather generous on the side of the electric winch. A good winch would probably use 50 to 55 lbs. of steam per B.H.P., a turbo alternator set allowing for electrical losses at generator and motor would have a steam consumption of 10 to 12 lbs. of steam per B.H.P. per hour; if the generator is Diesel driven, the fuel consumption would be about ·6 lbs. per B.H.P. hour at the winch which, allowing a coal evaporation of 1 lb. of coal per 10 lbs. of steam (a generous allowance) would be $\frac{5{\cdot}5}{{\cdot}6}$ *i.e.*, Diesel fuel would be one-ninth of that of coal. In the circumstance where the cost of fuel oil is four times that of the cost of coal, the economy would be of the nature of two to tnree times—still a considerable economy.

One of the advantages of the steam winch is that it is possible for the winch to stall when the load is in excess of the power. On a reduction of the load the winch will start to creep ahead showing its great flexibility; an electric motor in similar circumstances would overheat or turn out the armature; overload relays sometimes give trouble if frequently brought into use and most slipping clutches lie down when they are wanted to stand up, and motor generator control adds to the expense and complication. Heavy covering plates while keeping weather from the motors add to the difficulties of inspection. Another point in favour of the steam winch is that it will give some service to the point where it is just "holding together," whereas with electrical machinery a small disarrangement of the controls will sometimes cause a complete failure.

Mr. W. J. Paulin (By correspondence): Mr. Scott is to be complimented on the thoroughly practical nature of his paper which must prove of real value to many marine engineers who are extending their experiences in the field of electrical engineering now to be encountered in all the better class cargo vessels as well as passenger ships.

His enumeration of some of the advantages of electrical auxiliaries over that of steam are most concise and very much to the point, and in this respect invite grave consideration, particularly in this respect to ships' steering gears.

The loss by condensation in a steam gear, particularly when the most modern type of steering gear is employed right aft, is very great indeed, and some figures given recently in the discussion on Mr. Denholm Young's paper, "Losses of Efficiency in Steamship Performance," given at the N.E. Coast Institution of Engineers and Shipbuilders, on November 15th, 1928, emphasise these amazing losses.

The favourable contrast of the "All Electric Gear" operating on the Ward-Leonard principle by controlling the field current of the exciter by means of the Wheatstone Bridge principle, when once fully appreciated by our superintending engineers is bound to extend its adoption.

So far Continental engineers have taken it up with greater enthusiasm in their search for economy and reliability, but there are signs that British engineers now more fully appreciate its value. Its greater flexibility and resistance as against the electro-hydraulic gears is recognised as a valuable relief when the rudder is subject to blows from the sea in heavy weather, much to the advantage of the ships after structure and freedom from strains. The control from the bridge being electrical, consisting only of three wires, does away with all the troubles of freezing in cold weather experienced with hydraulic telemotor control. There is no doubt that the prejudice existing against electric steering gears originated in the earlier types, consisting of a single steering motor worked by a contactor system of control, or its equivalent, and the wear and tear and liability to break down due to the style of control made it something to avoid.

The contrast of the modern "All Electric" with Ward-Leonard control has only to be seen alongside to sweep away these prejudices and establish it as the most remarkable advance in reliability, freedom from breakdown and easiness of control, whilst the "All Electric" gain in economy of working and freedom from repairs as against the steam gears is no longer a matter of doubt.

Captain G. J. Scott (communicated): It was a great disappointment to me that I was not able to meet your members and to read my paper in person.

Mr. Glendenning has replied to the discussion with ability and judgment, and the following observations are more in the nature of emphasis on his conclusions.

Several speakers doubted the advantages of wood wedges. These are not only a much sounder design mechanically than binding wires, as explained by Mr. Glendenning, but as there must be a joint in the slot insulation where it overlaps at the mouth of the slot, the wood wedge, covering and enclosing the mouth of the slot throughout its length and for some distance beyond it at each end, protects the conductors in a scientific manner, which is impossible to obtain with binding wires.

The armature conductors are, as it were, hermetically sealed in the slot by the wood wedge.

After a considerable experience of Bakelite and Bakelised fibre I have come to the conclusion that it is not a reliable insulating material—at least on board ship. Micanite is somewhat expensive, and new and cheaper insulating materials for which exaggerated claims are made are continually being offered to electrical manufacturers, but for ship work, moulded micanite bound with silk tape is still the most reliable form of insulation known.

Both Mr. Thom and Mr Golding doubt the necessity of the splitting of small motors. Space, however, is often so restricted in ships' engine rooms that it is sometimes very difficult to open up a motor unless it is split. Further, when both brackets are split, the cleaning and re-varnishing of armatures and windings and the thorough examination of the brushgear and commutator which is advisable to undertake during the annual overhaul is performed with the greatest ease and with the least disturbance of the machine.

The terminal box on machines with split brackets should of course be fitted on the magnet to avoid the necessity of disturbing the cables during annual overhaul.

This answers Mr. Christianson's question with regard to the extent of cleaning recommended.

Mr. Kent refers to totally-enclosed motors. For certain positions where coal dust or acid fumes are present, they are necessary. Enclosed-ventilated machines of special ship design are satisfactory in most positions below deck, but to prevent carbon dust from the brushes and oily vapour from being drawn into the windings by the ventilating fan on the machine, this fan should preferably be fitted at the commutator end.

With regard to temperature rise, it should be remembered that armatures and windings are normally baked in an oven during manufacture to about 220°F. for 48 hours. As the maximum air temperature in the engine room may be taken as about 120°F., a rise of 63° will not bring the temperature of the motor to a dangerous figure.

Mr. Jobling asks for details of saving in fuel cost of electrical auxiliaries. This is given by Commander Elderton, who, however, does not, I think, allow sufficiently for condensation and leakage losses in the long steam pipes to winches, windlasses, and steering gear. The figure I gave for relative fuel costs of 7 to 1 was the result of two independent investigations by well-known superintending engineers.

When comparing the first cost of steam and electric auxiliaries, the cost of and space occupied by the fitting of the steam pipes should be taken into consideration.

As regards the relative maintenance cost, apart from fuel consumption, I do not think well designed electric auxiliaries require more constant attention than steam auxiliaries. An electric winch or windlass is always ready for use at a moment's notice, which is by no means the case with steam gear.

I believe that one of the greatest advantages of electric winches, windlasses, etc., is that they are capable of withstanding and exerting heavy overloads for a short period without fear of damage, while the overload capacity of steam gear is limited by the steam pressure, and in this respect the Austin system is similar to steam gear.

Several speakers remark on the absence of reference to the Austin system. This system is very interesting and ingenious, and gives results similar to the Ward-Leonard or motor-reducer system of control. The control gear required by the Austin system, is however, by no means simple, and is more complicated and expensive than that of the motor-reducer system, besides being more liable to give trouble owing to its being dependent on very clean low-resistance contacts. As full-load current is continually flowing in the Austin system, the motors have to be larger than in other systems, to avoid overheating. Very large special cables have to be used, and the voltage, rising to sometimes 600 volts, is, in my opinion, much too large for safety on board ship.

The discussion revealed considerable difference of opinion on minor points, but there was general agreement that electrical machinery must be specially designed and manufactured to meet the very special requirements found on board ship.

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Notes.

The following appeared in " The Marine Engineer,' March, 1889, and are reprinted in " The Marine Engineer and Motor Shipbuilder " of March, 1929 :—

TRIAL TRIP OF THE P. & O. STEAMER *Oriental*.—On February 1st the Peninsular and Oriental Steamship Navigation Company's steamer *Oriental*, built and engined by Messrs. Caird and Co., Greenock, went on her trial trip. This steamer, which has been built and engined under the superintendence of Mr. H. J. Taylor and Mr. J. Pettigrew, is of the following dimensions: length, 410ft.; breadth, 48ft.; depth, 36ft., having a gross tonnage of about 5,500 tons. There is an installation of electric light, incandescent lamps being in every room. The vessel is fitted with refrigerating chambers and engines, fresh-water tanks holding about 30,000 gallons. The engines are on the inverted, direct-acting, compound, triple-expansion principle, indicating about 5,000 h.p., with a very moderate consumption of coal. The steam steering-gear has been manufactured by Messrs. Muir and Caldwell, Glasgow, and is of most modern type. In addition to this there is, of course, hand steering-gear, consisting of two wheels 8ft. in diameter. There is an auxiliary rudder for use in going through the Suez Canal, to make the ship answer the helm quicker. The cargo is to be worked by hydraulic gear by Lord Armstrong's firm. The spar deck is strengthened for a gun platform, in accordance with Admiralty requirements, as in case of war many of these Company's vessels are converted into armed cruisers. The *Oriental* left the Tail of the Bank about 11.30 and proceeded to Wemyss Bay for the purpose of running the measured mile, the average speed attained being over 16 knots.

COLLAPSE OF BOILER FURNACES.—The following is an abstract of a report made by Mr. Parker, Chief Engineer-Surveyor to Lloyd's Register, on the collapsing of the furnaces of a boiler in a new steamer:—" The engines and boiler of this vessel, which were surveyed during their construction by the Society's surveyor's, are in all respects well constructed. The boiler is of the ordinary round multi-tubular form, 11ft. 6in. diam. and 10ft. long, fitted with two-ribbed furnaces 41in. diam. and 17/32nd in. thick, constructed and stayed, in accordance with the Society's rules, to work at a pressure of 160 lb. per sq. in. On examination of the boiler it was found that the port furnace had collapsed in two places to the extent of 14in., and the starboard furnace to 3in. The whole of the surfaces below the water-line, including tubes, chambers, furnaces and shell, were covered with small cubical crystals, samples of which have been analysed and found to consist of nearly pure chloride of sodium (or common salt), there being only traces of other matter. This is the first case of a furnace of this form collapsing, and, looking to the peculiar appearance of the inside of the boiler, the committee considered that it should be investigated. This is a case which shows the safety of furnaces of this form to resist collapse even when neglected until they become highly heated. If they had been plain furnaces the collapse would probably have been accompanied with rupture, and a serious accident might have occurred. In their cold state it would have taken a pressure of from 800 to 850 lb. to have collapsed them, but when hot they collapsed locally at 160 lb., the strengthening ribs keeping the remaining portions of the furnaces in their original position and preventing rupture taking place."

The following Presidential Address by Mr. Wm. G. Gass, M.I.Mech.E., to the Manchester Association of Engineers, is taken from "The Machinery Market" of November 9th:—

It is important, for the good of the association, that the papers and discussions should be maintained at the highest possible standard. Any falling off in this direction would mean a lessening of interest and usefulness. During the post-war period, the tendency has been to establish sectional societies of the engineering industry—societies which give themselves over to research in some specific branch, rather than of the industry as a whole. We, as an association, take in every branch, which enables us to cover wider grounds, and I am happy to say we have for this season papers of exceptional value and interest.

It is becoming more difficult every year for the President to find some aspect of engineering that has not been dealt with previously. I have been looking at some of these former addresses, and it has occurred to me that I might ask your consideration to what may be called, for want of a better term, the "financial side," for it seems to be a topic which has almost entirely escaped our attention. Even this subject is so extensive and many-sided that I shall not be able to more than touch the fringe of it, and on some of the debatable points, I offer my opinion with considerable diffidence.

I am rather inclined to think that the financial problems do not enter sufficiently into our engineering training. We are apt to overlook the fact that the financial side is as important in a successful business as the manufacturing side. We must not only make machines, but we must make them at competitive as well as profitable prices. It is no good designing or making a machine that must always be sold at a loss. Now it seems to me, that to many engineers, the financial side does not appeal, due to their whole training in other directions. At the commencement of their career it is overlooked, and has to be learned later by bitter experience.

Looking after the "Brass."—A case came under my notice of a young man, who was following his father in the business. He was talking to an old employee, who gave him this advice,

You look after the 'brass'; you can always get someone to do your engineering work." The advice was good in its way, but a successful business man is the one who combines the financial side with a sufficient amount of practical knowledge. Many of the business troubles from which the community is suffering, are, in my opinion, due to businesses having passed into the hands of people who were interested solely financially, and who have not practical business knowledge to run a successful concern.

It does not matter what is being manufactured, whether engineering or any other, it must be sold to make a profit. If it does cost more to produce than the price at which we can sell, the result is disastrous.

In spite of all the theories advanced by certain sections of the community, one has to remember that the only business income is from the sale of goods. Out of this has to be paid raw materials, wages, salaries, rent, rates, taxes, and other expenses, including profits. This monetary sense, shall we call it, or the ability to understand the fundamental conditions of successful business is unfortunately not a strong side of people who concentrate on the practical side. I, therefore, think it behoves the engineering world to see that some knowledge of the value of money, of trading conditions, of the causes of trading losses, of the general conditions controlling businesses, are included in the curriculum of schools and colleges which undertake the studies of higher grade subjects.

Very few students, on leaving school or college, have any idea or rudimentary knowledge of what is necessary to run a successful business.

Perhaps I might especially emphasize this subject as a necessary one for evening schools and technical colleges, where the students are already engaged in the day-time in our engineering works. Here we have students of an age when they are more or less seriously considering their life-time's occupation, and where the more studiously-minded receive a life's impression. I know it may be urged that many of these students will never have to control the financial side of a business, but such training is useful to the whole staff as well as the artisan.

Take the case of designing; if the draughtsman grasps or even has a rudimentary knowledge of production costs, he will appreciate the necessity of making designs for cheap production and of trading value. How often does one find that men of mechanical and designing skill are devoid of this monetary or business sense. It is so difficult to make some of them see the essential business points, not only in design, but everything else.

The author of Hudibras puts the whole thing in a nutshell when he says—

"The value of a thing
Is just as much as it will bring."

If only that view were appreciated it might clear away many difficulties, and would certainly make designers look at their work from a commercial standpoint.

The Fascination of Engineering.—To be known as an engineer has a fascination in itself. It is, indeed, an interesting occupation. The increased difficulties with which it is surrounded at the present time make the life more strenuous than formerly, and even greater effort will have to be expended to hold our position in the future. That there is greater difficulty is evident, if evidence were needed, when we see firms of great repute closing down, the plant and machinery sold up, and the name passing into the limbo of forgotten things. Many of these firms, 20 years ago, were looked upon as being the last word in fitness, strength, and ability, as indeed they were. Many reasons may be given for this, but I am certain, in 99 cases out of 100, the cause was financial. The cost of running these works was greater than the income, and the result "finis."

One must not say that if every person concerned had a business or financial training the result would have been different, but such training would have had an influence.

In all engineering works, as in other businesses, there is a section who are non-producers, but who are absolutely essential to the business. The wages or salaries of these persons must be covered in a cost of production. I am afraid this portion of the personnel does not always recognise fully their portion of manufacturing cost.

All rents, rates, taxes, power, light, and general upkeep are included in the cost of production, and, of course, must be considered in the selling price. These charges on production are frequently not appreciated by employees who do not actually come in contact with them. It is a knowledge of these points which should be part of the training in technical schools and colleges, quite as much as the technical side. I am sure we ought to impress this on the educational authorities. Further, the information should be given by men with practical business knowledge. Successful business men might be called upon to address the students from time to time.

Co-operation with Foremen and Men.—Whilst a good owner or manager can make his influence felt throughout a whole business, he must have the co-operation of the foreman and workmen. He must generalise and those under him see to the detail of carrying out his directions. Speaking in a general way, the common gibe that employers are unfitted for their positions is untrue. Business worry and anxious thought is only too common, though the one exercising it may not be recognised as an artisan. We are always being told that management would be improved if workers' suggestion schemes were encouraged and adopted. Employers do not, nor can they afford to turn the deaf ear to such suggestions. A good suggestion is well received, but many suggestions are prompted by mere idleness or awkwardness. It must be obvious that the best workman, and one with fertile ideas, will soon rise to a position of importance, and, suggested improvements more often, much more often, come from these men, than the rank and file, whose interest in their job is small.

The best men must and do come to the top and deserve recognition for their long hours of thought at and away from business. So these men become directors or capitalists. There is a certain section of the community to whom the word "capital" is as a red rag to a bull. It makes them almost foam at the mouth. It is generally found that people holding these views are usually ignorant of the conditions of business life, and of even the necessities of every-day life. Though our financial system may not be ideal, and we acknowledge it is not, yet it meets with and renders possible intercourse with the world at large.

Speaking generally, the members of this association are directly or indirectly connected with the manufacturing section. One of the necessities of our businesses is the accumulating of reserves. This is necessary to safety and to enable us to meet difficult situations. It is a stand-by for development. To pay such money away in excess dividends or other ways is inviting trouble later on. It is, unfortunately, a fact at the present time that we, as engineers, are not able to do much in this direction.

Now gold, from an engineering standpoint, except as a medium of exchange, is the most useless of all metals. As an engineering raw material it is, of course, out of the question. It may be owing to our ignorance, and for mechanical purposes, we may be doing it an injustice, but somehow I feel it will be a long time before its commercial use in this direction is found out. Money, too, as represented by gold, is of no value to the individual. We cannot eat it or drink it. It is only as a means of exchange or as a form of credit that it has any value.

False Ideas of Money Values.—The war has been responsible for many troubles, but one of the most serious is the false idea of the value of money which has arisen. With this has followed the craze for spending on things which have no real value. This may be due to a prevalent idea that the Government should step in to help, even if the individual does not try to stand on his own feet, and bolster up to make good where no effort has been made. I am not speaking dogmatically, but I think there are symptoms that this belief is not uncommonly held. What naturally follows from this will be the deterioration of the individual, a diminution of strength and personal character. Before long this will be reflected in the Government, and the loss of national credit ensues.

It may be asked, "What has this to do with engineering?" It is obvious that (as engineering in some form or other is the basis of all our other businesses and trades), if the general credit of the country fails, the engineer will fail, as there will be nothing for him to do. It is essential, in my opinion, that those who are engaged or will be engaged in the manufacturing side of engineering should have some understanding of business problems. This country buys its food by its manufactures, and not by what it buys and sells. A more general understanding of business principles, besides the mechanical and designing side is essential to success in business, and so make us more secure as a first-class nation.

I again commend this phase of our work to all those who have to do with the training in the technical schools and colleges.

Again, it is time we recognised once more that work, and not pleasure, is the basis of success. The amount of sheer nonsense which is talked about hard work and over-work is pitiable. Those who come to the top do it, in most cases, by sheer hard work, and, as a rule, are not worse for it. The foreign nations who are underselling us are working longer hours than we are, which is sufficient proof that work means success. It is not lower wages alone which are responsible. In one of my visits to the Continent, my client asked for an interview at 7 a.m. His comments on the hours worked in England were illuminating. He spoke with knowledge, because he visits Manchester to do business.

It certainly puzzles me when I find so many working men who consider it commendable strategy to curtail or limit productions, or, as a fitter once told his manager, "he was out to get as much as he could, for doing as little as he could."

I hope I have made my view clear that we are omitting from our national training something which is essential for better results. We cannot, in view of the increase in competition, omit anything which will lead to success and the holding of our own.

A Fuel Anomaly.—One of the results (affecting Britain particularly) of the advances engineers have made, is one which seems rather to hit back, to back-fire, so to speak; I speak of the oil engine and the motor car. Engineers have undoubtedly made great strides in the production of very fine internal combustion engines for oil and spirit. In so doing they have, unfortunately, struck a serious blow at what, in previous periods, has been looked on as the main cause of Britain's pre-eminence, that is, the coal trade. A more serious point about it than the immediate effect on that industry, is the fact that we are paying to foreign countries such large sums of money for the fuel being used.

We have what may be seen any day, motor 'buses, driven by petrol, taking colliers to their work in preference to going by the railway, which would use their coal, and so they are paying other countries for the fuel used in carrying them. We have the colliers themselves calling for 'buses and motor cars in preference to using the railway, and so reducing the demand for coal. It is the other side of the picture to that of the strides made in producing the engines, and one that should make people think.

The result of advancement is seen in the fact that no forward step can be taken without, perhaps, an adverse effect in some other direction.

I am not in any way under-rating the advances made, but facts like these have to be faced. Oil engines and motor cars mean we have to pay for our fuel abroad, where we used to pay for it at home. That means less money is coming into the country for the coal we used to use, and also what we sell. There is always another side to every step taken, and it could be followed up in many directions. It is now for the engineer and the chemist to make our coal trade valuable again by developing, and keeping, in our own country, the tremendous sums we are paying abroad.

If I have taken a step out of the general line by addressing you on this side of engineering, my apology must be that times are, so to speak, "out of joint," and anything that can be done to assist in straightening them out may be of assistance. Many of my observations are the result of experiences in my business career, and are also the result of my own early training, in which I did not regard the financial side as being as important as I found it really was.

British Patent Law.—A lecture on this subject was given by A. P. Thurston, D.Sc., to the Association of Supervising Engineers, and is fully reported in "The Machinery Market" of December 7th. In the opening paragraph the lecturer remarked that in all ages according to vigil searching, wits have graced their age with new inventive acts, and that history reveals the fact that the power, prosperity and civilisation of any race, throughout the ages has coincided, in some remarkable way with the inventive ability of the race, and with its power of putting those inventions into practice.

It will be granted without question that the genuine inventor is potentially one of the most valuable members of the community. The future progress and posterity of our country will be greatly influenced by the number and type of inventors which it will produce.

The various points referred to by the lecturer were: What is a Patent? What is an Invention worth? How a Patent is obtained? What is an Invention? Conditions of validity manufacture. Novelty. Utility. Ingenuity. Commercial consideration. Application for patent rights. Grounds of invalidity. Licenses of right. Cognate inventions. Patents of addition. Marking. In conclusion it was remarked that the Patent Law provides a useful channel for manufacturers who use it wisely to build up a sound business which will benefit both themselves, their employees, and the public. It also provides a means whereby any invention, which benefits the public can be rewarded.

Many discussions have taken place in our Reading Room on the subject of patents, and the difficulties in the way of inventors to carry on financially towards a successful issue. There are some inventions which, when demonstrated clearly, appeal directly for financial support in manufacturing, others do not so readily appear as likely to win a market value, while others seem of value as inventions, yet require further developments before they can be taken up commercially, and it occasionally happens that the developer obtains that which the early inventor was unable to achieve.

From " The Electrical Review," December 21st:—

The Birth of the Carbon Lamp. (An account of the circumstances attending the invention of the incandescent lamp, 50 years ago).—The possibility of rendering a loop of wire incandescent by passing a current of electricity through it was, of course, one of the earliest discoveries in electrical science; when the "electric light" with carbon arcs was invented and had attained to recognition as a practicable and efficient system of lighting on the large scale, the question of " sub-dividing the electric light" acquired absorbing interest, and innumerable inventors applied themselves to the problem, all sorts of devices being evolved, in many of which carbon rods raised to incandescence were employed. But the incandescent wire attracted most attention, and the necessity of using a material of high specific resistance was recognised. Unfortunately platinum, and alloys of platinum with other metals of high melting point, had to be run too near that temperature for safety, and were very liable, therefore, to burn out. Thin strips of carbon did not melt, but were rapidly oxidised, and although the idea of enclosing them *in vacuo* was understood, it was not then possible either to produce carbon " wire " or to obtain a satisfactorily high vacuum.

In 1845 J. W. Starr, an American, patented an apparatus employing metallic and carbon conductors *in vacuo*, and Joseph Swan, a native of Sunderland, having witnessed a demonstration of electric light with incandescent platino-iridium wire, saw in Starr's specification the germ of success. He began experimenting, and by 1855 he had succeeded in producing thin strips and spirals of carbonised paper—a novel invention at that time. However, his main occupation was the development of photographic processes, and it was not until 1877 that he resumed his experiments in earnest.

The researches of Mr. (afterwards Sir William) Crookes in 1875 with high vacua produced by the Sprengel pump had shown that the evacuation of glass bulbs was no longer an obstacle. Swan obtained the assistance of C. H. Stearn, an expert in high vacua, and they mounted his carbon strips in exhausted bulbs, but found difficulty in making effective connection with the " films " of carbon; hence carbon wires, made of plastic material and baked, were tried, fitted into platinum sockets. It was then found that after exhausting the bulbs, when the " wires " were heated much gas was given off, spoiling the vacuum. A most important invention followed—namely, heating the carbon wire by passing a current through it whilst the exhaustion of the bulb was being continued. This fundamental process was devised in 1878, and the Swan lamp was successfully made and exhibited at Newcastle-upon-Tyne in December of that year—exactly 50 years ago.

Swan proceeded to develop the manufacture of filaments of cotton yarn treated with sulphuric acid, which he called " parchmentised thread," and which when carbonised were strong, elastic, and homogeneous; later (in 1883) he invented the squirted nitro-cellulose process, and he invented many other improvements in the carbon lamp. Unfortunately he did not believe that the use of a carbon conductor in an evacuated globe was patentable, owing to previous knowledge, and it was not until January, 1880, that he patented his process of evacuation whilst the carbon was incandescent, and the manufacture of parchmentised thread.

In the United States, Mr. T. A. Edison had been busily engaged in experimental work, and from time to time during 1877 and 1878 he issued glowing statements with regard to his successes; but he was working on lamps of the old incandescent rod type, or on lamps with filaments of platino-iridium, etc., all of which proved failures. "The Telegraphic Journal and Electrical Review" of December 15th, 1878, p. 496, reports that "Mr. Edison authorises the statement that his light is produced by the incandescence of an alloy of platinum and iridium. . . . . A simple adjustable apparatus attached to each lamp regulates the amount of electricity it shall draw from the main current, and makes it entirely independent of any changes in the strength of the current as well as of all other lamps in the circuit. . . . . The details are still a secret." Numerous other references to the subject appeared in our pages in 1878 and 1879, including abstracts of Edison's patents for an "electric candle" (May 15th, 1879), and for lamps of platinum or other metals or alloys (July 15th, 1879). It was not until November 20th, 1879, that Edison obtained a British patent for an electric lamp with a carbon filament in an exhausted glass bulb, and no Edison lamps were exhibited in this country until February, 1880. In that year he patented the bamboo fibre filament.

Eventually Edison and Swan joined hands, and commenced the manufacture of lamps on Swan's processes, but under the broad Edison patent of November, 1879. A full account of the whole circumstances was printed in the "Electrical Review" of May 9th, 1924, pp. 742-3.

Mr. J. Swinburne, F.R.S., was to deliver a short lecture on Sir Joseph Swan's work at the Institution of Electrical Engineers yesterday prior to the ordinary meeting.

The following are from "The Syren and Shipping," December 26th:—

New Ideas in Ships.—Ship designs and propulsion are obviously passing through a period of evolution, and no one can say what a year, or even a month, may bring forth. While no individual development may deserve to be called revolutionary, the cumulative effect of all that has been done in 1928, and is likely to be done in 1929, represents a step forward more important than any that has been taken for generations back. From Belfast there comes the news that the 27,000 ton motor vessel which Messrs. Harland and Wolff are building there for the White Star Line is to be called *Britannic*. That seems a small matter—only one of nomenclature. But it raises the interesting question of the naming of the 1,000 ft. ship which is now being laid down, and gives fresh point to the speculations regarding the designs decided upon, and, very specially, the type of propelling machinery with which she is to be fitted. It was generally assumed, though without any particular justification, that *Britannic* would be the appropriate name for the world's largest vessel. The managers of the White Star Line evidently have something up their capacious sleeve which they consider still more appropriate, and the natural inference is that, when the proper time comes they will spring more than one surprise upon the public, including a departure in engineering which will make 1929 a real red-letter year in the history of marine propulsion. After *Britannic* the right name would seem to be *Oceanic*, as that was the name of the company's first liner, and also, at a later date, of the first vessel to exceed the *Great Eastern* in length. Neither of these *Oceanics* represented anything really revolutionary in marine engineering, but the new ship will, no matter what type of prime movers are ultimately adopted. She will introduce electric transmission on a scale not previously dreamt of, and if the current is generated by internal-combustion engines she will inaugurate an enormously important development. The P. and O. liner *Viceroy of India*, which is now being completed on the Clyde and is to sail on her maiden voyage—from London to Bombay—on March 28th, will, it is hoped, have made good long before the big White Star ship has left the stocks at Queen's Island; but there is a great difference between 19,300 tons and 20,800 i.h.p. on the one hand and 60,000 tons and no one outside official circles knows how much h.p. on the other. The difference is so much that even if the Belfast ship resembles the *Viceroy of India* in having steam turbines there will be no resemblance between the problems that will have to be solved and the results that will have to be attained. The generating of power and its application to the propellers will have more to do, not only with actual propulsion, but with the hull design and the internal arrangements than any previous machinery installation has, and the vessel is bound to be much more revolutionary in both respects than any large liner constructed in the past. These matters come before the public very appropriately at the end of the year, but the *Oceanic*—to risk the best guess at the name—does not, and will not, stand alone in giving 1928 and 1929 a high place in the literature of shipbuilding and marine engineering. There will have to be taken into account quite a number of other vessels, distinguished neither by size nor speed, but by hull improvements in detail, by the discarding of certain types of machinery and the adoption of others, and by a concentration on economy in running costs more intense than anything before experienced. It is not now so much a case of trying to produce a vessel having one feature which marks her out from all her predecessors—speaking, that is, of general traders—as one of taking up existing types of ships and engines and making them more profitable on service by lopping off little constructional and operating costs here and there, and utilising every possible new device for reducing the consumption of fuel without reducing either the speed or the carrying capacity.

Revolutionary Ideas.—It must not be assumed, however, that the phase through which the ship and engine designs are passing is wholly without ideas of a revolutionary character. The ideas exist all right, but although they are revolutionary, they are not always new. That old friend, jet propulsion, may have another look in. Much interest, it was said on the North-East Coast last week, was being taken in a new method of steamship propulsion. The inventor hailed from San Francisco, and he believed that if only shipowners would adopt his plan they could run their vessels from New York to Liverpool (he did not say why he ignored Southampton) in less than three days. The principle was so simple that it was strange that someone had not stumpled on it before. He was merely taking advantage of the fact that water could not be compressed. In the model with which he was experimenting, he used a steam engine of 30 h.p., connected direct to the twin driving pistons. These pistons worked in cylindrical pipes which drew in water and discharged it under high pressure. By pumping the sea water out, the vessel was both driven over the sea and steered. Nozzles and the ends of the pipes could be revolved at will, so as to guide his 80 ft. boat in any desired direction, or even to make it spin on its own centre of gravity like a top. Propeller and rudder were alike unnecessary, and very high speeds had been attained. In his model the propulsion and steering mechanism were combined —on a craft originally built for an outboard motor. The vessel was so shallow that the cylinders were placed beneath the hull, but, for practical purposes in future construction, nothing but the nozzles would protrude from the hull. The model had pistons 8 in. in diameter, operating on a 12 in. stroke. He reckoned that 24 in. pistons, with a stroke of 6 ft., would take an ordinary Atlantic liner across in less than three days. For still higher speeds convention hulls would not be safe, but they could be constructed so as to withstand speeds up to, or more than, 100 miles an hour. In his opinion, steam power was best for this particular purpose, as it could be so designed as to have the minimum of vibration; but the principle could be adapted to internal combustion engines or any other motive power. And—this is the most important point of all—once in motion the boat would keep running with no steam pressure showing on the gauge. The invention, therefore, would seem to be first cousin to that of the man who was to utilise a water turbine for the propulsion of ships. The idea in that case was to have a tunnel—a sort of circular duct keel—running from stem to stern and open at each end. This tunnel would contain a shaft, somewhere amidships, this shaft would carry a water turbine, and at the stern it would carry a propeller. Once the vessel was set a-going, the water rushing through the tunnel would drive the turbine, which in turn would drive the propeller, and this in its turn would drive the ship. Of course, the inventor admitted, a tug would be necessary to give the vessel and the apparatus a start, but once started it would carry on indefinitely, without any expenditure of power whatever. How his ship was to be stopped, re-started and manœuvred without an attendant tug, the inventor did not condescend to explain; but his idea of running his boat without any propelling power is not very much more out of the way than that of achieving the same purpose with no steam pressure showing on the gauge. As for the San Francisco man's surprise that no one had previously stumbled on his great principle of pumping water in and pumping it out again—that shows how little he has read of the side-lines of marine engineering. Jet propulsion was tried out many years ago in Great Britain, and never came to anything practical. It may be new in America, but it has been abandoned on this side of the Atlantic. In any case, a plan which provides for cutting down the Atlantic crossing to less than three days—with no steam-pressure showing on the gauges—must be more practically presented than it has yet been before it can be seriously considered. A ship of any size and form requires a certain amount of power to give her a certain speed, and nothing can compensate for the lack of that power.

Something New in Davits.—Ships' boats, except in so far as they utilise space on board which might be used for other purposes, are not directly associated with economy in the operation of the vessels on which they are carried, but their stowage and handling provide many opportunities for the designer and inventor. Of the inventing of davits there is apparently no end. Once more there is made public a form of launching gear for which extra special claims are made. This gear, it is stated by its designer, has the minimum of complications; it is entirely man-handled, and it is capable of putting boats into the water in the shortest possible time. The davit consists of a straight stem, 18 ft. or more in length, mounted on a gunmetal frame and supported in a trunnion. The two davits necessary for the launching of a boat are connected by a horizontal shaft running close to the deck and controlled by a single governing wheel at the side of one of the davit stems. This wheel is operated by one man and it works both davits. When it is turned, a loaded boat is automatically swung clear of the ship's side—a single operation swinging out the davits and at the same time automatically extending their length to 50 or 60 ft., according to the size used. The extension of length is operated by a case of rollers, working in unison with the swing of the main stem of the davit. For every foot the davit is swung out the length is increased. There can be no difficulty, the inventor claims, in swinging out a loaded boat in about three minutes, and the boat will swing clear of the hull, no matter what the list of the ship may be. Boats cannot be dashed against the side when they are being lowered, and they cannot be washed back by heavy seas or tipped or overturned in the process of lowering. There is nothing to go out of order, and the gearing cannot jam. The davits can be worked under any conditions and at any angle; they will remain rigid with an 8 ton loaded boat, and they can only be operated by the governing wheel. No boat tackles or falls are used in the ship, these being all operated from the boat. The automatic extension cannot become inoperative, and the davit must automatically double itself in length as it is swung out. Once the boats, are out they cannot be reached by any rush of passengers or crew, as each revolution of the controlling wheel carried them further away from the side of the ship. The davits can, the inventor also says, be made so as to swing a boat clear of the biggest liner with perfect safety and ease of operation. These claims are by no means modest, but the idea does look well on paper, and it will no doubt have the serious attention of holders of existing patents when it reaches the stage of practical experiment.

By invitation, representative attendance was given at the Whitechapel Art Gallery, where the Macpherson collection of marine paintings are on view. The opening was celebrated by Sir Jas. Caird, on February 14th. The collection is well worth seeing, and London is indebted to Sir James for his kindness in presenting so many paintings illustrative of historic events and of those who were associated with them in the days of old. The catalogue is well illustrated and the paintings well reproduced on art paper. The collection was on view at the Guildhall Art Gallery prior to the Whitechapel Art Gallery and is to be removed to Greenwich in April if the new Hall is ready.

The British Industries Fair at the White City was opened on February 18th, and our representative visit was on the 19th. There are a large number of exhibits, most of them being in connection with domestic appliances, clothing, office fittings, with the latest typewriters, multipliers, pens, pencils, etc., herbalists and chemists show what can be done to cure various ailments. The gramophones and records have a good show, and one highly attractive collection was in the clear rustless steel stalls, the various articles being well made to please the eye and incite purchasers. Several shipping companies have exhibits, and the Dominions have very good shows of their goods.

The Ideal Home Exhibition at Olympia was opened on February 26th, when, as usual, we were represented. The different types of houses on view with the labour-saving appliances appealed to many. The gardens well laid out with budding fruit trees, flowers and ornamentations gave pleasure to the onlookers. The area is much extended in the gallery, and to those interested in the exhibits referred to in the Press and the catalogue. Olympia is worth a visit.

The Royal Society of Arts desires to call attention to the Thos. Gray Memorial Trust Prizes for the Improvement and Encouragement of Navigation.

Under the will of the late Thomas L. Gray, the Royal Society of Arts has been appointed residuary legatee of his estate for the purpose of founding a memorial to his father the late Thomas Gray, C.B., who was for many years Assistant Secretary to the Board of Trade (Marine Department).

The objects of the Trust are " The advancement of the Science of Navigation and the Scientific and educational interests of the British Mercantile Marine.

The Council now offer the following prizes:—

PRIZE FOR AN INVENTION.

(i) A prize of £150 to any person who may bring to their notice a valuable improvement in the Science or Practice of Navigation proposed or invented by himself in the years 1928 and 1929.

In the event of more than one such improvement being approved, the Council reserve the right of dividing the amount into two or more prizes at their discretion.

Competitors must forward their proofs of claim on or before December 31st, 1929, to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2.

PRIZE FOR AN ESSAY.

(ii) A prize of £50 for an essay on the following subject:—

" You are overtaken by a revolving storm. Discuss the handling of a low-powered steamer from the time of the first indication of the approach of the storm until the storm has passed, supposing the ship to be in (*a*) the safe semicicle, (*b*) the dangerous semicircle, and (*c*) the direct path of the storm's centre."

Competitors must send in their essays not later than Dec. 31st, 1929, to the Secretary, Royal Society of Arts, at the above address.

The essays must be typed or clearly written. They must be sent in under a motto, accompanied by a sealed envelope enclos- the author's name, which must on no account be written on the essay. A breach of this regulation will result in disqualification.

The Judges will be appointed by the Council.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize or Prizes, if in the opinion of the Judges no suitable invention or essay is submitted.

The Council also reserve an option on the copyright of the successful essay.

G. K. Menzies, *Secretary*.

References have been made and questions raised by members in the Reading Rooms as to the Development of the steam engine during the last 60 years. The Presidential address of Maurice S. Gibb, C.B.E., to the North East Coast Institution of Engineers and Shipbuilders dealt with the subject in a very interesting way and carried our thoughts back to the *Aberdeen*, and to an opportunity afforded by invitation to examine the boilers after nearly 12 months service, when due for survey.

Another question has been *re* the manufacture of ball bearings. We paid a visit to the works some years ago to examine the process of manufacture from start to completion. In "The Machinery Market" of November 30th, there is an illustrated description of the works of the Skefko Ball Bearing Co., giving the whole process of manufacture in an interesting way.

Titanic Engineering Staff Memorial Fund.—The Committee has pleasure in acknowledging £1 1s. from Mr. J. C. Mitchell (Member), and 12/6 from Mr. W. R. Moitie (Associate).

Boiler Explosion Acts.

Report No. 2922. S.S. *Cragness*. O.N. 144728.

Report No. 2922 refers to explosions which occurred on board the *Cragness*, from the port and starboard main steam pipes. The investigation of the causes and the report made were by Mr. E. F. Moroney, Cardiff. The pipes from each of the three main boilers joined in a common junction piece attached to the steam regulating valve on the main engines. Each pipe was five inches internal diameter, solid drawn copper 3/16th inch thick, with gunmetal flanges $10\frac{7}{8}$ inches diameter, $\frac{7}{8}$in. thick, having eight bolts $\frac{7}{8}$in. diameter on a pitch circle $8\frac{1}{2}$ inches diameter. Bends to allow for expansion and vibration were provided and the pipes were arranged with a fall of about 11 inches between the engine and the boiler stop valves.

The original pipes were supplied by the makers of the engines, Messrs. Blair and Company, Limited, Stockton-on-Tees, when the vessel was new in 1924. These pipes were replaced on the port and starboard boilers by new pipes, at Grays Harbour, U.S.A., in December, 1927.

When the vessel was on the voyage between Yokohama and San Francisco, where she arrived on the 6th December, 1927, the two steam pipes gave way, the failures occurring within a period of about three days. Temporary repairs were effected by the ship's engineers. On arrival at San Francisco the defective ends were removed and short pieces of pipe were introduced to make up the length required. On the voyage from San Francisco to Portland, Oregon, the port and starboard pipes again failed at the necks next to the new short pieces. The short pieces were removed and replaced with sleeve pieces brazed to the ends of the pipes. After the voyage to Yokohama the vessel was returning light to Grays Harbour, U.S.A., when the port and starboard main steam pipes again gave way at the necks. Temporary repairs were effected as before by the ship's engineers. After this, at Grays Harbour, the two pipes were renewed. No further repairs were effected until the vessel arrived at Cardiff on Wednesday, the 16th May, 1928. A very serious defect in the neck of the starboard pipe similar to the previous cases was then discovered and all the main steam pipes were renewed.

The pipes have been under the supervision of Surveyors to the British Corporation Registry of Shipping, who witnessed the repairs and hydraulic tests on completion.

The vessel, including the boilers and machinery, was insured with Underwriters at Lloyd's.

The explosions did not result in anything more serious happening than the escape of steam through the cracks in the necks of the pipes, on each occasion when failure occurred.

The failures of the pipes were due to the movement and vibration of the main engines, through the insufficiency of the foundation bolts securing the bedplate to the tank top, when the vessel was light and labouring in heavy seaways.

The S.S. *Cragness* is a cargo vessel of 4,809 tons gross tonnage, built by Messrs. J. L. Thompson and Sons, Limited, Sunderland, in 1924. The machinery was supplied by Messrs. Blair and Company, Limited, Stockton-on-Tees. Steam is generated by three single-ended boilers, at a working pressure of

180 pounds per square inch, using coal or oil fuel as required. The main engines are of the ordinary single-screw inverted direct-acting marine type. The trade in which the vessel was engaged necessitated a large amount of running in ballast trim, and in consequence of encountering bad weather and heavy seas, there was considerable racing and vibration of the main engines. The bed-plate holding down bolts were insufficient to hold the engines securely, and the movement of the engines caused repeated failure of the port and starboard main steam pipes, which fractured at the necks of the flanges adjoining the branch piece on the engines, in the same position on each occasion. The vessel left Cardiff in March, 1927, and after an extended voyage returned to that port in May, 1928.

The trouble with the bedplate holding down bolts began early in the voyage, but it became more pronounced when the vessel was in ballast trim, between Japan and the U.S.A., necessitating the engines being frequently stopped at sea in order to tighten up these bolts. It was during this part of the voyage that the port and starboard main steam pipes gave way. These pipes cracked at the necks immediately behind the flanges. Temporary repairs were effected at sea by cropping the pipes, boring out the flanges to fit the pipes, beading over the pipes on to the loose flanges, and inserting filling pieces to make up the length. On arrival at San Francisco the holding down bolts were attended to by the ship's engineers, and the main steam pipes were sent ashore to be annealed and have the flanges re-brazed. Short lengths of pipe with flanges were fitted to make up the length. After leaving San Francisco for Portland, Oregon, bad weather was again encountered and further trouble with the holding down bolts and steam pipes was experienced.

At Portland the short lengths of pipes were removed and replaced by sleeve pieces brazed on to the ends of the port and starboard main steam pipes to make up the original length. The holding down bolts were again attended to by the ship's engineers. Here the vessel was loaded for Yokohama. On this voyage a cyclone was encountered, and although trouble with the holding down bolts and main steam pipes again took place, nothing could be done until the weather abated. It was then found that several of the bolts had broken. At Yokohama the vessel was dry docked, but nothing was done by the repairers to the holding down bolts. Returning to Grays Harbour, U.S.A., in ballast trim and again encountering bad weather with consequent racing and vibration of the engines, the bedplate moved on the tank top, loosening and breaking some of the bolts, also fracturing the steam pipes which were temporarily repaired at sea as before. On arrival at Grays Harbour new main steam pipes complete for the port and starboard boilers were made and the holding down bolts were attended to by shore workmen. Larger bolts were fitted in the bedplate corner stops, and about seven bolts renewed, which was all that could be done in the time available. The vessel was then loaded for Newcastle, New South Wales. Trouble with the bedplate moving was again experienced, but the vessel reached port without further mishap. After the vessel left Newcastle in ballast trim, the trouble with the holding down bolts and steam pipes recurred. A small jet of steam was noticed issuing from the neck of the starboard main steam pipe, but the vessel reached San Francisco safely. The foundation bolts were here attended to by the shore repairers, but nothing was done to the steam pipes. The vessel then proceeded to Vancouver to load grain for Rotterdam. On the voyage to Panama, the leakage from the starboard main steam pipe gradually became worse, but nothing was done to the pipe, and the vessel continued on her voyage, arriving at Rotterdam without further mishap. After discharging, the vessel left Rotterdam on Saturday, the 12th May, at 10 p.m., and arrived in Cardiff on Wednesday, the 16th May, 1928.

The starboard steam pipe when removed showed at the neck two very serious fractures, each about four inches long, diametrically opposite. These were open about 1/16th inch. The original pipes as supplied by the builders, Messrs. Blair and Company, Limited, had a special type of reinforced neck, which consists of a longitudinally brazed copper sleeve of the same thickness as the pipe, about 4½ inches long, fitting easily over the pipe end and brazed into a recess formed in the back of the pipe flange as indicated on the plate. This system has been in use by Messrs. Blair and Company, Limited, for many years, and is still being used. It has, however, the disadvantage of hiding defects which may develop in the pipes under the sleeves.

The whole of the pipes have now been renewed and larger expansion bends fitted, and with the proper securing of the main engine bedplate to the tank top, it is hoped to avoid a recurrence of the trouble.

Observations of Mr. A. E. Laslett, the Engineer Surveyor-in-Chief.

Defective main engine holding down bolts permitted excessive movement of the engines, particularly when the vessel was in light trim and during heavy weather. The steam pipes referred to in this report were arranged with a very moderate degree of flexibility that might have been sufficient to avoid undue stresses resulting from temperature changes only, but they were not sufficiently flexible to allow for excessive movement of the engines. It will be observed that the main steam pipe from the centre boiler, which was very much more flexible than those from the port and starboard boilers, was not affected, and that the starboard pipe, which was the least flexible of the three, gave the most trouble. The owners were well advised, in renewing the pipes, to provide larger expansion bends.

REPORT No. 2930. S.S. *Enterprise*. O.N. 119217.

Report No. 2930 was compiled and the investigation into the circumstances was made by Mr. C. H. Thirkell, Cardiff. The explosion occurred on the boiler of the S.S. *Enterprise*.

The boiler is of the cylindrical multitubular marine type, 16ft. 6ins. external diameter, and 11ft. in length. The shell plates are of steel 1 5/32nd inches thick, and the boiler was designed for a working pressure of 160 lbs. per square inch. There are four plain furnaces of the withdrawable type and the usual mountings are fitted.

The boiler was made by The North Eastern Marine Engineering Company, Limited, at their Sunderland works in 1905 and was, therefore, about twenty-three years old.

The vessel was purchased by the present owners in March, 1922. Since that date the following repairs have been executed to the boiler:—In June, 1922, the bottom rivets in the port lower combustion chamber back seam were renewed, and the seam welded for about 18ins. In December, 1922, owing to leakage, the seam was again re-riveted and the welding renewed. This repair was not quite satisfactory and the welding was added to in February, 1924, and again in February, 1925. In June, 1927, it was decided to renew part of this combustion chamber back and bottom, and a piece of the back plate measuring 4ft. 6ins. by 31ins. was cut out, and a new plate flanged, fitted and riveted, the butts being electrically welded. Eleven screwed stays in way of this patch were renewed and a portion of the combustion chamber bottom plate measuring 6ft. 4ins. by 28ins. was cut out and renewed in two pieces, the butts and the landing edges of the plates adjoining the repair being electrically welded, and two screwed stays between port and starboard lower chambers renewed. In the starboard lower combustion chamber one stay tube and four screwed stays were renewed, a defective edge of the tube hole built up and a small fracture in the landing edge of the back plate welded.

Three bottom manholes were built up and manhole doors refitted, and two small patches on the back end of the boiler caulked. On the completion of the above repair the boiler was subjected to a hydraulic test.

In December, 1927, it was discovered that the seams adjacent to the new plates in the port lower combustion chamber were leaking slightly and a small portion of the welding was porous. The defective welding was renewed, the seams where leaking were electrically welded and two rivets were caulked.

The boiler was inspected periodically by the Engineer Superintendent, Mr. F. Adie, who last inspected the boiler in December, 1927. It was classed with Lloyd's Register of Shipping and was last inspected by one of their surveyors at South Shields in June, 1927.

The vessel, including the boiler, was insured with Lloyd's Underwriters.

The lower part of the neck of the lower port furnace fractured for a length of about fourteen inches, and allowed the contents of the boiler to escape.

The explosion was caused through grooving at the root of the short radius of the bottle neck, attributed to straining of the material due to stresses set up by the expansion and contraction of the furnace. This action must have been proceeding over a considerable period before the plate fractured.

The S.S. *Enterprise* is a vessel of 1,114 tons gross, built in 1905, the propelling machinery consists of a single set of triple expansion condensing engines, steam being supplied by one boiler working under a pressure of 160 lbs. per square inch

The voyage during which the explosion occurred commenced at Burry Port on the 6th March, when the vessel left with a cargo of coal for Rouen. While proceeding up the River Seine on the 8th March, the Chief Engineer, Mr. Shipley, who holds a First Class Certificate of Competency, was in the engine room when he was informed by the fireman on duty in the stokehold that water was pouring out of the centre port ashpit following a slight report. The Chief Engineer visited the stokehold, and seeing the quantity of water escaping, gave orders to draw all the fires at the same time he opened the extra feed cock and started the auxiliary feed pumps on to the boiler. The water, however, was rapidly falling and in about three minutes it was out of sight in the water gauge glass and the Master was informed that all fires were drawn and it was only possible to proceed so long as the steam pressure, which was falling rapidly, would allow. At about 12.15 p.m. the engines stopped and the anchor was dropped.

The vessel was afterwards towed up the river to Rouen and the boiler, having been opened out in the meantime, was surveyed by one of the Surveyors to Lloyd's Register, and the fracture was electrically welded.

On the passage from Rouen to Goole a slight leak developed on the front end plate where it was flanged to take the bottom of the lower starboard furnace and the passage was completed on a reduced steam pressure. At Goole the boiler was again opened out and was inspected by one of the Surveyors to Lloyd's Register and also by one of the Board of Trade Surveyors, who reported that, on gutting out this defect preparatory to welding, the fracture was found to extend over a length of twenty-five inches and that further grooving was found on the flange of the end plate on the top side of the same furnace, also on the end plate where flanged to the lower part of the port lower furnace. These defects were welded in Goole.

The S.S. *Enterprise* is mostly engaged in making short voyages to Continental ports and is lying under banked fires frequently and for comparatively lengthy periods, and taking this into consideration in addition to the longitudinal stiffness of the furnaces and the age of the boiler it is not surprising to find that the plates are showing signs of distress, and the boiler should receive careful attention and inspection.

Observations of Mr. A. E. Laslett, the Engineer Surveyor-in-Chief.

Circular furnaces such as are used in marine boilers are often subject to fatigue due to heavy stresses imposed on the flanges. This effect was very marked in this case as the furnace was plain and the whole of the movements due to variations of temperature were concentrated on a contracted neck formed at the back end. Furnaces with the necks contracted to facilitate removal are generally corrugated. This improves the longitudinal flexibility, and the stresses due to expansion are less localised and therefore less severe on the ends.

REPORT No. 2936. S.S. *Kingsdon*. O.N. 120461.

Report No. 2936, based upon the investigation conducted by Mr. J. R. D. McCoy.

The boiler was of the cylindrical multitubular marine type, single-ended, 16ft. 6ins. mean diameter, and 10ft. 6ins. in length. The shell plates were of steel $1\frac{1}{4}$ins. thick, and the boiler was designed for a working pressure of 165 lbs. per sq. inch. There were four plain furnaces, and the usual mountings were fitted, including safety valves.

The boiler was made by The Clyde Shipbuilding and Engineering Company, Limited, Port Glasgow, in 1904, and was therefore 24 years old.

The following repairs were executed in February, 1928:— Leaky and defective landing edges at front end of shell plate and at front end of starboard low furnace were built up by electric welding. Several leaky and defective rivets in the latter seam were hardened up and caulked. The internal flanges of the three bottom manholes, badly corroded, were built up by electric welding, and the doors refitted.

The boiler has been inspected by the Superintendent Engineer, Mr. N. H. Reed. It was classed with Lloyd's Register of Shipping, and was last inspected by one of their Surveyors at Willington Quay on the 23rd February, 1928.

The vessel, including the boiler, was insured with Lloyd's Underwriters.

The front lower end plate flanging attached to fore end of port low furnace fractured through at the knuckle on the port top side for a length of about 11ins., allowing the contents of the boiler to escape.

The explosion was caused by the failure of the end plate at the flange due to fatigue from the alternating stresses set up by the expansion and contraction of the plain furnace.

The S.S. *Kingsdon* was a vessel of 1,228 tons gross, built in 1904. The propelling machinery consisted of a single set of triple expansion condensing engines, steam being supplied by one boiler working under a pressure of 165 lbs. per square inch.

The voyage during which the explosion occurred commenced at Swansea on the 2nd April, 1928. The vessel had discharged her cargo and left Tarranova at about 5.30 p.m. on 21st April, 1928, in ballast for Torrevieja. At about 9.30 p.m. on the same day the fireman on watch in the stokehold reported to the Chief Engineer, Mr. John Sullivan, that leakage was coming from the port low furnace front. The leakage increased until at about 10.20 p.m. it was found that the auxiliary pump could no longer cope with the loss of water, and the fires were drawn. The furnace front was removed and a fracture about 11ins. in length and open about 1/16th. inch was found in the front end plate where flanged to take the furnace. A later examination showed the crack to extend on the inner (water) side of the flange, partly through the plate for a length of about five inches each way. At about 9.30 a.m. next day the vessel was towed to a safe anchorage by the yacht *Crusader*, and later to Marseilles, where the boiler was opened out and surveyed by one of the Surveyors to Lloyd's Register. The fracture was electrically welded and the furnace, which was $2\frac{1}{2}$ inches down on the same side as the crack in the plate, was faired.

The explosion was not of a violent nature, but the escape of water into the furnace was sufficient to quench the fire in about three minutes. The failure of the plate is without doubt attributable to breathing or panting by expansion and contraction, probably contributed to by the collapse of the furnace which is said to have been down previous to the explosion.

Internal examination of the boiler showed no distinctive grooving or cracking on the inner side of the end plate flanging to the furnaces, but there were appearances of active corrosion. A similar crack, but of less extent, of which I have been unable to obtain particulars, was said to have developed on the starboard side of the starboard low furnace on a previous occasion, and had been repaired by welding. In view of the age of the boiler and the stiffness of the plain furnaces longitudinally, it is reasonable for the plate to show signs of distress and the flanging at the furnace mounts should receive careful attention.

Observations of Mr. A. E. Laslett, the Engineer Surveyor-in-Chief.

The construction of this boiler was such that it did not allow sufficient flexibility of the front end plate, so that fatigue stresses were set up in the knuckles where the plate was flanged to take the furnace mouths which caused failure. Where plain furnaces are adopted the arrangement of staying and flanging should be such that there is ample flexibility to provide for a movement under varying temperatures.

REPORT No. 2967. S.S. *M. J. Craig.*

Report No..2967. Explosion from a boiler in the S.S. *M. J. Craig*, investigated and reported upon by Mr. N. S. Couch, Swansea.

The boiler is of the single-ended, cylindrical, multitubular marine type, is made of steel and is worked under natural draught. It is 14ft. in diameter and 10ft. 6ins. in length. The shell is 1 5/32nd inches in thickness, the longitudinal joints being treble riveted and fitted with double butt straps. The boiler was fitted with three furnaces of the " Deighton " corrugated type, 3ft. 4ins. in internal diameter and 17/32nd inches in thickness, and was designed for a working pressure of 180 lbs. per square inch.

The usual mountings were provided, the spring-loaded safety valves being adjusted to lift at a pressure of 180 lbs. per square inch.

The boiler was made by Messrs. John G. Kincaid and Co., Ltd., Greenock, in the year 1921, and was therefore about seven years old.

No important repairs appear to have been made.

The boiler was inspected periodically by the Surveyors to Lloyd's Register of Shipping, and the last inspection was made by Mr. W. F. Webb, at Cardiff, on the 22nd and 24th November, 1927. The boiler was also inspected by Mr. J. F. Paysden, the Chief Engineer of the vessel, on the 11th July, 1928, at Garston, after it had been cleaned.

The boiler was insured with Lloyd's Underwriters.

The explosion was not of a violent nature. The crown of the centre furnace at the sixth corrugation from the furnace mouth bulged inwards $3\frac{1}{2}$ inches and in the centre of the bulge the plate craked circumferentially for a length of two inches, through which there was a leakage of water.

The explosion was caused by an accumulation of scale on the furnace crown which allowed the plate to be overheated.

The *M. J. Craig* is a vessel of 605 tons gross engaged in the cargo home trade, and propelled by triple expansion engines taking steam from one single-ended boiler working at a pressure of 180 lbs. per square inch.

The vessel left St. Brieux at 6 p.m. on the 13th October, 1928, bound for Cardiff. At 10 p.m. on the same day the Chief Engineer was informed by the Second Engineer, who was on watch, that the centre furnace had collapsed. The former went below and found on opening the furnace door that a bulge had formed on the furnace crown, from the centre of which water was escaping. He informed the master and it was decided to run for Swansea. The pressure was reduced to 130 lbs. per square inch, and an endeavour was made to salt up the fissure by pumping sea water into the boiler. In about three quarters of an hour the leak had stopped, but at three o'clock the following morning water was seen to be issuing from the fracture, and sea water was again pumped into the boiler, which, it is stated, once more stopped the leak. At 9 a.m. it was seen that both the wing furnaces had also bulged. The vessel, however, reached Swansea that evening and docked the next morning, the 15th October, when the boiler was blown down.

I visited the vessel on the 17th October, and found the furnaces thickly encrusted with scale and the boiler generally dirty. A piece of scale which I detached from the bulged portion of the centre furnace measured $\frac{5}{8}$ inch in thickness, while that on the port and starboard furnaces was $\frac{1}{4}$in. and $\frac{1}{2}$in. in thickness respectively. There was also evidence of a considerable amount of muddy deposit about the boiler. In addition to the local bulges which are shown on the accompanying Plate, the crown of each furnace was down, the maximum deflection being—port furnace $1\frac{1}{2}$ins., centre furnace $1\frac{7}{8}$ins., and starboard furnace $1\frac{1}{2}$ins. These deflections are indicated by dotted lines on the furnace sections (see Plate).

The boiler was last scaled in July, 1928, and was inspected by the Chief Engineer on the 11th of that month. It was the practice to clean the boiler every three months, so that cleaning was about due when the explosion occurred. Fresh water was not carried in the vessel for boiler purposes, and the feed make-up was taken from the sea. Opportunity was taken, however, when the vessel was in fresh water to freshen up the boiler, and this was done on seven occasions between the date of filling up after cleaning in July and the 27th September. The Chief

Engineer stated that he took the density on the morning of the 13th October, and the salinometer reading was 3/32nd.

The presence of mud in the boiler was doubtless due to the fact that it was often necessary to pump water into it when the vessel was on or near the bottom while in port.

Observations of Mr. A. E. Laslett, the Engineer Surveyor-in-Chief.

The crown of the three furnaces of the boiler collapsed through overheating caused by the presence on the surfaces of very thick scale, in one instance stated to have been $\frac{5}{8}$in. thick. As the boiler was fed with sea water, rapid incrustation should have been expected and considerable risk of damage by overheating had been incurred in fixing the interval between the scalings at three months. The case is an illustration of the hard conditions under which the boilers of many of these small home trade vessels are run, and the results might have been much more serious.

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Books added to the Library.

British Engineering Standards Specification No. 193, 1929. --British Standard Whitworth (small hexagon) B.S.W., bright hexagon bolts, nuts and set screws, split pins, washers and studs.

"The Motor Boat Manual." 9th edition. Presented by The Temple Press, 5/15, Rosebery Avenue, E.C.1.

The Year Book of Scientific and Learned Societies of Great Britain and Ireland. Purchased from Messrs. Chas. Griffin and Co., 42, Drury Lane, W.C.2.

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Election of Members.

List of those proposed and elected at Council Meeting of March 4th, 1929:—

Members.

Thomas William Benson, Lyncliff, Egremont Promenade, Wallasey.

William Woodyer Buckton, B.A., 131, Victoria Street, Westminster, S.W.1.

John Charles Budd, 12, Woodland Grove, Rock Ferry, Birkenhead.

William Cornell, Engr.-Lt., R.N.R., Kent House, Warley, Brentwood, Essex.

Wilfrid Goddard, 58, Chelsea Road, Southsea, Hants.

Emmanuel Griffith, Eryti View, Iregarth, Bangor, Carnarvonshire.

Frank Morten Henri Jones, 132, Burnt Ash Road, Lee, S.E.

Harold Leaity, 117, Broadfield Road, Hither Green, S.E.6.

John Duncan Macintyre, 17, Kenners Dene, Tynemouth, Northumberland.

Charles Edgar Melville, 41, Mallaby Street, Birkenhead.

Lionel Cecil Samuel Noake, Engr.-Lieut.-Comdr., R.N., H.M.S. *Medway*, *c/o* Vickers-Armstrongs, Ltd., Barrow-in-Furness.

Arthur Douglas Renwick, York House, 5-7, St. Mary Axe, E.C.3.

Adam Simpson, 7, Great Winchester Street, E.C.2.

George Douglas Slater, Brodstone, Llwyn-y-grant Terrace, Penylan, Cardiff.

William Easton Smart, 61, Oxford Street, South Shields.

Laurence Turner, Engr.-Comdr., R.N., The Laurels, Abbey Road, Barrow-in-Furness.

Horace Urban Wadley, St. Brelades, Bellevue Road, Wivenhoe, Essex.

Harold Victor Walker, 65, Rockfield Road, Anfield, Liverpool.

Companion.

Naismith Douglas Bruce, 12, Lorne Street, Glasgow, S.W.1.

Associate Members.

Guy N. Watts, P.O. Box 259, G.P.O., Freetown, Sierra Leone, B.W.A.

Associate.

Andrew Martin Leiper, 70, Nelson Street, Aberdeen.

Transferred from Associate Member to Member.

John Johnston Robertson, 14, Hendford Grove, Yeovil, Somerset.

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Board of Trade Examinations.

List of Candidates who are reported as having passed examination under the provisions of the Merchant Shipping Acts.

For week ended 16th February 1929:—

NAME.	GRADE.	PORT OF EXAMINATION.
Jenkins, John H.	1.C.M.E.	Cardiff
O'May, William H.	1.C.M.E.	,,
Gratwick, Leslie S.	1.C.	,,
Constant, Amos R.	2.C.	,,
Harris, Ivor G.	2.C.	,,
Berryman, George	2.C.	Glasgow
Smith, William I.	2.C.	,,
George, William R.	1.C.M.E.	,,
Howie, John F.	1.C.	,,
Mitchell, Hugh B.	1.C.	,,
Winning, Robert	1.C.	,,
Anderson, Stewart A.	1.C.	Leith
Ritchie, Alexander	1.C.	,,
Donaldson, Alexander S. I. ...	2.C.	,,
Sykes, Thomas I.	2.C.	,,
Hagan, Alfred N.	2.C.	Liverpool
Jackson, Kenneth E.	2.C.	,,
Lee, Robert	2.C.	,,
Woodruff, George G.	1.C.M.E.	,,
Heaney, Alexander M.	1.C.	,,
Kyffin, Edward	1.C.	,,
Kendall, John P.	1.C.M.	,,

For week ended 16th February 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Daniel, William G.	2.C.	Liverpool
Marshall, Edward T.	2.C.	,,
McLennan, Kenneth J. M. ...	2.C.	,,
Crockett, William N.	2.C.	Southampton
Smith, Norman	1.C.	,,
Hedley, Christopher J.	1.C.	North Shields
Inness, John G.	2.C.	,,
Hall, William E.	1.C.M.	,,
Marr, Walter L.	2.C.M.	,,

For week ended 23rd February, 1929:—

Hood, Samuel M.	1.C.M.E.	Liverpool
Shuck, William	1.C.M.E.	,,
Dawes, Horace W.	1.C.	,,
Hill, James A.	1.C.	,,
Relph, Eric W.	1.C.	,,
Woods, Stanley L.	1.C.	,,
Herkes, Edward R. W.	2.C.	,,
Foye, Robert	1.C.	Glasgow
Galbraith, Neil	1.C.	,,
MacGregor, James M.	1.C.	,,
McLellan, Kenneth	1.C.	,,
Clark, Gilbert	2.C.	,,
Graham, Stewart T.	2.C.	,,
Wingate, Gabriel	2.C.	,,
Begg, James M.	2.C.M.	,,
Blackmore, Walter H.	1.C.	London
Glavina, Saviour	1.C.	,,
McGuinness, Donald E.	1.C.	,,
de Wolf, John	2.C.	,,
Sydney-Smith, Vincent H. ...	2.C.	,,
Little, Basil W.	1.C.M.E.	North Shields
Muckle, William H.	1.C.M.E.	,,
Davison, William O.	1.C.	,,
Munro, John	1.C.	,,
Clack, George R.	2.C.	,,
Ray, Ernest	2.C.	,,
Brown, William E.	2.C.M.	,,
Cuthill, William	1.C.	Sunderland
Sykes, Thomas A.	1.C.	,,
Elsdon, Jonathan S.	2.C.	,,
Knox, John	2.C.	,,

For week ended 2nd March, 1929:—

Floyd, Percy G.	1.C.	Cardiff
Jenkins, Elwyn T.	1.C.	,,
Jarman, David E.	2.C.	,,
Kennedy, Robert E.	1.C.	Glasgow
Read, Edward C.	1.C.	,,
Glaog, John C.	2.C.	,,
McArthur, James	2.C.	,,
Taylor, Hugh E. P.	2.C.	,,
Thom, William	2.C.	,,
MacKinnon, John	1.C.M.E.	,,
O'Shea, William	1.C.M.E.	,,
Scott, William H.	1.C.M.E.	,,

For week ended 2nd March, 1929—*continued*.

NAME.	GRADE.	PORT OF EXAMINATION.
Allan, James S.	1.C.M.E.	Belfast
Boyd, Samuel	1.C.	,,
Mills, John M.	2.C.	,,
Bamforth, Joseph F. J.	1.C.	London
Dalais, Paul A. R.	1.C.	,,
Wilkinson, Henry W.	1.C.	,,
Clark, James A.	2.C.	,,
Delves, Sydney P.	2.C.	,,
Hannah, Ralph A.	2.C.	,,
Lethbridge, Frank N.	2.C.	,,
Wilson, Francis S.	2.C.	,,
Keppie, George B.	1.C.M.E.	Leith
Mouat, John	2.C.	,,
Thompson, Herbert E.	2.C.	,,
Kerr, John M.	2.C.M.	,,
Quinn, Charles W.	1.C.	Southampton
Pearson, Harold S.	2.C.	,,
French, Thomas	2.C.	North Shields
Gidney, Henry	2.C.	,,
Nicholson, William O.	2.C.	,,
Pringle, James	2.C.	,,
Scott, William H.	1.C.	Liverpool
Smale, William R.	1.C.	,,
Williams, Isaac L.	1.C.	,,
Wilson, John A.	1.C.	,,
Anderson, Robert M.	2.C.	,,
Hampton, William S.	2.C.	,,
Simpson, Thomas H.	2.C.	,,
Williams, John	2.C.	,,
Lloyd, John R.	1.C.M.E.	,,

For week ended 9th March, 1929:—

Burrows, Albert	1.C.M.E.	London
Thurston, Edwin K.	1.C.M.E.	,,
Walmsley, Dugald L.	1.C.M.E.	Glasgow
Macdonald, John	1.C.M.	,,
Allison, John	1.C.	,,
Black, Charles H.	1.C.	,,
Ewing, James	1.C.	,,
Gauld, Gordon	2.C.	,,
King, William B.	2.C.M.	,,
Marlborough, Eric	2.C.M.	,,
Benson, George R.	2.C.	London
Gill, John P.	2.C.	,,
Goodrich, Arthur E.	2.C.M.	,,
Hughes, Albert W.	1.C.	Liverpool
James, George G.	2.C.	,,
Williams, Gordon C.	2.C.	,,
Hanson, Arthur W.	2.C.	Hull
Mitchell, James H.	1.C.	,,
Robinson, James A.	1.C.	,,
Carnes, Charles H.	2.C.	,,
Marshall, Arthur D.	2.C.	,,
Nelson, Arthur H.	2.C.	,,
Hall, Robert	1.C.	North Shields
Lund, Horace	1.C.	,,
McKie, Donald	1.C.	,,
Smith, James	1.C.	,,

For week ended 9th March, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Dixon, John G.	2.C.	North Shields
Newton, Robert	2.C.	,,
Cleet, George S.	2.C.M.	,,
Simpson, Robert A.	2.C.M.	,,
Chicken, Norman	1.C.	Sunderland
Crisp, Edward B.	1.C.	,,
Davison, Henry S.	1.C.	,,
Farrage, Edward	1.C.	,,
Garthwaite, John	1.C.	
Hunter, George	2.C.	,,
Kidd, Charles P.	2.C.	,,
Nicholson, Walter	2.C.	,,
Strickland, Francis	2.C.	,,
Tate, Arthur B.	2.C.	,,

For week ended 16th March, 1929:—

Palmer, Frank J.	1.C.M.E.	London
Ross, James B.	2.C.M.E.	,,
Trew, Harry W. A.	2.C.M.E.	,,
Mould, Wilfred L.	1.C.	Cardiff
Cornick, Harold T.	2.C.	,,
Rowlands, David J. H.	2.C.	,,
Williams, John N.	2.C.	,,
Gall, Arthur A. H.	1.C.M.E.	,,
Blyth, James	2.C.	Glasgow
Fraser, Ian M.	2.C.	,,
Mitchell, James W.	2.C.	,,
Turnbull, Robert F.	1.C.M.	,,
Kelso, George G.	1.C.M.E	,,
Nicol, Allan R.	1.C.M.E.	,,
Moffatt, Colin	1.C.M.E.	Liverpool
Lumby, Eric	1.C.M.E.	,,
Colsell, Henry N.	1.C.	,,
Wall, Albert	1.C.	,,
MacDougall, John	1.C.E.	,,
Berney, John	2.C.	,,
Cooper, William	2.C.	,,
Mate, Reginald E.	2.C.	,,
Read, William	2.C.	,,
Sykes, Percival C.	2.C.	,,
Watterson, Cyril	2.C.	,,
Webster, James	2.C.	London
Masters, Douglas W. C.	2.C.	,,
Harris, Alfred E.	2.C.M.	Liverpool
Tyrer, Arthur E.	1.C.	London
Girvan, William	1.C.	,,
Hough, Edward R. P.	1.C.	,,
Harvey, John	1.C.M.E.	North Shields
Morris, Arthur	2.C.	,,
Black, John	1.C.	,,
Abbott, Ernest H.	1.C.	,,
Gibbs, Roy M.	2.C.	London
Ashley, William R.	2.C.	,,
Campbell, Howard V.	2.C.M.	Southampton