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Alternating Current for Ships' Auxiliary Machinery.

READ

By W. J. BELSEY.

On Tuesday, March 13th, 1934, at 6 p.m.

CHAIRMAN: Mr. S. N. KENT (Chairman of Council).

Synopsis.

THE application of electricity for driving auxiliaries on ships, although of recent development, has been increasing at a rapid rate, as indicated by the large generating plant installed on present day passenger liners. The power generated has been direct current and it is suggested that now is the time to investigate the possibility of using alternating current machinery on account of cheapness, reliability, efficiency, robustness, and low maintenance. It is established that alternating current is replacing direct current in such applications as land power stations, coal mines, etc., and an examination of the mechanical and electrical features of squirrel cage a.c. motors and d.c. motors clearly shows the simplicity of the a.c. motor over the d.c. motor. If for certain auxiliaries variable speed motors are absolutely necessary, this can be met by alternating current commutator motors which can have a wide speed range. The question as to the kind of a.c. motor to use for various auxiliaries, such as circulating pumps, feed pumps, etc., is examined. For domestic supply lighting, heating, and cooking, alternating current, the author states, shows up to great advantage. A comparison in weight, cost, and efficiency, between a.c. and d.c. machinery is given for a large passenger liner.

The use of electricity in ships for driving auxiliaries is a comparatively recent development, and, like most developments, started on a very small scale, its first application being a small generator for providing lighting. These small generators were all direct current and it may be assumed that the developments would naturally continue on the same lines, the application of electricity gradually increasing until the present stage was reached, where in passenger liners generating plant is installed of the following capacities :—

C.P.S. "Duchess" vessels	1,800 kw.
C.P.S. "Empress of Britain"	2,800 kw.
Orient liners	1,350 kw. to 15,00 kw.
P. & O. liners	1,500 kw. to 2,600 kw.
Cunard Co.'s No. 534 ...	9,100 kw.

Also in those recent vessels carrying frozen and chilled cargo generating machinery of 1,000 to 1,600 k.w. capacity is installed.

It therefore appears to the author that possibly now is the time to look closely into the problem of ships' electrical machinery with a view to ascertaining whether marine engineers are proceeding on the right lines in continuing to use direct current for driving auxiliary machinery or if it may not be better, cheaper, and more efficient to adopt alternating current.

The author would at the onset like to state that although he may be a member of a manufacturing organisation he has "no axe whatever to grind" because the organisation to which he belongs makes both alternating and direct current machinery and the only thing he is interested in is that the type of machinery fitted should be that which gives the most satisfaction, in every sense of the word, to the owner.

In a paper of this description it is impossible for the author to enter into details of design characteristics of the various machines, as this would involve the inclusion of a vast amount of detail which would serve no useful purpose. Therefore the author has endeavoured to be as brief as possible, just touching on the salient points, and having in mind the desire to provoke as much discussion as possible.

It might be well to state that a.c. auxiliaries have been fitted in four U.S. coast-guard cutters, and also in some of the Great Lake ore carriers. These were rather exceptional cases as these vessels were electrically propelled and power was taken from the main generators to drive the auxiliary machinery.

The first vessels in this country to have alternating current auxiliary generators were some tankers owned by the British Tanker Co. and also very recently the train ferry "Seatrain" which was built in the United States was fitted with alternating current auxiliaries throughout.

On land, it may be stated without any fear of contradiction, the use of direct current motors is gradually dying and in such applications as coal mines, cement mills, gold and tin dredgers, and artificial silk mills, where conditions are particularly bad, direct current is not even considered. This is not because alternating current is standard with all the supply companies, but rather on account of the inherent advantages possessed by the a.c. motors generally. Out of every 100 motors made in this country 80 are alternating current and 20 direct current.

Direct current motors as fitted in ships have reached a high stage of development and control gear has been made sound and reliable. Therefore the author can quite understand marine engineers asking "Why change if direct current machinery is so good?" The author's answer is "Change for something better and cheaper". It will be agreed that with direct current machinery the part that requires attention and care is the commutator and the brushgear. If on any direct current machine the commutator is neglected and allowed to get into a bad condition, unsatisfactory operation will result; in fact all motors are provided with means whereby the commutator can be inspected when the machine is running.

The advice to "change for something better and cheaper" is based on the squirrel cage induction motor which is the simplest type of motor made and covers a very wide field of application. In a large passenger vessel, with a total of 288 motors, not less than 266 could be of the squirrel cage type. This motor is the cheapest to make and the most robust, weighs less, is more efficient than any other type of motor for a given output and speed, and will stand a lot of punishment. It has but one insulated winding, that being the stator winding. As will be seen from the actual rotor this consists of a core made up of sheet iron punchings with bare metal bars of copper or aluminium. The rotor exhibited here has the bars and end rings of cast aluminium. On comparing this rotor with a direct current armature with its commutator brushes and brush rigging, it will be seen at once that the squirrel cage induction motor is a much better mechanical job and far more robust. Further, should a breakdown of the stator winding occur it necessitates little more than cutting out a coil or coils, when the motor can be run satisfactorily until a permanent repair can be made.

In the past the constant speed characteristics of the induction motor have always been brought forward against its use at sea, but are all these fine variations in speed really necessary? Is it not possible for the marine engineer to learn something from the land power stations, and would not the marine engineer be prepared to drop some of these unnecessary speed adjustments for the sake of getting a mechanically robust squirrel cage induction motor, and at the same time eliminate a large amount of bulky and costly control gear?

In all the large generating stations the auxiliaries are driven by alternating current induction motors. These motors do not get their supply from the station busbars but from a separate house generating set, so that if there was any great advantage to be gained from fine variations in speed, surely the station engineer would make his house supply direct current.

It is admitted that there are certain auxiliaries where it is necessary to have a finely graded variable speed, such as forced draught fans; these can always be met by alternating current commutator motors, with which it is possible to obtain the widest speed range ever required, and with the finest graduation. Also two, three, or four different definite speeds can be obtained on a squirrel cage induction motor by having a change pole winding without any sacrifice of its mechanical features. Thus two windings on the stator would give the following definite synchronous speeds:—6 poles 1,000 r.p.m., 10 poles 600 r.p.m., 12 poles 500 r.p.m., 20 poles

300 r.p.m. Also the squirrel cage motor lends itself rather well to having built-in speed reducing gears in the endshields.

It may be of interest to make a comparison of the efficiencies of the various types of alternating current motors as compared with direct current motors of the same output and speed :—

Constant Speed Motors.

		A.C. Motor.				
	Speed	Squirrel Cage.		Slipring		D.C. Motor.
H.P.	r.p.m.	% Eff.	P.F.	% Eff.	P.F.	% Eff.
5	750	85	·77	84	·72	80
10	750	86	·80	87	·75	83
20	500	87	·75	86	·71	86
50	400	89	·81	89	·80	87
150	400	92	·86	92	·84	91

Two Speed Motors.

	Speed	A.C. Motor.		D.C. Motor.
H.P.	r.p.m.	% Eff.	P.F.	% Eff.
5	345/715	83	·73	79
10	345/715	85	·73	80
20	275/570	86	·73	83

Variable Speed Motors.

10	250/600	75	·84	79
20	250/600	77	·85	83
50	250/600	82	·90	87

Generators (Diesel Engine Driven).

	A.C.	D.C.
KW.	% Eff.	% Eff.
200	92	90
400	93·5	92
500	94	92·5

The above are the efficiencies obtained on ordinary commercial competitive machines. No doubt by making the machines, both a.c. and d.c., more expensive slightly higher efficiencies could be obtained.

Each type of auxiliary machinery will now be examined in order to see which kind of alternating current motor would be best suited for its drive.

Main Circulating Pumps.

Marine engineers generally regard it as essential that these pumps should be driven by an adjustable speed device, be it a steam engine, turbine, or electric motor. In generating stations the circulating pumps are invariably driven by a constant speed a.c. motor, and these stations have to cover conditions varying almost as widely as those met with at sea, especially those generating stations where cooling towers are used.

The author is confident that in the case of a vessel sailing East through sea water varying in temperature from 40 deg. F. to 90 deg. F., the circulating pumps could be very efficiently driven by a change pole squirrel cage induction motor having two speeds, say, 500 and 600 r.p.m., or some similar ratio.

Forced Lubrication Pumps.

These pumps could be efficiently driven by a constant speed squirrel cage machine.

Centrifugal Pumps.

All centrifugal pumps, such as bilge, ballast, fresh water, general service, etc., could be driven by squirrel cage motors. Their characteristics are particularly suited to this form of motor, as the starting torque required is low and they build up torque as the square of the speed and absorb power as the cube of the speed.

Steering Gear Motors.

The electro-hydraulic steering gear seems the most popular form, and as it is already driven by a constant speed motor it will, therefore, be quite well driven by a single speed squirrel cage motor.

Forced Draught Fans.

A wide range of fine adjustment is desirable and here could be used alternating current commutator motors having as wide a range of speed as may be desired.

Ventilating Fans.

In days gone by variable speed motors having a fine speed adjustment for driving these fans were called for, but now even with direct current machines only two set speeds are called for, and these can be met with a change pole squirrel cage motor.

Refrigerating Machinery.

On land a very large percentage of CO_2 or ammonia machines are driven by alternating current squirrel cage motors, or by synchronous motors, and give satisfaction, and there seems to be no reason why these machines should not be driven in the same way at sea. If, however, the size of the motor is large and the starting current too great for the generating plant, slipring motors could be used. If, further, there are some special conditions at sea of which the author is not aware, necessitating a wide range of speed with fine graduation, this can be met by alternating current commutator motors.

Air Compressors.

Air compressors on land are driven in much the same way as CO_2 and ammonia compressors.

Winches and Deck Machinery.

Alternating current deck machinery will require special consideration as ships' winches, capstans, etc., have no exact counterpart in general use on land, but if the general principle of a.c. auxiliaries was accepted the winch and deck problem could be comparatively easily solved. There are at work all over the country many lifts and cranes which are operated by a.c. motors, so that it would appear to be only a question of getting down to the problem when a solution would be found. On the other hand a motor generator could be fitted which could be used to supply direct current to the winches, also for operating the capstans and other deck machines.

As marine engineers are aware, certain vessels have already been fitted with motor generators for operating constant current winches and other deck machinery.

Miscellaneous Applications.

The driving of positive displacement pumps and of engine turning gear, and all similar duties where a high starting torque is required, can be effectively carried out by a.c. slipring motors. In general all the types of alternating current motors mentioned above are standard machines, of which there are literally thousands in operation on land.

With regard to domestic supply for lighting, heating and cooking, here the alternating current shows up to great advantage. The vessel can be divided up in sections, each supplied from a transformer transforming down from, say, 440 volts to 110 volts. This latter voltage is better suited for lamps and galley working than is 220 volts as now used. One great advantage in dividing the galley and domestic supply into transformer sub-stations would be that in the event of an earth developing it would only affect its own section and the whole ship would not be to earth as is now the case even if only a small cooking device or lamp-holder goes down to earth. The majority of earths occur on the domestic supply and the author is confident that the engineers' work in looking for earths and clearing them would be cut down by a very large amount if alternating current were adopted.

To sum up, by taking the motor equipment of a large passenger liner the following table shows the types of alternating current motors which could be fitted :—

Squirrel Cage Motors. Constant Speed.	Squirrel Cage Motors. Two Speed Change Pole.	Slipring Motors.	A.C. Commutator Variable Speed Motors.
112	154	4	18

From the above it will be seen that out of a total of 288 motors, no less than 266 could be of simple squirrel cage type.

The advantages claimed for alternating current machinery are as follows :—

1. Simplicity.

As will have been seen, a squirrel cage motor is the essence of simplicity, consisting of only a rotor, a stator, two bearings, and three wires leading to it; with no brushgear, commutator, or brush rigging, and 90 per cent. of the motors driving auxiliary machines could be of this type. Costly and bulky control gear would be eliminated. The smaller motors could be switched straight across the line by a simple three-pole switch, or if desired, by a magnetic switch operated by a push button. The larger machines can be started by a starting compensator, one only being used for a number of machines, and the operation of starting can be performed by push buttons fitted near the motors. Alternating current variable speed commutator motors do not require any starting gear beyond a triple pole switch. In the few cases where slipring motors with high starting torque are required to be fitted, the starting and control gear would not be any more bulky than a starter for a d.c. motor of the same size.

2. Efficiency.

The overall efficiency of the complete installation would be rather higher with alternating current machinery than with direct current machinery, probably including the generating plant 2 to 2½ per cent. in favour of alternating current.

3. Weight.

The total weight of the electrical machinery including generators, switchgear, cables, motors and starters would be less with a.c. than with d.c. In the case of the large passenger liner previously mentioned the weight of all the electrical machinery and other items mentioned above would be as follows :—

Direct current machinery, etc. ...	392·3 tons
Alternating „ „ „ ...	286·5 tons
Showing a saving of	105·8 tons

4. Operation.

The operation of alternating current machinery would be much easier for the ships' engineers as it requires less attention and certainly less upkeep. The only difference in operation would be parallelling of the generators where it is necessary to synchronise before putting a generator on the busbars. There is nothing in this that could not be mastered by the ships' engineers in a few hours.

5. Cost.

The total cost of alternating current machinery would be substantially less than that of direct current machinery. In the case of the large passenger liner mentioned above, the saving in capital cost would be at least 12·5 per cent. This in itself is a substantial sum. In addition, many other minor advantages would reveal themselves, such as the elimination of small motor generator sets for bell ringing; these would be replaced by transformers. By running the lights on 110 volts large savings would be made in renewals. The electric galley being on 110 volts the cost of upkeep would be considerably reduced. Ships' telegraphs could be very satisfactorily operated by alternating current and, in fact, in some ships motor generator sets have been installed in order to supply three-phase alternating current to the ship's telegraphs.

All risk of any electrolytic action is avoided by the use of alternating current.

At the conclusion of this paper a few slides illustrating the application of various types of alternating current motors will be shown by the courtesy of the B.T.H. Company.

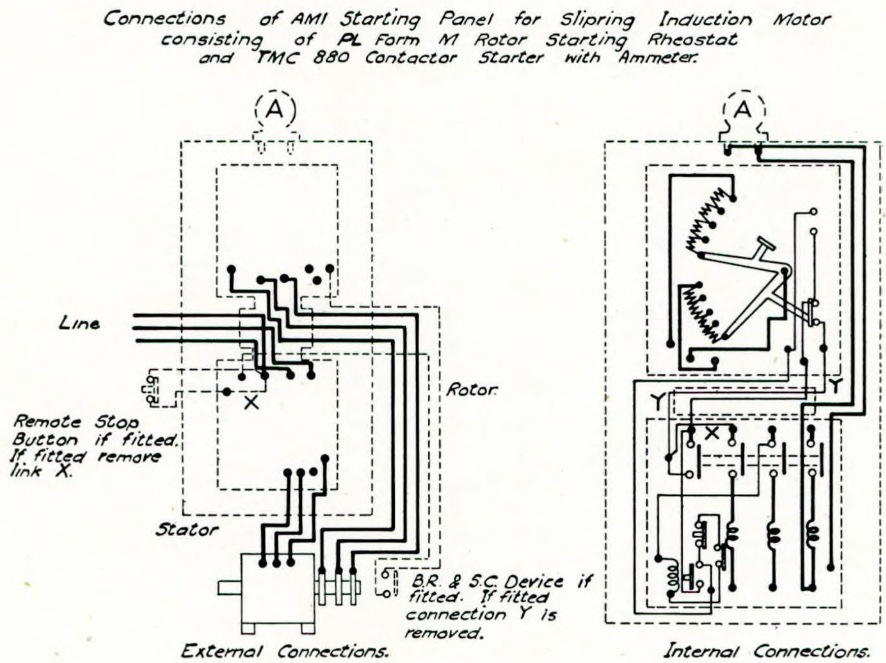

Connections of AMI Starting Panel for Slipring Induction Motor consisting of PL Form M Rotor Starting Rheostat and TMC 880 Contactor Starter with Ammeter.
A
Line
Rotor
Remote Stop Button if fitted. If fitted remove link X.
X
Stator
B.R. & S.C. Device if fitted. If fitted connection Y is removed.
External Connections.
Y
Internal Connections.

FIG. 1.

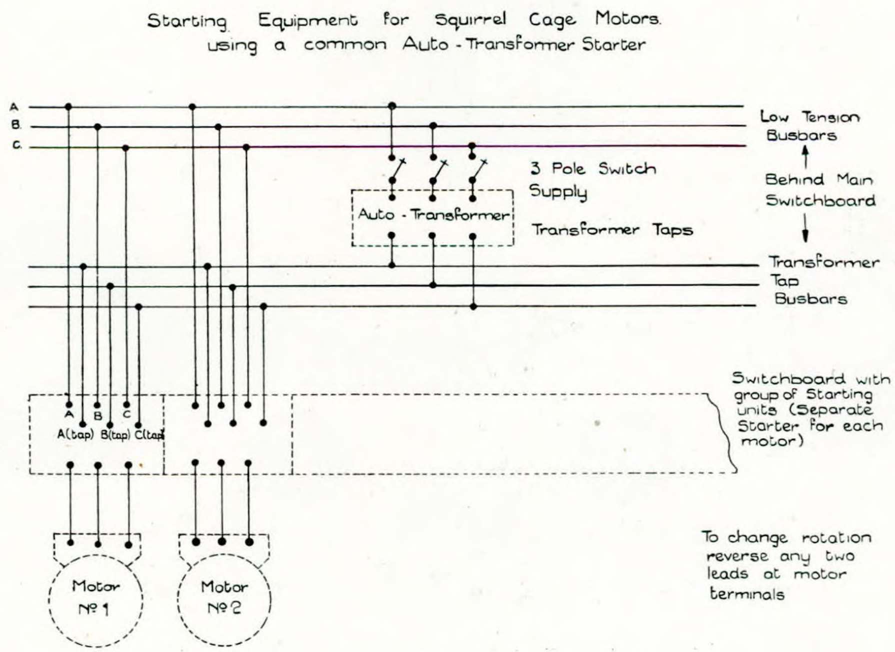

Starting Equipment for Squirrel Cage Motors. using a common Auto-Transformer Starter
A
B
C
Low Tension Busbars
3 Pole Switch Supply
Behind Main Switchboard
Auto-Transformer
Transformer Taps
Transformer Tap Busbars
A(tap) B(tap) C(tap)
Switchboard with group of Starting units (Separate Starter for each motor)
To change rotation reverse any two leads at motor terminals
Motor Nº 1
Motor Nº 2

FIG. 2.

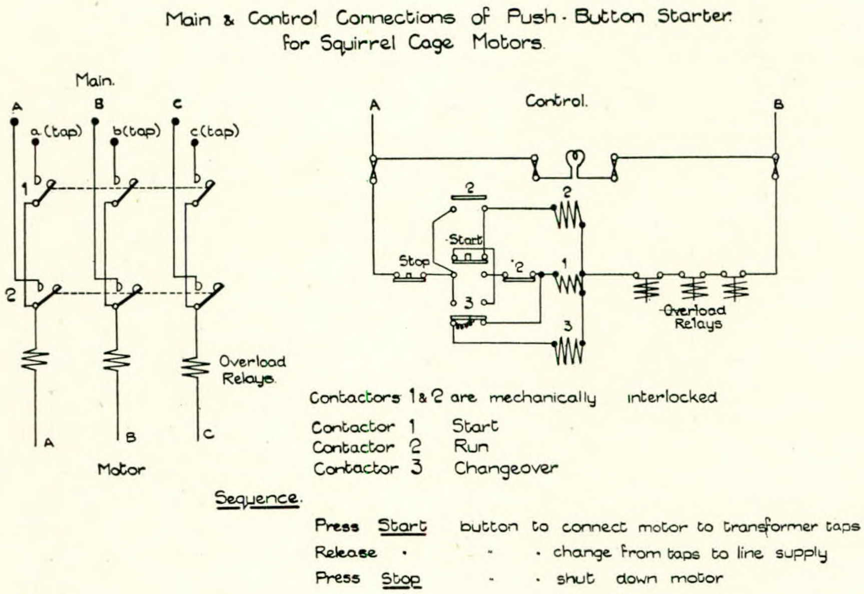


FIG. 3.

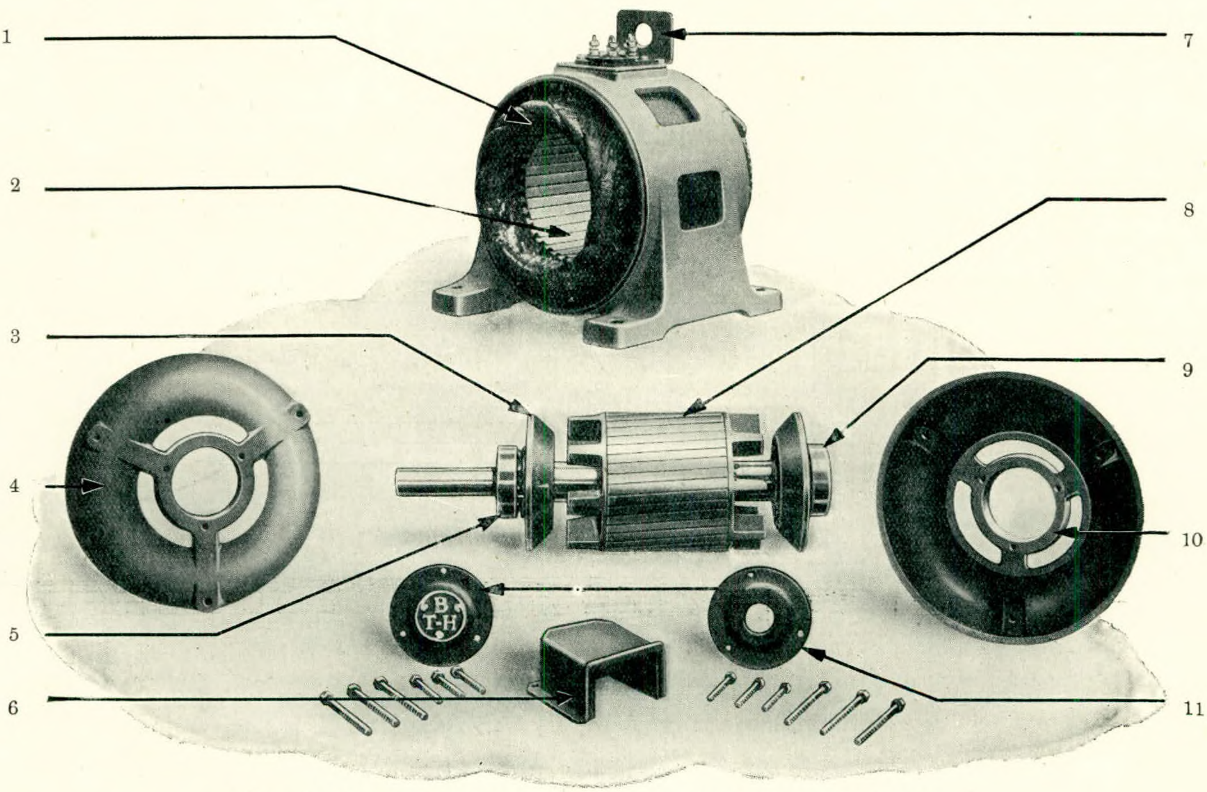


FIG. 4.—COMPONENT PARTS OF SQUIRREL CAGE INDUCTION MOTOR.
1. Stator winding. 2. Stator punchings. 3. Combined air deflector and dust cap. 4. Endshield. 5. Ball or roller bearing. 6. Terminal box cover. 7. Terminal box. 8. Specially cast aluminium rotor. 9. Ball bearing. 10. Bearing housing. 11. Dust caps.

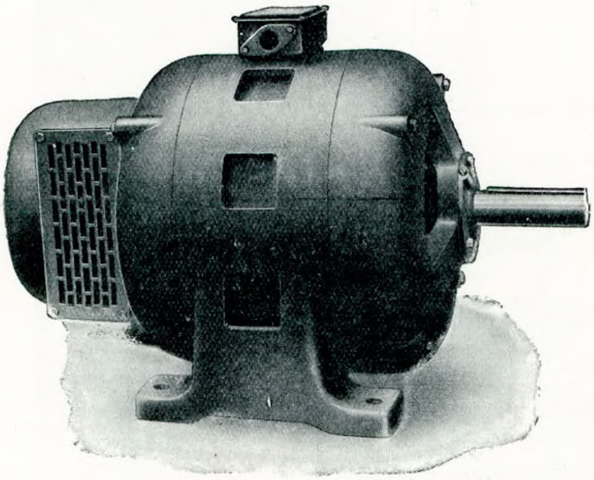


FIG. 5.—Screen protected, slipring, induction motor rated 15 h.p., 960 r.p.m., 50 cycles.

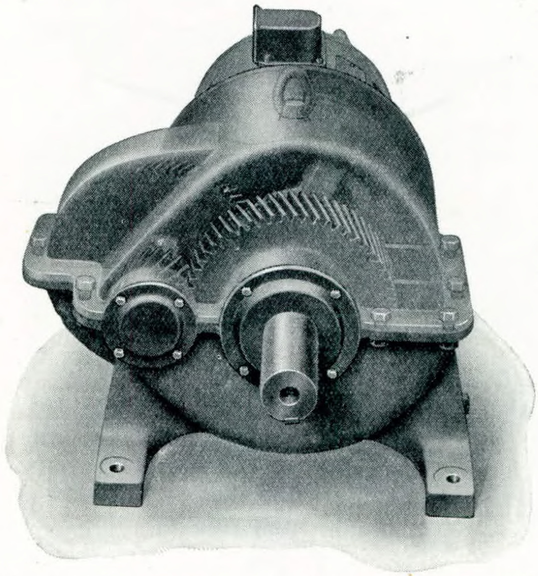


FIG. 8.—Geared motor unit with helical gears. The low speed shaft is directly in line with the rotor shaft as shown in the phantom view.

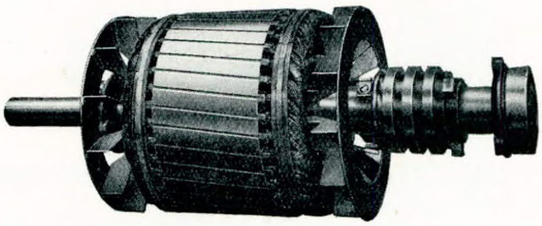


FIG. 6.—Complete rotor of slipring induction motor.

FIG. 7.—Flameproof squirrel cage induction motor driving chain conveyor in coal mine.

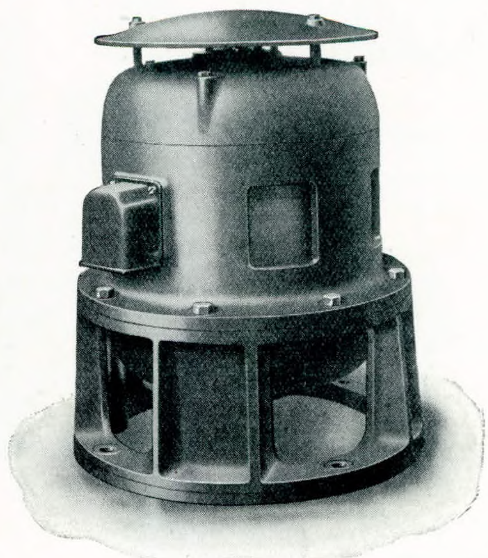


FIG. 9.—Vertical squirrel cage induction motor mounted on circular skirt base.

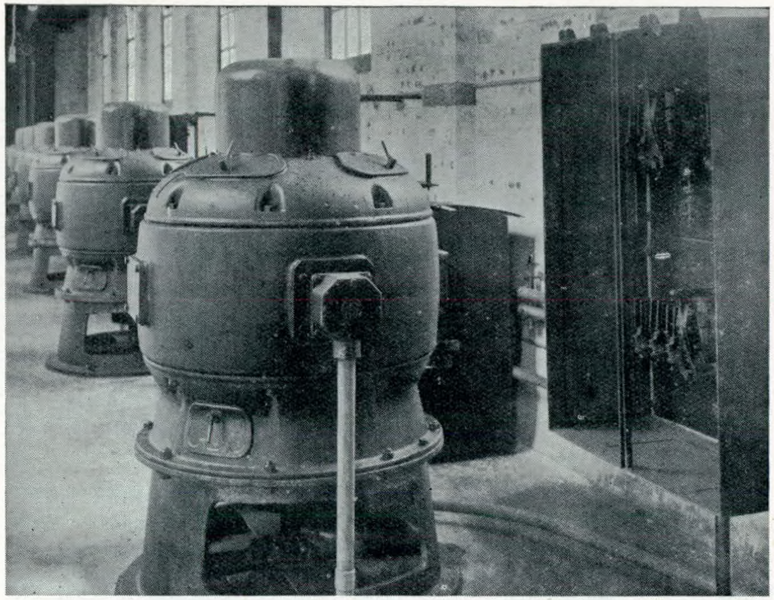


FIG. 10.—Vertical slipring induction motor rated 40 h.p., 1,180 r.p.m.

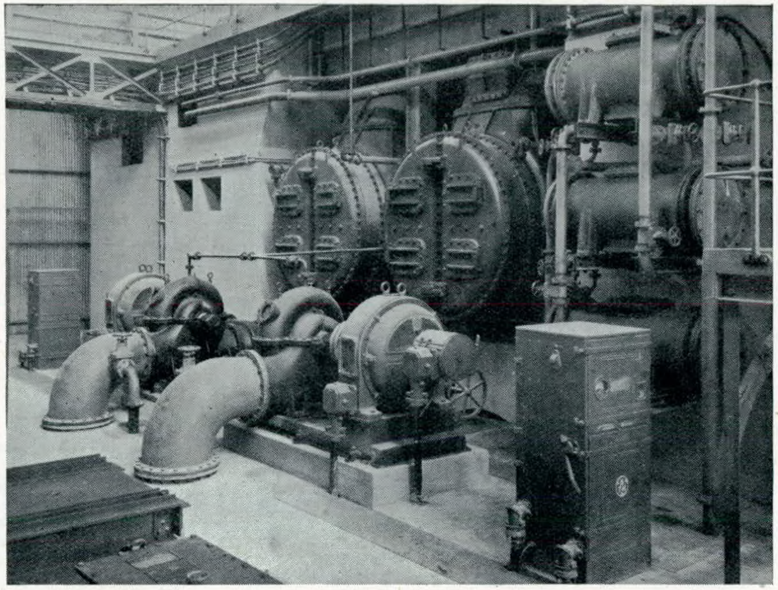


FIG. 11.—Slipring induction motors rated 265 h.p., 720 r.p.m., 400 volts, 50 cycles, 3 phase, driving circulating pumps in a power station.

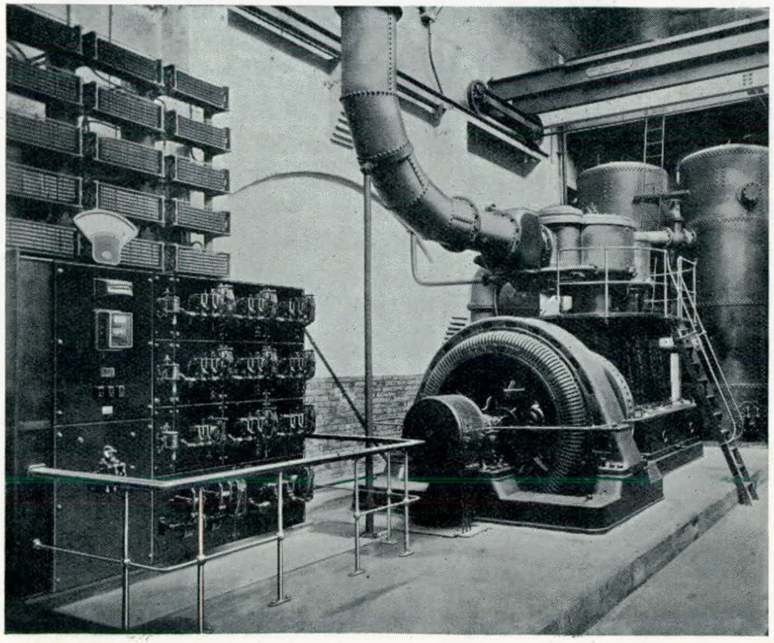


FIG. 12.—Slipring induction motor rated 850 h.p. driving air compressor at a shipyard.

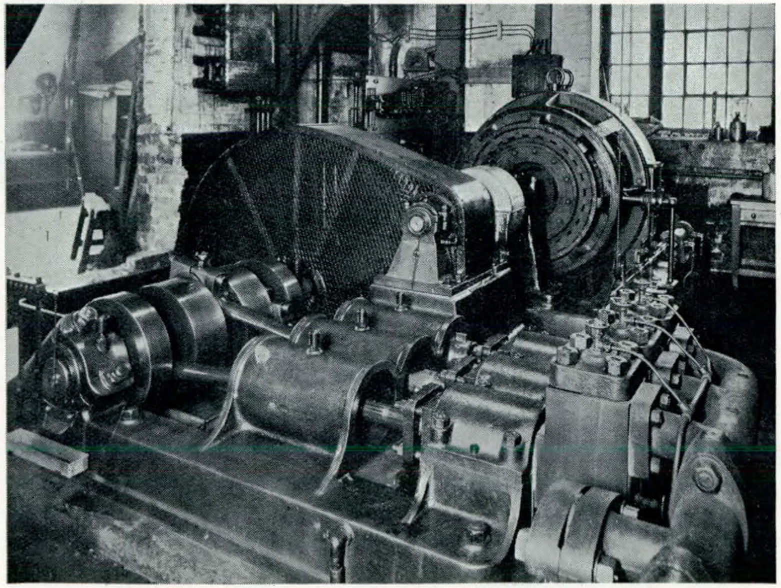


FIG. 13.—A.C. commutator motor rated 120 h.p. 500/200 r.p.m., 440 volts, 50 cycles, 3 phase, driving pump.

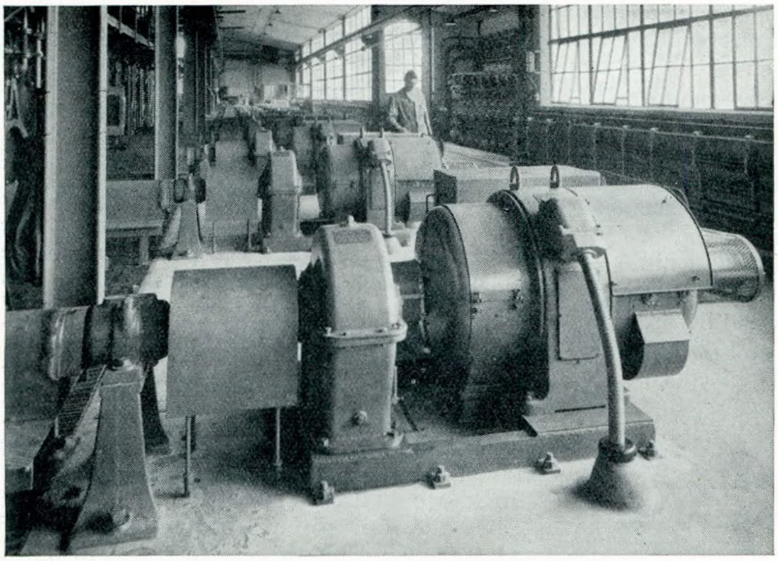


FIG. 14.—A.C. commutator motor operating in a paper making mill.

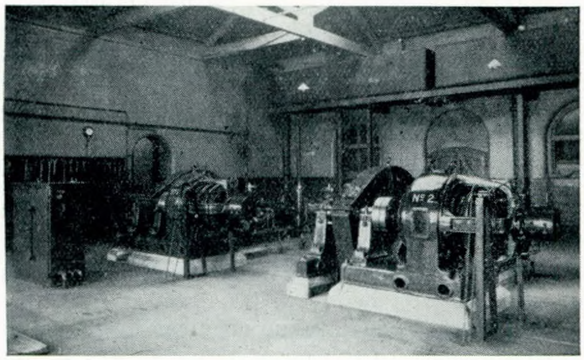


FIG. 15.—A.C. commutator motor rated 70/23 h.p., 690/230 r.p.m., driving pumps.

DISCUSSION.

Mr. J. McLaren (Vice-President) opening the discussion, said that twenty-five years ago he had read a paper at the White City on the subject of alternating current. His attention had first been attracted to this form of power when he was at Boston, U.S.A. There was a heavy snow storm at the time and he had noticed a man working a winch on the quay. On asking the operator how the winch could work in the wet and snow he had been informed that it was due to alternating current being used, and he had immediately commenced to study its possibilities. After considerable study of the problems involved he had given two papers, which, to his disappointment, were not received with the enthusiasm he had felt at the time they deserved.

He had advocated gas producers in those days to drive the generator and it seemed alright. There was no oil fuel and, to his mind, it was then the cheapest power available. To-day, however, they had better class ships, better cables and motors, etc., and it was quite feasible to drive all auxiliaries by alternating current. He had perhaps been a little premature when he advocated its use twenty-five years ago, but different and much more suitable conditions certainly obtained to-day.

Mr. Mather, Mr. Wm. McLaren and himself were all present at the meeting at the White City, and all three were present that evening.

Mr. G. O. Watson (Member) said that Mr. Belsey had covered the whole of this subject, but his treatment of some aspects of the case had necessarily been somewhat superficial. He had not gone very deeply into many matters which required further consideration, and it would pay every superintendent and owner to study the matter very closely. The speaker meant by that remark that there was a lot to be said for alternating current, but it required careful consideration.

In the early days when electricity was first used on board ships, the a.c. motor had not been invented. It was only since the war that the variable-speed commutator motor had been on the market. Prior to that, when variable speeds were required, the only thing was the slip-ring motor, which was very inefficient at reduced speeds. Also, users of the commutator type of motor at that time were in the hands of a few firms who specialised in them. Such conditions did not obtain to-day, as there was a number of firms who could supply the needs of the user.

Two great factors which made alternating current advantageous were that the lighting, heating and cooking could be entirelv isolated from the motor circuits and that electrolysis did not occur to anything like the extent prevailing with direct current. With regard to lighting, by distributing at 400 volts at the main it was possible to transform to 110 volts for the lights. They would be on the secondary side of the transformer and entirely isolated. With regard to electrolysis, this attacked the insulation and perhaps resulted in the wasting away of the conductors.

Another point not dealt with by the author was the reputed greater danger of shock existing with alternating current. The speaker was not convinced on this point, but it was always brought up in any discussion on alternating current and it certainly required most careful investigation. This country was rapidly changing over to a.c. and in a very short time the domestic supply of all their homes would be alternating current. This supply was 220 volts, but there was no reason why on ships it should not be 110 volts to reduce risks.

This seemed advisable as on board ship the risk of shock was greater due to the conditions which existed, such as wet feet, steel decks, etc.

The author had proposed the use of commutator motors. If squirrel-cage or slip-ring motors were used entirely, it would be very easy to enclose everything so that no parts were exposed; 400 volts might then be used. By using 400 volts three-phase with an earthed neutral, the maximum voltage at which shock to earth could be obtained would be 225.

In the paper which Mr. McClelland read before the Institution of Electrical Engineers in 1927, he gave some abstracts from the Home Office Reports of Electrical Accidents from which it appeared that in the four years 1923/6 there were forty-nine fatal accidents with alternating current and two with direct current. These figures, however, should not be interpreted without careful investigation of the causes in each instance to see whether they could not have occurred equally with direct current. For instance, he had that day been looking at the Home Office Report for 1932 (the latest published) and in one accident the electrician had been painting behind the switchboard and accidentally caused a short circuit. In another case an engineer measuring up for switchboard modifications was using a boxwood rule with an aluminium edge, and he laid his rule across the 440 volt a.c. bus-bars, with the result that he spent several weeks in hospital. Such accidents were just as likely to happen with direct current.

Alternating current was now used in laundries, dairies, dye works, and paper mills where there were damp conditions increasing the risk of shock.

The author gave the number of motors which would require to be commutator motors, but he did not mention the respective horse powers. If these were examined it would probably be found that the variable-speed motors represented 50 per cent. of the total horse power. The author gave 22 motors out of a total of 288, but these 22 represented a large proportion of the total horse power required, the larger fans, circulating pumps, etc., coming into the category of variable speed. Not many vessels had 288 motors, and it would be interesting if an example were furnished of an average-sized ship which had about 80 motors. As a matter of fact there were no ships building at present with more than about 90 motors.

Another argument in favour of 110 volts for the lamps was that a stronger filament and, consequently, longer life were obtained. It had been stated, however, that the filament tended to crystallize and become brittle with alternating current, but he thought the advantages outweighed this.

Interference with wireless telegraphy and ship's telephones was another point requiring attention. Direct current would be required for the telephones, but this could be remedied by using rectifiers, or secondary batteries which could be charged from the a.c. supply by using rectifiers. The running of the generators in parallel had also to be taken into consideration. The majority of ships had oil-driven generators, and although they ran satisfactorily care had to be exercised in the governing characteristics of the engines and the wave form of the generators. It was not so simple a matter to run a.c. generators in parallel as in the case of d.c., but it could be done and there was nothing experimental about it. The difficulty of synchronising was not greater than that of paralleling d.c. generators. It was not possible, however, to adjust the load with a.c. generators by altering the field rheostat as was the case with d.c. generators, as field adjustment merely changed the power factor.

Winches would present difficulty, because direct current was the only satisfactory proposition for these. However, if a motor generator was installed or the constant current principle used, the motor generator set could be used to drive it from the alternating current. It was surprising that more was not heard of the constant current principle for winches. It was very economical and there was no wastage of power in regulating resistances; it was the nearest approach to the steam engine characteristic, which was ideal for winches, and the winch could be stalled with impunity.

Another reason perhaps why alternating current was not more common was that marine engineers were more experienced with direct current and were, consequently, somewhat dubious of the former. As Dr. Dorey had suggested at the last meeting, perhaps the marine engineer preferred the "devil he knew to the devil he didn't know", but if that principle had been accepted in the past they would never have had turbines, Diesel engines, or in fact any development whatever.

It had been said that in practically all of the ship propulsion a.c. turbo-electric schemes in America they still used direct current for the auxiliaries. He thought the point had rather been missed there, because with a.c. propulsion with synchronous motors the frequency had to be varied and the power was therefore not suitable for driving auxiliaries.

There were many valuable assets in favour of alternating current, and he would like to see the respective merits of a.c. and d.c. ascertained analytically. He would also like to see an installation built, because very little progress could be made until practical experience was obtained. He did not think any owner or engineer would have cause for regret if he made such an experiment.

Professor G. B. Bryan (Royal Naval College, Greenwich) said that the use of alternating current was progressing in land stations and he saw no real reason why it should not be adopted in marine work to a greater extent.

Would the author tell them whether, where high starting torque was required, the double squirrel-cage motor could be used instead of the slip-ring type? The speaker thought that in that event a certain amount of trouble would be avoided.

With regard to Mr. Watson's statement that with ordinary a.c. propulsion the variable frequency, due to change of speed of the turbines to alter the speed of the ship, rendered the generator unsuitable for the auxiliaries, was it possible that the a.c. commutator motor was going to be developed to such a size that it would be used for the propulsion itself and the speed of the drive kept constant?

Mr. C. Wallace Saunders (Member) complimented the author particularly on the fact that he had dealt very fully with what was probably the next important step as far as electricity on board ship was concerned. It was a subject which should be treated very fully and probably for different classes of vessels and he would put them in the following categories, viz. :—

(*a*) Tankers and cargo boats.
(*b*) Insulated meat carriers and intermediate passenger vessels.
(*c*) Passenger liners.

Deck machinery, i.e., windlasses, capstans and winches, would present some difficulties. The author stated, however, that these should be fairly easy to overcome by the electrical designers because of the a.c. lifts and cranes of which they had experience ashore, but he thought it would be difficult to equal the a.c. motor for these purposes. As the discharging machinery of a tanker was generally pumps only, he thought the squirrel-cage motor would be ideal. On large liners he thought complications would be found in the distribution circuits for the various decks for the lighting, cabin fans, cabin heaters, galley, pantries, and in fact all single-phase apparatus, because of the difficulty there would be in balancing the load on the three phases. This would vary with the number of passengers per voyage and their distribution throughout the different decks, some desiring heat, others coolness and so on. It would be a difficult matter, he thought, to arrive at a balance between the phases. In this connection, and as an example of concentrated electricity on board a passenger liner, it was to be noted that there were vessels afloat (half the tonnage of the "Empress of Britain") with 3,000 kw. d.c. generation installed, whereas she had about the same. All this single phase 110-volt apparatus would require double the amount of copper in the cable that the 220 volt d.c. distribution would require.

He agreed with the author entirely that if the squirrel-cage motor could be used it was the ideal machine, because there was no more robust machine even on the mechanical end of the ship.

He thought that the marine engineer, where there was a case for alternating current, was the one who could assist in putting it on board his ship by studying the mechanical end. On all centrifugal pumps for either oil or water, and on all fans (whether forced draught, ventilating or cargo fans), he should be able to make greater use of the delivery valves in the case of the pumps and the dampers in the air trunks in the case of the fans to get the quantity or volume required without altering the speed of the motor. Then, of course, the squirrel-cage motor was admirably suitable, because in a similar way the marine engineer ought to be able to arrange for it to be started against a small starting torque.

Voltages were at present laid down by the classification societies and limited alternating current to 250 volts for power and 150 volts for accommodation distribution.

The author had stated clearly the case for alternating current on board ship, and the speaker would repeat that he thought it was the next step and therefore worth full consideration.

The speaker thought that if the commutator a.c. motor or the pole changing squirrel-cage motor had to be used for any purposes, then the tremendous advantages in the use of the plain squirrel-cage motor would be correspondingly reduced, and he thought that probably the next step would be that in place of the present d.c. generator there would be a smaller d.c. generator to cater for the power duties that could not be carried out by the plain squirrel-cage motor and, perhaps, accommodation distribution with a tandem a.c. generator or alternator to supply squirrel-cage motors where these could be used and wherever a.c. could be applied to the various distributions in the ship. He thought that ultimately the d.c. generator might be eliminated and a large generator installed, but further consideration would still have to be given before this could be accomplished.

Mr. J. J. McKenzie (Vice-President) said the author had pointed out that the British Tanker Company were the first in this country to apply alternating current on their ships, and the speaker believed this to be correct. Alternating current was used for engine room auxiliaries in twenty-five geared turbine vessels in the Company's fleet, with an average of ten motors in each engine room. Pressure of supply for power was 220 volts, the lighting being supplied by a motor-driven generator supplying current at 110 volts d.c. Mr. McKenzie pointed out that, the Company's vessels being oil tankers, they were now limited to 110 volts for all purposes with alternating current, and with direct current to 220 volts for power and 110 volts for lighting.

With regard to one of the previous speakers' remarks on sychronising, the a.c. generators were turbine-driven and no difficulty had been experienced in synchronising the machines. Recently his Company had gone in for Diesel ships and these had Diesel-driven generators supplying direct current, principally on account of the difficulty that would be experienced in getting the Diesel generators, if of the a.c. type, to run in parallel.

Referring to the remarks of Mr. Saunders, the speaker's experience was that no difficulty was encountered in driving the main circulating pumps by constant speed motors, their practice being to open the main injection, start the pump, and gradually open up the discharge until full load was obtained. Incidentally, only two of the ten motors referred to above were of the variable-speed type, one being for the fan and the other for the refrigerating machinery. With regard to the fan, it was found that more delicate adjustment could be obtained by running the motors at constant speed and fitting a baffle in the air inlet, with the result that in the later ships a constant speed motor had been fitted. The refrigerating plant had a variable-speed motor in order that it could be started up on low torque, full load being put on gradually.

Mr. McKenzie concluded by stating that when his Company first went in for alternating current they were thought by marine engineers to be taking a risk, but after thirteen years' experience they could say that they had found this system to be very reliable and the upkeep costs very low.

Mr. A. H. Mather (Vice-President) said that whilst he felt diffident about participating in a discussion on a purely electrical subject with so many electrical specialists present, the position had been eased to some extent by the fact that two papers in succession had been on electrical subjects. He considered it advantageous that Mr. Saunders' paper had been followed by the present one, as it helped the "mechanical minded" to become more "electrical minded" with the result that he did not feel quite so far out of his own sphere.

He had been much impressed by the indication given by the paper of the extent to which the use of alternating current on board ship had been developed since the time referred to by Mr. McLaren. This appeared to be specially the case in connection with auxiliary machinery, and the use of alternating current seemed to be recognised as a probable method of increasing economy in the use of electricity on board ship in place of direct current as used so largely at present.

He gathered from the discussion that one of the principal difficulties encountered in the employment of alternating current was that it must be generated at a constant standard, but the different requirements of the various auxiliaries for which it was to be used necessitated modification or regulation to meet these differences. Speaking from the mechanical standpoint, he wanted to know if that was due solely or primarily to the varying speeds required or to the methods of control required to meet the conditions of each machine in raising it from nothing to full load.

He had been rather surprised to hear the suggestion, mentioned more than once during the evening, that in manipulating certain pumps their operation could be facilitated by closing or partly closing the discharge valves. The mechanical engineer would be inclined to say that this was inviting trouble, but it appeared to be quite a practicable and recognised procedure with electrically-driven pumps as it had aroused no unfavourable comment. This procedure was, of course, only possible because of the use of electrical power.

The development of the use of alternating current for auxiliary purposes on board ship would simplify the problems of manufacture, because of the ready use of standard sizes and patterns of motors. The squirrel-cage motor lent itself admirably for this purpose as shown by the very simple and practical example exhibited by the author on the platform. This facility might have considerable bearing on the economics of marine engineering in the future, as indicated by some of the remarks made in a recent *article in the press by Mr. W. S. Burn, who, as they were aware, was awarded the Denny Gold Medal at the Annual Meeting last week.

Mr. E. G. Warne (Member) said that he thought he was correct in assuming that they were invited to consider the use of alternating current in three different classes of vessel, i.e. the average type of cargo ship, the tanker and the passenger liner. The speaker had thought when reading the paper that the best case which could have been made out was for the passenger liner, but Mr. Saunders seemed to introduce a lot of difficulties there. On examining the case for the tanker it would be found that the possibilities of the a.c. system in that direction were extremely limited by reason of the comparatively small number of auxiliaries. Cargo winches were not required and there was a tendency for the operation of the steering gear to be effected by exhaust heat, i.e. the steam engine. The third class, the cargo ship, was to the speaker's mind very important, and he doubted whether the author's proposition would apply to 50 per cent. of the tonnage in the mercantile marine. If the author admitted that a.c. was not suitable for driving ships' winches (and the author had suggested transforming a.c. back to d.c. for this purpose) then half the bottom was knocked out of his case.

Speaking as an engineer, therefore, he was rather inclined to think that it was not such a simple proposition, as a whole, as the author would lead them to believe.

The author mentioned, no doubt truly, that the electric hydraulic steering gear was the most popular form. Again, however, when proposing some development it was necessary to consider the current trend, and it seemed to the speaker that "all-electrical" steering gear was going to meet with approval.

* "The Marine Engineer", March, 1934, p. 78.

The author was suggesting an alteration which was extremely far-reaching. It had to be considered with the greatest care and would undoubtedly be so considered. Shipowners and engineers would bear in mind that they were being asked to make considerable alterations in their equipment and spares, while the attitude of their staffs was a point also, and although he was far from suggesting that progress could not be made on the lines the author had suggested, he thought they should consider *how* far they were prepared to upset the natural order of things as they had developed during the last thirty years.

Mr. T. Golding (Messrs. W. H. Allen, Sons & Co., Ltd.) said that he would have liked to have heard the opinions of marine operating engineers on the contention of the author that speed variations, etc., were not really required. He could not help feeling that marine engineers were asking for something necessary when they stipulated variable-speed motors, and if this were so the bulk of the author's argument was on a false basis.

He considered that it would be unlikely and unwise for marine engineers to sacrifice the many advantages they had from the use of variable speed motors even if the economy of cost, weight and electrical efficiency claimed by the author for alternating current installations were obtained, and as mentioned later he very much doubted if they really would be.

It would appear to be infinitely more simple and speedy for operating engineers to adjust the output of say a centrifugal pump by the usual procedure of operating the shunt field regulator than it would be if he had to climb to places often only reached with difficulty to close or open valves. The extreme simplicity of speed control of d.c. motors must be a great boon to engineers and there was at present no equally efficient and equally flexible control of a.c. motors available, for it must be remembered that the speed of a.c. commutator motors was only adjusted by actual work on the motor itself and this was often placed in a position where accessibility was not too good.

The author admitted the necessity for variable speed motors for such important auxiliaries as compressors, forced draught fans, winches, capstans, windlasses, auxiliary ventilating fans, etc., and suggested that these could be dealt with by the a.c. commutator motor. The motors for these duties, however, made up a very large part of the total motor load and if commutator motors were to be used for them, it appeared to him that the change of supply from d.c. to a.c. was not worth while, particularly as the a.c. commutator motor was notably far more troublesome and expensive to maintain than its d.c. counterpart. It would be found that if half of a ship's complement of motors were of the a.c. commutator type, the cost of maintenance would be higher than for a full complement of d.c. motors. It had been stated that the a.c. commutator motor was the brush maker's best friend.

The difficulty in regard to alternators running in parallel was quite correctly considered by the author to be of small magnitude under favourable conditions, but the speaker suggested that a very real difficulty would be encountered in this connection when turbines and Diesel engines both formed the prime movers of the power plant. The paralleling of an alternator driven by a Diesel engine with one driven by a turbine was something that most experienced power engineers would contemplate with fear and trepidation.

Mr. Watson had covered the ground extremely well and had put forward the case for both sides very fairly. The author, however, appeared to the speaker to have been rather unfair to the d.c. motors and equipment when taking out the weights and efficiencies. The efficiencies given in the table were perhaps efficiencies of commercial competitive machines, but they were very much lower than those put forward by many of the first-class marine motor makers at highly competitive prices. Similarly, in the case of the weights, the author had compared the industrial motor with the d.c. marine motor, and the latter was recognised to be a very much more robust machine. It was certain that if alternating current were to be tried out by first-class owners, the industrial a.c. motor would not find a place on their ship; they would require something much better, more on the lines of the high-class d.c. marine motor.

Mr. H. S. Carnegie (The English Electric Co., Ltd.) expressed the view that alternating current was coming more and more into the marine field.

The question of shock had been dealt with by Mr. Watson. One method for dealing with this which had been employed both at sea and on land, was to use very low voltages, especially in the machinery spaces, of about 25/30 volts for hand lamps. This enabled a very robust lamp to be used, while the danger of shock was almost entirely absent. He had seen a ship recently with hand lamps of this voltage in the machinery spaces. This low voltage was conveniently obtained with alternating current through a small static transformer.

As brought out by the author when dealing with squirrel-cage motors, for a generator driven by steam turbines the high speed was more suitable for alternating current. It was not so advantageous, however, with Diesel-driven alternators. The Diesel-driver alternator was rather larger in diameter and weighed more with its exciter than a corresponding d.c. generator. Notwithstanding this, there were many applications on board ship where the simplest type of motor, i.e., the squirrel-cage motor, could with advantage be used.

The use of the squirrel-cage motor raised the question of bearings. Most of these motors ran with a very fine air gap, which was of course a disadvantage, but this disadvantage was not apparent when ball or roller bearings were used. They had given great satisfaction on land and had entirely got over any possible difficulty of rubbing of the rotor against the stator.

The commutator motor, as emphasized by Mr. Golding, had certain disadvantages when compared with the d.c. motor. It cost more and weighed more, and he did not see a big field for this type on board ship because for the variable speed applications it would be better to convert to direct current the same as was done on land. This could be done quite well in rectifiers as well as by rotary converting plant. He thought it would not pay to put in commutator motors for variable-speed fan drives. A simpler and cheaper method was to use a slip-ring motor with resistance control in speed since this was more efficient at the top speed where most of the power was required, but less efficient at the bottom speed. The loss there, however, would be almost negligible since the power required by the fan fell off so greatly for lower speeds.

Another point was the question of "hum". With a.c. motors there was a tendency to more noise, and that might suggest the use of direct current in the passenger quarters and especially for lifts.

Automatic control gear and magnetic brakes were much more suitable for direct current than for alternating current. That was not meant to decry alternating current, but only to indicate that it would probably not be applied throughout. There were certain specific cases where its advantages were manifest.

A previous speaker had raised the question of the use of alternating current for electric steering gear. There seemed to be no difficulty about it; instead of a d.c. motor driving the motor generator set on Ward Leonard control an a.c. squirrel-cage motor would be substituted.

The illustrations might be of interest as they showed alternating current drives on board the British Tanker Co.'s vessels, which Mr. McKenzie had referred to, and which had now been in use for many years. Fig. 16 showed a 20 b.h.p. slip-ring a.c. motor driving a forced draught fan, the motor being of the totally-enclosed type but with pipe inlets arranged so that ducts could be added if required. Fig. 17 illustrated a circulating pump drive where the motor, again of the slip-ring type, was actually provided with inlet and outlet for ducting. Fig. 18 showed a 20 b.h.p. squirrel-cage motor for the hydro-electric steering gear. It would be noted also that these motors were provided with ball and roller type bearings of the sealed type.

In conclusion he would say that there seemed to be a big field for a.c. motors and the applications of the a.c. system on board ship; it would not be installed wholesale, however, but only for applications where it showed definite advantages.

Mr. J. H. Johnson (Messrs. Crompton Parkinson, Ltd.) said that the previous speakers had not referred to the voltage regulation and power factor, which were of considerable importance as these caused a large difference in torque of the auxiliary motors. It should be made clear, he thought, that under no circumstances should the auxiliary machine plant be operated from the main propelling generating plant. The whole object of using three-phase a.c. auxiliaries was simplicity and reliability of operation and, therefore, such machines as a.c. commutator motors should not be encouraged. This meant, if a.c. driven auxiliaries were to be successful, that it was essential to have the co-operation of the marine engineer to avoid, wherever possible, the use of variable speed motors, otherwise there would be no advantage in the change from direct to alternating current.

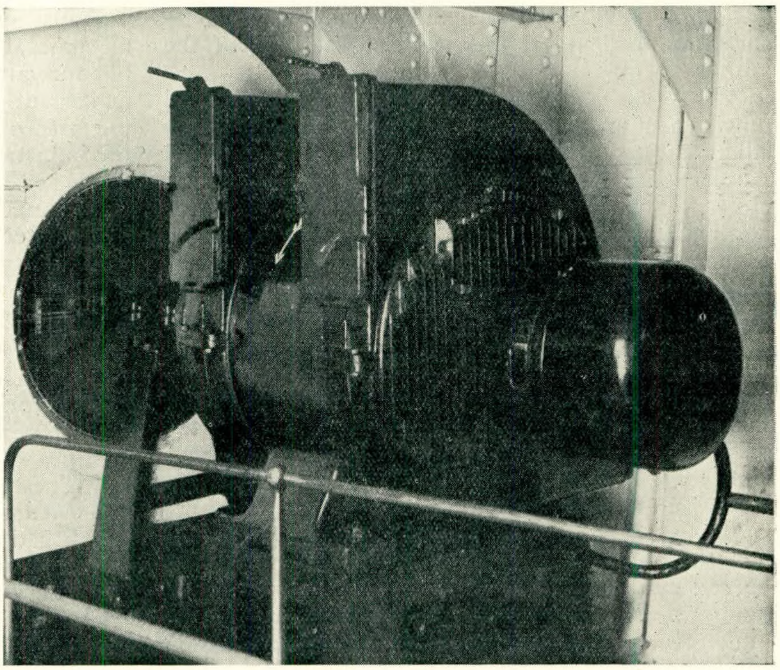


FIG. 16.

The voltage regulation was of importance as the torque of the motors varied as the square of the impressed voltage. If the pressure was to be kept constant, as it must be for the lighting, cooking and power circuits, automatic voltage regulators would be necessary in the engine room. This apparatus, however, was perfectly reliable in operation.

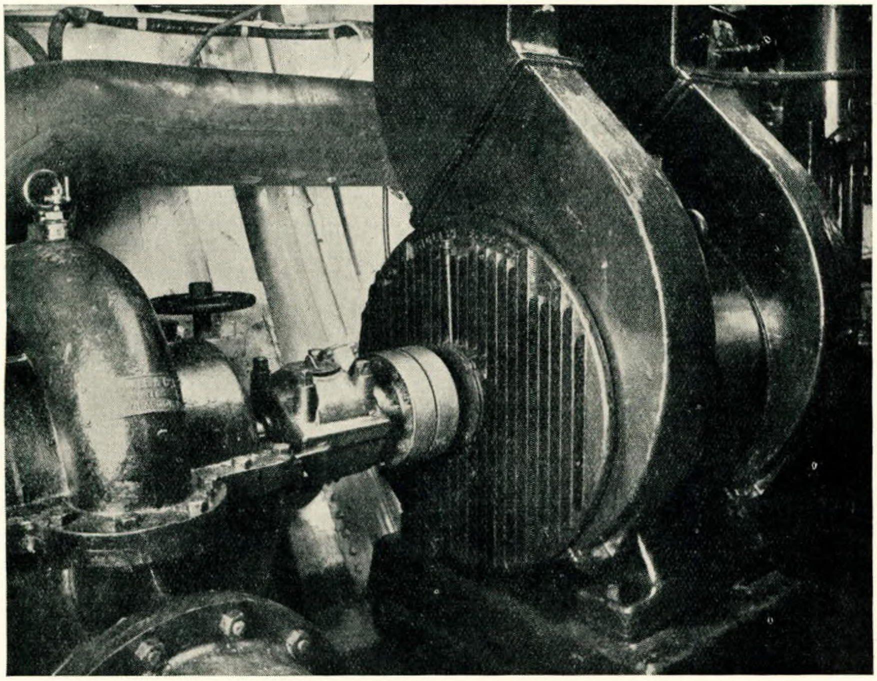


FIG. 17.

cargo ship, which after all was the most important, and when one considered that on these there were about twenty or thirty electrical winches, important windlasses, and a few capstans, it was clear that these were the items on board ship which needed the largest share of the power. If, therefore, direct current was required for these duties, could it reasonably be said to be worth while to install a.c. plant? Alternating current was not new, and it had taken the electricians many years to make it of any use on board ship.

He did not think any blame could be attributed to the marine engineer. If the electrical people could convince the shipowner that it would be advantageous to have alternating current on his ship carrying, say, 15 or 20 winches they might get somewhere. But it should be remembered that perhaps one, five, ten or even no winches at all might be working at any time, and if direct current was required for such a variable load he did not quite see any great advantage of installing a.c. plant for the small percentage of power required in the engine room.

The a.c. system often gave the advantage of using lamps at a lower pressure of, say, 110 volts and for use for cooking in the galleys and other similar places where dampness and moisture prevailed in confined spaces. It enabled the transmission to be carried out with the smallest size of cable to various positions in the ship and then distributed locally for the special circuits by means of the simple form of step-down transformer placed in any convenient position in the ship.

There was an obvious advantage with the constant speed squirrel-cage motor for driving steering gear with electro-hydraulic control and for other similar driving.

He hoped that marine engineers would give very careful consideration to the advantages of a constant speed a.c. motor and modify their requirements as regards variable speed machinery, similar to the developments which had been made by land engineers.

The Chairman said that he was not convinced the author had put up a case for alternating current. He was thinking of the ordinary

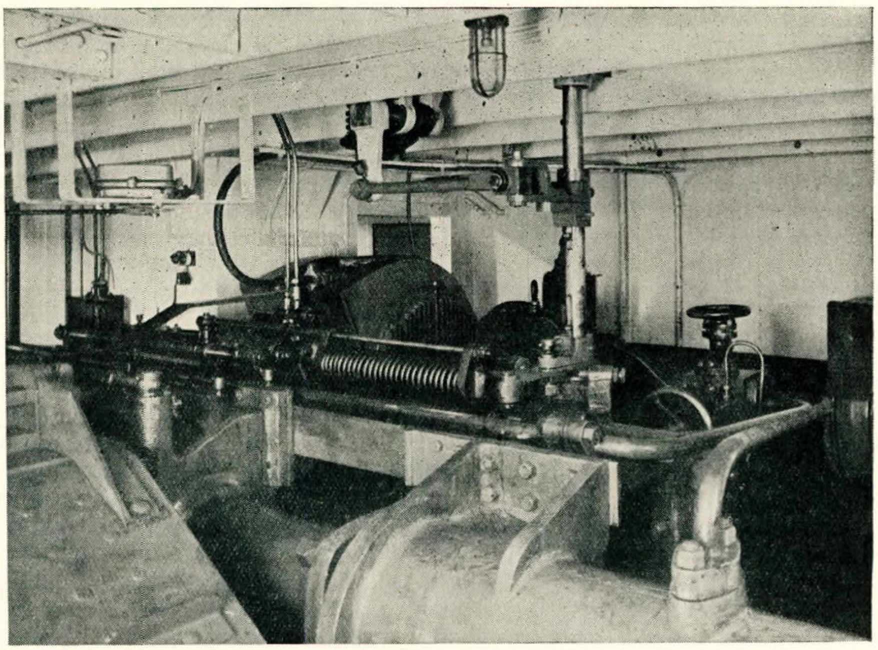


FIG. 18.

Mr. E. W. Green, O.B.E. (Member) proposed a hearty vote of thanks to the author. This was seconded by **Mr. F. M. Jones, B.Sc.** (Member) and accorded with enthusiasm. The author briefly replied.

By Correspondence.

Mr. W. Hamilton Martin (Member) wrote that he would like to ask one question in regard to a very important auxiliary drive on board naval vessels. He understood that on H.M.S. "Invincible", built in 1908 at Elswick and subsequently lost at the Falklands, electric training gear for the guns was installed and subsequently torn out and replaced by hydraulic gear because it could not be made to creep definitely and always overran. He did not know whether it was direct current or alternating current that was used, but it would be interesting to hear from the author whether he considered this could be successfully met to-day, or was such close control still too difficult a question? He knew that lifts could be quickly landed by automatic inching arrangements, but this was in no way to be compared with the onerous duties called for in hydraulic training gears for large guns. The hydraulic pumps were, of course, electrically driven, and as the last slide indicated alternating current could be used.

A great deal remained to be done it would seem before alternating current became as general as direct current on board ship.

Mr. R. H. Gough (Sunderland Forge & Engineering Co., Ltd.) wrote that Mr. Belsey's paper was suggestive and stimulating, even if one could not agree with all of his conclusions. Certain statements made and, more especially, certain facts which were not referred to, called for serious comment.

In the first place, it was not by mere chance or by being first in the field that the d.c. system was almost universal on board ship. The principles of alternating current had been thoroughly understood and a.c. machinery had been in use for the past forty or fifty years. During that time the a.c. system had admittedly made great strides on land installations, while direct current had correspondingly lost favour in the same sphere. All this was admitted, but it did not necessarily mean that marine engineers should adopt a similar policy. The conditions on board ship were so radically different and called for such special treatment, that those engaged in marine electrical engineering had found the direct current system to be essentially the more suitable for their purpose.

There was little doubt that the main factor in the displacement of the direct current system in favour of alternating current on land was the ease and simplicity with which it could be transmitted over long distance at high pressures with great economy in copper conductors and transformation, up or down, without the use of revolving machinery and consequent cost of attendance. This had been the principal factor and had outweighed certain disadvantages of alternating current application, the principal one, of course, being the comparative difficulty and expense of arranging variable-speed motors.

On board ship entirely different conditions prevailed. In the first place the distances of transmission were comparatively insignificant, and consequently the use of high voltages was neither necessary nor desirable. Even with the present-day standard voltage of 220 d.c., quite sufficient insulation difficulties were experienced, and to use higher pressures would involve much more expensive cables and increased cost in protecting live parts from the danger of shock or fire.

Another point which should be remembered when considering marine conditions was that the whole of the installation was contained in a moving steel structure, sub-divided by a number of steel bulkheads and decks. Some compartments had an ambient temperature which might be of the order of 150 to 160° F., and others might for weeks have an ambient temperature below freezing point. Further, cables and other electrical parts were subject to the risk of contact with sea-water, oily vapour and, constantly, to an atmosphere charged with salt and damp, all of which were conditions unfavourable to the use of high voltages.

The steel structure of the ship would present special difficulties in the distribution of alternating current on board. As was well-known, a single-phase conductor produced a rapidly alternating electro-magnetic flux in its vicinity, the effect of which was to cause local heating if the wire was passed through a hole in a steel plate or bar. This effect might be nullified by transmitting by three-phase conductors laid up into one cable. While this might be done from the main switchboard to certain selected sub-switchboards about the ship, it would be found necessary to split up at these boards into single-phase leads for lighting, small fans, heaters, etc. This involved the running of large numbers of single-phase conductors about the ship and, in many places, taking these through steel plates, decks, etc. To do this would necessitate cutting larger holes than would otherwise be necessary and bushing with non-ferrous material.

One point which Mr. Belsey had not touched upon in his scheme for providing a large number of induction motors throughout the vessels, was the bad effect these would have on the power factor of the installations and, without making exact calculations, it seemed probable that this would go down to something like 0·7 or even less. This was a serious matter, both from the point of view of generation and also transmission, involving, as it did, the provision of extra copper for the wattless current. It might, of course, be overcome by using condensers or a few synchronous motors, but these would greatly militate against the claims made of lower weight, cost and greater simplicity as compared with direct current.

It was somewhat difficult to follow Mr. Belsey's argument as to confining earths to the 110-volt section of the installation where, as he stated, they would only affect their own section and the whole ship would not be to earth. This seemed a rather dangerous theory from a fire protection point of view. Whether the earth showed upon the main switchboard or only on a sub-switchboard belonging to the 110-volt supply, it was still an earth and called for immediate attention. Even if the lighting services were taken from a four-wire system with earthed neutral, the same risk would apply as then the fault would be practically a short circuit and, if the fuse did not blow promptly, might have disastrous consequences.

Above all of the foregoing considerations loomed the question of winches and deck machinery. Mr. Belsey evidently appreciated the difficulty there but had no solution to offer except a converter to give the d.c. supply for this service which was so evidently necessary. He mentioned that "a motor generator set could be fitted".

In the first place, where was the owner who was going to rely on one motor generator to carry the whole of his cargo working plant, and run the risk of this breaking down and holding up his ship in port, possibly for weeks? Obviously a stand-by set would be essential. In vessels at present building there were twenty winches of 58 h.p. each, or 1,160 h.p. connected load. Allowing a load factor of 0.25, it would be necessary to provide for 290 h.p. at the winches and, taking into account the inefficiency of the motor generator set, two of these at 250 kW. each, or three at 125 kW., would need to be carried—no insignificant addition to the engine room equipment from the point of view of cost, space, or weight.

Mr. Belsey's reference to the British Tanker Co.'s vessels was interesting, but it should be remembered that these had been in commission for over ten years and the type had not been repeated, although many vessels with d.c. installations had since been ordered by these owners. Another important point to bear in mind was that alternating current was confined to machinery spaces and therefore the difficulties of distribution throughout the ship, already referred to, did not apply.

Taking everything into consideration, the case for changing to alternating current on board ships might fairly be said to be "not proven".

THE AUTHOR'S REPLY TO THE DISCUSSION.

The author, in reply, said that in general some of the criticism of his paper might be answered by suggesting that if the water-tube boiler had been invented and used on ships before the coming of the Scotch boiler, the advocates of the latter would have had a difficult time in getting it adopted. Imagine the arguments which could have been brought up against it; weight, space occupied for a given output, the devastating results of an explosion due to the large volume of water being released, etc. Similarly, if alternating current supply for auxiliaries on ships had been introduced first, direct current would have had a poor chance of being generally adopted. The author used the words "generally adopted", because as would be seen later in the reply to the Chairman's remarks, there were certain classes of vessels where direct current might be the most suitable form of electric supply.

The author thanked Mr. McLaren for his very interesting remarks, and it seemed a pity that his paper had not been more seriously considered.

In reply to Mr. Watson the author agreed that the slipring induction motor was inefficient if used as a variable speed machine by introducing resistances in the rotor circuit, but it was a very efficient machine if used as a constant speed. As far as the author could see, the only auxiliaries on a steam ship where variable speed was really essential were the forced draught fans, and it was only for these that he would advocate the use of a.c. commutator motors. The object of this paper was the elimination of commutators, and if a.c. commutator motors were to be substituted for direct current motors nothing would be achieved.

Regarding the circulating pump motor, which was as a rule the largest power consuming auxiliary on a steam ship, the author pointed out in his paper that a two-speed squirrel-cage motor would satisfy effectively all requirements of a steam ship sailing from this country to the East.

Regarding the danger of a shock, the author was of the opinion that if the power circuits were 440 volts and the hotel load on 110 volts, the danger of a shock would be less than with 220 volts d.c. throughout, for the reason that on the power circuits there would be nothing exposed that was alive. The hotel circuits being on 110 volts the danger of a fatal shock would be very remote. Very soon there would be no fatal shocks by direct current reported by the Home Office, for the simple reason that there would be little or no d.c. circuits from which shock could be obtained.

In reply to Professor Bryan, the author would say that with a double squirrel-cage motor full load starting torque could be obtained with two to two and a half times full load current, but with a slipring induction motor full load starting torque could be obtained with one to one and a quarter times full load current.

Regarding the use of a.c. commutator motors for propelling purposes, except in comparatively small machines, say less than 400 h.p., the commutator itself became a difficulty.

Replying to Mr. Saunders, the author did not think there would be any difficulty in balancing the circuits. After all, a passenger liner was nothing more than a floating hotel, and most of the larger hotels in London were supplied from a.c. mains and there was no difficulty in balancing the loads. The author was pleased Mr. Saunders agreed with him in that there was a case for a.c. auxiliary supply on many ships, and also the author agreed and in fact based his paper on the use of the simple, robust, trouble-free, squirrel-cage motor.

The author thanked Mr. McKenzie for his remarks, and congratulated him on his courage in breaking away from tradition by installing a.c. auxiliary machinery. With suitably designed machines there would be no difficulty in running Diesel engine-driven alternating current generators in parallel.

The author thanked Mr. Warne for his thoughtful remarks, but he considered Mr. Warne misunderstood Mr. Saunders. Mr. Saunders rightly pointed out that a number of points would require consideration if a.c. auxiliaries were fitted. Equally so, a new ship to be fitted with a d.c. equipment would require consideration.

The author replied to Mr. Golding's remarks by stating that the whole purpose of the paper was to get marine engineers seriously to consider if all this variable speed was not something of a fetish, and really unnecessary. Mr. Golding heard Mr. McKenzie say that from thirteen years' actual experience with alternating current auxiliaries he had not found the constant speed feature any disadvantage. Experience on land pointed in the same direction. Therefore, why waste money on a feature that in a great majority of cases was not really necessary?

Mr. Golding was not quite accurate when he stated that the author admitted the necessity for variable-speed compressors, forced draught fans, winches, windlass capstans and ventilating fans. Leaving out deck machinery there was only one of these duties for which the author admitted there was any real necessity for fine variable-speed adjustment, and that was the forced draught fans.

Regarding deck machinery, the author pointed out in his paper that this was a matter for consideration, but he did not doubt but what it could be satisfactorily solved.

Regarding the parallel operation of Diesel-driven alternators, the author also pointed out that his experience was that, providing two or more Diesel engine-driven alternators would run in parallel themselves, any or all would run in parallel with a turbine-driven alternator.

Regarding the matter of efficiencies as given in the paper, the author pointed out that these efficiencies were for ordinary industrial machines both a.c. and d.c. and he also indicated in the paper that these efficiencies could be improved with a little more cost. The same remarks applied to the question of weights.

The author thanked Mr. Carnegie for his remarks, which did not call for any comment as they were largely in agreement with the author's views.

The matter of noise was entirely a question of design, and if the designers were instructed to design the machines for noiseless operation they could do so.

The author thanked Mr. Johnson for his remarks, which also were largely in agreement with the author's views.

In reply to a communication from Mr. Hamilton Martin, as far as the author's knowledge went the electric training gear as fitted on H.M.S. "Invincible" was direct current, using a Ward Leonard control. Anyhow, the author would point out that the paper did not pretend to deal with special applications like the training of guns, but rather to deal with general principles. In this connection, however, it was of interest to note that the U.S. Navy were adopting alternating current for their auxiliary machinery in some of the later vessels.

In reply to a written communication from Mr. Gough, the author would point out that the worse the conditions were the more suitable was alternating current. Conditions on a ship could not be worse than conditions prevailing in a coal mine, but no one ever heard in these days of direct current being used in a coal mine.

Regarding the matter of earths, none of the speakers appeared to have any difficulty in following the author's arguments on this point, nor was there any suggestion by the author that an earth was not an extremely dangerous matter and should be cleared at once. Mr. Gough, however, the author was sure, would agree to the following:—

(*a*) That 95 per cent. of the earths which occurred on a ship were on the domestic supply circuits and apparatus.

(*b*) That there was a much greater liability for earths to occur on circuits and apparatus working on 220 volts than there was on 110 volts.

(*c*) That in the event of an earth it was much better to have this confined to a section rather than that the whole ship should be earthed.

With a d.c. installation if an earth occurred it was difficult to locate and isolate the circuit, but with transformer substations it would mean just simply cutting this section out until the earth was located, without disturbing the electric supply for the rest of the ship.

In reply to the Chairman the author pointed out that the paper was meant to apply to the large installations on passenger liners, where the winch load was important but was not the predominating feature as it was on the cargo liner, and therefore alternating current was not so attractive to this class of vessel and probably direct current would be more suitable.

In conclusion, the author reiterated that the commutator was inherently the weakest and most troublesome part of the electrical installation, and the idea underlying this paper was the elimination of the commutator.

INSTITUTE NOTES.

NEW YORK MEMBERS.

Dinner at The Engineers' Club.

We are indebted to our Vice-President at New York, Mr. James S. Milne, for the following report of a dinner which was held on Wednesday, March 14th, 1934, at The Engineers' Club, having been arranged by Mr. Milne in co-operation with the other local members of the Institute.

The guest of honour was Mr. Robert L. Hague, President of the Standard Shipping Company, subsidiary of The Standard Oil Company, and the following members and guests were present:—

Members.—Samuel Aitken, George Brown, William Compton, G. H. Gaskin, Robert L. Hague, H. J. Hartridge, John Heck, John Hudson, A. E. Jordan, J. H. King, Robert McGregor, James S. Milne, Joseph J. Nelis, Carl Petersen, A. E. Rowe and J. Herbert Todd.

Guests.—David Arnott (Chief Surveyor, American Bureau of Shipping), James French (Chief Surveyor for the United States and Canada, Lloyd's Register of Shipping), and Carl Klitgaard (Supt. of Construction and Repair, Standard Shipping Company).

The Toastmaster, Mr. Samuel Aitken, conducted the proceedings in a lively and humorous manner and kept the whole company in a happy mood from 6.30 until midnight.

The various speakers were unanimous in their loyalty and praise of the good work carried on by the Institute, many expressing their appreciation of the valuable technical information obtained from the TRANSACTIONS of the Institute, which are read and studied with the greatest interest.

The proceedings throughout afforded abundant evidence of a strong affection and admiration for the guest of honour, and clearly demonstrated that Mr. Hague occupies a unique position in the respect of his friends, both in America and abroad. In addition to carrying full responsibility for a fleet of over one hundred and fifty vessels, totalling nearly two million tons deadweight, he has built up one of the finest fleets of tankers in the world. This fleet, equipped with the latest developments of internal combustion and high pressure steam units, ranks with the best examples of operating efficiency at present afloat.

The admiration of all present for the humane side of Mr. Hague's career was particularly noticeable. Numerous incidents exemplifying his true and deep sense of humanity and his consideration for his fellow man, were narrated by some of those present who had been associated with him for nearly thirty years.

In the opinion of everyone present the dinner was an immense success, and many flattering comments were expressed to Mr. James S. Milne, Vice-President, and his fellow members on the Dinner Committee, Mr. Samuel Aitken and Mr. Robert McGregor.

It was agreed that the dinner should be made an annual or semi-annual event and that Mr. John Hudson be added to the present Committee with the intention of developing these meetings, in a selective manner, and using the occasion for the discussion and development of subjects particularly interesting and important to marine engineers. The Committee hope that there will be larger attendances at future meetings.

Members interested in these meetings or in other activities of the local members are advised to communicate with Mr. James S. Milne, at 401, Broadway, New York.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, March 19th, 1934.

Members.

George Andrew, 29, North Bridge Street, Airdrie, Scotland.

Archibald Balfour, 9, Woodhill Terrace, Gravesend, Kent.

George Brown, 31, Beech Street, Rutherford, New Jersey, U.S.A.

John James Carruth Buchan, Caradale, Grange Road, Newcastle-on-Tyne.

Ernest Davison, 28, Crondall Street, South Shields.

William Patrick Dowling, 86, Clyde Street, Island Bay, Wellington, N.Z.

Leonard Earl, c/o B.I. Engineers' Club, 15A, Kyd Street, Calcutta, India.

George Franc Fisher (Eng. Lieut., R.N.R.), c/o Marine Office, Kisumu, Kenya Colony.

William Westwood Forsyth, 5, Spring Crescent, Portswood, Southampton.

William James Frost, 46, Hopedale Road, Charlton, S.E.7.

James Peter Holden, Carn Brea, Norbury Grove, Hazelgrove, near Stockport.

Frederick John Linsdell, Glenesk, 324, Burgess Road, Southampton.

John Maitland, 20, Alexandra Drive, Surbiton, Surrey.

John McLeod Milne, 56, Vicar Street, Falkirk.

Carel Molenaar, 55, Jekerstraat, Amsterdam, Holland.

Joseph John Nelis, 1017, East 26th Street, Brooklyn, New York.

Athol O. M. Patterson, 49, Thornhouse Avenue, Irvine, Ayrshire.

Harold Guy Lee Pilditch, 26, The Park, Grimsby, Lincs.

Harold Ringshaw, 84, Lowther Road, Brighton, Sussex.

George Alwyne Ripley, 132, Rosslyn Street, Aigburth, Liverpool.

Robert Roberts, 552, Eastern Avenue, Ilford, Essex.
Reginald Shurly Rust, 7, Cadogan Road, Cromer, Norfolk.
Hedley Scott, 17, Barnfield Avenue, Shirley, Surrey.
Robert Stokle, 58, Moss Lane, Litherland, Liverpool, 21.
Charles Edward Milton Gray Strong, Sunnyside, Fishbourne, near Chichester, Sussex.
Henry Taylor, 7, Cedar Road, Darlington.
Maurice Wyndham Walter Weller, 32, West Park Road, Southampton.
Henry Dewar Wight, Elm Drive House, Leatherhead, Surrey.

Associate Members.

William Owen Butler, 18, Lonsdale Street, Anlaby Road, Hull.
Richard Edward Dore, Hotel Alexandra, Dovercourt, Essex.
Arthur Charles Efford, 6, Cotsford Avenue, New Malden, Surrey.
Robert Henry English, c/o Engineering Dept., Cunard S.S. Co., Ltd., Pier Head, Liverpool.
Alfred Gidney, 26, Westoe Parade, South Shields.
William Ernest Hayes, Synot House, 250, Selbourne Road, Luton, Beds.
Edmund Noel Michael Mitchell, 42, Belle-vue Road, Ramsgate, Kent.

Associates.

Thomas Devlin, 9, Burlington Street, Leith.
Norman Jolly, Basra, Norfolk Road, Lytham St. Annes, Lancs.
Harold Mackegg, 15, Repton Road, Orpington, Kent.
B. N. Mitter, 8/2A, Vidya Sagar Street, Calcutta.

Student.

Eric Samuel Smith, Holly Cottage, Freston, Ipswich, Suffolk.

Transferred from Associate Member to Member.

Bert Bateman, 25, Cecil Road, Rochester.
Robert James Blair, 35, Roxburgh Street, Greenock.
Horace Sidney George Kimber, Tamesis, Leasway, Westcliff-on-Sea, Essex.
Charles Hartley Delacourt Rogers, Langley Wood, South Hill Park, Bromley, Kent.
William Henry Smith, 14, Vansittart Terrace, Redcar, Yorks.
Paul Blomfield Sylow, 67, Gloucester Terrace, Lancaster Gate, W.2.
James Malcolm Whitton, 30, Shandon Place, Edinburgh.
Harold Napier Williams, Prospect, Rondebosch, Cape Town, South Africa.

Transferred from Student to Associate Member.

Thomas Percy Gibbeson, Wansbeck, Tynedale Avenue, Monkseaton.

List of those elected at Council Meeting held on Monday, April 9th, 1934.

Members.

William Alfred Corlett, 13, Elmsleigh Gardens, Cleadon, near Sunderland.
Frederick Braisby Gandy, 10, Windsor Terrace, Gosforth, Newcastle.
Murray Glover, c/o Red Ensign Club, Dock Street, S.E.1.
Lancelot Langan Hosey, The Association of Engineers, Singapore, S.S.
Sydney Peter Morris, 127, Kings Road, Brighton, Sussex.
Donald Lawrence Pitt, Brighton Resort, Waltair, India.
Thomas Walker, 17, Stockton Terrace, Grangetown, Sunderland.
William Frank Ward, 42, Gartmore Road, Goodmayes, Essex.
Sydney Benson Whalley, 10, Ripon Road, West End, Oswaldtwistle, Accrington, Lancs.

Associates.

Clarence Arthur Clench, 33, Park Lane, South Harrow, Middlesex.
Mervyn Mowbray Greve, St. Philips, Station Road, Dehiwala, Colombo, Ceylon.

Transferred from Student to Associate.

Carlo Smoquina, 73, Hillfield Drive, Heswall, Cheshire.

ADDITIONS TO THE LIBRARY.

Purchased.

Reports of the Progress of Applied Chemistry, Vol. XVIII, 1933, containing the following:—

"General, Plant, and Machinery", by Hampson and Vowler.
"Fuel", by Hodsman, Spivey, Milner and Blakeley.
"Gas, Destructive Distillation, Tar and Tar Products", by Foxwell.
"Mineral Oils", by Nash and Bowen.
"Colouring Matters and Dyes", by Rodd and Piggott.
'Textiles, Fibres, and Cellulose", by Withers.
"Pulp and Paper", by Harrison.
"Bleaching, Dyeing, Printing and Finishing", by Speakman.
"Acids, Alkalis, Salts, etc.", by Parkes.
"Glass", by Robertson.
"Refractories, Ceramics, and Cement", by Lynam and Rees.
"Iron and Steel", by Hudson.
"Non-Ferrous Metals", by Powell.
"Electro-Chemical and Electro-Metallurgical Industries", by Wernick.
"Oils, Fats, and Waxes", by Hilditch.
"Paints, Pigments, Varnishes and Resins", by Members of the Oil and Colour Chemists' Associations.
"Rubber", by Dawson.
"Leather and Glue", by Atkin.
"Soils and Fertilisers", by Crowther.
"Sugars, Starches, and Gums", by Eynon and Lane.
"The Fermentation Industries", by Hopkins and Norris.
"Foods", by Elsdon.
"Fine Chemicals, Medicinal Substances and Essential Oils", by Stedman.
"Photographic Materials and Processes", by Horton.
"Sanitation and Water Purification", by Garner.

The British Corporation Register of Shipping and Aircraft. Register of Ships, 1934.

Statutory Rules and Orders, 1934, No. 184. Load Line (Amendment) Rules. H. M. Stationery Office, 4d. net.

Instructions as to the Survey of Passenger Ships engaged in special trades in the Far East—Sub-division, Life Saving Appliances, and Fire Appliances. H.M. Stationery Office, 6d. net.

List of the Principal Acts of Parliament, Regulations, Orders, Instructions, Notices, etc., relating to Merchant Shipping issued prior to the 1st January, 1934. H.M. Stationery Office, 6d. net.

Notes on the Grants to Research Workers and Students (revised February, 1934). H.M. Stationery Office, 2d. net.

King's Rules and A.I. Amendments (K.R.2/34). H.M. Stationery Office, 1d. net.

The Use of Derrick Cranes. Home Office Safety Pamphlet No. 15. H.M. Stationery Office, 6d. net.

Deterioration of Structures in Sea-Water. Fourteenth (interim) Report of the Committee of the Institution of Civil Engineers. Department of Scientific and Industrial Research. H.M. Stationery Office, 1s. 6d. net.

"The Stock Exchange Official Year-Book, 1934". Published by Thomas Skinner & Co., Gresham House, Old Broad Street, E.C.2. 60s. net.

"Universities Year Book, 1934". G. Bell & Sons, Ltd., 15s. net.

"Principles of Mechanism", by F. Dyson. Oxford University Press (Humphrey Milford), 12s. net, post free 12s. 6d.

"Engineering Knowledge (Vol. II)". Containing all the latest questions set for Steam and Motor Certificates. By Setford, Stevenson and Elsby. Published by The College of Engineering. 18s. 6d. net.

The "Shipping World" Year Book, 1934. "The Shipping World" Offices, Effingham House, Arundel Street, Strand, W.C.2. 25s. net, post free.

Presented by the Publishers.

Diesel Engine Users Association publications:—

"Report on Heavy-Oil Engine Working Costs (1932-33)".

"Small Marine Diesel Engines", by O. Wans.

Transactions of the Society of Engineers containing the following papers:—

"The Modern Cinema", by Hall and Hough.

"Glass Bottle-making Machinery", by Gutteridge.

"A New Automatic Radial Sluice Gate", by Shenton.

"Nasmyth: Father and Son", by Wilkie.

"Reinforced Concrete—Its Application to Modern Housing", by Kaylor.

The following British Standard Specifications:—

No. 109-1934. Air-Break Knife Switches and Air-Break Isolating Switches for voltages not exceeding 660 volts.

No. 124-1934. Totally-enclosed Air-Break Switches for voltages not exceeding 660 volts.

No. 215-1934. Hard-Drawn Aluminium and Steel-Cored Aluminium Conductors for overhead Power Transmission Purposes.

"Modern Heavy Oil Engines and their Lubrication". Shell Mex, Ltd.

"Experiments on the Compression of Samples of Deck Plating and the Application of the Results in relation to the Thickness of such Plating in certain conditions of Loading". Paper by Dr. James Montgomerie, read on 8th April, 1934, before the Japan Society of Naval Architects.

"Schools, 1934". Published by Truman & Knightley, Ltd., 61, Conduit Street, London, W.1.

The present year's edition of this most useful and comprehensive guide to the scholastic facilities of Great Britain, like its predecessors, is a model of excellence. Since its inception early in 1924 a steady level of constant progress in the work has been maintained, and each issue has been marked by some additional feature calculated to render more simple the task of a parent or guardian who turns to its pages for information regarding a school.

"Motorshipping in 1933", by A. C. Hardy. Published by "The Journal of Commerce". 7s. 6d. net.

The success of the new form of Mr. Hardy's diarised impressions of the motorship industry published last year has led him wisely to present his retrospective survey of 1933 in a similar work.

As is now well-known, this work comprises the weekly impressions of motorshipping development which the author contributes to the columns of the Shipbuilding and Engineering Edition of "The Journal of Commerce". Major developments of the year are recorded and the principal ships which have been completed during the year are discussed and illustrated. The book can be said to view the motorshipping industry from an international standpoint and, while present trends are tabulated, an attempt is made to show the way which future trends will take.

"Heat-Power Engineering", by Barnard, Ellenwood and Hirshfeld. Part II., Steam Generation and Prime Movers. Chapman & Hall. 34s. net.

This book is now in its third edition and has been completely re-written by the two first named authors. It is intended as a text-book covering the main apparatus in steam power plants and is the second volume of a series of three. The work deals chiefly with structural and operating principles as applied to steam prime movers and steam generating apparatus. The field covered is a somewhat extensive one, dealing as it does with almost the whole range of modern steam practice including steam turbines, nozzle design and efficiency, engine governors and valve gears, fuels and combustion, exhaust gas analysis, heat transmission, furnace design and construction, boilers, superheaters, re-heaters, economisers, etc.

The book comprises some eight hundred pages of facts and data which are correlated with the most up-to-date research experiences. One is particularly gratified to notice a very complete reference to the transactions and reports of the various learned institutions, a procedure which cannot fail to be of the greatest use to the earnest student, because obviously in a work of this character some of the treatment must perforce be scanty.

Although dealing principally with steam work, a small chapter, which is nevertheless very well written, forms a useful introduction to internal combustion engine work. One is also glad to notice that due regard has been paid to the economics of steam generation and that in this connection the authors have dealt with principles instead of quoting numberless figures which are rapidly rendered obsolete.

The general arrangement, sketches and graphs are very well conceived. The examples are taken principally from American practice, but at the same time due regard has been paid to modern British features, and this makes the book particularly suitable for reference purposes. The authors state that it was written principally for college use and whilst the price and scope are both somewhat too big to make it suitable for technical school work, it should find a place in the reference libraries of up-to-date schools.

To sum up, the book can be well recommended; it can be read with facility and generally the authors and publishers are to be congratulated on presenting so much useful information in the limits of one volume.

"The Atom", by John Tutin, D.Sc. Longmans, Green & Co. 6s. net.

Some twenty years ago Lord Rutherford, as a result of a series of experiments which he carried out, suggested a certain picture of the structure of the atom. He thought that the atom might consist of a comparatively heavy nucleus, around which smaller particles were spinning. Under this system atoms of all the elements are similar, the difference between them being only in the number of electrified particles or electrons, forming the outer planets of this solar system.

Since Lord Rutherford first developed this theory many scientists all over the world have carried out experiments and made calculations, all of which appear to confirm the truth or partial truth of it, but there are certain differences in the behaviour of the elements and many experimental results which have not been so far capable of explanation by the Rutherford theory.

It has been necessary, for instance, to assume that the explanation of certain known facts is that the ordinary laws of cause and effect cannot be applied when considering the structure and behaviour of the atom. Now this is a very important matter from the general point of view, because the moment we admit that an effect may be without a cause and the result of pure accident, we must admit the possibility of the accidental nature of life itself. It is difficult for the engineer to imagine that scientists have accepted the hypothesis that one can have an effect without a cause, but it is only recently that Jeans and Eddington have drawn attention to the fact that physicists had denied Sir Isaac Newton's words that "the main business of natural philosophy . . . is to deduce causes from effects till we come to the very first cause, which is certainly not mechanical".

It must not be thought that Dr. Tutin's book deals primarily with the philosophical aspect of the present theory of the atomic structure. Indeed this is only a secondary consideration, but it serves as an example of the almost unlimited possible results of a new theory which he puts forward. He examines the origin of Lord Rutherford's theory and he shows that when it was developed there were two alternative arrangements of the atom, both of which would satisfy the known facts. One—that the atom might have a heavy nucleus with lighter particles around it, such as Lord Rutherford suggested, and the other that the heavier particles might be outside the nucleus. Dr. Tutin suggests that this latter arrangement is the true one and that if the protons and electrons are arranged in this way, it is possible to explain the hitherto unexplainable difference between the atom of one element and another. On the Rutherford theory, for example, the atom of carbon, which is supposed to have six planetary electrons, differs in almost every conceivable physical and chemical respect from that of nitrogen, but the only difference between the supposed atomic structure of the two elements is that nitrogen has seven planetary electrons against carbon's six. Dr. Tutin explains how by reconstructing the various atoms on his system such differences are not only explicable but to be expected, and an example of the uncanny way in which he has applied the theory is in the explanation of why the steel, developed by Sir Robert Hadfield in 1883, is non-magnetic. Sir Robert Hadfield discovered experimentally that a certain percentage of manganese rendered iron non-magnetic and, although many scientists have sought for an explanation, it has not been forthcoming until now, when Dr. Tutin shows why it is so and why a certain proportion of manganese will render iron non-magnetic.

Again it has been known for some time that certain alloys which contain no magnetic constituents may be highly magnetic. Dr. Tutin explains why this should be so.

These examples are sufficient to indicate the almost unlimited possibilities which are opened up if this theory is sound and, although the average reader can hardly judge the value of many of the examples which are given, he can understand their implications.

Prof. Frederick Soddy, the greatest authority on the atomic structure after Lord Rutherford, in an introduction to the book, says: "If in regard to useful practical knowledge the new view provides a working hypothesis where the old theories are worse than useless, it will be assured of a welcome".

The book is clearly and interestingly written. It is not "popular science", but to anyone with a scientific turn of mind, the development of the argument is fascinating.

BOARD OF TRADE EXAMINATIONS.

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

Name.	Grade.	Port of Examination.
For week ended 15th March, 1934:—		
Huxtable, Frederick J. ...	2.C.	Cardiff
Cowan, Andrew McM. ...	2.C.	Glasgow
Mackenzie, Hugh	2.C.	„
Nicolson, George	2.C.	„
Couper, John G.	2.C.M.	„
Stevenson, James	2.C.M.	„
Smith, Charles H.	2.C.	Liverpool
Wakeham, Eric R.	2.C.M.	„
Moar, John	2.C.	Newcastle
Nevill, John H.	Ex.1.C.	London
Cleghorn, Thomas G. ...	2.C.M.E.	Newcastle
Gibbs, Thomas H.	2.C.M.E.	Liverpool
For week ended 22nd March, 1934:—		
McAllister, George	1.C.	Glasgow
Robertson, William	1.C.	„
Wallace, William M. ...	1.C.	„
Allison, Norman J.	Ex.1.C.	Liverpool
Collin, Ronald B.	1.C.	„
Edwards, Charles L. ...	1.C.	„
Evans, Evan A.	1.C.	„
Milligan, Robert B.	1.C.	„
Jackson, Ernest L.	1.C.M.E.	„
Balls, Robert M.	1.C.	Newcastle
Christison, George	1.C.	„
Gandy, Frederic B	1.C.	„
Calamel, Joseph M.	1.C.M.E.	„
Bateman, Bert	1.C.	London
Burrow, Norris	1.C.	„
Crockett, William N. ...	1.C.	„
Frost, William J.	1.C.	„
Shivas, John S.	1.C.	„
Whittaker, Howard P. ...	1.C.	„
Johnston, George	1.C.M.E.	„
Potter, Frederick E. ...	1.C.M.E.	„
Hadley, Richard E.	1.C.M.E.	Cardiff
Connelly, James R.	1.C.M.E.	Liverpool
Frood, John K.	1.C.M.E.	Glasgow

Name.	Grade.	Port of Examination.
For week ended 29th March, 1934:—		
Auger, Edwin C. B. ...	2.C.	London
Hayes, Cornelius J.	2.C.	"
Hopkins, Cecil A.	2.C.	"
Wilkinson, James A. ...	2.C.	"
Alder, Arthur A.	2.C.	Newcastle
Chell, Charles E.	2.C.	"
Stewart, James	2.C.	"
Brown, Richard H. ...	2.C.M.	"
Bulmer, James B.	2.C.M.	"
Coxon, Gordon	2.C.M.	"
Broad, Lewis L.	2.C.	Liverpool
Brown, William S. R. ...	2.C.	"
Cummings, John A. ...	2.C.	"
Dodds, Wilfred M. ...	2.C.	"
King, George A.	2.C.	"
Peat, Septimus A.	2.C.	"
Bowman, John H.	2.C.M.E.	Newcastle
Crumley, William F. F. ...	2.C.	Glasgow
Lorkin, Frederick C. ...	2.C.	"
Mackie, John	2.C.	"
Middlemiss, Richard A. ...	2.C.	"
Ritchie, Henry C.	2.C.	"
Coyne, Robert B.	2.C.M.	"
MacKay, Thomas McB ...	2.C.M.	"
McLean, Allan	2.C.M.	"
Moore, Thomas J. A. ...	2.C.M.	"
For week ended 5th April, 1934:—		
Arnold, Harry	1.C.	London
Bisset, James R.	1.C.	"
Brown, Thomas F. C. ...	1.C.	"
Devereux, Norman	1.C.	"
McMullan, George	1.C.	"
Ryder, Frank	1.C.	"
Webb, William J.	1.C.	"
Wootten, Harold W. ...	1.C.	"
Lane, William H.	1.C.M.	"
Kennett, Charles	1.C.	Dublin
McMurtry, William	1.C.	"
Allison, James W.	1.C.	Glasgow
Beatts, William K.	1.C.	"
Beauchamp, Claud W. ...	1.C.	"
Innes, Alan	1.C.	"
MacDonald, Dennis M. ...	1.C.	"
Niven, John	1.C.	"
Peat, Stephen J. W. ...	1.C.	"
Russell, Charles S.	1.C.	"
Forsyth, George	1.C.M.	"
Butterworth, Bryce K. ...	1.C.M.	"
Kerr, William	1.C.S.E.	Glasgow
McArthur, James	1.C.M.E.	London
Blakelock, Robert S. ...	1.C.	Newcastle
Clayton, Charles S.	1.C.	"
Dale, Frank R.	1.C.	"
Dodgins, Robert N.	1.C.	"
Hill, Henry	1.C.	"
Johnson, Alexander	1.C.	"
Musther, George H. ...	1.C.	"
Oliver, Thomas V.	1.C.	"
Robertson, James	1.C.	"
Charlton, John	1.C.M.	"
Young, Wilfred	1.C.M.	"
Gemmell, Henry M. ...	1.C.M.E.	"
Hetherington, Harry J. ...	1.C.M.E.	"

BENEVOLENT FUND.

The Committee gratefully acknowledge receipt of the following donations:—W. W. Buckton (Member), 10s. 6d.; C. W. Ferdinands (Member), £1 1s.; W. E. G. Wallace (Member), 2s.; J. L. Coates (Member), 10s.

JUNIOR SECTION.

Steel Tube Manufacture.

A lecture on the above subject, illustrated by an excellent series of films, was delivered at the Institute on Thursday, March 15th, 1934, by Dr. J. W. Jenkin, Director of Research, Tube Investments, Ltd. The chair was occupied by Dr. S. F. Dorey (Vice-President), and a large audience of Junior and Senior Members and visitors listened with close attention to the lecturer's fluent and comprehensive survey of present-day practice in the manufacture of steel tubes for general industrial purposes. A discussion ensued, to which the lecturer replied, thereby adding considerably to the already valuable instruction imparted by his talk and by the film demonstration.

A cordial vote of thanks to Dr. Jenkin was proposed by Mr. K. P. Harman, seconded by Mr. H. R. Tyrrell, and carried with enthusiasm.

ABSTRACTS.

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

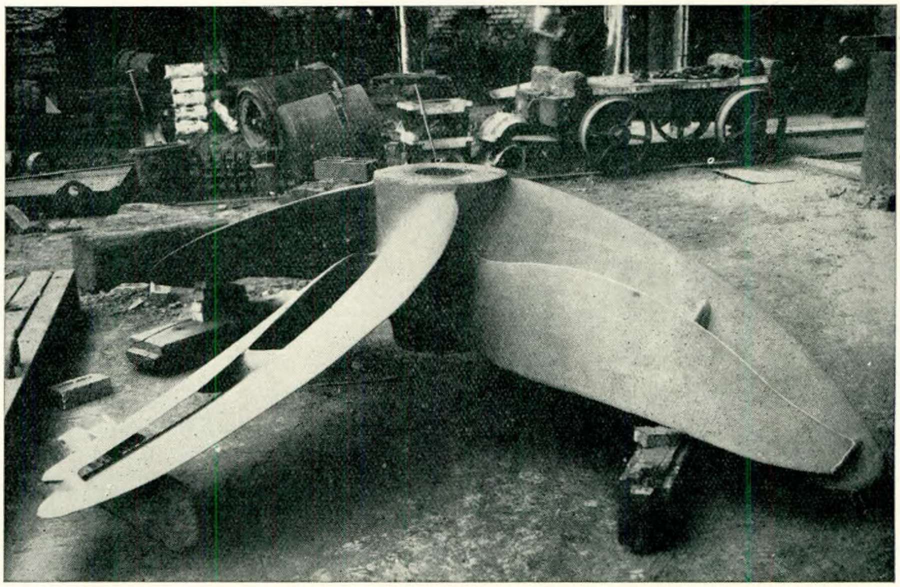
A New Unislip Propeller.

"The Marine Engineer", February, 1934.

In the Unislip propeller the aerofoil blade sections are designed to suit the particular wake conditions pertaining at that radius with a view to obtaining a higher overall efficiency than is possible when an average wake value is assumed for the propeller as a whole.

Recently a new design has been introduced which has already been applied to a number of vessels of various size. It will be seen that what are virtually double blades are employed. Each of the blades comprises a primary and a reaction blade which differ not only in relative size and shape, but also, and to a very large extent, in pitch distribution, and the nature of streamlining of the blade cross-sections, which are of aerofoil form.

As is generally known, the action of an ordinary screw propeller blade is accompanied by the formation of a vortex created by the flow of water past the back of the blade. The existence of this vortex requires no proof, as not only is it scientifically known, but actual photographic records have been made of the vortex being formed at the back of the blade near the following edge. Moreover, such everyday occurrences such as excessive pitting of cast-iron screws in this region of the blade serve as a rough indication of the



existence of vortices which tear the metal away from the face of the blade.

In the Unislip Turbo screw, the reaction blade is interposed in the region of vortex formation, which causes the flow past the back of the primary blade to be deflected into the channel formed between the back of the primary blade and the driving face of the reaction blade. The cross current thus formed prevents the formation of the main vortex, and by this means a large amount of energy which is normally wasted in setting a mass of water in rotation is utilised to a more useful purpose, namely that of increasing the fore and aft thrust.

This principle of operation is associated with a complex pitch variation on both the primary and the reaction blades, the object being to operate each element of the blade surface, whether situated on the primary or the reaction blade, at optimum efficiency, thus following the principle which the same designers adopted in developing the original Unislip propeller.

As regards the strength of the propeller, the primary blade is made strong enough to take the full load, and the reaction blade is of equivalent strength to the primary blade. As the illustration shows, the blades are also connected by webs; the propeller is actually stronger than an ordinary screw for the same conditions.

Baffleless Thimble-tube Boilers.

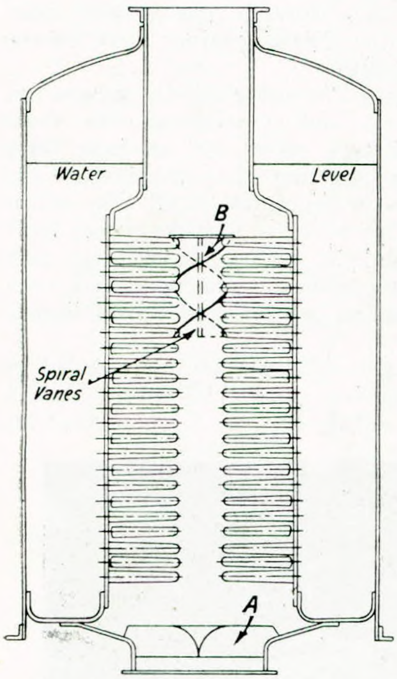
"The Marine Engineer", April, 1934.

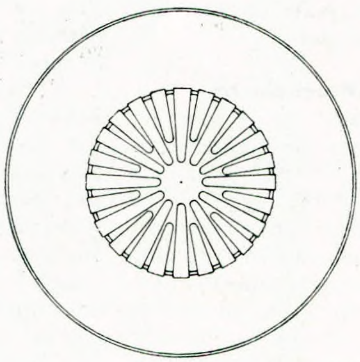
The firm marketing Baffleless thimble tube boilers have made available skeleton drawings of an elevation, section and sectional expansion of a baffleless waste-heat boiler for a motorship, Figs. 1, 2 and 3. These drawings illustrate quite clearly the manner in which opportunity has been taken, by an ingenious arrangement of the tubes, to ensure thorough combing of the complete section of the tube space, without the waste of any space in the provision of a central obstruction.

At first sight the invention which has brought about this improvement has the appearance of being very elementary, but close study of the following points serves to confirm that there is a considerable amount of careful planning involved in these baffleless boiler proposals. Consider Fig. 4, showing a section through one of the combing tube rows, and it will be noted that there is practically no parallel part in the spaces between adjacent tubes in that row, and, further, that there are certain spots at which definite angular constructions appear in the plan of the interspaces. These constructions arise partly as a result of the presence of different sizes and lengths of the tubes, but more particularly from very careful planning of the profiles of the individual tubes.

Successive rows of tubes are angularly rotated relative to one another, and from Fig. 3, which shows an expansion of the tube intersections with a cylindrical surface, a short distance from the tube plate, it will be seen that the disposition of the tubes of different sizes is so managed that the gas is encouraged to make a zig-zag path through the tube space as it rises.

From Fig. 2, in conjunction with Fig. 1, it might appear that the gas is assured of an easier path straight up through the centre of the boiler than it is along the outer circumference of the tube space. This is true, but with the reservation that the sectional area of this comparatively easy path is quite small compared with the sectional area of the whole tube space. Further, the designers have deliberately made a point of ensuring the gas an easier passage for some distance up through the centre of the boiler for the purpose of stimulating the generation of steam at the closed ends of the thimbles, it being a well-recognised principle of thimble-tube steam generation that the most effective results are achieved by concentrating the heating effect at the point in order to accentuate the impulsive or piston-like action of the steam as it is generated within the tube. A further incentive to this point generation of steam in the thimbles individually, is given by a lengthening of the parallel part of the longer thimbles and a sharpening of the rate of taper, so that instead of the thimble





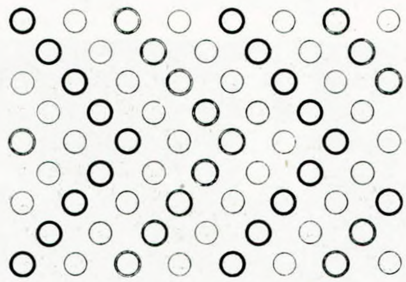


FIG. 1.—Sectional elevation of a Baffleless boiler showing the devices, at A and B, introduced to promote gas turbulence. FIG. 2 (Upper).—Showing the disposition of the long and short tubes. FIG. 3.—Arrangement of tubes for turbulence.

having a uniformly progressive rate of change of heating-surface to water-content along its length, this ratio jumps up suddenly as the thimble passes from the parallel tube form to the sharply tapered end section. There is also a distinct improvement in the ratio heating-surface over water-content in the tube as a whole as compared with a uniformly tapered tube of the same nose diameter, and an even greater improvement in comparison with a uniformly tapered tube of the same total water content. These geometrical factors are of considerable importance, and may be simply confirmed by reference to Fig. 4. They indicate important directions along which changes have been made in comparison with thimble-tube boilers of older type having annular tube spaces.

The two devices A and B (Fig. 1) have been introduced especially to cause turbulence. The spiralled vanes introduced into the throat of the gas inlet are pitched in the opposite direction to the pitch on the zig-zag arising from the arrangement of the tubes, and shown in Fig. 3, and they have the effect of throwing the gas into conflict with these larger tubes at the outset of their path. This effect is akin to that produced by the slats introduced ahead of cold tube nest in certain experiments.

As the gases ascend through the boiler, the changes of direction of main tube flow and the discontinuous manner in which the spaces between adjacent tubes vary in size, combine to disturb the placidity of the gas flow to the maximum possible degree, a fact which is made very obvious by superimposing several sets of tube rows, each displaced rotationally, and noting the haphazard manner in which channels present themselves for the passage of the gas. There can be no doubt, after making this test, as to the efficiency of these new designs in promoting turbulence. Such turbulence leads to cooling of the hot gases by the passing of their heat into the water in the thimble tubes, and this in its turn leads to the creation of a tendency for the hotter gas, which has been flowing more easily up past the thimble points, to be drawn towards the shell of the tube space as it nears the upper part of its passage.

The addition of the device B at this stage, confirms this tendency and accelerates the turbulence of flow through the final few rows of tubes, by setting up a tangential and outward impulse which again directs the stream of gas against the line of the large tubes. The device B may be regarded as being similar to an ordinary tube retarder but formed of a double element. Both A and B are attached to suitable central members,

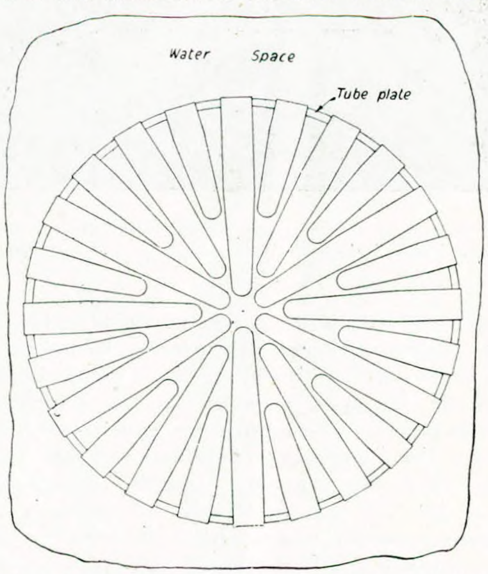


FIG. 4.—Section through a Baffleless boiler showing tube arrangements.

and being simply of light narrow plate section, are easily placed and retained in position.

City of Vernon, California, Diesel-electric Generating Central Station.

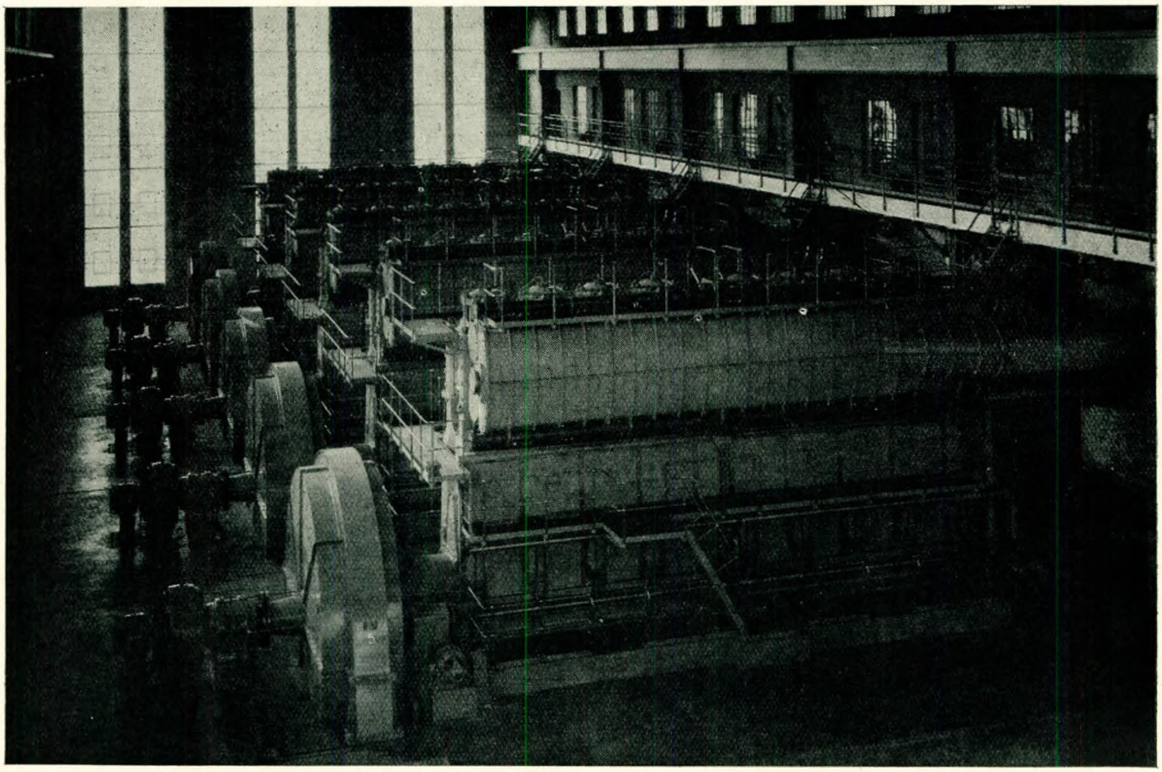
By Howard McCurdy, Chief Engineer to the Department of Light and Power, City of Vernon, Cal., U.S.A.

"Gas and Oil Power", January and February, 1934.

The construction of a large Diesel-electric generating central station for the City of Vernon, California, has created a great deal of interest and comment because of its size and choice of prime movers. Vernon is a city which is exclusively industrial in character, containing 360 factories and commercial institutions such as steel, paper and lumber mills, oil refineries, packing houses, cold storage, ice, tile, pottery and chemical plants, drop forges, machine shops, foundries, furnaces, flour and cotton seed oil mills, etc. Because of the nature of the industries, it can be realized that the selection of oil engines for this service speaks well for the increasing confidence in this class of prime mover for stationary plants. Quite significant is the fact that Southern California is served by many modern steam and hydro-electric plants. The completion of Boulder Dam and its power plants will further flood this market with cheap excess power. To protect the industries of the City of Vernon and furnish low power rates without high taxation, Diesel engines were chosen to meet this competition.

The building provides space for the present five 7,000 b.h.p. Diesels and generators with room for an additional two units, the machine shop together with the starting air compressor and storage bottle. Large windows on all side of the generating room provide a maximum of light. Because of the sunlight, diffusion glass was used which breaks up the intensity and spreads it over the entire room making it an unusually well-lighted engine room.

Being the largest Diesel engines produced by an American builder, the Hamilton M.A.N. 7,000 b.h.p. units installed in the Vernon plant are worthy of a little close study. Each of these units, rated at 6,850 b.h.p. are of the airless-injection type and have eight double-acting, two-stroke cycle cylinders with a bore of 24in. and a stroke of 36in., which gives a mean effective pressure of 66lb. per sq. in. At the standard engine rotation of 167 r.p.m., the piston speed of 1,002ft. per minute is conservative in view of modern materials and design. It is worthy of mention that with the firing order chosen all forces originating in the rotating and reciprocating masses are entirely balanced, consequently the engine runs without noticeable vibrations; no



A striking view of the five 7,000 b.h.p. Hamilton-M.A.N. two-stroke cycle double-acting airless-injection engines and Allis-Chalmers alternators in the new City of Vernon, Cal., municipal power station, the largest of its kind in America.

critical vibrations occur anywhere near the operating range.

Fuel from the day tank is delivered to the engine injection pump by gravity. The injection pump is of the by-pass control constant-stroke type. The amount forced through the discharge valve depends upon the timing of the by-pass valve, all of which are actuated by a control shaft and oil servomotor. The latter is under control of the engine governor which is driven from the crank-shaft.

The maximum compression is 446lb. per sq. in. for both upper and lower cylinders, while the scavenging air pressure is approximately 2lb. per sq. in. at all loads. Of the heat resulting from fuel combustion in the engine at full load, the allocation is as follows:—

	B.Th.U.'s	%
Engine shaft (net h.p.) ...	16,500,000	36·3
Cooling water	11,800,000	26·0
Exhaust gases	15,400,000	33·7
Friction, radition, etc. ...	1,800,000	4·0
	45,500,000	100·00

The net efficiency of 36·3 per cent. proves the perfect combustion and scavenging of these double-acting, two-stroke Diesels. The exhaust gas analysis reveals that at full load the air charge is over 250 per cent. of the theoretical amount needed for combustion, and the volume of air handled by the blower, 27,000 cub. ft. per min., is but 7 per cent. more than the cylinder volumes, indicating an exceedingly low loss due to air short-circuiting from the scavenging ports to the exhaust ports. The fuel consumptions shown by the shop tests are exceptionally good.

Scavenging Air Supply Arrangements.

Since the five 7,000 b.h.p. Diesels in the Vernon plant are of the double-acting two-stroke type, means other than the movement of the pistons is needed to clear the cylinder of exhaust gases and recharge them with fresh air for the next cycle. Flexibility and capacity dictated the employment of separately-driven centrifugal blowers for that purpose, of which there are five, one for each engine. In keeping with the basic requirement that the maintenance of the engine be kept at the lowest possible level, clean combustion air was essential and since the sandy nature of the surrounding soil and semi-arid climate make air pollution by dust of some moment, all air is first cleaned before it reaches the blowers. The space between one side of the engine room and the boiler room was formed into an air well. In this space are located five scrubbers to clean the air of all dust. Water washers were chosen since the water reduced the air temperature and permitted the handling of a greater weight of air by a blower of given dimensions.

Recovering Waste Heat.

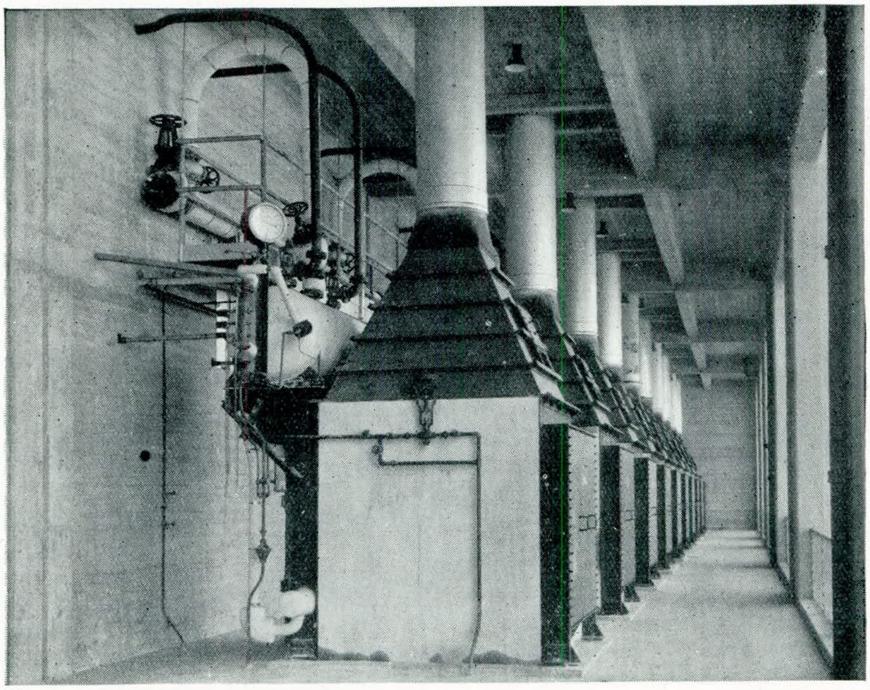
Engineers will find in the Vernon exhaust system ideas of wide adoption. While there have been many devices installed in Diesel plants to supply make-up water from the exhaust heat, the Vernon installation is the first in the United States where a modern system of evaporators has been applied. The installation of the evaporators, which will give far more distilled water than will be needed for cooling water make-up, was predicted on the prospect that all the available distilled water could be sold.

Each of the engines is equipped with two headers leading from the exhaust manifolds, one serving the top and the second the lower ends of the engine cylinders. These pipes, which are jacketed with rock-wool to reduce radiation losses, pass horizontally over the oil-equipment pits between the blower rooms to the bases of ten silencer-type, water-tube, waste-heat boilers, the lower ends of these boilers being below the ceiling of the evaporator floor. Each boiler consists of a steam drum designed for a working pressure of 100lb. per sq. in. gauge. To this drum are connected steam generating elements consisting of 2in. 11-gauge seamless steel boiler tubes. The portion of these tubes placed in the path of the exhaust gases is covered with cast iron extended surfaces in the shape of gilled rings. This surface presents six times the heat-absorbing surface per lineal foot that would be presented by the bare steel tubing. The boilers may be operated as mufflers and without containing any water, provided the gas temperature does not exceed 750° F. The mean operating condition is considered 87½ per cent. of the engine load. Steam generation is based on a curve submitted to the city authorities showing expected capacities of the boiler. There are 96 heating elements per boiler, the length of each heating element in the gas passage being 6ft. 6in., and the total heating surface 1,872 sq. ft. The volume of water in the boiler is 36½ cub. ft., the efficiency of the boiler being designed at 62 per cent. At 50lb. absolute pressure and 87½ per cent. rating, the boiler horsepower developed will be 65 and the temperature of the gases leaving the boiler about 370° F.

The connecting exhaust pipe extends through the box to help the silencing, and is slotted for gas emission. The water tubes are in the section above the floor, from which they are accessible for repairs without staging. The "cat-walk" extends behind the boilers at the drum level. The steam discharge bends rise over the cat-walk and down to the steam header, which is supported between the cat-walk and the wall. A vertical rise is made by the exhaust through the boilers and stacks overhead. The latter are supported on the boiler-room roof, with slip sections supported on the boilers and telescoped in the exterior stacks.

Part of the steam generated is used to heat the fuel oil and lubricating oil prior to centrifuging and to supply the evaporators. This brings the evaporator system, already mentioned, into the picture. To obtain the distilled water for cooling water make-up and other purposes, an evaporator system was installed thereby doing away with the necessity of scaling the boiler tubes.

For cooling the engine cylinders and pistons, distilled water is circulated through the heat-exchangers, where the heat is absorbed by water in the secondary system, to be later given up in the cooling tower. As a result of the double-circuit cooling water system adopted for the Vernon plant, pure water only is circulated through the engine jackets and pistons, with the make-up water supplied by the evaporator system already described. The raw water available in August at Vernon had a permanent hardness of 11 parts per million, a causticity of 0, and an alkalinity of 10 pH, but the characteristics vary with the season, so that the employment of raw water directly was deemed inexpedient.



Battery of Foster-Wheeler water-tube-type waste-heat boilers at Vernon.

It was estimated, and test results showed a remarkable agreement, that the cooling system would need to remove 14,420,000 B.Th.U. per hour from each engine under full load conditions. It was highly desirable, furthermore, to hold the temperature rise of the water passing through the engine to a normal value of approximately 25° F. These were the conditions about which the cooling system was designed.

The engine circulating water is stored in a closed rectangular concrete reservoir in the yard. This reservoir is divided into two sections, only one section being in use at a time. Each section has a capacity to provide 10 min. retention. The water passes from one end through the pump suction header loop to the engine circulating pumps.

Each engine has two single-stage centrifugal pumps, a 5in. for cylinder and a 4in. for piston and generator cooling, both connected to a common motor of 50 h.p. capacity mounted between them. While the pumps have a common suction header they discharge into separate systems, each cylinder water pump has a capacity of 770 g.p.m. and the piston water pump is rated at 480 g.p.m., at 90 and 110ft. head respectively. In addition to the five, there is a spare unit.

From the engine, the generator, piston, and cylinder water lines join again in a common discharge line which rises up the blower room wall to the light well floor, where the water passes out to a common loop return header, thence by gravity to the heat-exchangers in the yard to the end of the storage basin opposite from the suction end. The heat-exchangers serve each engine, but any of the groups of two may operate with any of the five engines. Raw water flows through the tubes in two passes with the jacket water flowing around the tubes in two passes. The shell passes are separated by an insulated baffle, which prevents by-passing of either liquid or heat.

The cooling towers have two suction basins, both connected to a loop line which passes back of the pump room in a header for the tower, or raw water pumps. The tower pumps discharge into a loop header located in the pipe trench, one end of which passes under the rear stairway and the other through the west basement wall to form a header in front of the heat-exchangers. From the heat-exchangers another loop is formed around the front of the cooling towers, with branches to each tower section. All the forced-draught cooling towers are constructed in one continuous structure, with divisions for each engine.

Fuel System.

The fuel oil handling system is provided with all the accessories needed to insure that clean fuel reaches the engine. To permit the purchase of oil in economical quantities, two tanks, one of 399,000 and the second 630,000 gals., are located outside the building. Fuel is received over a spur track in tank car lots. It flows by gravity to the oil pump house, which is constructed separate from the main building and which contains all pumps and centrifuges for fuel oil and the lubricating oil transfer pumps.

On one side of the room is located the fuel oil unloading pump along with the motor-operated edge-type filter, one centrifuge with space for an additional one, a day pump to by-pass the centrifuges in emergency, and a dead front switchboard. The unloading pump is a 3in. single-stage, double-suction centrifugal with horizontal split shell, designed to handle 250 gals. of fuel oil per minute, with the oil having a specific gravity of 0·91 at 60° F. The total head is 40ft., which the pump develops at 1,450 r.p.m. To drive this pump, a 5 h.p. motor is direct-connected to the pump shaft. Oil leaving the pump is forced through the edge-type filter, which has 0·01in. spacing, into the storage tanks. A motor-driven cleaning element on the filter keeps the filter edges clear of grit and dirt.

As with all the other sections of the Vernon plant, the lubricating oil system has been designed with an eye to economy and reliability. The lubricating oil is received by tank cars and transferred by a gear pump to storage tanks located in the yard. The same transfer pumps that unload the cars to storage, pump the lubricants to the plant. The cylinder oil is pumped from yard storage to a 400 gal. tank located on the roof of the waste-heat boiler room. From this tank the oil is piped by gravity to a header under the cat-walk behind the engines; from here it is piped to the lubricators on the engines. The operators fill each lubricator by turning on spring valves. For cold weather the roof tank is provided with a steam coil connected to the steam header of the waste-heat boilers.

The bearing oil is pumped to the individual sump tank of each engine for its first filling or refill. For make-up, the oil flows by gravity to 10 gal. batch measuring tanks and thence to the sump tank. Each engine has an individual crankcase oil system, the equipment of which is located in alcoves between the blower-rooms, on the water pump room level.

The generators are directly connected to each of the 7,000 b.h.p. Diesels of 7,500 kVA 7,200-volt, three-phase, 50-cycle, 167 r.p.m., 80 per cent. power factor, alternating current generator. Each generator is provided with direct-connected, 70kW., 250-volt, shunt-wound main exciter and a 4 kW. compound-wound pilot exciter, both of which are located outside the outer bearing of the generator shaft. The rotor of each generator is made to supply the entire flywheel effect required to give uniformity of motion and successful parallel operation. The rotor spider, therefore, is a substantial welded structure. The poles are bolted to the spider rims for convenience and accessibility, plates are placed between the spider arms to eliminate windage. Pressure needed to force air through the machine, as well as through the air coolers, is produced by fans attached to the spider rim.

The "Rupa" Coal Dust Motor.

By Rud. Pawlikowski, Dipl. Ing.

"The Internal Combustion Engineer", November, December, 1933, January, 1934.

The "Rupa" internal combustion motor normally uses powdered coal or ground vegetable matter as fuel, but can also be operated as a Diesel motor burning gas oil or other fuel oil. It can be built as a single- or double-acting machine for operation on either the four-stroke or the two-stroke cycle.

Four-stroke Cycle Operation.

The motor is generally started by means of compressed air, as in the case of Diesel motors. The starting air is cut off after about three strokes, the powdered coal valve being opened at the same time. The events during successive strokes are then as follows:—

First Stroke.—The piston draws atmospheric air into the main cylinder through an intake valve. At the same time, the requisite quantity of powdered coal is drawn into an ante-chamber *a* (Fig. 1) through two valves *g* and *h* from the two chambers *d*.

Second Stroke.—The air-intake and fuel valves being closed, the cylinder charge is compressed to about 32 atmos., 450° C. (842° F.) by the kinetic energy of the flywheel, as in Diesel motors. Some of the hot compressed air is driven through the holes *b* into the cloud of dust in the ante-chamber. Combustion of dust occurs to the extent permitted by the oxygen in the air present, and this results in an increase of pressure so that the pressure in the ante-chamber reaches about 82 atmos. at the end of the compression stroke in the main cylinder.

Third Stroke.—As the piston again moves downward, the partially burnt powdered coal is driven, by the pressure in the ante-chamber, through the holes *b* into the main cylinder, where it finds sufficient hot air for complete combustion. This is, of course, the working stroke of the cycle.

Fourth Stroke.—The exhaust valve opens and the returning piston expels the products of combustion.

Several distinctive features of this cycle should be noted. The fuel is introduced into the ante-chamber simultaneously with the air in the main cylinder. Both materials are compressed during the compression stroke but they remain separate (except for the air entering the ante-chamber) up to the end of the compression. The powdered coal is not deposited on any surface on to which it can cake, but is maintained in suspension. In due course its ash, also in suspension, is carried out by the exhaust gases.

This series of events represents a substantial improvement on the Diesel cycle, in which the fuel oil is injected at the end of the compression stroke and must be atomised, heated, gasified and ignited in a very small fraction of a stroke. The time available for the corresponding events in the Rupa motor is at least 10 to 15 times as long, viz., the whole compression stroke, thus affording ample opportunity for the ignition of the less readily ignitable fuel. The ignition lag in the Rupa motor occurs during the compression stroke and therefore does not affect the working of the machine.

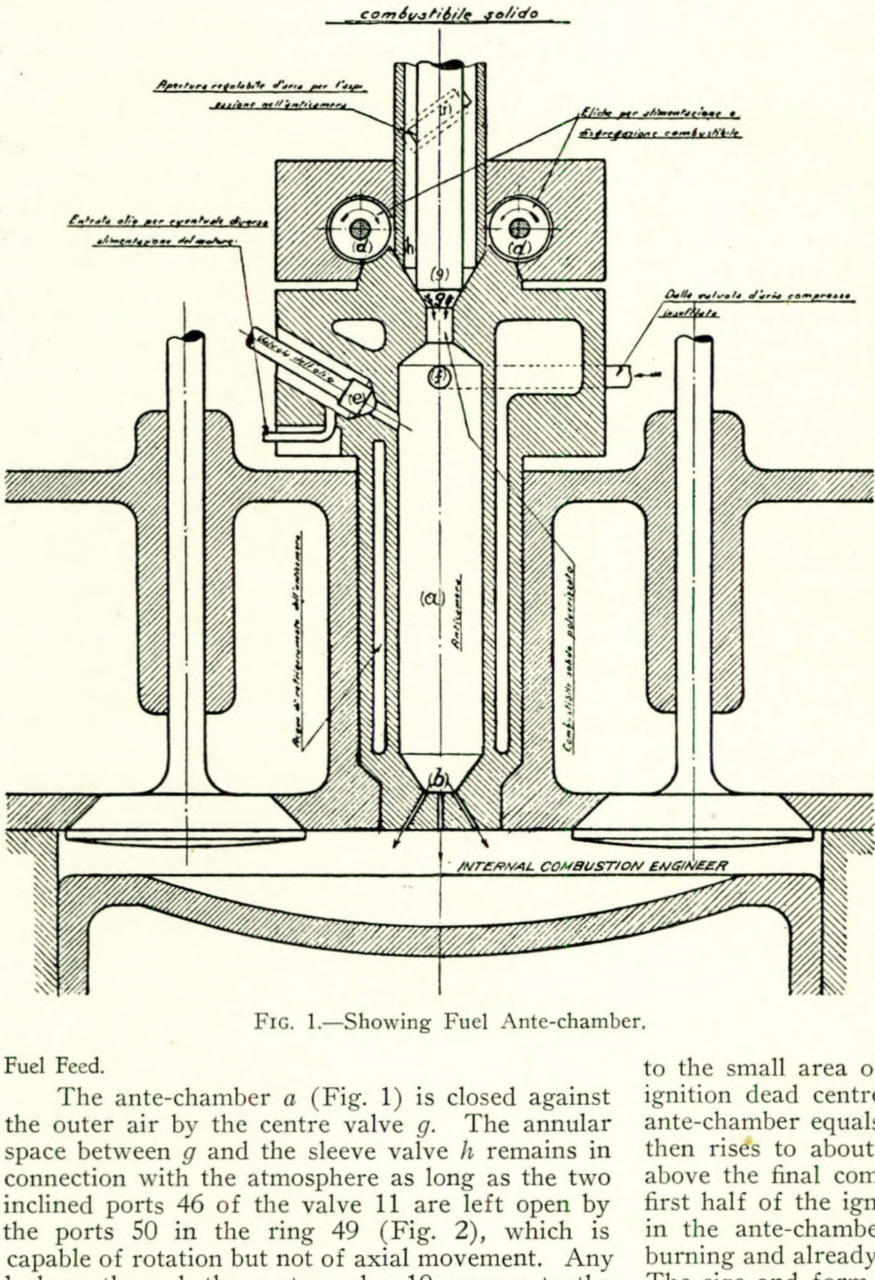


FIG. 1.—Showing Fuel Ante-chamber.

Fuel Feed.

The ante-chamber *a* (Fig. 1) is closed against the outer air by the centre valve *g*. The annular space between *g* and the sleeve valve *h* remains in connection with the atmosphere as long as the two inclined ports 46 of the valve 11 are left open by the ports 50 in the ring 49 (Fig. 2), which is capable of rotation but not of axial movement. Any leakage through the centre valve 10 escapes to the open air, and cannot reach the powdered coal space 53.

For the charging of the ante-chamber, the valve gear first opens the centre valve 10 and air flows into the chamber 3 until the collar 52 on the rising centre valve engages with the shoulder of the sleeve valve 11 and lifts the latter, thus closing the ports 46 against the ring ports 50 after an adjustable period depending on the initial displacement between the two sets of openings. In other words, the adjustment of the ring 49 determines the quantity of intermediate air admitted between the centre valve 10 and the sleeve valve 11 and, therefore, the maximum pressure of the ignition in the main cylinder.

The governor mechanism regulates the lift of the sleeve valve 11, the amount and duration of the lift increasing with the load on the motor, so that a corresponding amount of coal may pass from the space 53 or from the two agitator-screw chambers *d* (Fig. 1) into the ante-chamber. The agitator screws can produce the necessary air pressure in *d*. In the latest Rupa motors, however, the agitator screws have only a hand crank; the vacuum in the ante-chamber during the suction stroke is sufficient to draw in the powdered coal in a state of suspension.

In due course the sleeve valve *h* and 11 (Figs. 1 and 2) closes the coal space *d* and 53, but the centre valve *g* and 10 remains open for a short time, during which air blows over its seating, removing the last traces of coal and ensuring tight closing of the valve.

Combustion and Governing.

The pressure in the ante-chamber during the compression stroke lags behind that in the main cylinder owing to the small area of the holes *b* (Fig. 1). At the ignition dead centre, however, the pressure in the ante-chamber equals that in the main cylinder, and then rises to about 82 atmos., or about 50 atmos. above the final compression pressure. During the first half of the ignition stroke the excess pressure in the ante-chamber drives its contents, partially burning and already highly heated, into the cylinder. The size and form of the ante-chamber have been

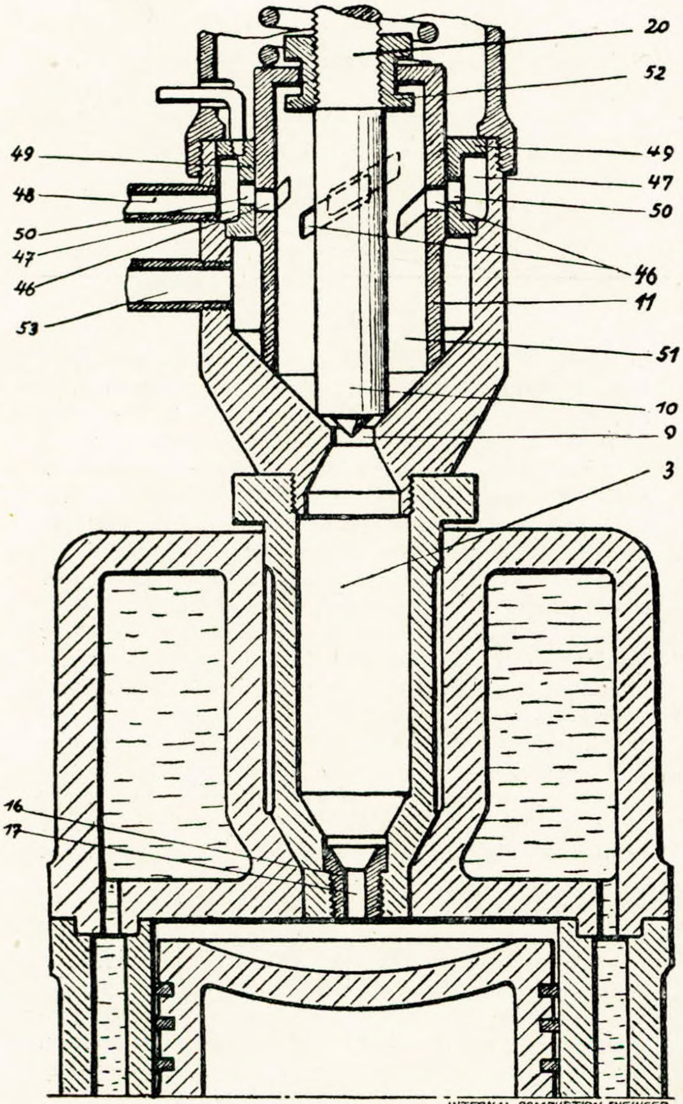


Fig. 2.—Showing Fuel Control Gear.

determined, after prolonged trials with about 500 different constructions, so that ignition commences exactly at the dead centre, as shown by the indicator diagram (Fig. 4) with 48 atmos. maximum pressure after four charges of compressed air.

The heavier the load on the engine, the earlier and longer the governor opens the sleeve valve *h* (Fig. 1) during the suction stroke. To this end, the horizontal rack of the governor displaces a pinion nut 2 (Fig. 6) on the stem of the sleeve valve *h* (Fig. 1) downwards as the load increases, and upwards as the load decreases. The charging valve lever 3 (Fig. 6) thus lifts the valve *h* to varying extents, admitting each time the quantity of fuel corresponding to the governor position.

The accuracy with which the very small charges of fuel are measured is shown by the 50 diagrams in Figs. 7 and 8. Each charge ignites fully and with certainty, so that on gradually changing from full-load to light-load the ignition curves lie exactly alongside each other.

The charging valve lever 3 (Fig. 6) can be lowered about the point 5 to such an extent that the charging valve is no longer lifted. This adjustment, required when the motor is to be changed over to oil, can be made without stopping the machine.

Running on Oil.

By means of an ordinary oil pump, liquid fuel can be injected, at an angle with the cylinder axis, through the atomising nozzle e (Fig. 1) in the ante-chamber. The injection can be timed to occur at practically any instant during the suction or compression stroke, thus providing a considerably longer period of preparation for the combustion of the oil than can be obtained in a Diesel motor.

It is also possible to use oil and powdered solid fuel simultaneously, the faster-burning fuel then accelerating the combustion of the slower-burning material. For example, Fig. 9 shows how Indian coal from Lahore, of low gas and high ash content, is burnt rapidly with an ignition pressure of 41 atmos. by aid of gas oil. On the other hand, oils which ignite with difficulty can be burnt more readily in conjunction with brown coal.

The Rupa motor can be started with coal or oil, and it can be changed from one fuel to another —*e.g.*, from coal to gas oil and back again, coal to vegetable meal or *vice versa,* or one kind of coal to another, with or without ignition oil—while the engine is running and without interruption of working.

Injection Air.

The Rupa motor can work with or without air injection. The passage *f* (Fig. 1) of the air injection valve 6 (Fig. 6) terminates in the ante-chamber. Control is provided by the lever 7 (Fig. 6), which enables the camshaft to be adjusted in a segment 8 by means of the hand screw wheel 9. The injection air, at a pressure of 45 to 60 atmos., cannot enter until the pressure developed by ignition has fallen below this value by flowing from the ante-chamber to the main cylinder. The action

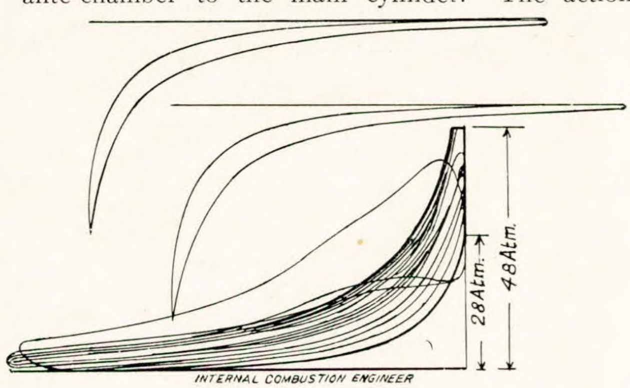


Fig. 4.

of the injection air is then to augment the ante-chamber blast and to accelerate the combustion of the residual fuel. If the motor is to be used without air injection, the eccentric 10 (Fig. 6) can be turned by the spindle 11 on starting or during operation so that the injection lever 7 no longer engages the valve spindle at 6.

High-speed Airless Injection Motor.

The Kosmos Co. has hitherto fitted its stationary Rupa motors of the 160 to 260 r.p.m. class with air injection valves in order to make possible trials with the most diverse fuels. On the other hand, a high-speed portable unit must be as light and simple as possible, and the Company therefore arranged the machine shown in Fig. 10

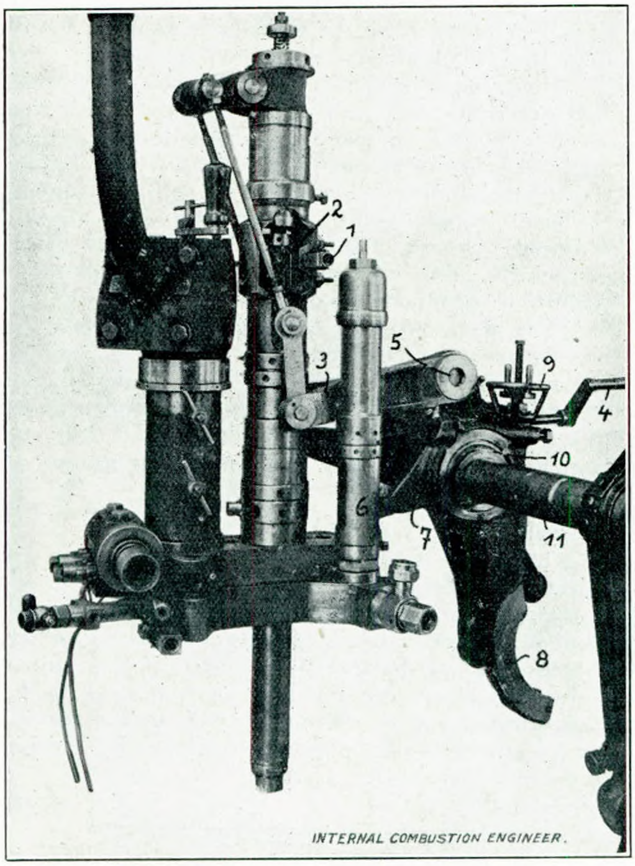


Fig. 6.—Fuel Control Gear.

without an injection air pump. A horizontal Deutz-Diesel motor of 190mm. cylinder diameter by 320mm. stroke ($7\frac{1}{2}$ by $12\frac{5}{8}$in.) 400 r.p.m., without compressor, was fitted with the water-cooled ante-chamber 2. The coal lies in the two chambers 4, in which agitator screws are unnecessary, the suction of the main piston being sufficient, in this instance, to draw the fuel into the ante-chamber. The centre valve 1 and the sleeve valve 3 are opened by two co-axial pressure-oil pistons during the suction stroke. The pressure-oil is oscillated

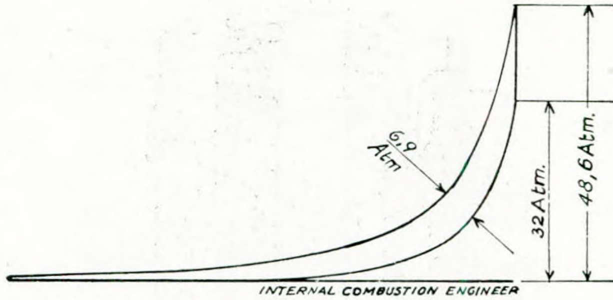


Fig. 7.

in a tube 58 by a pump 63 (Fig. 11) with an amplitude determined by the regulator 68; alternatively, the oil can be diverted into the pipe 59 by the lever 73 if the charging valve is to remain stationary.

The sharp seating edge of the centre valve 1 (Fig. 10) keeps the ante-chamber 2 closed during the compression and ignition strokes. The variable lift of the sleeve valve 3 regulates the amount of the coal feed from 4 according to the load. The centre valve travels downwards alone for about 3mm. ($\frac{1}{8}$in.) before it engages with the sleeve valve and closes the intermediate air gap 6. The ante-chamber 2 is cleared on opening, *viâ* 5 and 7, and draws in fresh air as long as the sleeve valve 3 remains closed at the beginning of the suction stroke and again at the end of the latter until the centre valve is closed. The intermediate air 5 thus keeps clean the seating of the centre valve, and also influences the ignition pressure to a considerable extent.

The ante-chamber discharges horizontally in the machine axis to the main cylinder *viâ* 9 and has, under the fuel valve, an adjusting piston 8 which enables the ante-chamber volume to be varied while the machine is running. In the continuation of the passage 9 there is an injection nozzle 10 through which the standard Deutz pump injects gas oil when this fuel is employed.

The motor ignites satisfactorily the most varied fuels, such as brown coal, hard coal without the assistance of oil or other ignition agent, powdered peat and gas oil, even when the speed is raised to about 500 to 550 r.p.m. No provision is made in this machine for the use of injection air.

The lubrication of this particular engine offers difficulties, but no changes were introduced because

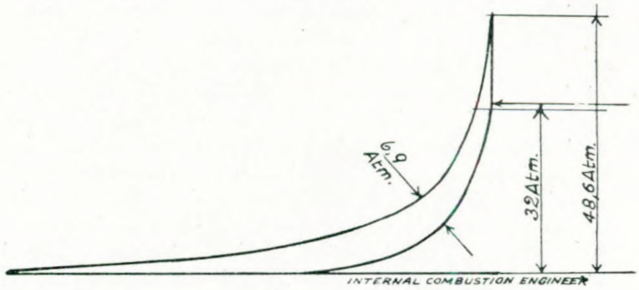


Fig. 8.

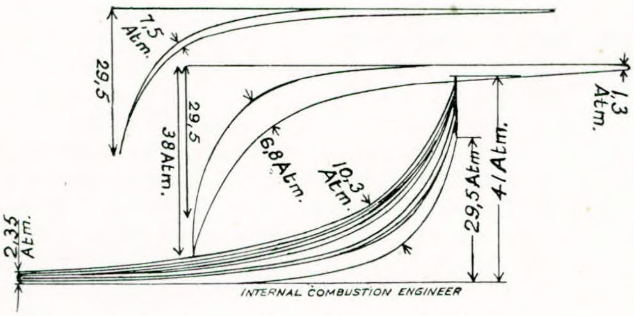


Fig. 9.

the lubrication problem has been completely solved in the other five Rupa motors. Also, this machine is not economical in fuel when operating as a Rupa motor because the exhaust and air suction valves are operated by the same cam, with the result that the air intake commences at about 45° crank angle, which is too late for the Rupa cycle. Nevertheless, the tests on this small engine fully realised the primary purpose of the conversion and showed that—

(1) The new ante-chamber ensures satisfactory ignition and reliable running even with small cylinders of only about 9 litres (0·32 cub. ft.) swept volume.

(2) By suitable design of the ante-chamber and regulation of its volume by means of the adjusting piston, good diagrams can be obtained nothwithstanding the different ignition characteristics of various fuels.

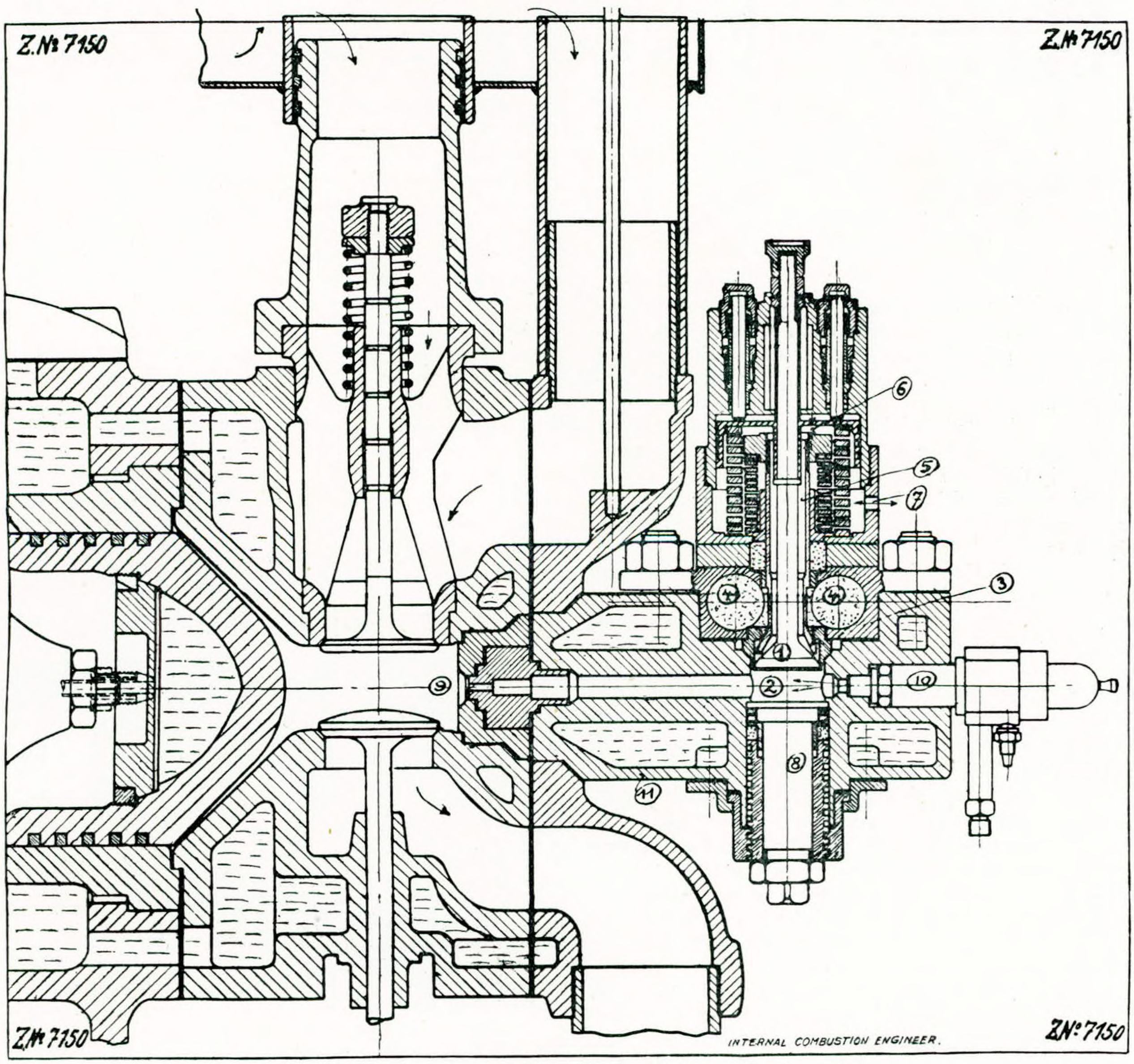


Fig. 10.—Section showing Rupa Motor with Coal Chamber at 4.

(3) The diagrams relating to operation at 500 to 550 r.p.m. afford no reason for supposing that speeds of 1,000 to 2,000 r.p.m. will occasion any difficulty.

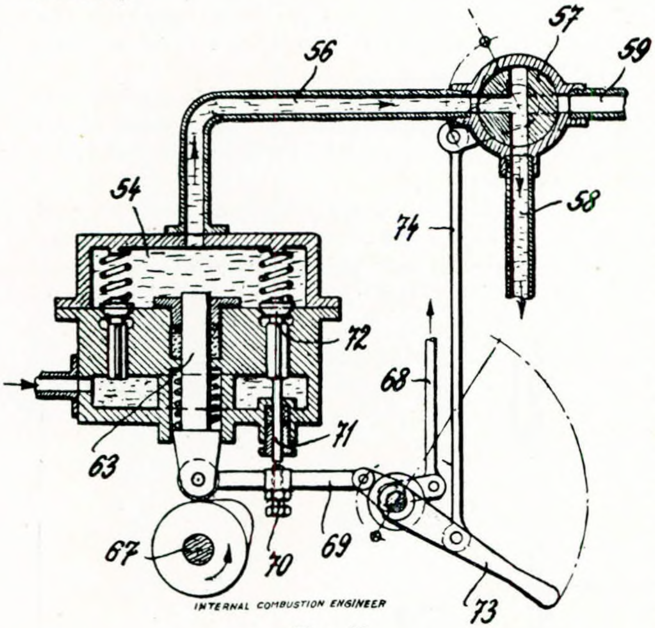


FIG. 11.

(4) Without the use of any compressed air for injection purposes, the ante-chamber operates satisfactorily on the partial pre-ignition principle and gives a good width in the upper part of the diagram.

(5) With this self-acting ante-chamber, compressorless operation is possible with a small quantity of ignition oil if the latter be atomised by the injection pump either in the ante-chamber or in the main cylinder in front of the mouth of the ante-chamber.

In brief, these investigations demonstrate the feasibility of small high-speed Rupa motors, without compressor, injection-air valve gear, or screw feed for the powdered fuel, and with simple pressure-oil operation of the fuel valve under governor control. Such motors would be suitable for tractors, dredgers, cranes, locomotives, and agricultural machinery.

Fuels Employed.

The indicator diagrams in Fig. 13 relating to the use of different fuels in Rupa motors are extraordinarily interesting. In each case the nature of the fuel is stated, together with notes as to the manner of its use, whether with or without injection air, and with or without addition of gas oil or powdered brown coal, low temperature coke or napthalene to facilitate ignition.

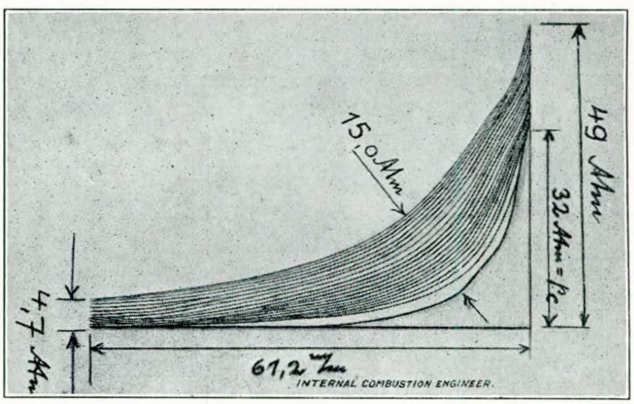
Regarding the fineness of the fuel employed, a few trials generally suffice to indicate the coarsest size of any particular material that can be burnt satisfactorily within the period allowed by the speed of the motor. The finest particles absorb the heat of compression most rapidly, ignite first and assist the combustion of much larger material.

The brown coal of Germany and many other districts falls largely to powder in the course of being dried for briquetting. The fine material carried off by the vapour being recovered by electrostatic precipitation, it contains no particles of steel—such as are apt to be present when pulverising mills are employed—and, being usually a material for which there is little demand, it is obtainable in Germany at from 1·4 to 0·7 pf. per kg. (about 14s. to 7s. per ton, at par). This material is available in the immediate vicinity of Görlitz and is used as standard fuel by the Kosmos Co.

According to its hardness and brittleness, black coal is prepared for use in the Rupa motor by pulverisation in one or the other form of beater, roll or ball mill with air separation of the fine material produced. Vegetable matter, such as peat, sawdust, leaves, hay, pine needles, twigs, maize stalks, husks of rice, soya beans, palm nuts, cotton pods, poppy heads, olives, copra, hemp and linseed, is dried and powdered in beater mills.

Of the heat consumption of about 2,000 to 2,800 calories per metric h.p. hour (8,050 to 11,250 B.Th.U. per b.h.p. hour) derived from the combustion of the powdered fuel, about one-third goes to the cooling water, which leaves at 60° C. to 100° C. (140° F. to 212° F.), and one-third passes out with the exhaust gases. If only 35 per cent. of the total waste heat be utilised effectively this amounts to about 450 to 660 calories per metric h.p. hour (1,800 to 2,660 B.Th.U. per b.h.p. hour), which is sufficient to evaporate 0·7 to 1·0 kg. (1·5 to 2·2lb.) of moisture from vegetable matter, *i.e.*, enough to dry the vegetable refuse required by the Rupa motor. In other words, the Rupa motor is capable of drying its own requirements of fuel, and needs no ignition flame or electrical ignition apparatus.

The risk of fire is negligible when the Rupa



Regulating Diagram of No. 7 Rupa Engine, showing Expansions over a Wide Range of Loads.

motor is employed. During the period 1911 to 1933, the Kosmos Co. has experimented with innumerable kinds of powdered fuel without any fire or any evidence of need for fire insurance.

No trouble has been experienced from sulphur in the eight Rupa motors built to date. The exhaust gases being discharged at temperatures higher than 212° F., there is no liquid H_2O to form sulphuric acid from such sulphurous oxides as may be present in the gases. Also, the alkaline earthy material in the ash neutralises any acidic vapour with which it comes in contact.

Prolonged running, mainly with ordinary cast-iron liners and piston rings, has shown that many factors influence the rate of wear, which, however, can be made nearly as low in the Rupa motor as in the Diesel engine. The path of the flame in the main cylinder is of great importance; also the construction of the cylinder and piston, their tightness, cooling and lubrication. In the latest constructions the cylinder wear amounts only to about 0·12mm. increase in diameter during 1,000 working hours.

Brown coal ignites at about 17 atmos. gauge pressure; Mediterranean lignite, containing 34 per cent. ash, ignites at 22 to 23 atmos. gauge (Fig. 13); and even German hard-coal tar oil starts cold with 24 atmos. compression (Fig. 14), thanks to the Rupa ante-chamber, whereas it is difficult to burn in Diesel motors even with 33 to 35 atmos. compression. The No. 1 Rupa motor fired for the first time in 1916 but still, in September, 1933, gives a good diagram (Fig. 13) and reliable operation with Mediterranean lignite, although the cylinder has been worn from 420mm. to 426mm. dia. (about 16½ to 16¾in.) at the combustion end and the piston is about 1mm. (0·039in.) smaller in diameter at the top than at the bottom. On the upper dead-centre, at the moment of maximum compression and ignition, there is an annular gap of 3·5mm. (0·138in.) radial width between the liner and the piston.

When the piston of this engine was drawn, shortly after the trials to which Fig. 13 refers, it was found that pieces about 6¾in. in length were missing from each of the top two piston rings. Only two fragments, about ⅝×⅜×½in., with completely rounded edges, still remained in the grooves. No trace of the rest of the rings could be found hence they must have broken into pieces small enough to pass through the annular clearance into the combustion space and thence through the exhaust valve. There were no grooves, cracks or other damage on the liner, and it was only necessary to fit two new piston rings before returning the engine to service. The exhaust valve and seating showed the usual amount of pitting, but were sufficiently tight for satisfactory running.

Obviously, the above engine was dependent on its third piston ring for sealing a relatively enormous clearance (the result of many years of wear), and the full facts are stated in order to demonstrate the satisfactory operation secured under conditions far exceeding normal wear.

Plans are now completed for the construction of specially designed high-speed Rupa motors (as distinct from converted oil engines), and particulars of the wear on the liners and rings of these machines will be awaited with much interest. Care has been taken to make the liners easily interchangeable at little cost, and it is expected that a life of two to three years will be obtained from the liners and six to eight months from the piston rings of stationary motors. The total cost of these replacements will be negligible compared with the saving effected by the use of cheap coal instead of gas oil.

Up to the present eight motors, built as oil-burning Diesels, have been converted to operation as Rupa motors. They include one-, two- and

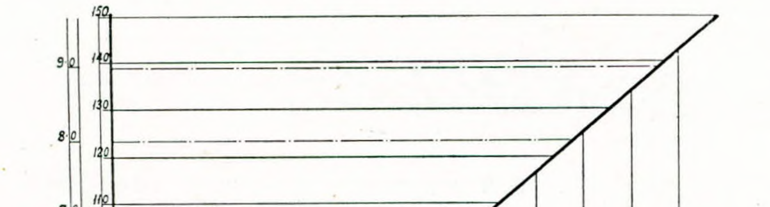


FIG. 15.

three-cylinder horizontal and vertical, four-stroke and two-stroke machines with compression ignition from 32 to 17 atmos. and with hot-bulb ignition at 5·8 atmos. compression. The speeds of these motors range from 160 to 550 r.p.m., and they are used with and without screw feed for the fuel, with and without piston cooling, with soft and hard liners, and with and without injection-air, the latter indicating the advanced stage of development attained. Most of these motors were built by the Görlitz works of the Kosmos Company, but the largest machine yet constructed is a 140 h.p. unit built in other workshops.

Trial Data.

Fig. 15 shows the best test results of the 80 h.p. No. 1 Rupa motor, and Fig. 16 those of the 150 h.p., No. 8 three-cylinder machine.

Prof. W. Trinks, of the Carnegie Institute, Pittsburgh, found the consumption of the No. 7 Rupa motor to be 1,000 kg. and 1,520 kg. (2,205 and 3,352lb.) respectively during 18 and 28 hours running at 140 h.p., corresponding to average consumptions of 0·88 and 0·87lb. per b.h.p.-hr.

The lubrication of the piston can be effected by any good Diesel lubricating oil, which will not emulsify on washing with hot water, and can therefore be well cleaned. The consumption is about one-third higher than that of the corresponding Diesel motor.

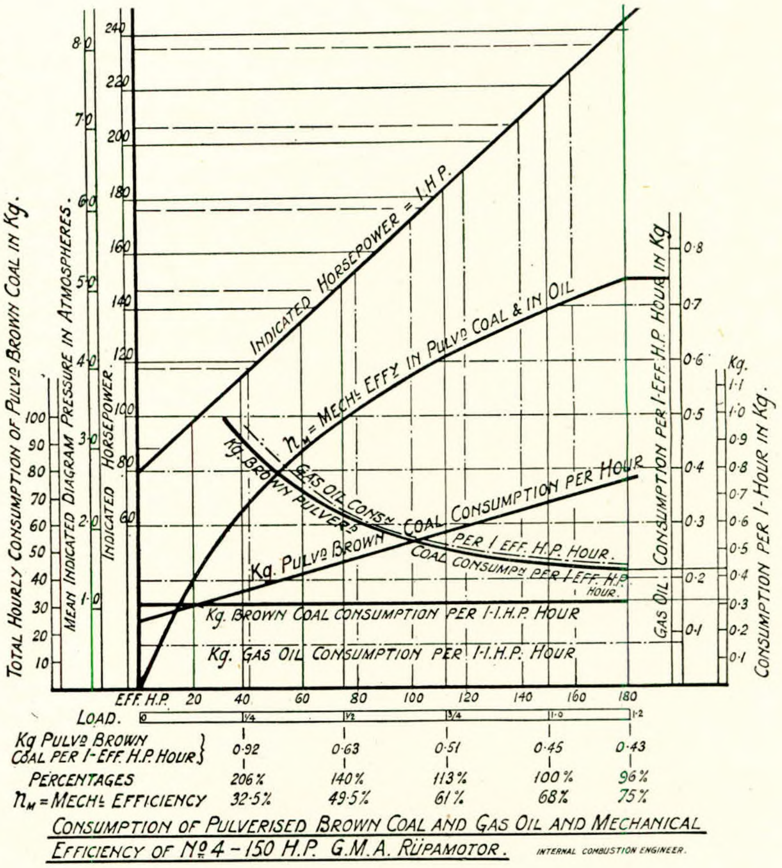


Fig. 16.

Economic Considerations.

In most countries coal is cheaper than petroleum, and, in many, vegetable material of very low ash content is the cheapest fuel. Such localities offer attractive opportunities for the use of Rupa motors.

As regards the competition to be anticipated from oils made by the hydrogenation of coal, Prof. William A. Bone has estimated* the capital cost of a hydrogenation plant, for the production of 1 million tons of oil per annum, to be about £35,000,000, the manufacturing cost being about 1·1d. per lb. of oil thus produced. From this quantity of fuel it would be possible to produce about 5,000-million h.p.-hr., corresponding to the operation of 1,670,000 h.p. of Diesel motors for 3,000 hours per annum.

Allowing 21s. per h.p. for the extra cost of Rupa motors compared with Diesels, an investment of 21s.×1,670,000=£1,750,000 would enable the same h.p.-hours per annum to be generated directly from native coal as could be produced by Diesel engines burning the oil output of a £35,000,000 hydrogenation plant.

In addition, however, to this enormous saving of capital, the Rupa motors would cost less than the Diesels for fuel. A Rupa motor burning hard coal of 13,500 B.Th.U. per lb. consumes only about 9,050/13,500=0·67 lb. per h.p.-hr., costing, say, 0·07d. at 19s. 6d. per ton. On this basis the 5,000-million h.p.-hr. per annum costs about £1,460,000, compared with £10,300,000 per annum for the same amount of energy derived from oil at 1·1d. per lb., and allowing for a consumption of 0·45lb. per b.h.p.-hr. The fuel cost of the Rupa motor burning coal is thus about one-seventh of that of the Diesel using hydrogenation oil.

Accepting the estimate that 1lb. of oil can be produced from 4lb. of coal, and will yield 1/0·45= 2·22 h.p.-hr. in a Diesel engine, the hydrogenation system would consume 5,000,000,000×4/(2·22× 2,240)=4,000,000 tons of coal per annum for the production of 5,000-million h.p.-hr., which would require the use of only 1,500,000 tons of coal in Rupa motors.

If the same amount of power were produced from natural oil at 0·27d. per lb., the fuel bill would

*"The Observer", January 22nd, 1933.

be £2,530,000 per annum, or £2,530,000−£1,460,000=£1,070,000 per annum more than the coal bill of the Rupa motors. This saving alone would recoup the £1,750,000 higher cost of the Rupa motors (compared with Diesels) in 1·75/1·07 =1·65 years. Allowing for the duty on imported oil, the Rupa motors would pay for themselves much sooner.

Whereas the Diesel motor can only operate on suitable oils, the Rupa motor can operate on any coal or ground vegetable matter as well as a wider range of oils; there are, in fact, suitable fuels for the Rupa motor in every country.

The present position of the Rupa motor, after many years of development and research, is that it is tried, proven and ready for commercial production as a medium-speed stationary prime mover. Compared with the Diesel motor, it is already at the stage of development reached by the latter when airless injection was first employed. The high-speed Rupa motor is not at so advanced a stage; the vital component, the coal-feed attachment, has, however, been tested satisfactorily at high speeds, and the construction of high-speed motors is expected to be achieved in the near future.

I would refer readers also to the following discussions of the Rupa engine by the well-known Diesel engineer, W. Hamilton Martin, M.I.N.A., for which I should like to express to him my best thanks:—

(1) Journal of the Institute of Fuel, No. 17, June 31, page 338.

(2) Transactions of the Institute of Marine Engineers, No. 5, June, 1929, page 279. W. E. Woodeson, Junr., B.Sc.

(3) Transactions of the Institute of Marine Engineers, No. 11, December, 1931, pages 542 and 543. Alan E. L. Chorlton, C.B.E., M.P.

(4) Transactions of the Institute of Marine Engineers, No. 10, November, 1932, pages 500/01 and 508/09. A. F. Evans.

(5) Reprint from "Fuel Economist", July, 1932, "Colloidal Fuel", by John L. Strevens.

(6) Transactions of the North-East Coast Institution of Engineers and Shipbuilders, 1933, "The Rejuvenation and Reconditioning of Ships and their Machinery", by Andrew Hamilton, C.B.E.

(7) Transactions of the Institute of Marine Engineers, No. 4, May, 1933, pages 136 and 137. Paper by Dipl. Ingr. Alfred Büchi.

(8) Joint Meeting Report of the Institution of Naval Architects and l'Association Technique, Maritime et Aeronautique in Paris, July, 1931, see Trans. I.N.A., vol. lxxiii, page 338, and Bulletin de l'A.T.M.A., No.

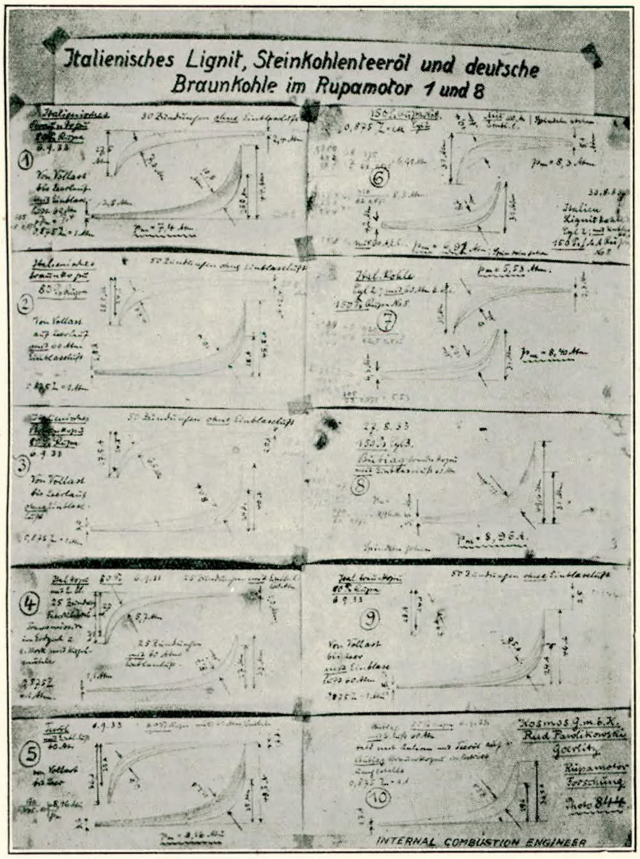


FIG. 13.—Italian Lignite, Coal Tar Oil, and German Brown Coal in Rupamotor, Nos. 1 and 8.

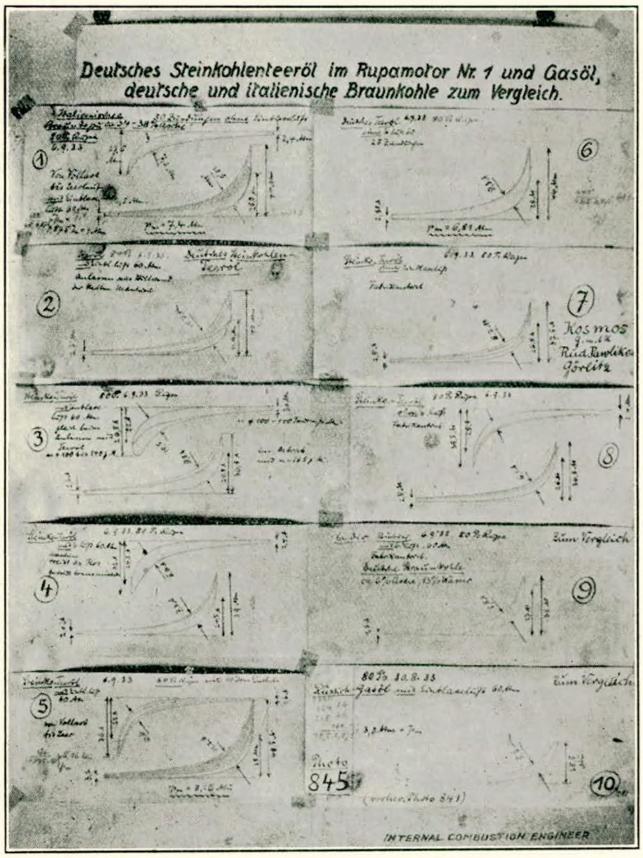


FIG. 14.—German Coal Tar Oil in Rupamotor, No. 1, and Gas Oil, German and Italian Brown Coal for Comparison Purposes.

35, Session 1931, Paul Dumanois, pages 938-39, "Considérations sur de Evolution des Moteurs Marins".
(9) Pamphlet of "The British Science Guild", on "The Economic Significance of Coal", of March, 1933, pages 44/46.
(10) Report on the 49th Ordinary General Meeting of the Sociétè des Ingénieurs Civils de France (British Section) of May, 1933, pages 49/50. Paper by Dr. G. E. Blythe ,B.Sc.
(11) Transactions of the Institute of Marine Engineers, No. 10, November, 1933, pages 251/53 and 205, and also Journal of Institute of Fuel, December, 1933, vol. vii, pages 83/84, on "Oil from Coal", by Dr. Ormandy and Dr. Burns.
(12) Transactions of the Institute of Marine Engineers, No. 1, January, 1930, "The Origin and Development of Oil Engines", by Arthur F. Evans, pages 951/54 and 959/60.
(13) Transactions of the Institute of Marine Engineers, No. 1, January, 1932, "Pulverised Coal Diesel Engines", pages 46/7.
(14) Transactions of the Institute of Marine Engineers, No. 11, December, 1932, page 541, "The Production, Handling and Marketing of Coal for Marine Purposes", by W. J. Drummond.

The "British Coast".

"Motor Ship", February, 1934.

Deck Machinery.

The new Clarke, Chapman Macfarlane winch should have ample opportunities of demonstrating its utility in the "British Coast". One man controls all the operations of lifting, slewing and topping; the reach of the derrick is 24ft. on each side of the ship's centre line. There are three drums which give simultaneous control of all the motions of the derrick, three operating handles being provided in connection with a master control box. None of the gear is slack, whether the ship is rolling or on an even keel.

The lift is 3 tons at 100ft. per min., or 1½ tons at 200ft., and the light-hook speed is 400ft. per min. Three motors are provided. That for hoisting is rated at 25 b.h.p., the "derricking" motor is a 20 b.h.p. machine, and the motor used for slewing is of 12½ b.h.p. An important feature of the winch is that the sling is always dropped square over the load in the hold, as determined by the dimensions of the hatch.

The Steering Gear.

A drawing is reproduced to scale showing the layout of the steering gear, which, as we have mentioned, is of the all-electric type, the motor being a machine of 9 b.h.p. on a half-hour rating, running continuously in one direction. A reverse motion is obtained mechanically through reduction and reversing gear, hunting gear (similar in principle to the device employed with steam plant, used for the same purpose) being provided. The power absorbed by the machine is equivalent to the work involved, as and when the rudder is moved. The gearwheels are enclosed in a cast-iron box and run in an oil bath.

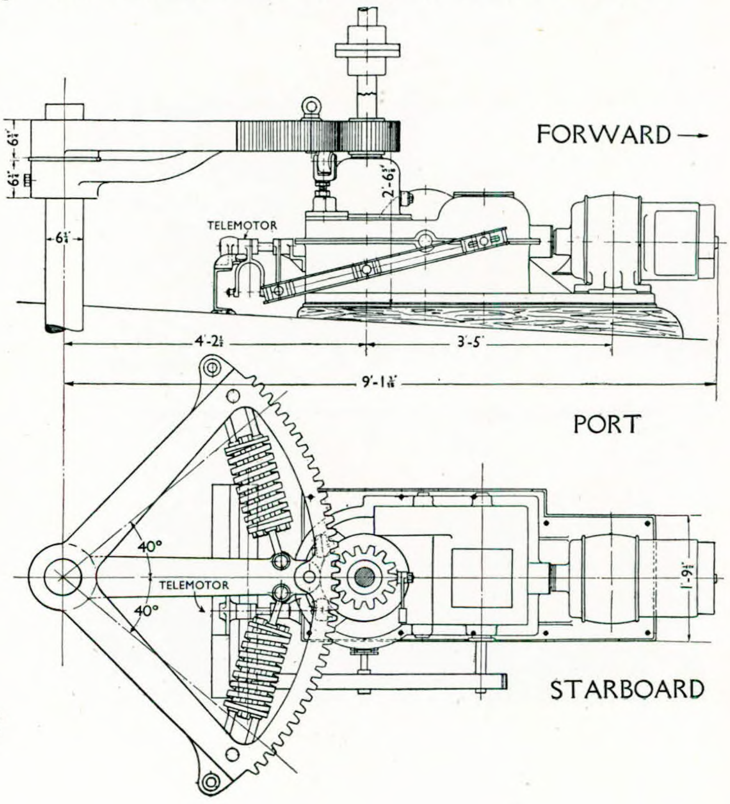
Explosion from a Master Deck Steam Valve Chest on board M.V. "Caroni River".

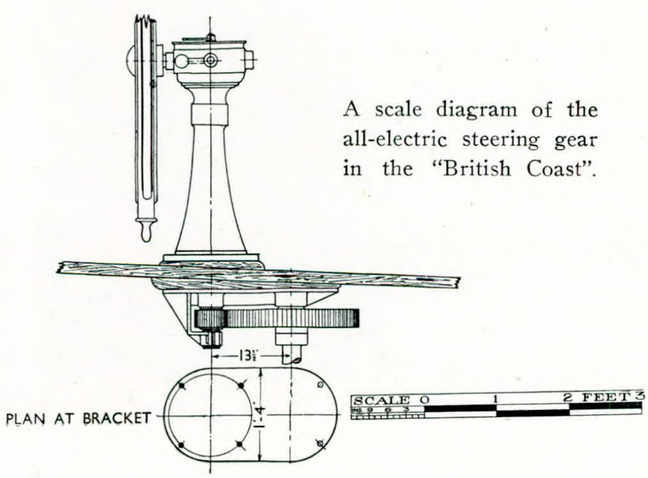
The explosion occurred on the 3rd June, 1933, when the vessel was in dry dock at Falmouth.

Nine men were injured. Seven of these men were scalded by hot water and steam.

The master valve consisted of a cast iron globe valve chest having a gun metal valve and valve seat. The diameters of the valve and of the branches to the chest were 5 inches.

The chest fractured above the seat and a part of the globe chest, with the cover, spindle and valve attached, was blown violently against the starboard





A scale diagram of the all-electric steering gear in the "British Coast".

side of the engine casing. A considerable quantity of water was blown from the chest followed by steam which continued to escape freely until shut down.

The explosion was caused by water hammer action.

Observations of the Engineer Surveyor-in-Chief, Board of Trade.

This case is another illustration of the danger attending the admission of steam to a pipe range which is improperly drained or in which water of condensation can accumulate, and also the care required to ensure that steam shut off valves are maintained in good condition.

Under the ordinary steaming conditions the arrangement for draining the steam pipe range had apparently worked satisfactorily, but, after entering dry dock, the boilers on board the ship were shut down, and arrangements made for steam for auxiliary purposes to be supplied from the shore, the connection to the range being made at a branch on the after deck and two valves were slightly opened to provide additional drainage. Water of condensation had, however, accumulated in the pipes within the engine casing, and when steam was opened from the shore, it was also admitted to the pipes within the engine casing owing to a leaking shut off valve, and the conditions were conducive to the water hammer action which resulted in the violent fracture of the valve chest.

The pipes in which water hammer occurred were drained into a tank in the engine room, the end of the drain pipe being submerged. This was not a satisfactory arrangement and amendments have now been made and additional drains fitted, all exhausting direct to the atmosphere, so that the drainage will be visible and the possibility of water being forced up the pipe is precluded. Under these conditions a recurrence of the circumstances which led to this serious explosion is not anticipated.

Overcoming Vibration in Ships.

Results Achieved with a "Vibration Neutralizer" in the Motor Ship "Maria".

By Hugh Loser.

"The Motor Ship", April, 1934.

It was found that the motor ship "Maria", which was built for the Cosulich Line a few years ago, vibrated in a vertical direction, twice with each revolution of the engine, the vibration being most marked at the bow and stern and on the bridge.

In June, 1933, a vibration neutralizer, manufactured by the Cantieri Riuniti dell'Adriatico, was installed, and the results have proved satisfactory. The neutralizer (Fig. 1) was fitted in the poop, just over the propellers under the main deck. Its weight is 12 tons. The neutralizing effect extends throughout the ship, including the bridge, and seven months of continuous service have shown that the effect remains unaltered.

The design and construction of the device are based upon a series of experiments carried out by the writer and on a number of tests on board the ship during the past four years. The principle on which the neutralizer operates is known as the principle of added masses with elastic support. It consists essentially of a metallic tank (A), Fig. 3, supported by a double set of springs (B), compressed between the two frames (C and D) and a rib (E) projecting from the side of (A). The frames are inter-connected by four tie rods (F), on which the tank is guided in the direction of the axis of the spring, by means of the guide rollers (G).

The tank is divided into a number of small cells containing sea water or other liquid. Filling takes place through the flexible pipe (H).

During the vibration of the tank, the liquid

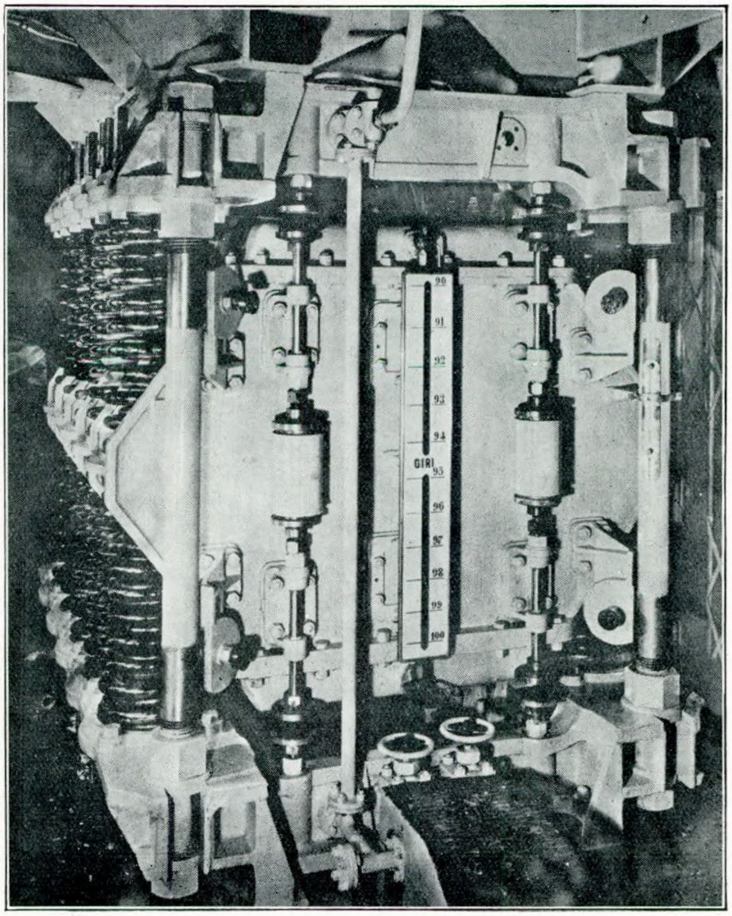


Fig. 1.

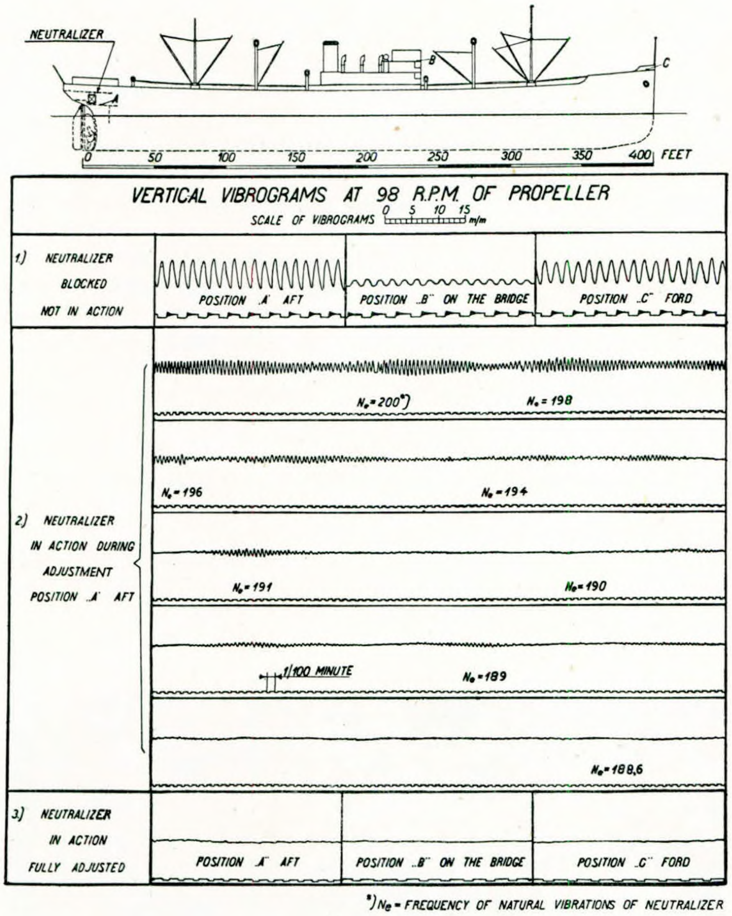


Fig. 2.

constitutes with it a single mass just as if the tank had merely increased in weight. There are two manœuvring valves, that for delivery (I) and the other for discharge (L) while an air pipe line (M) has a flexible portion (N). The depth gauge, with a graduated scale (O), shows the depth of liquid necessary for a given number of revolutions of the propelling engine. The device is adjustable.

The tank (A), which can only vibrate in the direction permitted by the rollers (G) and the tie rods (F), is excited by the vibration of the ship, and does not require any other motive power. Among other things, the quantity of the liquid controls the angle of the phase displacement between the vibrations of the tank and those of the ship. This phase displacement must be regulated in order to obtain the desired neutralizing effect.

The vibrations of the "Maria" have a frequency of approximately 200 per minute, and this is about the lowest at which neutralizers can be utilised, owing to the weight becoming excessive. For frequencies from 200 per minute up to 1,000 per minute, which mostly come into the question with the vibration of the stern caused by propellers, or the running of Diesel engines, the weight is moderate if a suitable position be chosen.

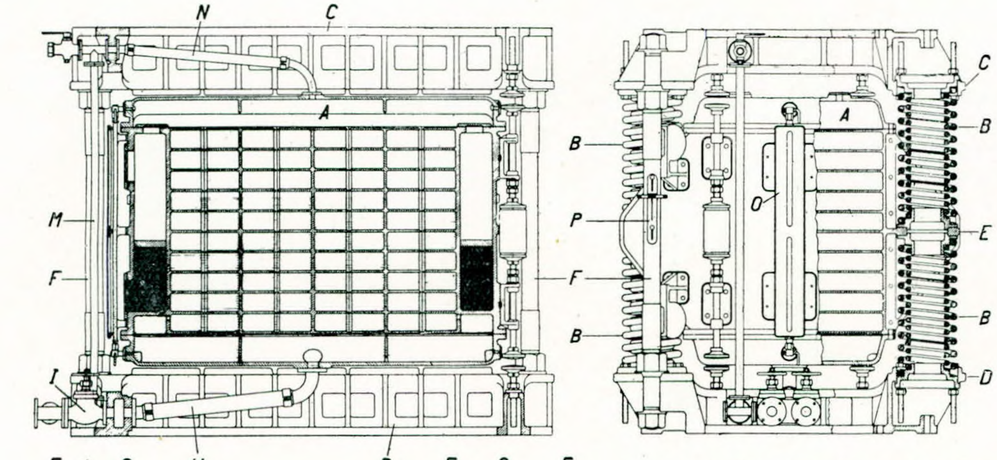
The problem is not to balance the excitation of the vibrations of the ship. It is to create, by the functioning of a neutralizer, a system of forces, termed neutral forces, in regard to vibration. In Fig. 4 a vibration of the ship is indicated, which can be brought into being either by a periodical force (P) or a periodical moment (M) composed of a couple of periodical forces (Q) having an arm (l). In order to eliminate vibration, it is sufficient for the two equivalent excitations (P) and (M) to act simultaneously on the ship, as in Fig. 4, but outphased bv half a period as in Fig. 5. These excitations do not form a system of forces in equilibrium, but of neutral forces as regards the vibration of the ship.

It is possible to achieve this end with a single device suitably arranged, as in the case of the "Maria", on the vessel's poop. In this ship the original vibration was caused by an excitation (P) exercised by the compressor and the scavenging pump of the propelling engine. Of this original vibration, after the neutralizer was fitted, a part remained so far as was necessary for the excitation of the oscillating weight. This part becomes a minimum when the weight oscillates in a suitable phase with the phase of the first excitation (P) so that the system of neutral forces may be developed.

Fig. 6 illustrates the case of the "Maria". The system consists of an original excitation (P), plus the force transmitted by the neutralizer, which excitation (P+Q) tends to increase the original vibration, and by the system of neutral forces, having a moment (M) equal to $Q \times P$, which neutralizes the excitation (P+Q). Residual vibration for the excitation of the tank is 6 per cent. of the original vibration. The double amplitude without the neutralizer reached 6mm. and was reduced to 0·4mm. with the neutralizer in service. The average neutralizing effect is 94 per cent. (Fig. 2).

The vibratory cycle of the weight and that of the original excitation (P) must be of equal phase. It is therefore necessary to select a suitable position for installing the neutralizer and have a means permitting the regulation of the phase displacement between the vibrations of the oscillating weights and those of the ship. The reason for this is as follows:—

Every elastic structure, such as a ship or the neutralizer, vibrates with a frequency similar to that of its excitation, but with the phase retarded with respect to the latter. If we take the period (T, Fig. 7) of the vibration (ϵ), also the similar



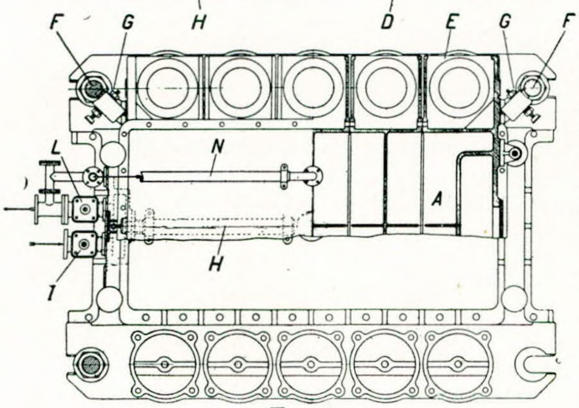


FIG. 3.

period of its excitation (P) as being 360 deg., the vibration (ϵ) in respect of the excitation is displaced with respect to the latter by an angle (ϵ). The time lag depends on the damping action to which the elastic structure is subjected, also on the natural frequency (N) of the excitation and the natural frequency (Ne)—the ideal frequency of the elastic structure obtained without damping — of the elastic system. The law correlating the angle (ϵ) and the frequencies N and Ne has been known for some time (see "Vibration Problems in Engineering", by Timoshenko, published by Constable & Co., Ltd.), but it must be borne in mind, in order to recognise the requirements which a neutralizer must fulfil.

This law is shown graphically in Fig. 8. The curves ϵ, ϵ_1 and ϵ_2 give the angle of phase displacement, dependent on the ratio $\left(\frac{N}{Ne}\right)$ between the frequency of the excitation and the natural frequency (Ne) of the elastic structure for various conditions for damping. The smaller the damping action the steeper will be the curve.

If the ratio $\left(\frac{N}{Ne}\right)$ is less than 1, the angle ϵ is less than 90 deg. It is equal to 90 deg. if N equals Ne, and is between 90 deg. and 180 deg. if the ratio of $\left(\frac{N}{Ne}\right)$ is greater than 1.

This law stands good for both the neutralizer and the ship. The vibration of a ship usually presents itself subdivided by nodes into sections (a, b, c, Fig. 9) outphased by 180 degrees. In the considerations which follow let it be assumed that the ship vibrates in the neighbourhood of its excitation (P)—that is, in the arm (b) postphased in respect to the excitation of an angle which may, of course, have any value between 0 and 180 degrees. In order to give rise to the system of neutral forces of Fig. 9, it is necessary for the

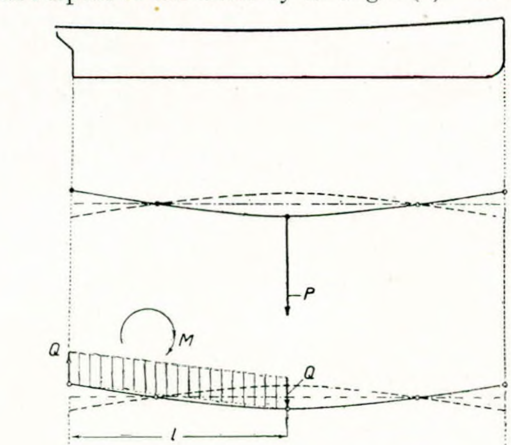


FIG. 4.

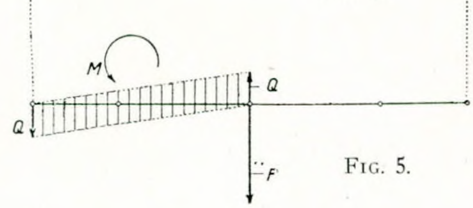


FIG. 5.

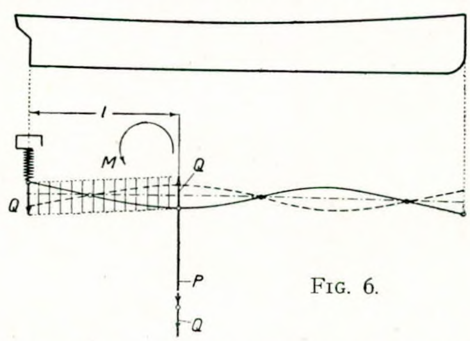


FIG. 6.

neutralizer to vibrate in phase with the excitation (P)—that is to say, displaced by $\epsilon_1 = 180° - \epsilon$ in respect to the section exciting it (see Fig. 9).

The parity of phase between Q and P would also be desirable even if the neutralizer were situated in the section (b) itself, as in Fig. 10. But in this case the parity of phase is impossible because the neutralizer would have to vibrate in respect to the section (b), which excites it with its

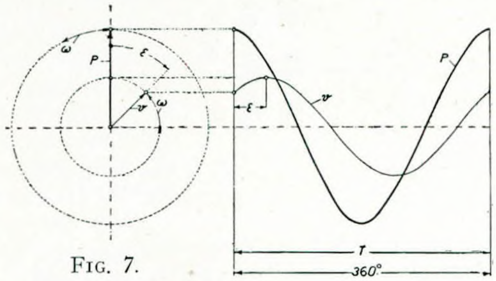


FIG. 7.

phase advanced by the angle ϵ, a phenomenon not permitted by physical laws. We shall get, however, also a system of neutral forces $Q-P$ and $M=Q1$, assuming that the neutralizer vibrates again with its phase retarded in respect to that of the section (b) by the angle $\epsilon_1 = 180° - \epsilon$. The force (Q) is, in this case, greater than the original excitation (P) (Fig. 10), and a similar arrangement would necessitate the installation of neutralizers of excessive dimensions and weight. The two forces (P) and (Q) are equal and opposite only in case the neutralizer be arranged in a position directly above or below the excitation (P).

Therefore, whatever be the position of the neutralizer, it follows that the two angles considered, viz., ϵ and ϵ_1, must always be complementary. This condition leads to the consideration that the natural frequency (N_2) of the neutralizer must be different from the natural frequency (N_1) of the vessel in the manner illustrated in Figs. 11, 12 and 13.

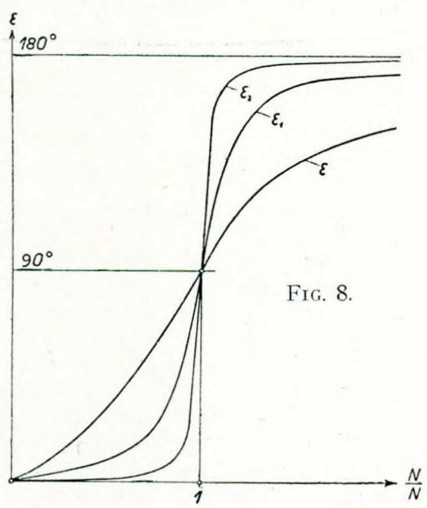
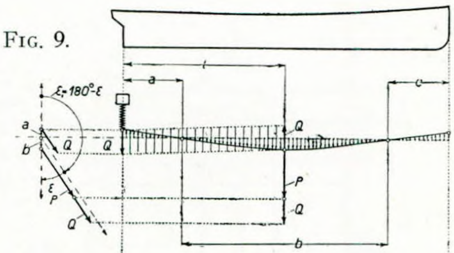


FIG. 8.

FIG. 9.



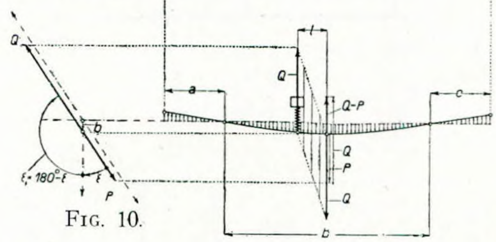


FIG. 10.

The steepest curve shows the variations of the lap angles of the neutralizer, which is almost free from damping reactions. The dotted curve shows the vessel which vibrates for the most part immersed in the water, which is a condition of considerable damping.

In Fig. 11 $\frac{N}{N_1}$ is assumed to be <1 and $\frac{N}{N_2}$ is therefore > 1, the equivalent ratios being $N_1 > N > N_2$; in Fig. 12 the equality of the frequencies N and N_1 is assumed, i.e., $N_1 = N = N_2$. From Fig. 13, in which is assumed that $\frac{N}{N_1} > 1$, it follows that $N_1 < N < N_2$, or, in other words, the natural frequency of the neutralizer must deviate from the excitation frequency in the opposite direction from that in which the natural frequency of the ship deviates in respect to it. The difference between the natural frequencies of the neutralizer and of the ship disappears in the event of coinci-

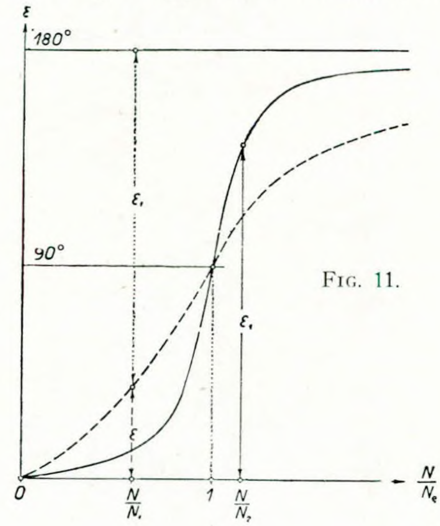


FIG. 11.

dence between the natural frequency of the ship and that of the excitation—that is, for ideal synchronism.

The neutralizer needs limited excitations to vibrate strongly and, consequently, to transmit to the ship an appreciable force (Q) if the frequency of its excitation approaches its natural one. Now it would appear from the foregoing that in this regard difficulties arise for its practical application, in that a large share of the vibrations which affect ships are forced vibrations, as for instance, those due to the running of the Diesel motors and to the propellers. These difficulties can be overcome, however, if the neutralizer be freed as far as possible from damping.

In the device being described, the presence of minimum dampings is ensured by the special guide rollers and by the low basic stress in the springs, giving rise only to slight molecular friction; the constant value of the weight of the mass is ensured by its subdivision into a sufficient number of cells, and the constancy of the thrust characteristic of the springs on the vibrating tank is guaranteed by the rollers and tie-rods, which compel the tank to vibrate in the direction of the axis of the springs. Such construction likewise renders the neutralizer independent of the roll.

During the taking of the readings illustrated in Fig. 2, the motor ship "Maria" had a critical frequency exceeding 210. This knowledge was arrived at by forcing the motor up to 105 revolutions for a short time for the purpose of investigation. The vibrations continually increased in

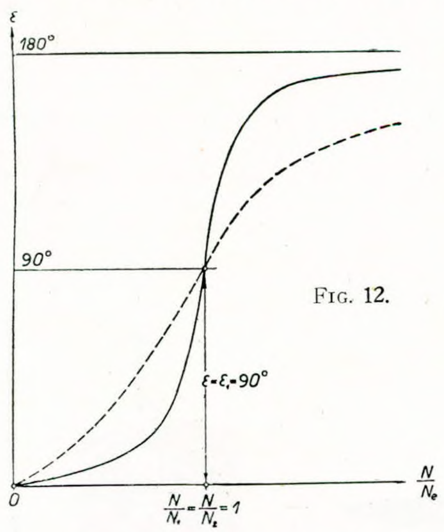


FIG. 12.

amplitude. Now it is known that the ideal natural frequency, considered in this article, is greater than the frequency at which the maximum amplitudes of a strongly damped vibrating system, such as a floating vessel, are noted. When the vibration diagrams were taken the number of revolutions of the propelling motor was 98, and the excitation took place, as already stated, twice per revolution, the frequency being therefore 196 per minute. The maximum damping effect was obtained by bringing the natural frequency of the neutralizer to 188·6 per minute by regulating the water. Evidently it was a case as illustrated in Fig. 11. The force (Q)

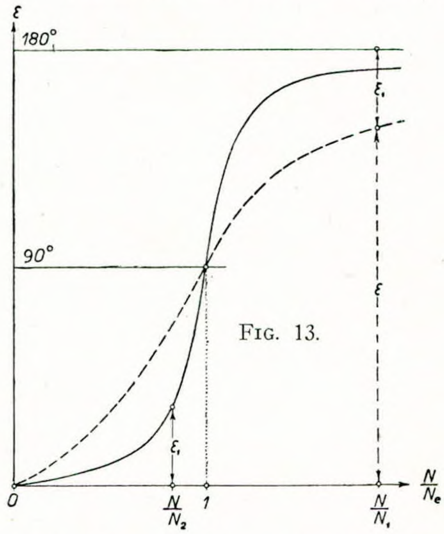


FIG. 13.

transmitted by the neutralizer to the ship was about 8 tons, and in the roughest sea this force reached the maximum value of about 10 tons, as recorded by a device fitted on the neutralizer indicating the maximum amplitude (Fig. 3).

A variation of its natural frequency of about 1 per thousand corresponds to one c.m. variation of level of water in the tank of the neutralizer of the motor ship "Maria".

In the case of vibrations which are a multiple of the number of revolutions of the motors, the correct level of the liquid in the tank can be determined approximately by the scale fitted on the tank.

This indicator enables the operator to fill the tank rapidly until the liquid has reached the level corresponding to a number of revolutions a little lower than the actual revolutions of the motors, and, after having duly throttled the delivery valve, he can leave the neutralizer to itself and pay attention to the vibrations of the ship. He will also close the valve after having observed that the ship is practically without vibration.

Its weight of 12 tons is certainly not excessive in comparison with the ship's displacement of 11,700 tons, nor the space occupied, about 2 cubic metres.

Oertz Streamline Rudders.

"Journal of Commerce", 15th March, 1934.

The importance of the manner in which the water closes after an immersed body has passed through it is emphasised when the influence of the rudder upon the efficiency of any hull form is considered. In other words, the run of the hull lines and the form of the rudder have a much more important bearing on power absorption than is generally recognised.

Study of the effect of streamlining, and making analogies between the streamline sections and ordinary flat plates, together with the knowledge that the law of air and water flow are identical, led Dr. Oertz to apply the aeroplane wing idea to a ship's rudder, but many eminent engineers and naval architects maintained, on the appearance of the device, that there could be no comparison between the wing of an aeroplane and the rudder of a normal merchant ship.

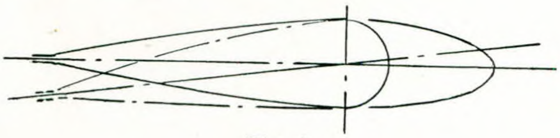


FIG. 1.

Most technical men are acquainted with the theory of the law which causes an aeroplane to rise from the ground. The Oertz rudder is based on this theory, but as the function of a rudder must be for either port or starboard side, by designing the rudder in two parts, the wing theory is used for either helm position, and the wing law is used for steering the ship.

Fig. 1 depicts the section of a rudder in midship position. The dotted outline indicates the rudder with so many degrees of helm, port and starboard. From this it will be seen that under the normal working helm angles the vessel is controlled by the use of the aeroplane wing law. In other words there is no flat surface exposed to pressure, and this effects a considerable economy in power to propel the vessel.

This principle also explains why an Oertz rudder is claimed to give better results than a balanced rudder having the same section in the fore and aft line, because a balanced rudder takes an angle as a whole, and, therefore, exposes, to a moderate extent, a flat surface to pressure, as shown in Fig. 2.

The twin-screw turbine ship, "Lady of Man", of the Isle of Man Steam Packet Co., Ltd., was the first British high-speed cross-channel steamer to be fitted with an Oertz rudder. The elevation and plan indicate how the ship's lines terminate at approximately

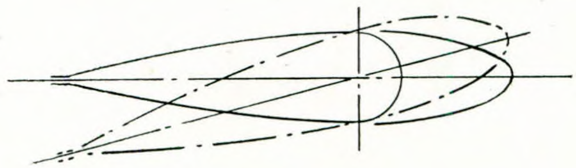


FIG. 2.

the propellers, and show the aperture in the deadwood created immediately in front of the rudder. This allows the eddies and whirls formed at the after end of the ship's hull to be split by the streamline form, and also allows the full benefit of the aerodynamic laws to operate on the two-part streamline in a similar manner to an aeroplane wing.

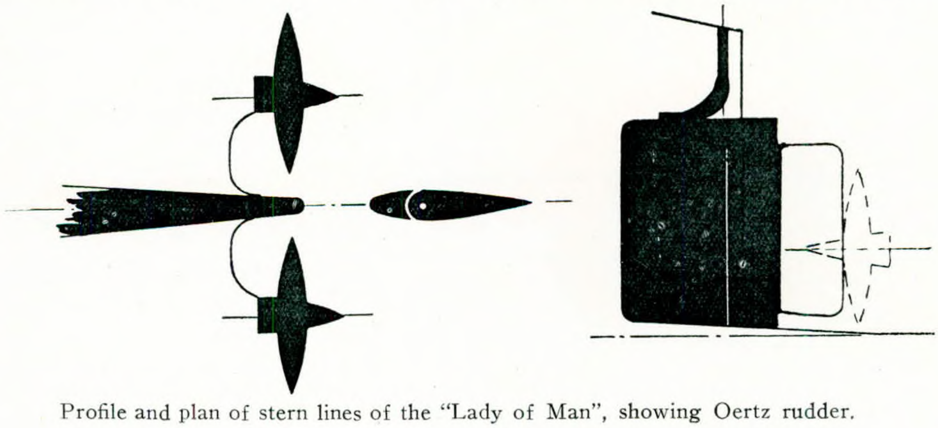
The increase of speed and the saving of fuel which a rudder designed upon the Oertz model compared with the standard plate type of rudder is shown in the attached table, in which the results achieved in the London and North-Eastern Railway Company's cross-Channel steamer "Bury" before and after conversion are detailed.

PERFORMANCE OF THE "BURY" BEFORE AND AFTER CONVERSION.

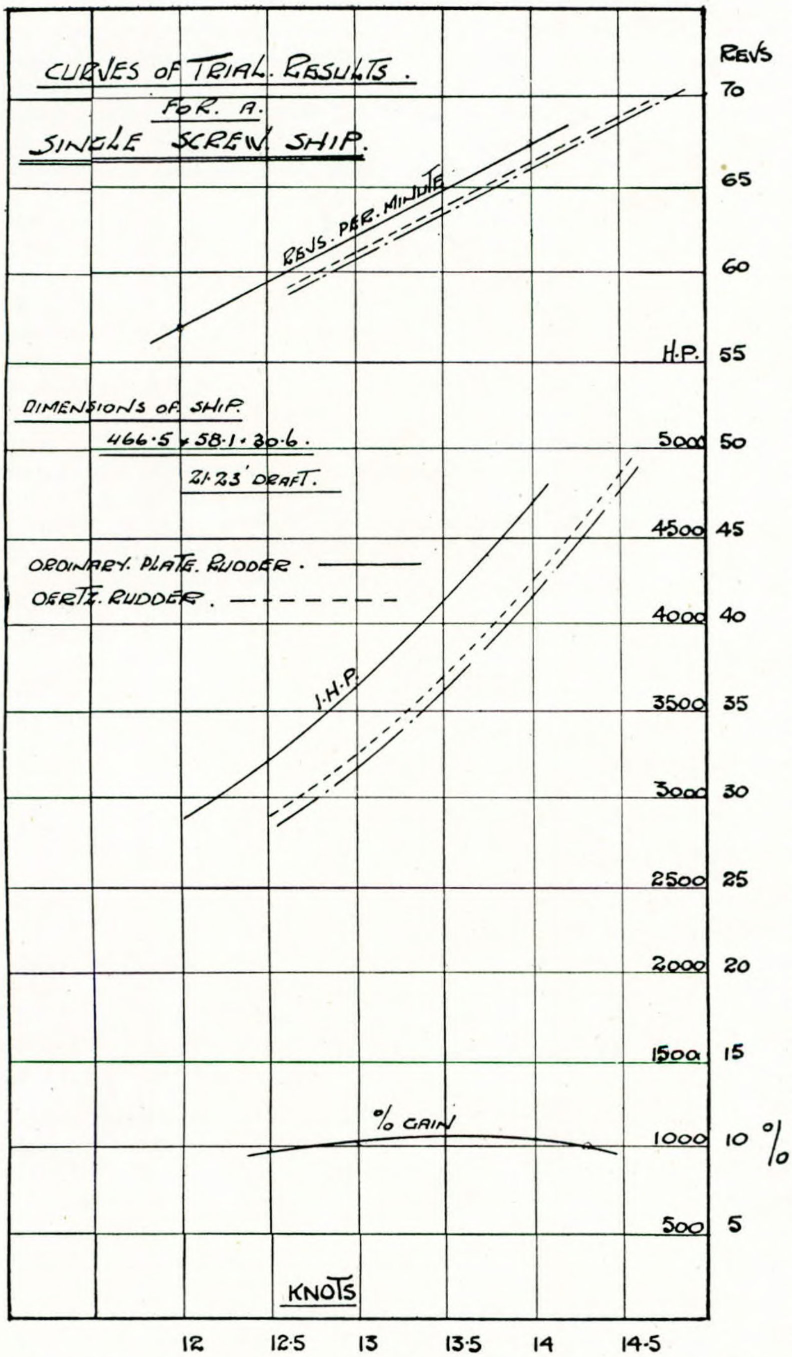
	Revs.	Slip.	Speed.	Coal Consumption. Nett.	Nett Sea passage Cons.	Displacement. Cons.	C.C. port to port.	C.C. sea passage.
Plate Rudder ...	77·0	10·09	11·96	37·15	28·8	2,454	8,385	11,055
Oertz Rudder...	77	7·58	12·08	35	25·0	2,532	9,415	12,985

Some of the largest liners, such as the "Bremen", "Rex" and "Conte di Savoia", of the multiple-screw class, are fitted with this rudder, whilst high-speed twin-screw, cross-channel ships, tankers, cargo ships, yachts, and mere launches have also been fitted.

A specially interesting curve giving compara-



Profile and plan of stern lines of the "Lady of Man", showing Oertz rudder.



Comparative results obtained at trials made at Skelmorlie measured mile. Full lines indicate power with plate rudder; dotted lines indicate power with Oertz rudder.

tive results and the reduction of horse-power recorded over progressive trials of a 466ft. single-screw ship is reproduced above.

Publications.

"The Metallurgist", Supplement to "The Engineer", March, 1934.

The amount of scientific and technical matter which appears in the world's publications seems to be increasing continuously, and it already constitutes a serious difficulty. The man who wishes to be up to date in his technical or professional knowledge feels the need of keeping in touch with this immense amount of matter and finds it increasingly difficult to do so. In fact, there are only two courses open to him. One is to read through the abstracts of papers which are published by various societies and journals, and the other is to confine himself to the study of one or two leading publications and only to go beyond these when his attention is called to something of special interest. Neither alternative is satisfactory.

The man who relies upon abstracts has very little opportunity of forming any critical opinion as to the value of the matter contained in the various papers referred to, and he is apt to accept the stated conclusions as reproduced by the abstractor as adequately and well established. He will, of course, come across cases where obvious divergences of facts or opinions become manifest and he will realise that at least one of two differing views must be wrong. What is more likely is that he will fail to realise that a good deal of uncontroverted material is far from being perfectly sound. At the present time an immense amount of material is published as the result of so-called researches carried out by students for the purpose of obtaining a higher degree, and much of this material, although it may furnish useful data and valuable suggestions, is apt to be vitiated by some oversight in regard to the methods used or inadequacy in either the number of measurements, or the materials upon which they are made. This kind of inadequacy can scarcely be detected by examination of abstracts, and it is only the careful reader of the original paper who will form the opinion that too much reliance cannot be placed upon the results or the conclusions drawn from them. Nor is this kind of difficulty entirely confined to the work of junior authors, since there are, unfortunately, a number of men who publish papers upon very insufficient grounds.

This need, for a need it appears to be, of critically sifting the wheat from the chaff in our scientific and technical publications, raises a still greater difficulty in the mind of the reader who wishes to be not only up to date, but as sound in his knowledge as possible. It should be the function of either our technical press or of our great technical and scientific institutions to carry out to some extent the sifting process required, but in actual fact, little or nothing of that sort is attempted. Only a few technical journals, among which "The Metallurgist" may claim to be one of the first, attempt the publication of critical reviews of published work. A particularly interesting development in this direction is presented by reviews which appear in our American contemporary, "Metals and Alloys", in which a whole group of recent publications relating to a particular subject is summarised and critically discussed. Matter of this kind does not add to the burden of the technical reader, but goes far to lighten it. The great bulk of ordinary abstracts is apt to prove a delusion rather than a help unless it is used as a mere index of contents; for those who pin their faith on statements contained in abstracts alone are apt to build upon an insecure foundation unless the name and status of the author guarantees a certain value to the views expressed and the data published, and of necessity can only apply to a fraction of the new work which appears.

To a very limited extent our great institutions perform a somewhat similar service by the publication of papers together with their discussions. These discussions constitute a feature of very great value, and it is interesting to see that even in Germany this method of publication has been extensively adopted. It may be that in a good many instances a discussion contains little of immediate value or interest, but the very fact that a paper has been read and has been open to discussion at a meeting where a number of eminent specialists are present, does serve as some measure of guarantee that nothing really unreliable or unsatisfactory can have passed through without comment, generally of a highly instructive nature. It might be suggested that a critical refereeing of papers before they are accepted for publication even in an ordinary technical paper might serve the same purpose, but it is a very difficult thing, because one disagrees with the conclusions which an author has drawn, or does not feel entirely satisfied as to the reliability of his results, to go to the length of suppressing his work by refusing it publication. To state one's views plainly at an open meeting during a discussion is a much simpler and wiser course, since it not only gives the author an opportunity to reply so that he can, if he is in a position to do so, substantiate the correctness of his views or data, but it also gives the reader of that discussion, and still more the man who hears it, an opportunity of forming his own judgment as to the opinion which has been expressed of the work, and as to the value both of that work and of that opinion. One might say, therefore, that the reader who confines himself to the journals of our leading institutions would be on safe ground, but, unfortunately, the space at the disposal of these bodies for publication purposes is strictly limited by reason of expense, so that a large mass of important matter has to find publication elsewhere, and this is increasingly the case as the volume of technical and scientific publication increases.

The only conclusion we can draw from these considerations is that, on the one hand, the activities of our Institutions, particularly in the publication of papers which have been discussed, should be supported to the utmost, so that they shall be enabled to deal with as large a number of papers as possible. For the remainder of the published materials it seems that careful critical analysis by competent men in the technical press is the best possible course, and we hope that technical journalism may be able to develop in that direction. Such critical treatment, of course, carries with it a high degree of responsibility, since a brilliant, new idea which may strike a reviewer as far-fetched or bizarre may be set back for a number of years by a severe adverse criticism, whereas, on the other hand, a plausible fad may be given a run which it does not in the least deserve. Errors of this kind can only be avoided by care and discretion and the application of a broad outlook which should not readily reject the unknown or accept as gospel whatever may be put forward, even by men of high status. There can be no doubt, however, that critical summarising reviews covering a considerable number of publications on a given subject and appearing at fairly regular intervals, would prove a boon to the anxious reader of technical literature who has to cover an immense field and had not much time in which to cover it.

Oil-electric Ferry Boats.

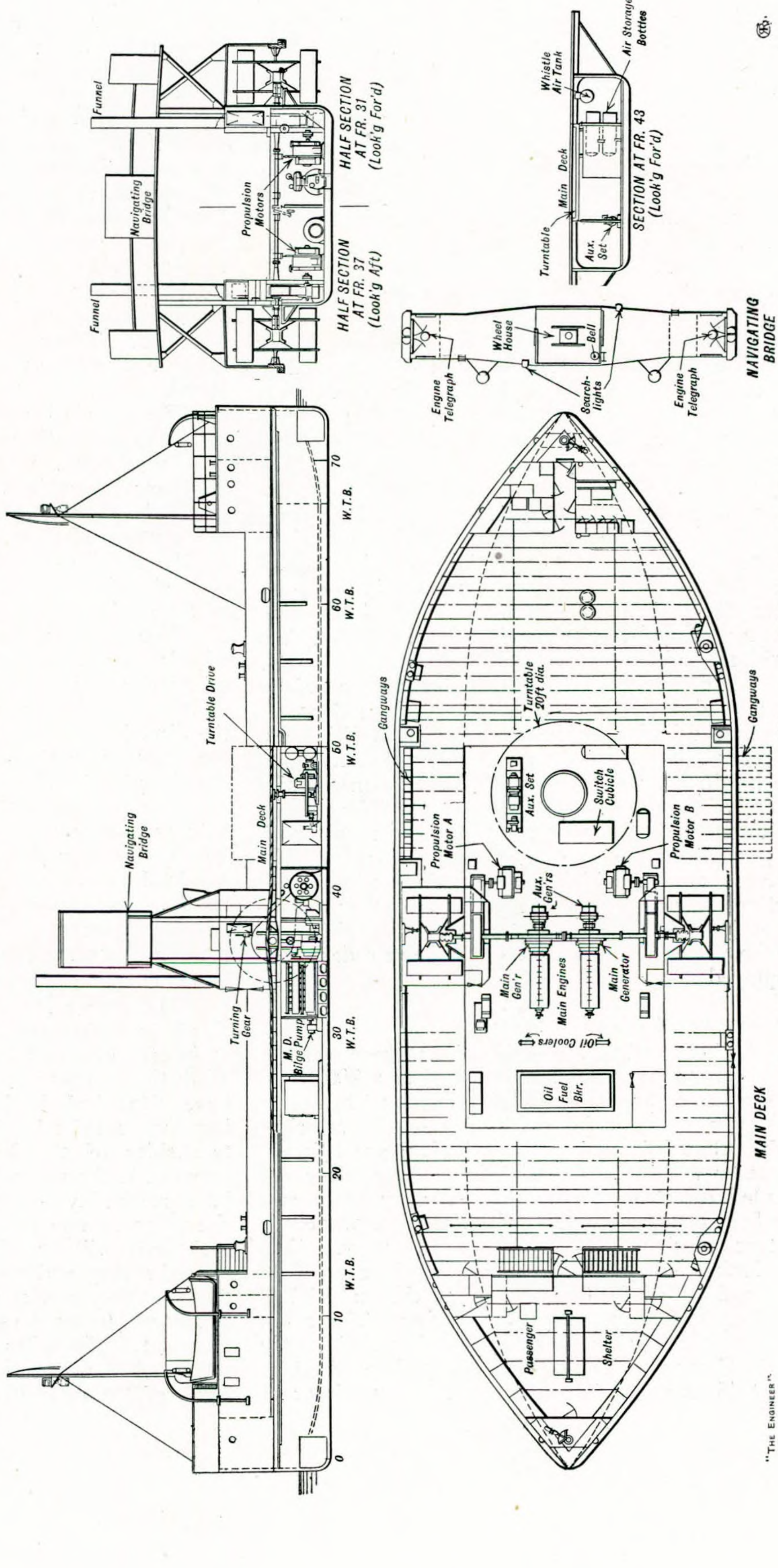
"The Engineer", 9th March, 1934.

The two oil-electric paddle ferry boats recently completed by William Denny & Bros., Ltd., at Dumbarton, for passenger and motor vehicle traffic between North and South Queensferry, on the Firth of Forth, one of which is illustrated herewith, are of interest, not only because they are the first boats of their kind to be built in this country, but also because they are all-welded vessels. Reference to this fact was made at the recent annual meeting of the British Corporation Register, to which we referred in last week's issue.

In designing these special vessels attention had to be paid to their operating conditions, and although end loading and discharging is generally to be preferred, it was decided to adopt the side loading principle. Again, the limited loaded draught of 4ft. 3in. almost ruled out the propeller drive, with the result that side paddles were adopted. With independent electric drive they give the advantage of very easy manœuvring. As the vessels will be in continuous service throughout the year with only one period of withdrawal for survey, no attempt was made to lighten scantlings, and all parts of the hull structure which have to sustain rolling loads were designed with a good margin of strength.

The principal dimensions of these two ferry boats, the "Robert the Bruce" and "Queen Margaret", are as follows:—Overall length, 149ft.; breadth moulded, 28ft.; depth moulded, 7ft. 10in.; breadth over sponsons, 47ft. 8in. The full output of 400 b.h.p. gives a speed of about 10 knots. Although they are about the same size, the "Robert the Bruce" is designed for carrying about 500 persons in addition to vehicular traffic, whilst the "Queen Margaret" has accommodation for only 200 persons, which fully meets normal requirements of the service for which she is intended. The boats can accept for traffic any motor car or goods-carrying vehicle not exceeding a loaded weight of 11 tons. As will be seen from the drawing, the passenger accommodation is arranged in the poop and the accommodation for the officers and the crew in the forecastle, leaving the whole of the main deck for vehicles. There is a double motor car gangway on either side. The gangways are electrically operated and when not required they can be hinged up so as to form part of the bulwarks. In the centre of the deck, between the gangways, is a 20ft. electric turntable, while for berthing purposes two electrically operated capstans are provided.

The hulls are double-ended and carry a rudder at each end, the rudder not in use being held in the fore-



General Arrangement and Sectional Views of Oil-Electric Ferry Boat.

and-aft position by an electrically controlled locking pin worked from the navigating bridge.

Welded Construction Details.

By employing electric welding instead of riveted construction it became possible to build the hulls in large sections in the welding shed, and by making use of the largest sizes of plates to effect the maximum economy in material. All the flanged floor plates, intercostals, and engine seatings were welded directly to the hull, no angle connections being fitted. The frames and beams are of ordinary angle section and the beams were fitted in one length the entire width of the sponsons where possible. A good deal of work was completed in the shed before erection. The heaviest panel was the bottom shell, containing the main engine seatings, which has a width of 24ft. and a length in the fore-and-aft direction of 16ft. 6in. The largest panel was one of the completed deck sections, which was 45ft. athwartships and 18ft. fore-and-aft. The final panel was the navigating bridge complete with the bulwarks, the wheel house, and the wing cabs. It was lifted on board in one piece after the machinery had been installed, its supporting struts having previously been fitted into position.

All the details of construction were carefully considered in conjunction with the British Corporation before beginning the work, and it is of interest to record that the only major alteration made to the original proposals was the increase in the size of one of the pre-constructed sections. The benefits which were obtained by completing as much work as possible in the welding bay were so great that a certain amount of inconvenience in handling large sections was accepted, in view of the other advantages gained. We may state that throughout all welding operations Murex Cresta electrodes were employed.

Propelling and Auxiliary Machinery,

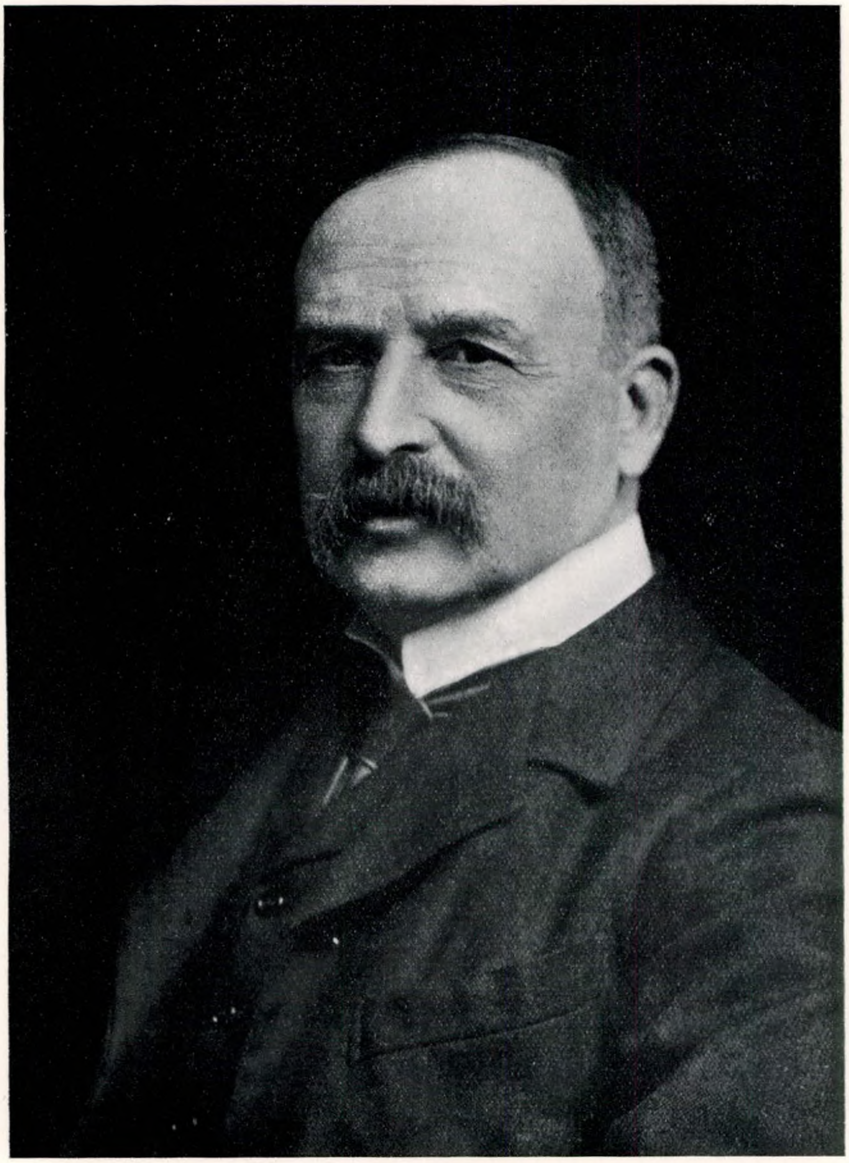
As indicated in our illustrations, there are two main generating sets. Each comprises a 200 b.h.p. "Paxman" eight-cylinder engine designed to run at 750 r.p.m. and working on the four-stroke principle with airless injection. The cylinders are 6½in. in diameter with a stroke of 10in. The engines are coupled direct to Metropolitan-Vickers main and auxiliary generator units. There are two propelling motors, designed to run at 270 r.p.m. when developing full power. Each motor is coupled to one paddle shaft through a "Wellman Bibby" coupling and chain reduction gearing. The chain gearing, which was supplied by Renold and Coventry Chain Company, Ltd., drives the paddle wheel at about 45 r.p.m. at full power, and the gearing and paddle wheels have been so designed as to give good efficiency in either direction of rotation. Normally the paddles rotate independently of each other in either direction of rotation, thereby facilitating rapid manœuvring. Each propelling motor takes its current direct from one main generator, and arrangements are made so that, in the event of one motor or generator being placed out of commission, both wheels can be quickly coupled together by means of a cross connecting shaft and coupling and both wheels driven by one motor. A safety cut-out switch to prevent overloading of the propelling motor under these special conditions is provided. There are also counters and gear to indicate when the paddles are running at the same speed.

For general auxiliary services there is the combined generating, air compressing, and pumping unit illustrated, which is driven by a Russell Newbery oil engine arranged for remote control. It can be stopped and started by push buttons at the starting platform. As our drawing indicates, all the switches, starters, and controllers for the main electrical units are mounted in a central cubicle in the engine-room.

The main propelling motor controller hand wheels operate in conjunction with the engine telegraphs in such a manner that, when the captain on the bridge moves the transmitter handles in the direction in which the boat is required to move, the pointers on the engine-room receivers move in the direction in which the respective controller hand wheels must be rotated by the engineer in order to carry out correctly the order from the bridge. All the interconnecting and isolating switches and overload breakers for the two main engine-driven auxiliary excitation generators and the independent auxiliary generator set are mounted on a separate panel in the same cubicle.

Service Operating Conditions.

The present ferry service across the Firth of Forth is maintained by one steamer, which sails at hourly intervals between 7.30 a.m. and 9 p.m. With the two new oil-electric ferry boats which we have described it is proposed to maintain an improved service by simultaneous sailings from the two sides of the Firth at half-hourly intervals between 7.30 a.m. and 11.30 p.m. The service will be a seven-day one all the year round, with the exception of one month, probably February, when each boat will be withdrawn for a fortnight for annual survey and overhaul. It may be pointed out that the ferry service now offered is of considerable advantage to road users, as it saves distances of from 30 to 50 miles, compared with the Stirling route, when proceeding from Edinburgh to towns north of the river Forth.



The late Mr. JAMES DENNY, Past-President.

Elliott & Fry.

OBITUARY.—Mr. James Denny, (Past-President).

Members will hear with regret of the death, in his eighty-fifth year, of Mr. James Denny (Past President) which occurred on Thursday, April 20th, at Dunstane, Dumbarton.

James Denny was the second son of the late Mr. James Denny, shipbuilder, of Levenford, who joined Dr. Peter Denny and the other partners of the famous Dumbarton firm when they combined to establish Denny Brothers. An education at Dumbarton, Helensburgh and Edinburgh was followed by his apprenticeship, his graduation from the fitting shop to the drawing office, and to his partnership in his twenty-second year. His first position of responsibility was that of shop manager, and the first machinery job of which he had sole charge was that of the "Rajputana". It is estimated that from that stage in his career propelling machinery of over 2,000,000 h.p. passed through his care. Responsibility for the rapidly developing engine works fell to his lot and his consideration was the evolution of designs calculated to give the highest speeds at sea. He watched the paddle engine through its initial phases, was introduced to the screw with the trunk piston geared engine, built triple-expansion engines of various types, and assisted in an early adaptation of the turbine in which wing screws were driven by an ordinary triple-expansion engine, and the centre screw was actuated by a low-pressure turbine. His firm associated themselves with the late Sir Charles Parsons and Mr. John Williamson in building the first commercial turbine steamer "King Edward" in 1901, and as tribute to his work his colleagues asked him to preside at the launching ceremony. Once inaugurated, the turbine assumed rapid expansion both in Admiralty and mercantile work.

Following his partnership at the engine works in 1871 he was associated in the partnership at the shipyard in 1881. Mr. Walter Brock, the senior partner, died in 1907, and Mr. Denny became head of both firms. He was first chairman of directors when the firms were incorporated as a limited company in 1918, but retired from that position in the following year, although it was not until 1931 that he severed his last link as a director.

Outside his business life he served for a period as a Member of Council of the Institution of Engineers and Shipbuilders in Scotland. He was one of the first members of the Committee, representative of various maritime interests, appointed to assist the Board of Trade on the claims of the shipping industries. He was also a Member of the Committee of Lloyd's Register and President of The Institute of Marine Engineers in 1908-10.

He was held in the highest regard by a wide circle of friends, including many of the present Council and Members of the Institute.