THE INSTITUTE OF MARINE ENGINEERS

TRANSACTIONS

1968, Vol. 80

DREDGERS AND THEIR MACHINERY

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For dredging magnetite sand in Japan, a suction dredger has been designed to work in depths from 70 ft to 140 ft. To enable this dredging unit to work in open seas, the actual dredging operation will be performed by a remote controlled "dredging beam". The dredge pump and cutter gear are incorporated in this dredging beam, which will operate at sea-floor level, powered and controlled from a catamaran-type surface vessel.

The dredging beam itself has a T shape, with fixed spuds at the ends of the cross-beam of the T, the end of the long beam being taken up by the actual dredging gear.

By means of a combination of cantilevering and swinging, the dredging beam can cut a relatively wide path over the sea floor. Special means for counteracting the influence of the swell upon movement control of the dredging beam as well as the suction pipe are described.

The ore intake at 700 yd^3/h, based on a solids concentration of 15 per cent is fed into a treatment plant, which is situated on one of the pontoons of the catamaran, the other pontoon being occupied by the power plant.

The treatment plant consists of screens (2 mm) and cyclones. The solids of over 2 mm (tailings) are discharged into separate barges. After settling, the solids fraction from the cyclones will be pumped to the final treatment plant on a separate tender pontoon. A number of research impulses, deriving from this project, which will lead to a fully automated swing movement while maintaining maximum production is discussed.

INTRODUCTION

The author is neither a marine engineer nor a naval architect but comes from the mining profession and has been associated all his professional life with heavy plant and its performance under the stresses of nature.

Having experienced the change in emphasis from brawn to brain in one industry, he is now actively engaged in working on the same change-over in the dredging industry.

His paper has three aspects, mining, dredging and research.

BACKGROUND TO THE PROJECT

With the ever increasing rate of depletion of the land-bound economic reserves of ore and fossil fuels, the necessity arises of either finding a more economical way of extracting ore and fossil fuels from the earth or of extending the exploitable area of the earth as a whole, which means that the water-covered areas must also be included.

As is undoubtedly known, the struggle to lower the economic cut-off limit is continually going on and large gains are still being made in this respect.

To illustrate the raw materials position, it can be stated that in living memory more raw materials have been used by mankind than since its origin, say one million years ago. When extrapolating the curve of this tendency into the future, one can only hope that it will flatten off.

In the past the exploration for minerals stopped at the coast, but gradually explorations and exploitations have moved into the sea and lakes, first in shallow and sheltered waters, but more recently into deeper and rougher parts of the sea. As a source of minerals, the sea has been little exploited relative to its potential. With regard to mineral resources the sea can be divided into five regions: the beaches, the water itself, the littoral sea (also called the continental shelves), the surface sediments on the sea bottom and the hard rock beneath these sediments.

LITTORAL MINING

Although it is tempting to take a very big jump ahead and start exploiting such rich deep-sea deposits as the manganese nodules, it is probably wiser, and is certainly more economic, to start nearer the shore. Moreover, there is the advantage here that a certain beginning has already been made in so far as the mining of tin, phosphate and diamonds is concerned and, of course, everyone is well aware of the present efforts in the fields of oil and gas in the North Sea.

When extracting ores from the littoral sea there are three possibilities which are more or less continuous operations—bucket dredging, suction dredging and trailing dredging. The two main points in which dredging in these surroundings differs from normal practice are the depths and conditions of wind and water. Another smaller point is that the material to be dredged can be, as is the case with deposits of iron sands, appreciably heavier than normal. Thus, in addition to the efforts being made to increase the percentage of solids in the mixture, another problem manifests itself, that of vertical lifting and transportation. Consequently, on the dredging side there are the considerations of depth, weather, water and a heavy mixture, whereas on the mining side the considerations are the highest degree of extraction of the mineral and the "safe" disposal of tailings in such a way that they will not be taken up again.

The summing-up of these considerations could be stated as the achievement of the highest economic degree of mineral extraction at the highest economic rate for the highest number of workable days—truly an all-time high.

JAPANESE IRON SAND DEPOSITS

In Japan, where good quality iron ore is a scarce commodity, attention has long been given to the marine iron sand

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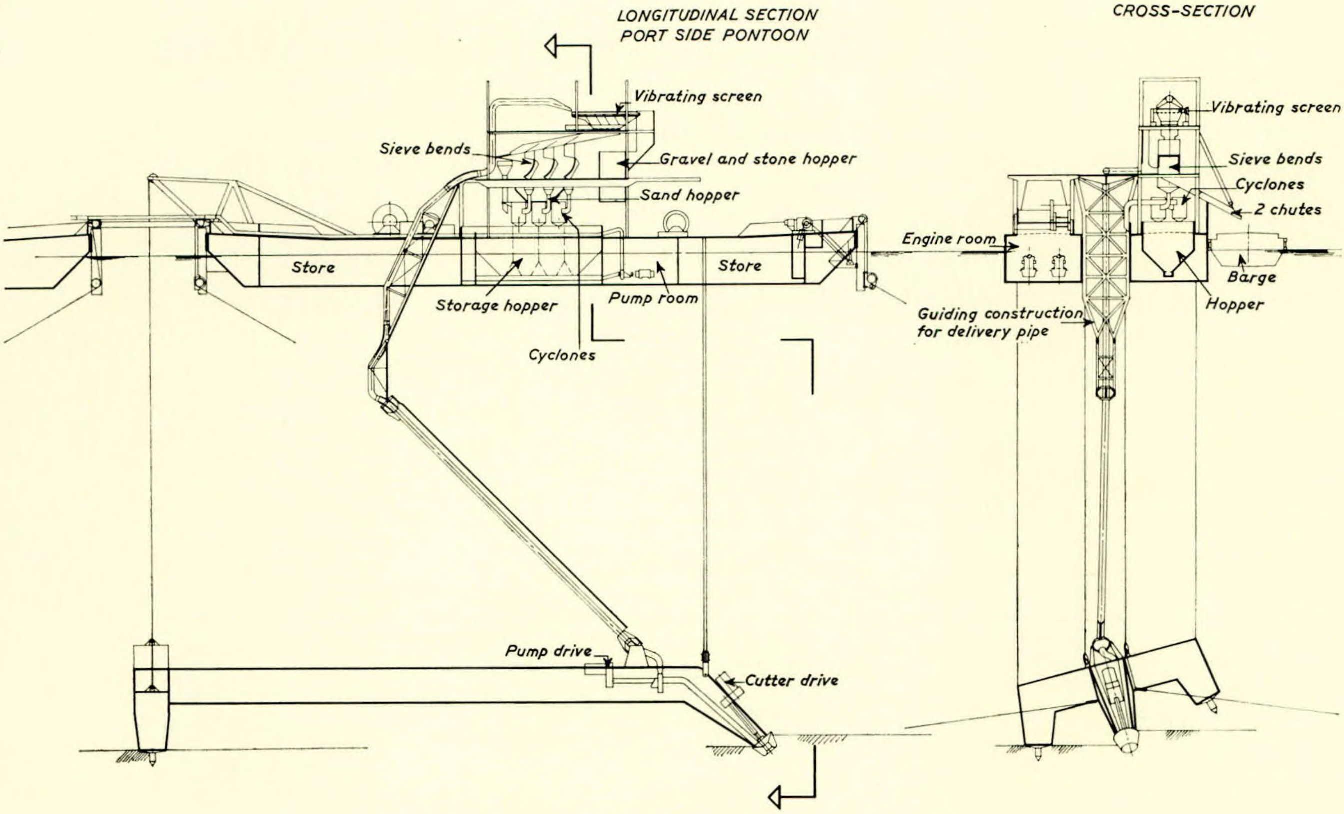

FIG. 1—*Basic concept—Separate dredging element*

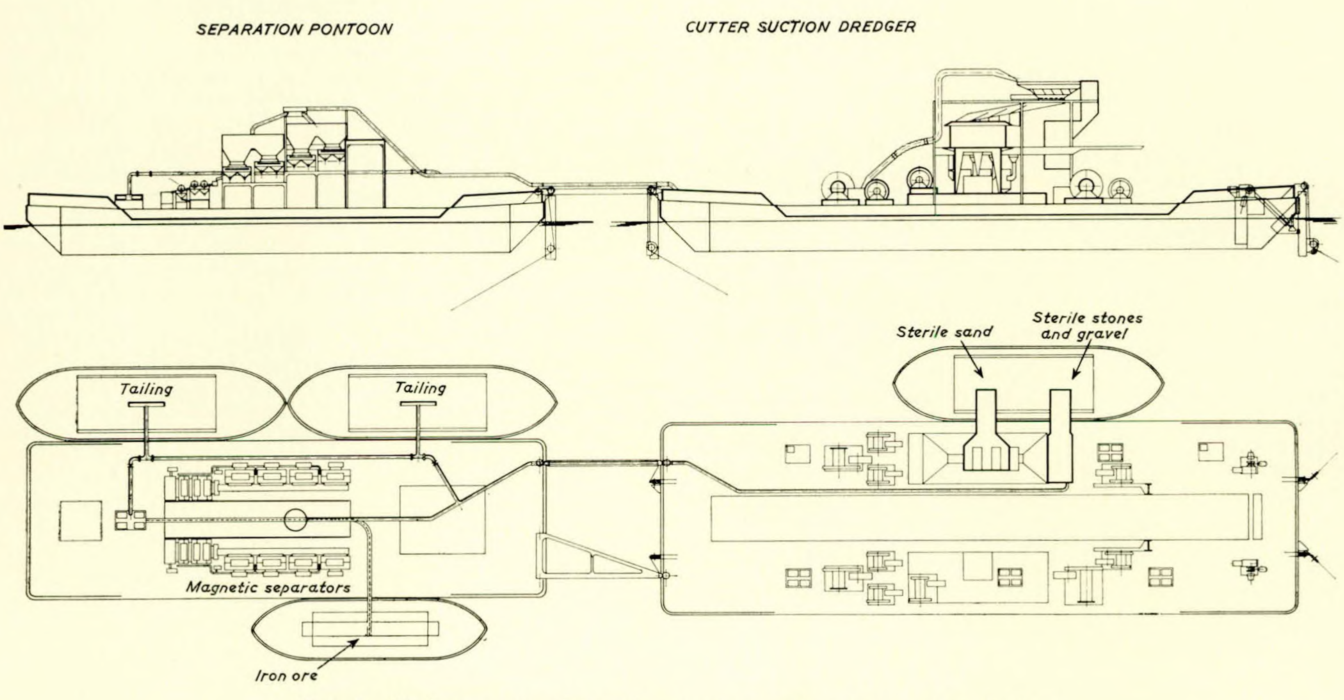

FIG. 2—*Basic concept—Separation pontoon and suction cutting dredger*

deposits of which considerable reserves (40 million tons of 36 per cent Fe) are available.

The analysis of this marine ore, as obtained from cores, is as follows:

a) apparent specific gravity of dredged material ... ... 1·7
b) screen analysis—gravel and decomposed rock ... ... 30-40 per cent
   sand, sometimes with clay ... 60-70 per cent
   shells ... ... trace
c) content of iron sand in the material (in magnetic separator) less than 5 per cent
d) apparent specific gravity of iron sand 2-2·5
e) iron sand occurs mainly in the gravel and decomposed rock layers
f) analysis of iron sand:
   sand ... ... 63 per cent
   magnetic fraction ... ... 37 per cent
   specific gravity of magnetic fraction ... ... 4·31
   specific gravity of total sample 3·28
   specific gravity of wet sample ... 2·35-2·40

Before succeeding in covering their demand in iron ores by long term contracts for rich overseas ores (Australian, South African, Brazilian, Indian, etc.) the emphasis was on the exploitation of the marine deposits and it is only recently that this exploitation has shown a downward trend.

It was during the period of continuing interest in the mining of these marine iron sands that I.H.C. Holland made a special study of the problem of mining, i.e. dredging, these sands. Notwithstanding the diminished demands upon the Japanese iron sands, it is the author's opinion that in the very near future the same considerations will arise with other mineral deposits in other parts of the world.

DESIGN AND LAYOUT OF EQUIPMENT

The requirement, which was as simple as it was difficult, was for the design of a dredging unit capable of dredging 700 yd^3 solids/h from a depth of 70-140 ft in open sea. Treatment of the dredged material was to take place at the dredging unit with the subsequent shipment of the concentrate and disposal of the tailings.

The working depth was somewhat greater than normal, but nothing extraordinary. It was the necessity of working in the open sea, with the inherent forces of wind and water, combined with the movement of the water, that made the design job so interesting.

As can be seen from Figs. 1 and 2, the basic concept was a separate dredging element, working at the bottom of the sea, but operated and controlled from the mother vessel, with which it is firmly, though movably, connected.

It is stressed here that in this design the author's company has not made the ultimate step of still further uncoupling both vessel and dredging element; the main reason being that the maximum depth required did not necessitate such an audacious design.

The dredging element consists of a very heavy beam with the dredging element, in this case the cutter, working from the end of the long stem. Both ends of the crossbeam act as pivots, not unlike huge thumb tacks. The working of this unit is as follows; by means of wires one pivot point is lifted free from the bottom, so that the other pivot point can act as a true fulcrum. By means of wires and anchors, the whole beam swings over a certain arc, the wires being operated by winches on the mother vessel. To assist in this "dog legging" swing action the wires are shorn through sheaves at both sides of the cutter head and at the pivot points. When making a starboard sweep the port board pivot is lifted and the starboard one lowered, so that at the end of the sweep, this pivot point has moved forward. By switching fulcrums at each end of the sweep, the beam moves itself forward.

Fig. 3 gives a very clear elucidation of the wire play, together with the possibilities with different anchor distances.

This dredging unit comprises the cutter head already mentioned and the dredging pump, both in a conventional arrangement, though the underwater motors for pump and cutter are electrically driven. A delivery pipeline of 20-in diameter, flexible in parts, leads from the pump to the mother vessel.

Electricity was chosen for the motive power for two main reasons. The first was that an electric cable is easier to handle underwater than a high pressure hydraulic hose, the second, that for hard going with the cutter, for instance when encountering soft rocks or cemented sediments, a high inertia of the electric motors gives a welcome reserve in cutting force.

The movements between the vessel and the dredging beam,

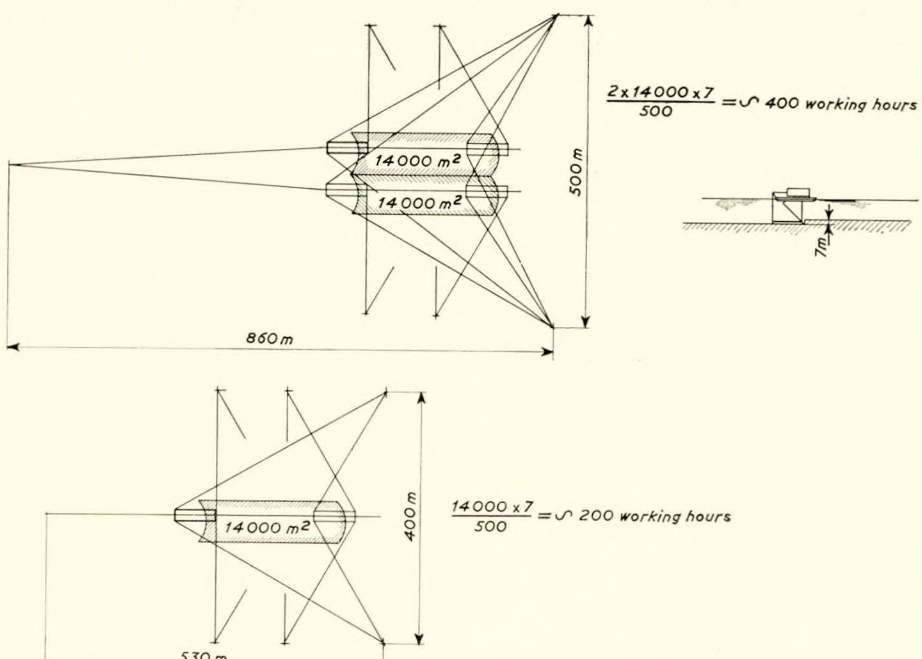

FIG. 3—*Relationship between dredged area and place of anchors*

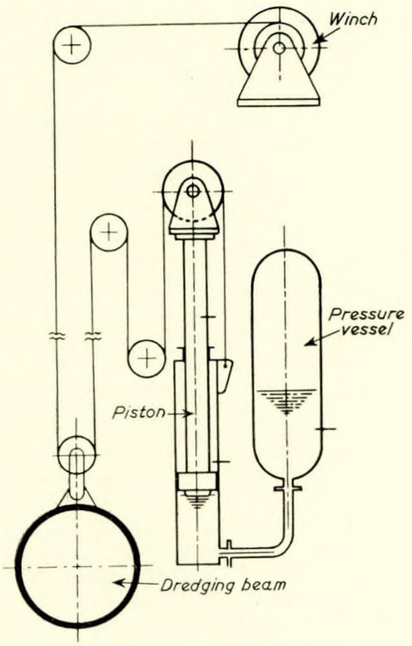

FIG. 4—*Schematic diagram of swell compensating gear*

such as those caused by rough seas, are absorbed by the swell compensating gear. This is an hydraulic-pneumatic device to keep the wires between the parts at a constant tension, as shown in Fig. 4.

The mother vessel consists of two pontoons forming a catamaran, the space between the pontoons being large enough to accommodate the dredging beam in the raised position for transport, inspection and maintenance purposes. When in the raised position, the cross-bar with the two spud-like pivot points is abaft the mother vessel, thus forming a compact unit for transportation. The dredging unit is raised by three wires, one at the cutter head and one at each pivot point. The whole operation is governed by two swinging wires and three hoisting wires on the dredging unit and four mooring wires to keep the vessel stationary above the fulcrum.

It will be easily understood that, as it is essential that the mother vessel more or less follows the movements of the dredging beam, a great deal of sequence control and automation of the winches is involved.

Upon delivery above water, the water/sand mixture, with an average of 15 per cent solids, is delivered to the top part of the mother vessel. By means of vibrating screens and sieve bends, the first benefication is achieved, as anything above 2 mm, being sterile, is dumped into a special tailings barge.

The resulting underflow is thickened by cyclones. The thickened mixture is discharged into a buffer hopper where further settling takes place. From this hopper, the ore is pumped at a constant rate to the magnetic separators on the separation pontoon. Should the iron content of the raw material drop below the previously selected cut-off point, the underflow of the sieve bends is pumped directly into the tailings barges alongside the separation pontoon.

The power installation is fully Diesel-electric, the system being based on the fact that the dredging operations continue round the clock with an average of 600 working hours per month.

The whole power plant is installed on the starboard pontoon, the port pontoon accommodating the treatment plant in so far as this is not located on the separation pontoon.

The main feature of the Diesel-electric system is that each of the Diesel engines can be overhauled during operation. Other features are:

1) equal distribution of the total electric load on the running Diesel generator sets;
2) most suitable speed/torque control of cutter and sand pump;
3) correct and safe control systems for all winches.

Some design data are:

Length overall with beam raised	206 ft 8 in
Length of pontoon, i.e. mother vessel	180 ft 0 in
Width of each pontoon ...	21 ft 4 in
Width overall	56 ft 0 in
Depth at side at half length ...	13 ft 4 in
Mean draught with beam in raised position, deadweight of 620 tons	9 ft approx.
Maximum dredging depth ...	140 ft 0 in
Pump motor continuous rating	730 hp
Cutter motor continuous rating	300 hp
Diameter of suction pipeline ...	20 in
Diameter of delivery pipeline	20 in

MODEL TESTS

As this design incorporated a number of new and untried features a scale model was made and tested which gave rise to the following main modifications.

The delivery pipe needed an extra joint as longitudinal movement between mother vessel and beam when raising the latter caused severe loadings in the pipe construction.

Special features for the pivot point were needed to ensure firstly, sufficient grip on hard rock and, secondly, sufficient grip in soft sediment without penetrating this too deeply.

Taking the wind forces into consideration, it is essential to keep the silhouette of the surface vessels as low as possible.

The study of the problems brought about by designing this kind of equipment, also as seen in the light of the model test, gave rise to a number of questions which served as impulses to the research on dredging and associated subjects.

RESEARCH

It would be outside the scope of this paper to discuss at length all the research carried out on this project. Moreover, on close inspection, quite a number of problems proved to have a more general bearing than anticipated.

From the treatment side, the author's company considered problems of thickening without the usual loss of power inherent in cyclones. Dependent upon the value of the solids, a way was found that proved to be of possible use in normal dredging operations.

To extend the use of this kind of dredging equipment to the mining of non-magnetic minerals, a concentrator of the jig type has been perfected so that the jig working can be adapted to the kind of mineral, i.e. specific weight and size of grains, that is to be concentrated. By means of an hydraulic system, the stroke intensity and the frequency can be regulated at will.

The underwater pump was the focal point of much research work. With the ever-increasing depth, most probably coupled with increasing density of the mixture, the underwater pump will come more to the fore.

Three different methods of pumping were considered—centrifugal, jet and airlift. Although research has not been finalized, in this case the underwater centrifugal pump is superior to the other two. In special cases, however, both jet pump and airlift are to be preferred to the centrifugal pump.

A remarkable fact is that with increasing depth or mixture density the advantages of the airlift also increase, much more rapidly than the disadvantages.

In comparing the wear between the three pumps, the highest marks go to the airlift, with the centrifugal pump coming at the bottom of the list.

Finally, the transmission of power to the pump becomes much more difficult with increasing dredging depth. Even when considering the rather loose ties between dredging beam and mother vessel, the transmission of power must be guaranteed with as little vulnerability as possible. The motive power —electricity, high pressure fluid, or compressed air—has to be

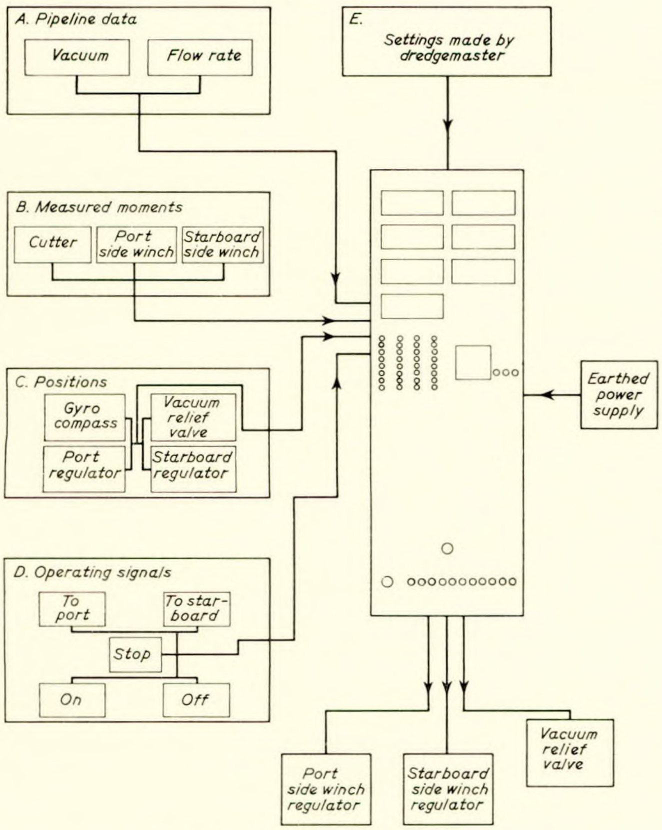

FIG. 5—*Signals fed to computer*

transmitted by cable or combined pipe and hose and it is here, again, that the airlift is superior to the other two forms of pump. The author foresees that, especially for deep dredging equipment, the airlift will come into far wider use than is expected at present.

Accepting that deposits in deeper and rougher waters are to be dredged by a near continuous operation, then the cutter element must be such that both repair and maintenance take far less time than at present. It is clear that interrupting a mining operation and starting it again is rather a costly affair, but the main difficulty lies in the fact that raising the dredging apparatus sufficiently to undertake repair or exchange can be, and generally speaking will be, made most difficult by the conditions of wind and water.

The properties of the present day cutters hinder the deeper dredging operations. In the first place the one-sided rotation of the cutter head, which means that it is either undercutting or overcutting, entails a different production for alternate swings. As far as mining operation is concerned this is a wasteful practice, considering that all the work is done for a partial recovery. Moreover, the tension in the swing wires will be very different, as is quite well known. Then there is working in hard ground to consider. Without going to the extremes of actually cutting hard rock, the author thinks that it is essential that in future operations softer rocks or cemented sediments be dealt with more satisfactorily than at present.

Theoretically it has been established that the best effects will be obtained with a resonance cutter. This principle implies that the rock-breaking effort of the cutter teeth causes resonance in the drive of the cutter head. This principle, combined with a facing of the teeth not unlike the ram blast bit, will give a cutter head that can tackle rocks, but the difficulty of overcutting and undercutting has not yet been overcome.

The "Philishave" model—two cutter heads counter-rotating on a balancing rod—has been considered. This enables the cutting on alternate swings to be done in the same way, the leading head skimping the surface overcutting, while the trailing head does the actual work, undercutting; however, quite apart from the difficulty with the suction mouths, it is not considered that this model fulfils the first requirement for deep dredging—sturdiness.

The author's company is very actively engaged on this cutter question, and it looks as if a real breakthrough can be anticipated in the immediate future.

One of the most important aspects of deep dredging will be that of controlling the operations. As visibility is nil, other means must be used to effect control and it is here that big advances have been made in automation.

Besides a number of special instruments required to monitor the dredging operations, it was felt that the prime provision for further progress in depth, and on to rougher waters, was the automation of the operation as the number manipulation increases beyond the point of normal human capability.

These considerations led to the development of the I.H.C. Cutter Automaton which controls the warping winches of a cutter suction dredge and also the vacuum relief valve to achieve the maximum production without:

1) the cutter motor being overloaded;
2) the warping winches being overloaded;
3) sedimentation taking place in the delivery pipe;
4) choking of the dredge pump;
5) exceeding of the planned channel width;
6) interruption of the dredging process by sudden burial of the suction mouth.

Because of the number of different signals received, coupled with the fact that any one of these is just as important as a

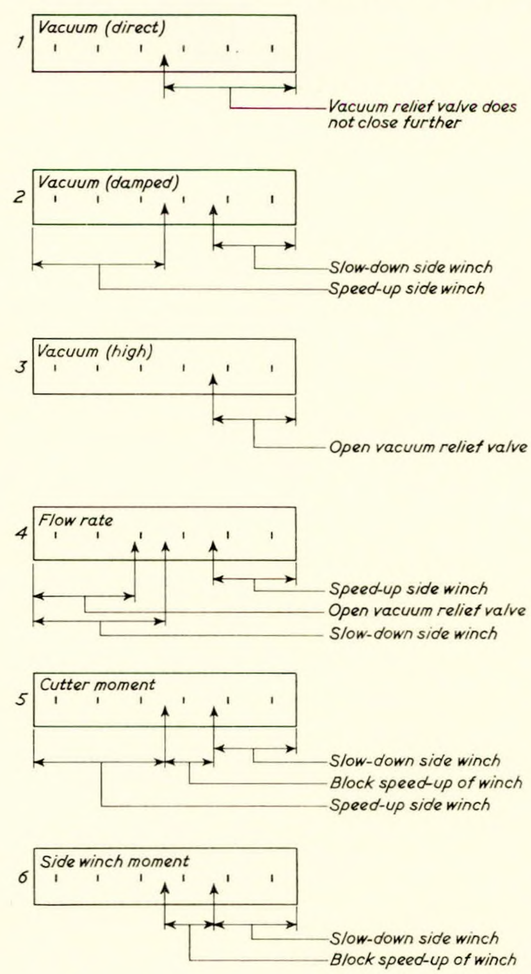

FIG. 6—*Settings to be made by the dredgemaster*

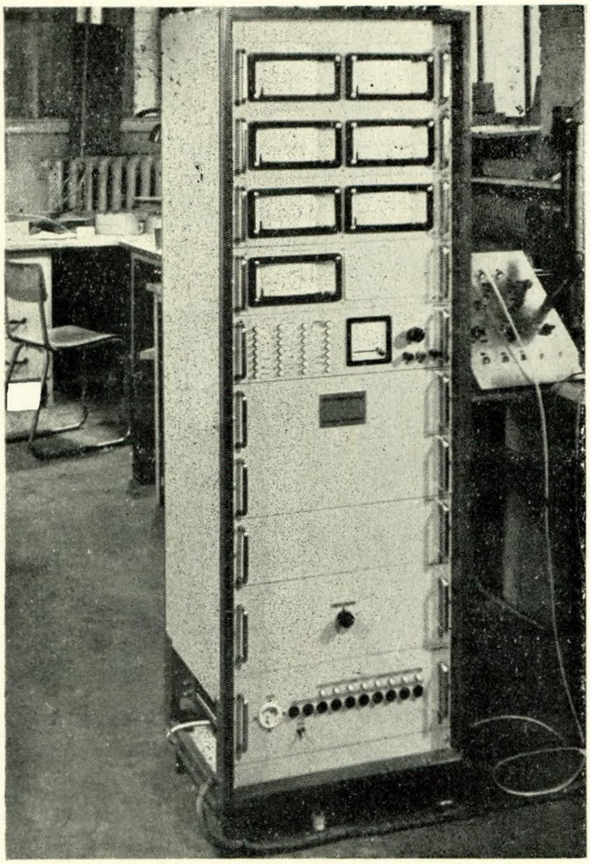

FIG. 7—*Digital computer controlling operation*

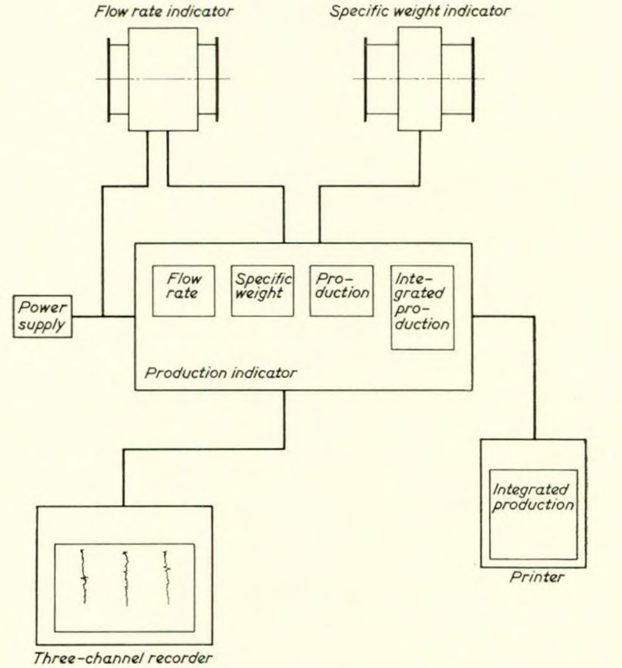

FIG. 8—*Comprehensive production measurement installation*

combination of several, a digital computer was selected to control the operation.

The signals fed to the computer comprise: pipeline data, loadings of cutter and winch motors, positions of the gyro compass, vacuum relief valves and winch regulators, as well as the operating signals "swing", "go", "forward" and "stop" and a number of settings made by the dredgemaster, such as the points where winches needed to be speeded up, those relating to the vacuum of the dredge pump or the torque on the cutter motor.

The limit of the tension on the two swing wires is important, above this, further speeding up of the winch is blocked or the pulling winch is slowed down. In limiting the stress imposed upon the swing wires either the working life of the wires can be increased or the slipping of the anchors in the type of soil concerned can be avoided, see Figs. 5 and 6.

The signals received are compared by the computer with the preset values and the computer decides whether or not it is necessary to act. Switching speed, time lapses and the number of steps over which control is exercised are also adjustable.

For this purpose the computer has eighty printed circuit panels in addition to power supply connexions and fifty input and sixteen output channels, see Fig. 7.

The dredgemaster programmes the computer in the optimum manner with the aid of the I.H.C. Production Indicator, showing the rate of production at any given moment. This instrument calculates the production per unit of time from the flow rate and the signal received indicating the specific weight of the dredged mixture. As the instrument comprises an integrator it also shows the average production over a given period, see Fig. 8.

Further automation has taken place in trailing suction dredging where the task of keeping the oscillations of the swell compensating gear close to the middle position of the piston was the first item to be removed from the direct control of the dredger operator.

Positioning of the visor regulating the actual "digging" current then followed by making it dependent upon the vacuum of the dredge pump and the concentration of the mixture.

Only the ultimate step of regulating the speed of trailing and the force with which the trailing head is pressed against the sea bottom, so as to optimize production, still remains to be taken; this will be achieved in the very near future.

Discussion

MR. E. B. BUDD (Member) said that Professor Velzeboer's paper had given an insight into the successful amalgamation of a number of widely differing techniques to solve a particular specialist problem.

Could Professor Velzeboer comment on any erosive wear problems that might have arisen while transferring marine ore with such a horrifying analysis? In particular could he speak of the material of the pipes and impellers, any protective treatments and the velocity of flow? On sheer bulk alone Mr. Budd had arrived at a solid velocity of 2·5 ft/s but, clearly, with water dilution, velocities would be considerably higher.

Was the swell compensating gear, in effect, a simple cushioning device or did it, by means of a sensing element, vary the displacement of the piston?

He also asked how flow was measured on automatic cutter control.

MR. P. A. DELME-RADCLIFFE said that, as a mining engineer, he differed slightly from Professor Velzeboer in that, in his opinion, the interest in working mineral deposits under the sea was being taken here and now.

It was essential for the mining engineer to know how these problems were being solved and what the dredging engineer could do. In a recent case of offshore exploration for tin, before going too far, the question had to be asked: how deep were they prepared to go? If a deposit were found at 100 ft depth it was worthwhile proceeding, at 150 ft it probably was, at 200 ft it became a rapidly increasing problem and so on. If the deposit were very rich in tin or gold, one could afford to spend a great deal to get it out.

Was the deposit, referred to in the paper, shallow? Apparently all the material was fairly fine grain. Occasionally in looking for tin and gold etc. he had had to deal with a river deposit full of fossil timber which created its own problems. Had the author ever considered a cutting arrangement somewhat similar to a bucket wheel excavator or whether a very short bucket ladder at the bottom of the beam might not be more suitable for digging into the face of the deposit and not rolling the cutter across it?

MR. W. T. DUNNE had been associated with Mr. Delmé-Radcliffe in offshore dredging. Up to date they had been confined largely to bucket dredging. This had developed from their interest in dredging on land, largely for tin. They had found that bucket dredging was the most effective method for removal of the detrital material from the bedrock, digging without the series of sophisticated controls mentioned. Mr. Delmé-Radcliffe's combination of bucket-wheel dredging and suction dredging seemed an ideal type of combination for sea dredging. It was most important in the mineral industry to remove everything from the bedrock, particularly as they had fine sand layers, sometimes even down to six inches where the mineral content was very low indeed, and they were very much dependent on digging everything. With soft bedrock, bucket dredging was the answer, as they took a little of the bedrock to ensure removal of all the detrital material. They were dealing with concentrates which comprised about 0·01 per cent of the total material being dredged, as against the five per cent in the paper. It was therefore very much less in quantity and was most important that everything should be removed, so the actual process was also important. They were getting away from bucket dredging as they went into deeper water, and had not extended beyond 150 ft in bucket dredging activities. The maximum was about 120 ft at the moment in sea dredging. In the evident need to change from bucket dredging he was interested in the author's system, it was a first move towards detaching the digging apparatus from the actual dredge. This was an advance that had to come in dredging for minerals on the sea bed at increasing depths. The one problem anticipated with suction dredging was the stability of the suction load in fairly rough sea conditions. The advances suggested had also been projected in papers written in America.

It was all-important to take the responsibility for the effectiveness of the digging from the dredge operator as plant became more and more complicated and to this end they were using closed circuit television and other aids.

The author suggested separating the material taken off the bottom to about 2 mm (less than 0·1 in). They customarily separated at about 0·5 in, so they were treating very much larger quantities and it was essential not to lose more than a very small percentage. This was a problem which became of very real importance to the mineral engineer, and the amount of material treated would call for a very much larger treatment plant, adding to the problem of the size of pontoon or ship to be used, or alternatively whether it should all be put into one combined pontoon.

In treatment of pumped material, the water was always in excess of the type of feed in bucket dredging. There was a de-watering problem which was very great indeed when dealing with the very large quantities involved.

For a long time they had known about the swell compensating gear developed mainly by the Dutch interests in dredging operations of various types. The author's figure showed a trailing suction unit. The suction cutter was a much heavier unit altogether, and they were dependent very largely in this on the pressure of the face of the cutter against the material. Was this compensated for in conjunction with the actual weight of the unit on the bottom, as being a further factor affecting the swell compensator?

This type of operation was one that was going to have a real application in mineral dredging.

MR. W. A. DELL (Member) wondered whether any dredger of this design had been built and put into operation. It would seem that this was the design stage for a particular application without its ever having been constructed.

In Fig. 3 there seemed to be a dredging track or two tracks side by side, about 250 m long, with three anchor positions for the side line wires. He presumed that the anchors were moved for advancing the dredge. A stern line was shown. Was it intended to use any head line, or was all the fore and aft movement to be taken on the pivoting spud? If so, what was the reason for the stern line wire?

In the second paragraph of the section on Research, it was stated that author's company had "considered problems of thickening without the usual loss of power inherent in cyclones". What was meant by "cyclones"?

He understood the author to have said that if the hopper load were read off and compared with the recorded output of the pump, the difference would be the wastage over the side of the dredger through the overflows. This would be true if the hopper were completely full of spoil, but if there were still some water left a correction factor would have to be introduced for the specific gravity of the spoil and the density of the water.

MR. W. C. B. PASTOORS asked if the action of the swing wires from the actual cover arm to the mother vessel, was compensated by a swell compensator or some other means when movement of the mother vessel was caused by the winch wires being held in or left going out.

With regard to the flexibility of the entire arrangement, what had been the design swell action in this set-up? Here two pontoons were coupled together and the tailing put into barges lying alongside. From experience he knew that such an operation would only be possible in limited swell conditions. What was the author's opinion concerning the disposal of the tailings as well as the concentrates when they operated in the worst conditions at the limited swell.

With regard to the specific weight indicator, of which there were two main types, the electric induction instrument might give a wrong indication, offshore, being sensitive to the salinity of the water, whilst that based on the specific gravity of the particles might be affected by the separate values for sand and minerals. He wondered whether reliance could be placed on the values obtained from the systems.

The Chairman (MR. R. COOK, M.Sc., Honorary Treasurer) recalled that in his youth a very familiar noise was that made by the suction dredgers which were used and, he believed, were still used to keep the channel open at the mouth of the Tyne. This noise was scarcely musical and it could be heard for a very considerable distance especially at night, and must have been distressing to those living within a mile or so.

Did the modern bucket dredger still emit these horrible noises?

Correspondence

MR. G. A. BOURCEAU (Member) noted, in a written contribution, that one side of the cutter suction dredger contained the engine room, whilst the other side comprised the hopper.

As the hopper might either be empty or contain sand, differences in its load condition would not only affect the draught of the dredger pontoon, but could also cause a list. The difference in load on the starboard and port hoisting cables of the separate dredging element would also influence the list of the dredger. Theses effects would be distinct from the movements of the separation pontoon.

Since the two pontoons were coupled on one side by a heavy triangular construction and on the other side by the sand pipe, how was movement possible, between the two pontoons, without creating severe strain in the sand pipe or its connexions at the pontoons?

He also noted that the cutter of the dredging element had sometimes to work in fairly hard soil and supposed, therefore, that it might be necessary to apply strong transverse force on the cutter. Because of the length of the hoisting cables, this would only be possible through considerable transverse movement of the dredging pontoon and, to compensate, the vertical component in the hoisting cables would lift the cutter head. How had this problem been overcome?

Author's Reply

In reply to Mr. Budd the author said that the mixture of the ore and water would have a velocity of about 15 ft/s when using a conventional cutter, consequently wear and abrasion would have to be considered in the layout of such equipment.

Both wear and abrasion were subject to much research and the results indicated that one of the most important factors was the positioning of the pipe elements to each other. When joining the pieces of pipe together care should be taken that each element was in as good as possible alignment with the adjacent pipes.

On the other hand, polyurethane linings were in use for pipes and were giving good results. More recently high molecular polyethylene had been tested and gave extremely good results. It had been discovered that the high insulational property of the polyethylene influenced the magnetic flux measurements. How far this insulation effect caused a repulse of the sand grains from the lining due to electrical phenomena was being studied.

The impellers and pumps were made according to three different principles of wear resistance:

1) cast steel but reparable by welding on the spot;
2) white cast iron on a high chromium base;
3) coated with rubber or polyurethane.

The big heavy pumps were generally made in cast steel so that complete exchange was not often necessary. Any wear was made good by welding on the spot. Special electrodes were used to increase the wear resistance.

At the other end of the range, where the material to be pumped was uniform in size and surprise items in the form of motorblocks or other heavy and bulky materials were completely absent, pump-housing and impeller were coated, giving extremely good results.

For the bulk of the pumps in between these two extremes, a hard casting, such as diamond steel or nihard, was used.

Generally speaking the aim was to keep the velocity of the mixture low, but this lower limit was dependent on the critical velocity of the mixture, i.e. where settling took place, and on the capacity wanted, but also on the critical-speed/concentration relation.

The swell compensating gear was not a cushioning device, but the piston was indeed governed by a sensing element, which in the case of a trailing suction dredger was the suction head. The force with which the suction head rested on the sea bottom was kept constant by the pressure in the hydraulic accumulator, any variation of this force resulted in a variation of force in the suspension wire. The latter variation was taken up by the expansion or compression of the gas above the accumulator fluid.

With automatic control on the cutter, the flow was measured by means of an electromagnetic flux measuring device. Provided the device was mounted in a vertical pipe section where both flow and specific gravity had a more or less symmetrical pattern across the pipe diameter the results were excellent.

The author entirely agreed with Mr. Delmé-Radcliffe that the future had already begun. Considerable work had been done at sea but nearly always in shallow and sheltered waters. Both depth and swell had hindered the development of sea mining up to the present. The project under discussion was intended to work reserves at a greater depth and to a large degree independent from the conditions of wind and water.

With increasing depth the cost price of the "run of mine" product would undoubtedly rise, but in the range mentioned by Mr. Delmé-Radcliffe this would represent no essential cost factor. The project foresaw a very flat cost/depth graph to say 300-500 ft. For depths greater than 500 ft, the author felt that a reliable cost/depth prognosis would need the experience gathered from the shallower range.

The project discussed was intended to work between 70 and 140 ft, but the possibility of working in a greater depth was taken into consideration in the design.

The material to be dredged was indeed fairly fine grained which together with the nature of the deposit did not cause undue anxiety when applying a conventional cutterhead device.

The bucket dredger was a very good digging instrument and from this consideration the first requirements for a new dredging device were laid down. The requirements of a future dredging device were listed to be:

a) capable of achieving a high production in various unsolidified materials;
b) capable of dealing with buried timber;
c) capable of dealing with boulders;
d) capable of dealing with sticky clay;
e) capable of dealing with low grade alluvial gold or tin ores.

Without going as far as saying that everyone of these possibilities had been realized to the highest possible degree in the latest design, it was felt that the data so far obtained in research, indicated that a major improvement would result.

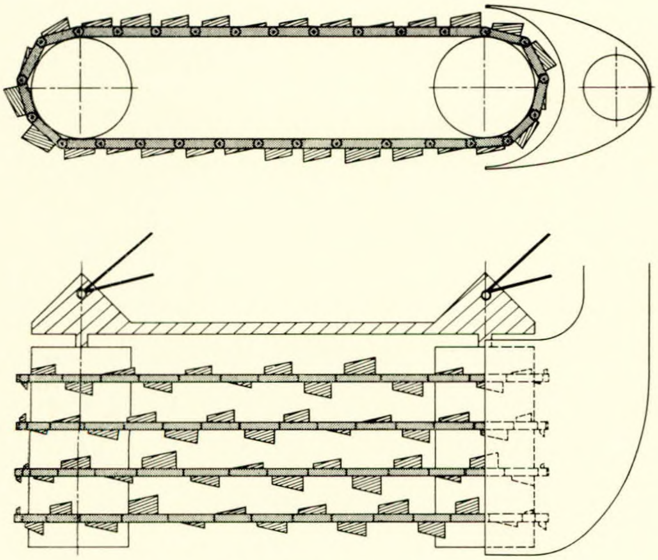

FIG. 9—*Homotropical cutter device*

The new dredging device could be seen as a number of bucket chains side by side, the buckets having been transformed into cutting edges (see Fig. 9). Consequently the author's company had split the dual function of the bucket, i.e. digging and transporting, by letting the cutting edges do the digging, whereas the suction stream, helped by the movement of the cutting edges, transported the loose material.

By doing this they avoided the provisions of the compromise and designed the cutting edges solely for their main task, i.e. cutting.

Replying to Mr. Dunne, the author said that the nature of the deposits made it essential that the bedrock was swept clean of any heavy minerals.

Should the bedrock be weathered and of such a nature that it formed the ideal settling conditions for heavy minerals, it became essential that the top of the bedrock was also removed.

Consequently the dredger device must be strong enough to "scrape" the weathered top of the bedrock and the suction current must be strong enough to scour the newly cut rock face clean of any heavy minerals.

As already indicated in reply to Mr. Delmé-Radcliffe, the design of the "business" end of the cutter was such that it fulfilled these essential requirements. It must be understood, however, that nature could play tricks, for example there were small crevasses where even the new device was incapable of removing all the heavy mineral deposits.

In the latest design of dredging equipment the function of the dredger operator was far more to supervise the computer controlled working of the dredger than to actually handle the dredging operation himself.

At the same time that the operator was relieved of the actual handling, the computer gave the possibility of optimizing production. When positioning by electronic means was used, then the data derived from this could be compared with a previously prepared plot. The resulting signals could be fed into the computer so that a completely automatized mining operation would result, only supervised by the operator.

The size distribution of the iron sands made it possible to take the first separation at 2 mm, but in ores of different size distribution other screen sizes would have to be used. In principle this screen size was chosen to separate the sterile coarse from the rest of the ore which should contain all the valuable material.

The treatment at sea at the throughputs envisaged would create some interesting problems for treatment engineers but it was felt that these problems were far from unsurmountable. For instance the fact that the whole mass of water and ore was already contained in a pipe at a certain pressure and velocity was advantageous for thickening purposes by cyclone or otherwise.

Moreover it was estimated that the present day concentration values would be increased considerably when using the homotropical cutter, where it was hoped to reach concentrations of 50 per cent.

The swell compensating gear was designed to keep the load on the wires constant, independent of the movement of the winches. By charging the hydraulic accumulator to a pre-designed pressure, the load on the wires was pre-set.

The indication of the position of the piston was fed into a computer which commanded the winch in such a way that the oscillations took place around the middle position of the piston.

Consequently the load in the wire itself was immaterial and therefore the pressure of the cutter against the face could be chosen so that the cutting effort yielded the maximum result.

This pressure was one variable governing the production and by using the automatic control the production, which must be the maximum within the capability of the equipment, governed the pressure of the cutter against the face.

In reply to Mr. Dell, the author said that the actual dredger was still in the design stage, major discoveries of iron ore in Australia having postponed its realization. Fig. 3 showing the dredging tracks, was indeed misleading in showing the swing wires, stern and head wires of the mother vessel and cutter beam and even those not completely.

This figure was only meant to give the relationship between dredged area and the placing of the anchors. The moving of the anchors was a large time-consuming factor in the production process. The figure showed that by putting the anchors further out and working the panels parallel the dead time of anchor moving could be reduced considerably.

Cyclones in ore treatment were quite different from the atmospheric manifestations, although they were both based upon the same principle, hence the name. In an ore treatment cyclone the solids/water mixture was exposed to a rotational field of force which, compared with the gravitational field, could be varied at will and was chosen at much greater intensity than the latter.

The stopping point of a hopper's loading procedure had been the target of much research, as the actual loading speed of the hopper diminished when nearly full due to the flow becoming smaller and smaller.

It was therefore essential that the actual increase in solid load be compared with the production in solids of the pump. By comparing these two data the amount of spillage over the side could be assessed.

The correction factor that might be in Mr. Dell's mind was the correction for the weight of the solids underwater, in other words the correction for the specific gravity of the water. This correction could be calibrated into the measuring scale, the only correction then needed being due to the variation in salinity, but this was very small indeed.

Replying to Mr. Pastoors the author said that the swing wires of the cutter arm were definitely subjected to variations in load due to movement of the surface vessel. Consequently these load variations must be compensated and it was in this respect that the swell compensating gear, originally designed to cope only with the vertical movements of the ship, came in.

By introducing automatic control of the winch, which was governed by the swell compensator, the mining operation was practically free from the influence of the movements of the mother vessel.

As the force in the swing wires was governed by the computer so as to achieve an optimum in production, so, indeed, were the movements of the mother vessel filtered out by the computer, based upon the signals of the swell compensator.

The picture of the two vessels side by side presupposed a mild swell at the most. When actual seagoing conditions were encountered tailing disposal would have to be by pipeline.

As this pipeline was very vulnerable at the sea surface and when on the sea bottom, restricted the movements of the mother vessel, it was foreseen that the pipeline would be suspended somewhere in between, delivering the tailings to a more or less fixed tailing dump location.

The concentrate would be pumped via a hose to a concentrate barge. This operation should take place at certain intervals as the mother vessel must be able to store at least two barge loads of concentrate in its holds; the transfer of concentrate would be not unlike the Navy's oiling operations at sea.

The specific weight indicator, as designed by the author's company, relied upon the absorption of gamma rays. The salinity of the water played a rôle, but this was insignificant in comparison with the values obtained from a sand-water mixture. In case this was felt to be unacceptable the measuring device could be calibrated on the corresponding specific gravity of the salt water.

It was known, however, that present day application of the measuring device often caused errors of a much higher order than did the difference in salinity, but this was due to a horizontal mounting of the device. This horizontal position was responsible for the asymmetrical disposition of the solids in the flow as well as the flow itself and consequently the measured data were not representative for the whole area of the pipe.

This was particularly so when the velocity of the flow was nearing the critical value.

The induction flow measuring device was not affected by the salinity of water since the resistance in the rest of the measuring circuit was very much higher than the difference in the resistance of the water.

Replying to Mr. Cook the author remarked that the noises referred to were horrible to the ear both from a musical angle as well as from an engineering angle.

These noises came mainly from two sources. The high screeching noise was caused by lack of lubrication between the links and pins of the chain, as water was a very poor lubricant indeed at this low speed. The author was afraid that removing this noise, although well within the reach of present day techniques, would be uneconomic.

The heavy clanking noise was caused by the chainlinks hitting upon the pentagon tumbler. This noise too could be and had been eliminated in the latest designs of dredgers by introducing a shock absorber between link and tumbler.

In reply to Mr. Bourceau the author said that it was correct to suppose that the loadings of the two pontoons of the mother vessel could be quite different, even without taking the pull in the swing wires into consideration. Consequently a list was caused, but owing to the catamaran layout of the vessel this list was limited to a maximum of $\pm 3°$, which was considered not to cause any undue hindrance to the operations.

The connexion between the two vessels, i.e. mother vessel and treatment vessel, was by triangular construction and a rod type connexion. From the illustration it was not clear that this latter connexion supported only the sand pipe, which, having only to conduct the mixture stream, carried no weight or load other than its own.

Compared with the mother vessel, the end of the triangular construction could move up and down in a plane vertical through the connexion line through the hinges of the triangle on the mother vessel. The connexion rod end on the other side was entirely free to move and thus the combination of both allowed the treatment vessel to roll and pitch more or less freely, and it was only the horizontal movements that were restrained.

The stresses in the connexion rod and the triangle were kept well within the permissible limits.

The load in the swing wires had to be substracted from the weight of the cutter beam, resulting in a lower maximum vertical load on either cutter or pivot point. The weight of the cutter beam was many times greater than the load in the swing wires. Moreover the vertical sheave for the swing wires was at the short cross-beam so that it influenced the load on the pivot point far more than the vertical load on the cutter.

The cutter depth was pre-set and kept constant by means of a lifting wire and a swell-compensator-like device and it was thought that the very small variation in vertical load on the cutter did not interfere with its working. Consequently the mother vessel stayed more or less vertical above the cutter beam and did not need to worry about the pull in the swing wires interfering with the vertical load on the cutter and/or pivot.

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*Patent Specification

Advanced Shipboard Power Generation

The Hamburg/South America Line has installed comprehensive remote controls, fully automatic electric supply systems, data loggers and high-performance rotary refrigerator compressors in their cargo liners, refrigerator ships and tankers. The group of six 22½-knot refrigerated motorships on order from Blohm and Voss for these owners will have a very advanced electrical generation system. Each will be propelled by twin 16-cylinder Ottensener Eisenwerke/S.E.M.T./Pielstick type engines developing a total of 14 880 bhp and driving a single controllable pitch propeller through Siemens electromagnetic slip couplings and Renk 500/124 rev/min twin input/single output reduction gears.

Driven from the forward end of each main engine which operates in normal sea service at 500 rev/min but may "idle" at down to 150 rev/min, is a 450-V 60-c/s alternator which can deliver its full output of 1250 kW over the speed range of 500-300 rev/min and a minium of 300 kW when the engine speed is in the range 300-150 rev/min. In these particular ships, speed is adjusted mainly by propeller pitch, but with a fixed installation, 150 engine rev/min would correspond to about 42 rev/min at the shaft, or slower than "dead slow". Sustained operation at such speeds would be quite abnormal and only likely in case of fog, when the independent auxiliary generators would in any case almost certainly be run up to carry the load. The ability to carry a reduced, but still substantial, load at low speed does give plenty of time to effect the change-over.

The problem with all shaft-driven alternators is one of varying frequency and the result that the speed of normal squirrel cage motors will rise and fall in concert with the main engines and thus may in many cases be incompatible with the duty of the driven elements, such as pumps or fans.

The Siemens system which has been applied to these ships ensures an electrical supply from the shaft-driven alternators at constant frequency and voltage, regardless of the speed at which they are operated. The principle adopted is one of double conversion, the power being generated in a six-phase alternator, the output of which is taken directly to a silicon rectifier. The d.c. current which results, is then passed to an a.c. line-commutated thyristor inverter which is triggered by an electronic control unit, the resulting alternating current being at 450-V 60-c/s.—*Marine Engineer and Naval Architect, August 1967, Vol. 90, pp. 333-335.*

Engine with Two-stage Turbocharging

By applying two-stage series turbocharging and intercooling to their 13½ in by 16½ in Supairthermal six- and eight-cylinder in-line models Nordberg have increased the b.m.e.p. ratings at 514 rev/min from 200 to 250 lb/in². The makers call this tandem turbo-charging and will offer the engines for industrial and marine applications at up to 460 bhp per cylinder.

Two standard Brown, Boveri turbochargers are used. The high-pressure one (first stage gas and second stage air) operates

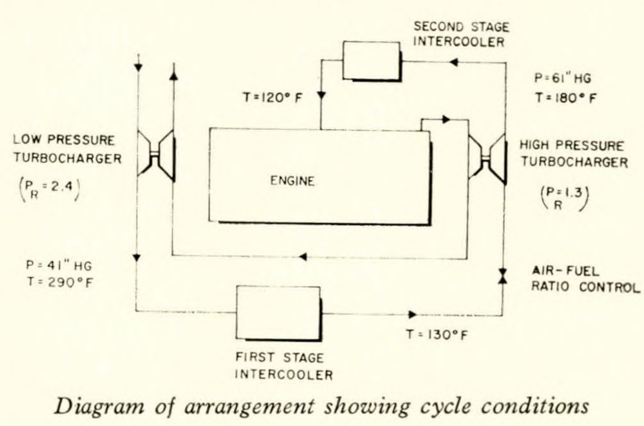


Diagram of arrangement showing cycle conditions on the pulse system and is of VTR-320 type with 2·4 : 1 pressure ratio, while the low pressure turbocharger (second stage gas and first stage air) works on the constant pressure system and is of the larger VTR-400 size, with 1·3 : 1 pressure ratio. This combination provides the rapid response to load change of the pulse system and the high efficiency of the constant pressure system. Intercooling takes place after each turbocharger and the engines retain the Supairthermal feature of variable inlet valve closure timing.

Mechanical changes from the basic design in order to accommodate the higher peak firing pressure, still a conservative 1470 lb/in^2, are higher-strength ductile iron pistons and cylinder heads, a tougher alloy-steel crankshaft and connecting rods of greater section with high load-carrying solid aluminium crankpin bearings. The bedplate has been stiffened and the camshaft and cams have been redesigned to withstand the greater forces imposed by the fuel pumps.—*Gas and Oil Power, July/August 1967, Vol. 63, pp. 112-113.*

Fast Frigate Design

For navies requiring vessels larger than the Diesel-driven patrol boats of slightly over 100 ft and of about 100 ton displacement and the corvettes of some 200 ft and 500 ton, Vosper Thornycroft have designed two types of fast frigate known as the Mark 5 and the Mark 7.

One of the major factors taken into consideration during the designing of the Mark 5 frigate was that the vessel should be of sufficient size to enable powerful anti-submarine, anti-ship and anti-aircraft weapons of the latest types to be carried. The vessel was to be seaworthy in all weather and the war-time complement should not greatly exceed 100 men. A CODOG propulsion system was to be adopted in which the gas turbine machinery would give a maximum speed well in excess of contemporary vessels while the Diesel machinery would provide for very long range cruising. These factors, together with a number of other requirements, resulted in a ship of some 1200 ton and 310 ft overall.

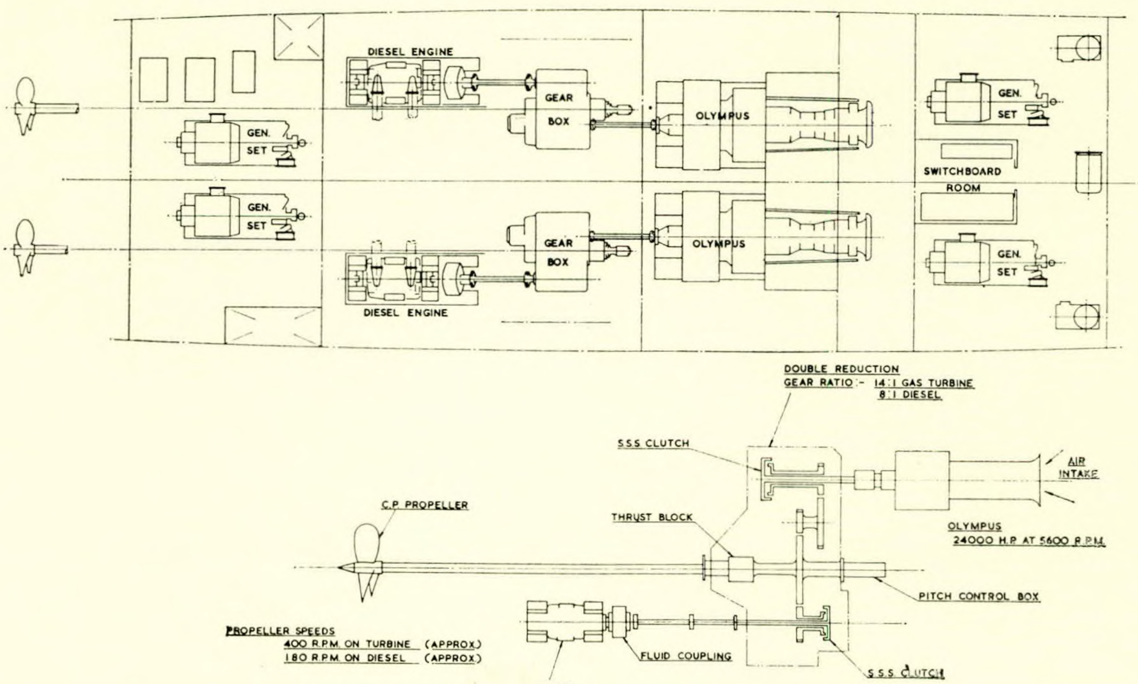
A CODOG machinery arrangement has been adopted for the vessel which has twin controllable pitch propellers. Each shaft is powered by a Rolls-Royce Olympus gas turbine and a Paxman 16-cylinder Diesel engine. Each Olympus turbine develops 24 000 shp at 5600 rev/min. The drive from each turbine is transmitted through a synchro self-shifting (S.S.S.) clutch to a double reduction gear-box with a reduction ratio of 14 : 1 to give a propeller shaft speed of about 400 rev/min. The Diesel engines each develop 1900 hp at 1500 rev/min and are each connected to their respective gear-box input shafts through a fluid coupling. The input shaft on each gear-box is connected to an 8 : 1 reduction gear through an S.S.S. clutch to give a propeller shaft speed of 180 rev/min.

The maximum speed when using the gas turbines is of the order of 40 knots and under Diesel power for long range cruising, the maximum speed is 17-18 knots. It is interesting to note that the maximum speed using Diesel engines is achieved by only 10 per cent of the power required at 40 knots. —*Shipbuilding International, September 1967, Vol. 10, pp. 56-58.*

Development of High Temperature Alloys for Marine Gas Turbines

This report summarizes the results of work conducted by the General Electric Co., under contract to the U.S. Navy Marine Engineering Laboratory, with the aim of developing alloys suitable for use in marine gas turbines, i.e. under conditions involving exposure to the combined attack of sulphur introduced *viâ* the Diesel fuel and salt introduced *viâ* sea water ingested with air for combustion. The specific aims were:

1) establishment of alloys with the corrosion resistance required for service in a marine gas turbine operated with 5000 h between overhauls at a firing temperature of 1750°F (955°C) (i.e. resulting in a service temperature of up to 1600°F (870°C) in the case of turbine blades and of 1900°F (1040°C) in the case of vanes) using fuel containing one per cent sulphur burnt with air containing about one ppm of sea salt;
2) development of nickel-base blading alloys combining the required corrosion resistance with rupture strength and ductility equivalent to those of Alloy 713C blades



Arrangement of the CODOG machinery and gearing at 1600°F and cobalt-base vane alloys combining the required corrosion resistance with a performance at 1900°F equivalent to that of vanes in the cobalt-base alloy WI-52.

The nominal compositions of the commercial and experimental (Melni, Melco and Tel) alloys evaluated are given.

In developing the experimental alloys use was made of a computerized technique (Phacomp) enabling elements believed to improve hot corrosion resistance to be included at the maximum levels compatible with the exclusion of detrimental secondary phases. Most of the alloys prepared were based on the composition of Udimet 500, the chromium and cobalt contents being increased and yttrium and lanthanum added. A rhenium addition was also made with the aim of controlling electron vacancy effects. The Tel alloys were developed to explore the influence also of molybdenum, tungsten, aluminium and titanium.

The majority of the corrosion tests were conducted in a simulated gas turbine burner rig under conditions of accelerated corrosion using rotating round or wedge-shaped specimens but some tests were performed with a Lynn burner. Data were obtained on the effects of temperature, air/fuel ratio, specimen configuration and rotation, and the presence of atomized sea water. To determine strength properties, alloys were subjected to 100-h rupture tests—at 1600°F in the case of nickel-base blade alloys and 1900°F in the case of the cobalt-base vane alloys.—*Bergman, P. A., Sims, C. T., and Beltran, A. M., 1966, U.S. Navy Marine Engineering Laboratory Rep. AD 269786, Nickel Bulletin, 1967, Vol. 40, No. 4, pp. 92-94.*

Marine Engine for More Than 40 000 bhp at 102 rev/min

Keeping the pace with the tendency towards still larger ships and even more powerful propulsion plants, Fiat Grandi Motori has designed and developed a new two-stroke single-acting, crosshead-type Diesel engine with a bore of 1060 mm and a piston stroke of 1900 mm. It has been designed for a maximum continuous rating of 3400 bhp/cylinder at 102 rev/min and a 12-cylinder unit will therefore develop more than 40 000 bhp.

Generally speaking the constructional characteristics of this engine are similar to those which have been well proven on the other large Fiat two-stroke crosshead marine engines. Notable characteristics may be classed as follows:

1) Cylinder scavenging is of the cross type and is made possible by inlet and outlet ports located on the lower part of the liner. No driven components are placed in the scavenging air inlet or in the exhaust-gas passage located on the opposite side of the cylinder. This simple construction makes it easier to utilize poor quality fuels. The scavenging and exhaust ports are separated by hollow bars circulated on the inside by cooling water. This structural arrangement prevents the formation of carbon deposits on the ports, thus ensuring the ability of the engine to burn low grade fuels.

2) The lower part of the cylinder is completely open to the atmosphere and therefore there is no possibility of combustion residues accumulating in closed sections of the cylinder with the consequent risk of explosion. The lower part of the liner can be inspected readily at any time.

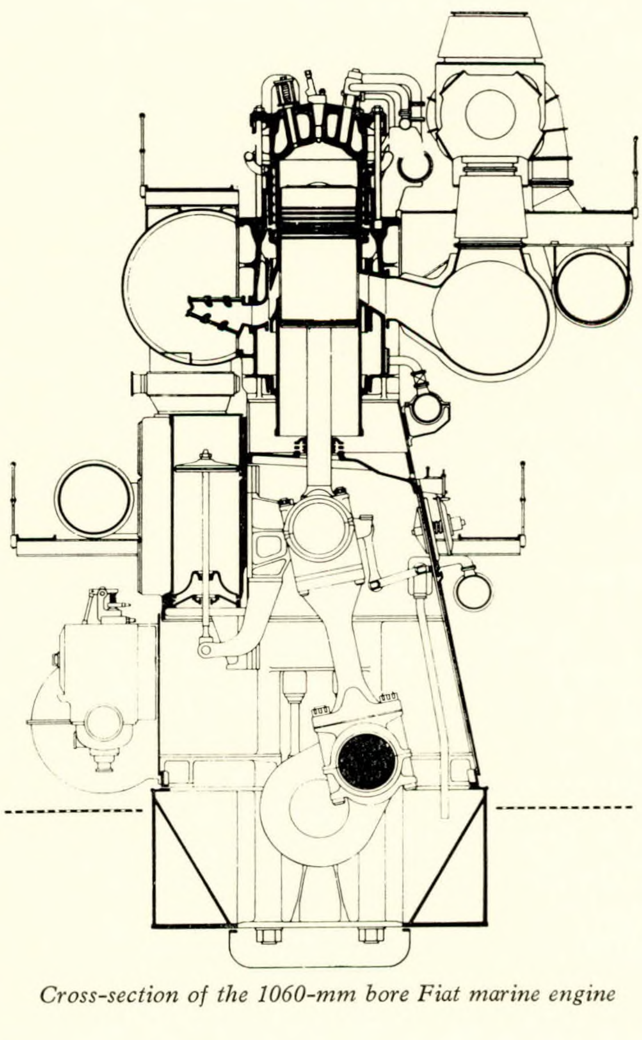
3) A diaphragm sealing the piston rod passage is located between the cylinder and the crankcase. This arrangement avoids any possibility of oil contamination of the crankcase due to the passing of unburnt residues from the cylinder down into the crankcase, which could cause serious corrosion.

4) The supercharging of the engine is effected by turboblowers operated by exhaust gas on the constant-pressure system. This system was adopted by Fiat from the beginning and the correctness of this choice has been confirmed by long and careful experiments carried out from 1952 to 1954 on a Fiat engine of 680-mm bore installed in a Fiat power plant. This constant-pressure system is more suitable to the ever higher performances of the engines and presents appreciable advantages, such as simplified exhaust piping arrangements, the possibility of supercharging the engine with differing numbers and sizes of turboblower and the liberty offered to place these turboblowers well away from the engine when the layout of the engine room makes such an arrangement more advantageous.

   With a constant-pressure system the engine has a comparatively large exhaust manifold which evens out the pressure pulsation to the benefit of the efficiency and preservation of the turboblower blading. The exhaust-gas temperature being lower than that in the pulse system is a further reason for a good preservation of the blading.

   The large size of the exhaust-gas manifold has a silencing effect to such an extent that the exhaust silencer can quite often be eliminated. It is of interest to note that some other engine builders are now changing from the pulse to the constant-pressure system.

5) Reciprocating air pumps, one per cylinder and controlled by the crankgear, are arranged in series with the turboblowers. These pumps contribute to obtaining excellent combustion and a correct behaviour of the engine at any rating and at low speeds and dur-



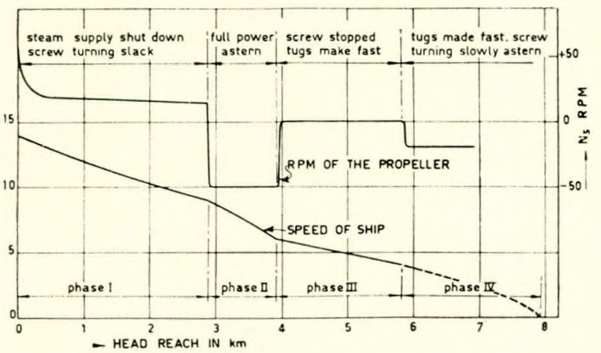
Cross-section of the 1060-mm bore Fiat marine engine ing manoeuvring. This results in preventing the exhaust ports from fouling because of carbon deposits, with a further improvement in the engine's ability to burn low grade fuels.—*Motor Ship, Special Survey, August 1967, Vol. 48, pp. 27-30.*

Effect of Propeller Type on Stopping Abilities of Large Ships

Four different propeller types have been compared with respect to their ability to stop a 100 000 dwt tanker. The basis of comparison is the stopping manoeuvre represented. In the figure the four phases in which the whole stopping manoeuvre can be divided are indicated.

In phase I the steam supply or fuel throttle is cut, the propeller is turning slack and the ship speed decreases with hull resistance until the moment when the rev/min are sufficiently low to allow the screw rotation to be reversed.

In phase II the ship is further slowed down by the screw running full power astern until a forward speed of about 6 knots has been reached. At this speed with a backing propeller, a ship will normally lose steerageway and it is possible for



Schematic representation of a stopping manoeuvre of a large tanker

tugs to make fast. Phase III can then start; the propeller is stopped, the tugs make fast and finally in phase IV, with the propeller slowly turning astern the stopping manoeuvre will be completed.

For a comparison of the examined propeller types, the characteristics for phases I, II, III and IV of the stopping manoeuvre have been derived from results of model tests where the total braking force (hull resistance plus propeller force) has been measured at different rotative speeds of the propeller at constant ship's speed for each test.

This quasi-steady approach of analysing a stopping manoeuvre is correct for large ships with relatively small power and consequently long stopping times. The propeller designs have been made for a 100 000 dwt tanker, having an available power of 28 000 shp at 85 rev/min.—*Shipping World and Shipbuilder, August 1967, Vol. 160, pp. 1362-1364; 1366-1367.*

Burner with Sonic Fuel Atomizer

The Todd AO Sonic burner utilizes the sonic fuel atomizer which is exclusive to Todd registers.

Specifically designed for pressure firing, the unit has a smooth start-up and wide turn-down ratio, thereby maintaining perfect flame stability and high combustion efficiency throughout the modulation range. An inherent item in the standard AO burner is a slow speed compressor supplying a continuous quiet supply of atomizing air. This compressor is not required on gas operation and may be eliminated in installations where compressed air or steam at low pressure is available.

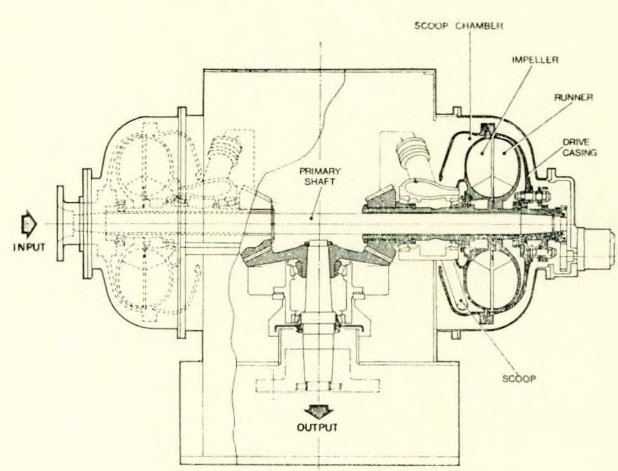
The burner is centred round a sonic fuel atomizer employing powerful sonic energy. A controlled amount of liquid fuel is fed into this and the interaction of ultrasonic power and the fuel results in uniformly small droplets of the latter. Each micro-atomized droplet of fuel is a perfect sphere surrounded by a layer of air thus permitting optimum fuel/air ratio and perfect combustion. The resulting implosive flame pattern differs from the standard explosive type, allowing greater control and safety. No moving parts are incorporated in the atomizer and the mixing, atomizing, agitation and blending occur in a free open area.

Tests have indicated that ultrasonic atomization is far superior to all other current methods, producing almost perfect combustion conditions. The gas-borne stack solids are found to be as low as 0·06 per cent of the weight of fuel burned even when operating with the heaviest of fuel oils. This figure approaches the theoretical minimum possible as most heavy residual fuels contain about 0·045 per cent incombustible ash. As a result of more complete combustion with a minimum of excess air, the resultant flame temperatures are higher and as the flame produced has a low forward velocity, it can transfer its heat to the boiler surface efficiently.

The energy required to atomize the fuel is extremely low and any liquid fuel, regardless of viscosity, can be satisfactorily atomized providing that it can be easily pumped to the point of injection to the sonic field. The sonic atomizer gives high flame stability and is self-cleaning through the scrubbing effect of sonic energy when the fuel shut-off precedes air shut-down. —*Shipbuilding International, September 1967, Vol. 10, p. 28.*

Fluidrive Transmission for Bow Thrusters

An interesting solution to the problem of starting a powerful motor-driven transverse bow propeller has been found by the Fluidrive Engineering Co. Ltd. The direct-on-line starting of a.c. electric motors of 300 hp and upwards generally imposes too great a voltage drop on the system so that it is usual to run up a separate Diesel-alternator, connected solely for that duty. The Fluidrive transmission incorporates a spiral bevel reverse gear, and forward or reverse motion is selected by means of filling and emptying fluid couplings associated with pinions for the respective directions. In addition to providing disconnexion of the drive it is capable of affording fast, smooth and infinitely-variable speed regulation of the vertical output shaft in the range of 5 to 1, against a centrifugal load in either direction of rotation. The electric motor may be started at any convenient time prior to commencement of operation, leaving the output shaft stationary. Any form of reduced voltage starting may be adopted, in order



Section through Fluidrive right angle torque converter reverse gear to avoid overloading the electric supply available. Remote control can be readily applied.

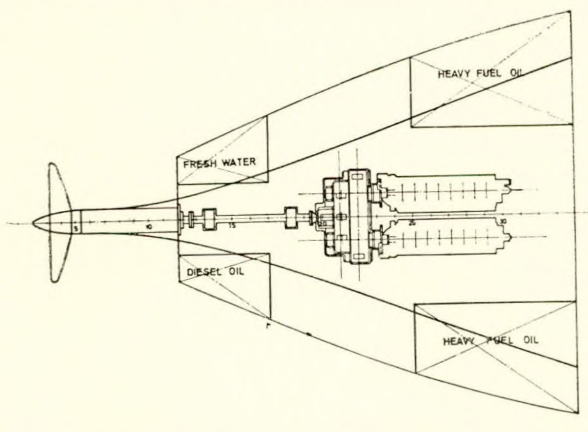
Oil is introduced into the chosen fluid coupling circuit by means of a circulating pump driven from the primary shaft. The depth of the rim of oil in the scoop chamber is controlled by the position of the sliding scoop tube which trims oil from the chamber and returns it to the sump. Since the scoop chamber is in full communication with the working circuit through connecting holes in its periphery, variations of the setting of the scoop will control the volume of oil in the working circuit and hence the speed of the output shaft. The drive casings of both fluid couplings are interconnected by a long shaft coupled to the driving motor. This long shaft passes through the hollow secondary shafts from which the primary members are supported by journal and location bearings. The secondary shafts are supported and located by anti-friction bearings in the stationary scoop housings, these scoop housings also acting as guides for the sliding scoop tubes. Each secondary shaft carries at one end, the runner of its fluid coupling and at the other end a bevel wheel on the output shaft.—*Marine Engineer and Naval Architect, August 1967, Vol. 90, p. 370.*

Liberty Replacement from Yugoslavia

Brodogradiliste Split, established as a major Adriatic yard by the Chantiers et Ateliers de la Loire between the wars, is Yugoslavia's second most important shipyard, delivering a wide range of vessels, mainly of standard design. Of topical interest is the 14 000 dwt *Zagreb*-class utility cargo vessel which has been designed by Dipl.-Ing. Igor Belamaric. The principal particulars are as follows:

Class	LR, BV, ABS, NV
Length, o.a.	426 ft 0 in
Length, b.p.	410 ft 0 in
Breadth, moulded	64 ft 0 in
Depth to upper deck, moulded	42 ft 0 in
Depth to second deck, moulded	29 ft 6 in
Cargo space	700 000 ft^3
Cargo deadweight	14 000 ton
Ballast	3200 ton
Fuel—260 t h.v.f. 50 t Diesel (all in engine room tanks)	310 ton
Lubricating oil	25 ton
Fresh water	100 ton
Crew, stores, spares, etc. ...	65 ton
Gross measurement	7800 ton
Net measurement	5700 ton
Trial speed at 26 ft 2½ in draught and 3400 bhp ...	14 knots
Endurance	8000 miles

In addition to the classification requirements the vessel is built to meet the Safety of Life at Sea Convention 1960, Suez and Panama Navigation Rules, the International Load Line Convention, the 1953 Board of Trade Regulations for crew accommodation and also complies with the latest SOLAS Grain Loading Regulations. It will be noted that this ship has an unusually high cargo deadweight relative to the total deadweight capacity.



Basic machinery arrangement. Note that all fuel tanks are in this space

The structure is as simple as possible commensurate with good stowage and performance. A continuous upper deck has a straight-lined sheer forward and sheer aft is only due to deck camber while the second deck, without sheer or camber, is stepped 4 ft up aft of the holds to maintain height in way of the crew accommodation. A transom stern makes available plenty of space for working wires while the absence of a raised forecastle improves the deck area in this vicinity.

The basic machinery specification provides for two MAN G8V 30/45 ATL direct-reversing 16-cylinder engines of a medium-speed moderately-rated design and rated to develop 1700 bhp each at 500 rev/min. They are geared to the single screw with a reduction ratio of from 5 to 5·5 : 1 and can operate on fuel with a viscosity of up to 800 sec Redwood No. 1. There is provision for changing over rapidly to Diesel oil for starting and shutting down. The specific fuel consumption on Diesel oil is 157 g/bhp h, subject to the usual five per cent tolerance. The exhaust is led up through twin trunks at the after corners of the superstructure and discharged to the atmosphere through the silencer tailpipes, without any funnel casing. The main shaft is carried in self-lubricated oil bath bearings, white metal-lined, and drives a four-bladed manganese bronze propeller.

Perhaps the most interesting feature is the very wide range of main engine options which is offered to meet owners particular preferences.

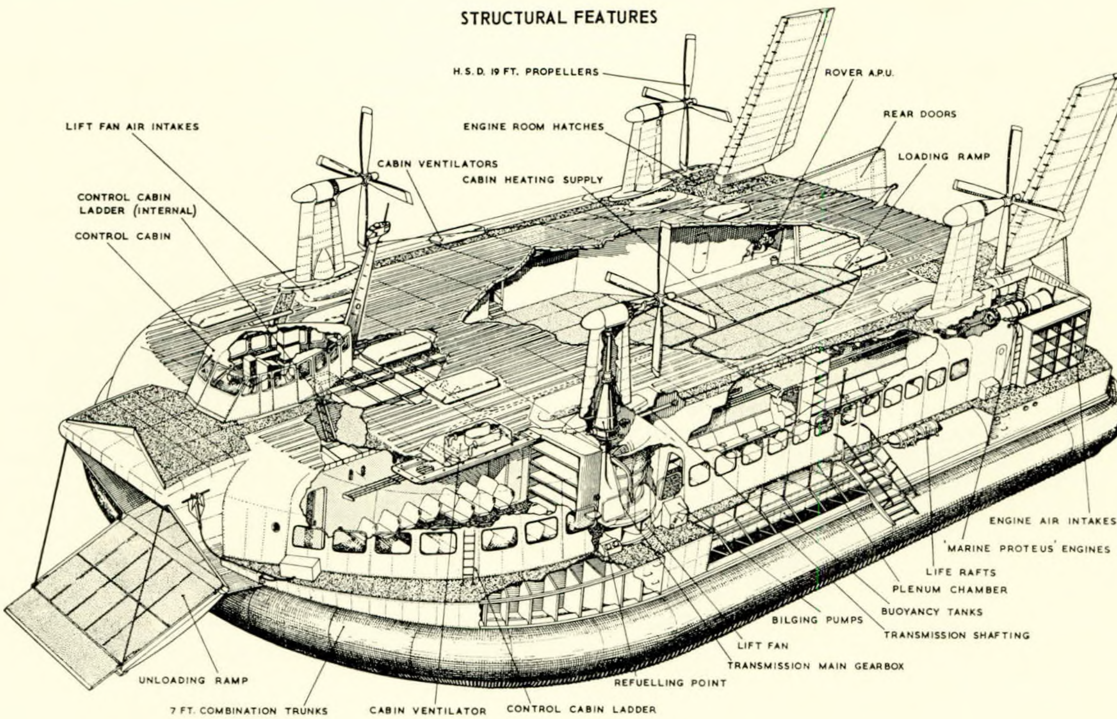
Essential auxiliaries comprise a 150 ton/h ballast and standby salt water circulating pump in support of the engine-driven salt water pumps. Two 60/90 general service bilge and fire pumps, a 10 ton/h heavy fuel transfer pump, two 10 m^3/h starting-air compressors, two starting-air bottles and a 6 m^3/h emergency compressor. There is a vertical composite boiler delivering one ton at 100 lb/in^2 and two 1½-ton feed pumps.—*Marine Engineer and Naval Architect, August 1967, Vol. 90, pp. 338-339.*

World's Largest Hovercraft

The SR.N4 with a normal operating weight of 165 ton is considered to be the optimum size of hovercraft for operation over open coastal waters. It will be capable of maintaining services in seas of up to 12 ft wave heights at speeds of up to 70 knots over stage lengths of 100 miles. The basic craft will be able to carry 50 ton of payload, equivalent to 34 cars and 174 seated passengers but serveral alternative versions have been proposed, for example one carrying 30 cars and 254 passengers, or an all-passenger version for 609. Dimensions are:

Length, o.a.	130 ft 2 in
Beam, o.a.	76 ft 10 in
Height, o.a.	42 ft 5 in
Bow ramp aperture ...	18 ft × 11 ft 6 in
Stern door aperture ...	31 ft × 11 ft 6 in
Vehicle deck headroom ...	11 ft 3 in
Cushion area	7342 ft^2
Cushion loading at 165 ton, a.u.w.	50 lb/ft^2
Buoyancy reserve at 165 ton, a.u.w.	250 per cent (total buoyancy approximately 550 ton)

The SR.N4 is an all metal craft constructed chiefly of light alloy materials and powered by four Bristol Siddeley Marine Proteus gas turbine engines mounted in pairs in two engine rooms at the rear of the craft, each engine driving a propulsion propeller and a centrifugal lifting fan. The propellers are mounted on pylons which can be pivoted to change



Layout of basic craft

the direction of thrust and control the craft. Fins mounted aft of the rear propellers move in conjunction with the rear pylons to give additional directional stability which is further enhanced by geared rudders.

The propeller transmission also drives the lifting fans which are mounted below each propeller. Air is drawn by the fan through intakes on each side of the pylon and directed through plenum chambers under the passenger cabins into the peripheral trunks, whence it is directed inboard beneath the craft to create the air cushion. The control cabin is situated on the cabin roof ahead of the forward pylons and provides accommodation for three crew plus one supernumerary.

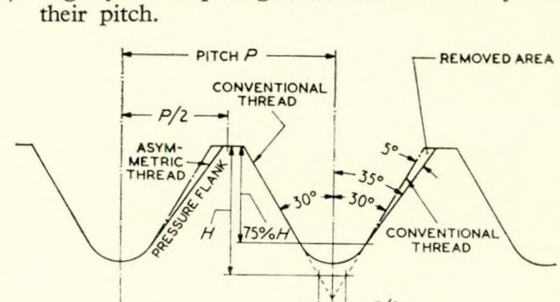
Each of the Marine Proteus engines drives one of four identical propeller/fan units, two forward and two aft. The propulsion propellers are Hawker Siddeley Dynamics four-bladed type with variable and reversible pitch and are 19 ft in diameter, while the BHC lift fans are centrifugal and twelve-bladed and of 11 ft 6 in diameter. The Proteus engine fitted in the SR.N4 develops 3400 shp at continuous rating and up to 4250 shp for emergency conditions or for limited use in extreme weather conditions. The power distribution is accomplished by means of integrated lift/propulsion i.e. since the gear ratios between the engine, fan and propeller are fixed, by changing the propeller pitch and hence varying the speed of the system, the power absorbed by the fixed pitch fan is also altered. This power can be varied from almost zero to 2100 shp within the engine speed limitations. A typical division at maximum cruise power would be 2000 shp to the propeller and 1150 shp to the fan, the remaining 250 shp being accounted for by engine power fall-off due to the turbine rev/min drop, transmission losses and the auxiliary drives. Accessibility of the engine is a most important feature of the engine room layout and it is envisaged that an engine change will be possible in three to four hours.—*Ford, T., Hovering Craft and Hydrofoil, March 1967, Vol. 6, pp. 20-27.*

Bolts with Asymmetric Threads

Fatigue is triggered by stress concentrations, such as those found at notches and changes of section. It is therefore not surprising that a threaded bolt is one of the most fatigue-prone parts in existence and localized stresses at the thread roots are up to six times as high as the average stress in the unthreaded body of a bolt. With these considerations in mind, a study of the fundamentals of the common screw thread was initiated in 1960 in the U.S.A. at the research laboratories of the Standard Pressed Steel Co., with particular reference to high-strength aircraft bolts, and this work led to a modification of the root of the thread by increasing its radius, with a consequent reduction in stress concentrations and an increase in bolt fatigue strength. So successful was this new 75 per cent depth-form, designated the "Hi R" thread, that the U.S. government adopted a new standard (MIL-S-8879), now widely used, to define this full-radius thread.

The latest thread innovation introduced by this company is the asymmetric thread, which is essentially based on the same thread design as MIL-S-8879 bolts (commonly known as "J" bolts) but incorporates two remarkably simple changes which increase fatigue life still further. These two changes are:

1) removal, as shown, of a 5° segment from the load-bearing or pressure flank of each thread, thereby making the included angle 65° instead of the conventional 60°;
2) slightly closer spacing between the threads by reducing their pitch.



Removal of a 5° segment from the pressure flank of a conventional MIL-S-8879 thread to produce an asymmetric thread

It should be noted, that the major and minor diameters of bolts with these asymmetric threads are maintained to MIL-S-8879 tolerances, and the bolts can be substituted in any design where "J" bolts are specified; also, standard tapped threads and nuts can still be used, though locknuts may have to be modified slightly.

The addition of 5° to the load-bearing flank lowers the point of greatest pressure on the thread, bringing it closer to the root. As a result, the bending stress on the thread is substantially reduced, and there is less stress concentration. It is true that the bending stress on the internal mating thread increases correspondingly but there is a greater mass behind the thread in a nut, so that the stress is less critical and, in the case of tapped holes, the chance of fatigue failure in the structure is even further decreased.

The effect of the slight reduction in pitch is a more uniform distribution of load among the threads. In this connexion, about half the fatigue load in a conventional bolt is carried by the lower 30 per cent of the threads, i.e. those closest to the nut or bearing face. This distribution arises from the elasticity inherent in all materials. Initially, both the bolt and nut have perfectly mating threads but the bolt stretches under load, while the nut compresses, causing mismatching of threads and a higher stress concentration on the more heavily loaded threads. The slight reduction in the pitch (or, as it has been called, the negative lead correction) of the asymmetric-thread bolts is a nominal 0·0025 in/in, so that, for a 10-tpi bolt, the modification amounts to a shortening of only 0·0025 in per thread. Even so, this tiny correction is sufficient to compensate for stretch in the bolt metal, placing each thread where it ought to be for uniform loading when the bolt is in tension.—*Engineers' Digest, June 1967, Vol. 28, pp. 85-86; Abstract from Product Engineering, 8th May 1967, Vol. 38, pp. 161-162.*

Design of a Hinged Tanker

The original hinged ship, *Connector,* was built in 1863 to carry coal between Newcastle and London. The advantage claimed was one of improved cargo discharge, as one section could be left at one discharging point while the other two discharged at another point. *Connector* was unsuccessful and the idea has lain dormant for nearly a century. Interest has revived recently for the following reasons:

1) hull steel weight can be reduced because of smaller vertical bending moment;
2) increased deadweight can be passed through physical limitations such as canals, locks, shallow waterways and harbours;
3) cargo discharge may be improved through disconnexion of sections.

This paper deals with the design and analysis of a proposed Suez Canal tanker which exploits the first two factors mentioned in the foregoing. Many of the conclusions of the analysis can be applied to hinged ships as a class.

Physical limitations such as a canal often dictate a long, slender vessel for maximum capacity. Economics, however, limit the length of the ship due to greatly increased steel costs if the ship exceeds certain proportions. This limit can be extended if a hinge is fitted at mid-length. The economic gain of increased size may overcome the inherent disadvantages of the hinge. Basic dimensions of the proposed hinged ship for Suez Canal transit are:

1) a length between perpendiculars of 1050 ft is considered the maximum permissible to negotiate the bends in the canal;
2) beam of 128 ft is the current maximum permissible on a regular canal-transit basis;
3) a draft of 44 ft was selected, based on the proposed depth of the canal by 1975.

The figure shows the general arrangement and layout.

The hinge was the most difficult design problem and the whole hinged ship concept depends on its successful solution. The structural phase of the hinge design must start with an evaluation of hull girder loadings. The forces acting on the hull which must be transmitted through the hinge are the following:

1) lateral moment;
2) torsional moment;
3) direct shear;
4) forces due to forward speed;
5) shock loads.

The lateral moment already discussed is by far the largest force involved, constituting 90 per cent of the force in the hinge area.

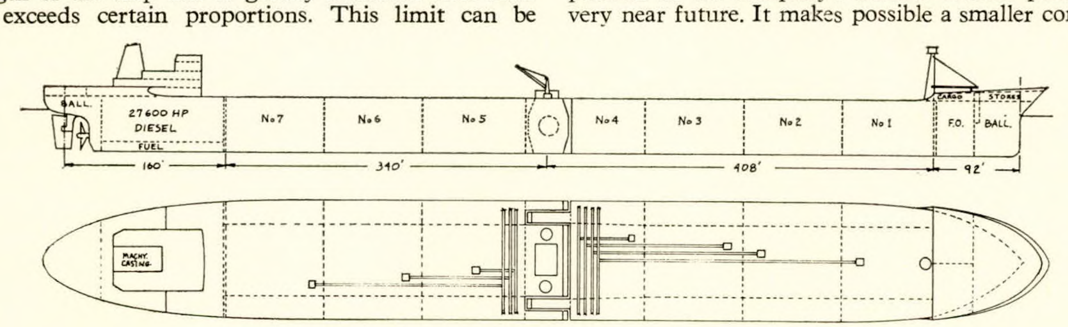
Vertical direct shear arising from a wave train was found to be relatively small. In addition, conditions of maximum vertical shear do not coincide with conditions of maximum lateral moment and torsional moment. It is possible however, to have maximum lateral moment and maximum torsional moment occurring in phase. Estimated forces due to forward speed and shock loads were considered insignificant. The following factors will influence the immediate hinge design:

1) transmission of hull girder forces;
2) bearing pressures;
3) range of deflexion;
4) hydrodynamic resistance.

A solid steel pin, if used, would need to be over 4ft in diameter to resist the applied loads. Not only would a pin of this type be difficult to fabricate, but transmission of the loads to the hull would require an extremely heavy structure. In addition, bearing pressures would be so high as to preclude most bearing materials. Thus, hollow 20 ft-diameter pins were designed, using a 2½-in HY-80 steel shell with internal stiffening. The pin would be tapered so that bearing wear could be compensated by moving them outboard slightly.—*Boylston, J. W. and Wood, W. A., Marine Technology, July 1967, Vol. 4, pp. 219-231.*

Ice Condenser

An emergency dump condenser that would swiftly and safely absorb any heat accidentally released to the interior of a container for a nuclear reactor has been developed by engineers at the Westinghouse Pressurized Water Reactor Division. The ice condenser reactor containment system will be incorporated in the company's nuclear reactor plant designs in the very near future. It makes possible a smaller containment build-



General arrangement—hinged tanker

ing having a lower design pressure—leading to a capital cost reduction. The ice immediately absorbs any heat and eliminates any prolonged rise in the containment pressure; therefore, a less severe duty is imposed on the structure and inherent plant safety is enhanced. The ice condenser has no rotating equipment and thus is always ready for immediate service in emergency. In essence, the ice condenser is merely a cold storage compartment surrounding the nuclear steam supply system. The ice is kept frozen by standard refrigeration equipment the only operating component of the system. Insulated access panels which normally separate the ice from the reactor compartment will spring open on a slight pressure rise to provide a path for the steam to reach the ice.

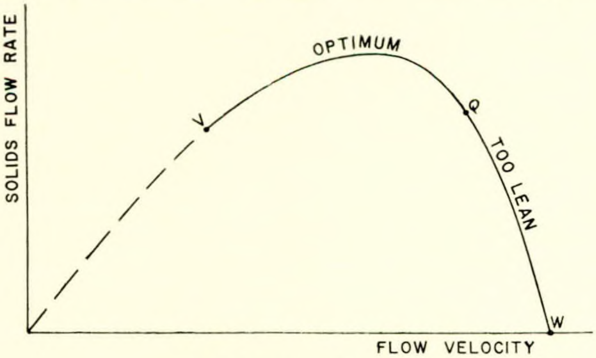
Should steam be accidentally released to the inside of the containment, any resulting rise in pressure and heat would immediately be absorbed by the ice. Since ice is an excellent absorber of heat energy, equilibrium would be rapidly restored to the containment's interior, assuring complete safety to plant operating personnel and equipment. In addition, the reduced plant construction costs will enhance the competitive position of nuclear power. — *Marine Engineer and Naval Architect, September 1967; Vol. 90, p. 415.*

Automating the Hydraulic Dredge

The hydraulic dredging process can be defined as a series of earth moving operations, namely, cutting the material loose from the bottom of the waterway, picking the loosened material up and transporting it elsewhere. Within each of these operations there are variables which can be measured and controlled. For example, as regards cutting the material loose, we can measure and control the rate of advance of the cutting edge, the pressure and volume of water jets, if any, and the tension in the swinging wires. Also, we can measure the shear strength of the material being excavated. As regards picking up the loosened material, we can measure and control the dredging depth. We can measure the flow density and the vacuum at the dredge pump. As regards transporting the material elsewhere, we can measure and control the pump speed and the length of pipeline. We can measure the horsepower, discharge pressure and flow velocity.

It is humanly impossible to be attentive to more than one of these changing variables at a time and to respond fast enough to all the process changes with the required corrective actions. Logic machines do not have these human limitations. They can simultaneously attend to any number of variables and make intelligent control decisions many times faster and more accurately than the dredge operator.

The criterion for optimum dredge production obviously is minimum cost per cubic yard dredged. For most dredging projects this criterion is equivalent to maximum cubic yards transported per unit of time. Thus, the process variable we want to control is the solid flow rate expressed in units such as cubic yards per minute. The curve illustrated shows the relationship that exists between solid flow rate and flow velocity for a specific centrifugal pumping unit and piping layout.



Hydraulic dredging

All other factors remaining the same, the flow velocity is a maximum when pumping water. This corresponds to zero solid flow rate at point (W) on the end of the curve. As the suctionhead digs into the material the suction inlet is blocked off decreasing the velocity, the flow mixture density increases, increasing the total head on the pump which, in turn, decreases the velocity also. The solid flow rate increases until it reaches a maximum whereafter any further increase in density is at too low a velocity, causing the solid flow rate to fall off from its maximum. At the same time as the solid pick-up increases, the vacuum also increases until the suction limitation of the pump is reached interrupting the flow process. This suction limit is indicated by point (V) on the curve. Between (W) and (Q) the flow mixture is too lean for economic transport. Between (Q) and (V) the solid flow rate is at its best. Thus, the control objective is to hold the process between these two limiting points.

As shown, the curve is limited to one degree of freedom. The other three degrees of freedom are taken care of by assuming constant pump speed, piping layout and character of material dredged. The water pumping velocity, point (W) on the curve, is approximately proportional to the pump speed divided by the cube root of the length of pipeline. Thus with increasing pump speed or with decreasing length of pipeline point (W) will shift to the right and the peak of the curve will be higher in proportion to the magnitude of (W). In addition point (V) will move along the curve to the right. And with further increase in pump speed if sufficient power is available point (V), the vacuum limit of the pump, will move along the curve on down to point (W). Operation beyond this point is not possible due to cavitation of the pump.

The point of high vacuum (V) on the curve, corresponds to the point of minimum desired flow velocity and the point of high velocity (Q) corresponds to the point of minimum effective vacuum. Thus, at point (Q) we can apply the logic control proposition that when the velocity is high and the vacuum is low, the flow mixture will be too lean and the operator should dig-in to feed more solids into the suctionhead. Also, at point (V), when the velocity is low and the vacuum is high, the mixture will be too heavy and the pump is in danger of cavitating, therefore the operator should slacken the dredging.—*Denning, R. A., World Dredging and Marine Construction, July/August 1967, Vol. 3, pp. 20; 22; 24; 26; 28-29.*

Canadian Built Seiner Trawler

A dual-purpose vessel, designed for catching tuna by purse seining and fitted with stern trawling gear, has recently entered service for the Atlantic Sugar Refineries Co. Ltd., Montreal. Named, *Atlantic-John Park,* the 1000 dwt seiner/trawler was built by the Canadian Vickers shipyards in Montreal.

Principal particulars of the vessel are:

Length, o.a.	200 ft 0 in
Length, b.p.	177 ft 2 in
Breadth, moulded	39 ft 4 in
Depth to upper deck ...	29 ft 0 in
Depth to main deck forward	21 ft 8 in
Depth to main deck aft ...	19 ft 8 in
Scantling draught	19 ft 0 in
Corresponding deadweight ...	1000 tons
Endurance at 13 knots ...	16 000 miles

For seining, a skiff is mounted on the extreme aft end of the vessel and when released, slides down a ramp into the water. When the fish are caught in the seine net they are transferred aboard the vessel by a brailing net and dropped through hoppers on the upper deck port and starboard into brine freezing tanks situated in the 'tweendeck. In the brine tanks, fish can be frozen at the rate of approximately 100 tons/day. When frozen, the fish are transferred from the tanks into an insulated cargo hold by conveyor belts in the 'tweendecks.

The fish hold has a capacity of about 900 tons and is maintained to a temperature of −20°F (−29°C) by a cold air circulation system, provided by Canadian Ice Machine Co. which utilizes an ammonia refrigeration plant situated in the engine room.

All the purse seining deck machinery is hydraulically operated and consists of a three-drum seining winch complete with topping winch, corkline winch, vang winches, choker winches, and a patented power block attached to the main boom for net hauling.

Atlantic-John Park is fitted with a steering gear of Svendborg manufacture and which can move the rudder from hard-over to hard-over in 20 seconds.

Main propulsion is provided by a Nohab-Polar M66T-type engine, capable of a continuous service output of 2400 bhp at 250 rev/min. The propeller is five-bladed, solid bronze, and was supplied by Lips.

An interesting feature of the ship is a Tamco bow-thrust unit which can develop a force of 4000 lb. The thruster is designed on the water jet principle and is of the vertical type which protrudes below the hull of the ship and can be rotated to provide thrust in any direction. When not in use the nozzle can be retracted flush with the hull.—*Motor Ship, September 1967, Vol. 48, p. 15.*

Cold Shrinking a 29-ft Keyless Propeller

More details have become available of the method of fitting the 55-ton 29 ft $2\frac{1}{2}$ in diameter set-bladed Zeise propeller for the 190 000 dwt tanker *Esso Malaysia* at Kieler Howaldswerke. The process, developed by SKF, has been used for flangeless shafting with muff couplings for a considerable number of years. The hub is expanded by oil pressure and the propeller is forced into the cone by means of a ring piston built into the propeller nut. This method has the advantage that the pull up, calculated in advance, can be achieved without difficulty. In this case, by way of experiment, the propeller—after it had been left on the cone overnight—was taken off by the same method and subsequently replaced. Releasing and replacing took approximately 20 minutes for each operation, two men operating the hand oil pumps without any effort. The circumferential stresses at the hub periphery were measured by two different methods to check the strain in the hub and the measured results were in close agreement with the calculated values.

The technical data are:

1) 30 000 shp at 80 rev/min;
2) diameter of shaft at forward end of cone 826 mm;
3) taper 1 to 15;
4) bearing length of hub 1553 mm;
5) forward o.d. of hub at measuring position 1580 mm;
6) pull up 12·5 mm (ensuring a margin of safety against slip of 3·3 rated at 20°C);
7) maximum expansion oil pressure 710 kg/cm^2;
8) ring piston area 2200 cm^2;
9) maximum force on pressure at ring piston 400 kg/cm^2 (total press up force 865 ton);
10) maximum circumferential stress at the hub in final position 3·97 kg/mm^2 (after releasing the expansion oil pressure 3·57 kg/mm^2).

Marine Engineer and Naval Architect, September 1967; Vol. 90, p. 404.

Large-bore Problems

The annual report of Det norske Veritas makes reference to research being undertaken into current problems arising in large-bore Diesel engines. Thermal loading in engines with a cylinder diameter or over 800 mm has led to a number of occurrences which have become generally known as "large-bore" problems. As a part of the task of combating these problems N.V. have worked out a programme for computer processing which calculates temperature field and heat flux on the basis of measured temperatures in pistons and cylinder liners. A programme for the calculation of thermal stresses has also been developed (based on a programme from the Institute of Naval Architecture in the Norwegian Technical University). This programme complex which has now been assembled will permit an assessment of the piston and liner construction and will make possible an optimization of these elements when the necessary calculation parameters are available.

Measurements taken on a motor tanker with a cylinder diameter of 850 mm have been analysed and have provided valuable information on temperature level in large Diesel engines, e.g. what the influencing factors are and how the heat is transferred from the flue gas to the walls of the combustion chamber. A special computer programme has also been made for thermo-dynamic calculations based upon theoretical and measured indicator diagrams (for the calculation of gas temperatures and subsequently material temperatures). Certain instances of cylinder wear have been exhaustively studied and piston ring temperatures have been measured while running.

Det norske Veritas has also joined forces with other institutions which are operating in the so-called large-bore project. These are the Norwegian Technical University, the Ship Research Institute of Norway and various oil companies, engine producers and shipowners.—*Marine Engineer and Naval Architect, September 1967, Vol. 90, p. 392.*

50-Knot Gas Turbine Patrol Boats

The first of the Vosper triple screw, 96 ft gas turbine patrol boats of the Perkasa class, which were laid down in 1964 and 1965 for the Royal Malaysian Navy, has now been commissioned and the remaining three are completing trials. They are in general similar to the Søløven class, ordered for the Royal Danish Navy in 1962, these are of the same size and hull form as the well known Brave class.

A particular design requirement of the K.D. Perkasa class, named after the first of the four to be completed, was that these craft should be capable of at least 50 knots in tropical conditions where high ambient air temperatures reduce the power obtainable from gas turbine power plants. To meet this requirement there must be an ample margin, in terms of speed, and, in fact, speeds as high as 57 knots have been obtained by these craft on recent trials.

Built at the Portchester yard of the Vosper Thornycroft Group, the Perkasa class is designed to be adaptable to any of the three roles of gunboat, torpedo boat or minelayer.

The main hull is built of laminated timber, in accordance with established Vosper practice. After much research and experience with different materials for vessels of this class, the builders remain convinced that laminated timber construction offers the best compromise obtainable at the present state of knowledge for vessels of this size, taking into account strength, weight and cost. Timber is particularly good at resisting the high dynamic loads imposed when high-speed craft are driven into a head sea, and it also lends itself to the construction of skin panels which do not require excessively complicated stiffener systems.

The three shafts, of which the outer two turn outboard and the centre-line shaft is right-handed, are each coupled to a Rolls Royce Proteus gas turbine, developing 4250 bhp through a Vosper vee-drive gear-box, reduction gear and a synchro self-shifting (S.S.S.) clutch, which automatically prevents transmission of torque to and from the cruise engines. The turbine exhausts discharge direct through the transom and their thrust makes a contribution to the boat's forward speed. Two General Motors Diesel engines with reverse/reduction gears of 190 bhp each are installed, to be used for cruising and manoeuvring purposes. These engines also drive through S.S.S. clutches and are connected to the outer vee-drive gear-boxes. The port vee-drive box contains an idler wheel to give the required shaft rotation, all the engines turning the same way. The Proteus turbines are started by bleed air from the Rover gas turbines driving the alternators. The cruise engines are started hydraulically, taking energy from accumulators charged by the hand pump.—*Shipbuilding International, August 1967, Vol. 10, pp. 18-20.*

Freedom Ships

A particularly interesting development in connexion with the expansion of the Freedom range of ship is that Ishikawajima Harima H.I. are now planning to build one of the early vessels in the series with a twin-engined installation driving a single contra-rotating propeller. The engines will also be the I.H.I. Pielstick type and the ship is likely to be the first merchant vessel to be equipped with a contra-rotating propeller.

The Freedom ships are being built at I.H.I.'s Tokyo and Nagoya shipyards under a production programme which, when in full swing, requires a ship to be delivered every 20-25 days i.e. about 30 ships a year. For the most part, these will have 12-cylinder engines of 4540 bhp at 480 rev/min to give a service speed of 13·9 knots.

A feature of this Liberty-replacement programme is the measure of success which I.H.I. have had in getting owners to accept a medium-speed geared Diesel engine installation. Experience of such machinery, particularly by most operators of Liberty-type tonnage, is relatively scant. Their first preference was for a four-cylinder slow-speed oil engine but suspicions and early reluctance to accept medium-speed machinery have been overcome to the extent that 42 Freedoms with such machinery are now on order.—*Motor Ship, October 1967, Vol. 48, p. 295.*

Scottish-built Reefer for German Owners

Handed over recently, shortly after the launch of her sister-ship *Padua, Parma* is the first of a pair of refrigerated cargo liners built at the Cartsdyke yard of Scott's Shipbuilding and Engineering Co. for F. Laeisz, owner of the "Flying P" line.

As is to be expected in a high-speed (22·63 knots was attained in the trial condition) fine-lined vessel of this type, stability posed problems. The resolution of these is reflected in the principal particulars, where the beam/length ratio is somewhat lower than might have been expected, and the choice of a ten-cylinder engine of comparatively small bore for the propulsion of the vessel. The disadvantage of the greater length of the selected unit, compared with that of a larger bore engine with fewer cylinders, is more than compensated by a lower centre of gravity and a higher rotational speed which suits a propeller, the diameter of which is restricted by draught limitations.

Parma is powered by a ten-cylinder turbocharged Kincaid-B and W 62-VTZBF-140 Diesel engine, arranged to operate on fuel of up to 3500 sec Redwood No. 1, with a maximum compression ratio of 12 000 bhp at 139 rev/min and a service rating of 10 900 bhp at 135 rev/min; the unit is also capable of being operated at 40 rev/min. The four Elsinore Shipbuilding and Engineering HSM TH40 IIS turbochargers are provided with a system whereby air and water can be injected into the exhaust gas inlets to clean the turbine blades while the engine is running.

A separate machinery control room is not provided but there is a considerable degree of automatic control and centralization of instruments at the engine control station where a 55-point Lyngso alarm system is installed.

An "on-plant" temperature controller causes valves on the salt water outlet and by-pass of the lubricating oil cooler to be actuated by a 3-15 lb/in^2 air signal. A similar system is applied to the sea water discharge from the scavenge air coolers and turbocharger lubricating oil coolers while a temperature transmitter working in conjunction with a ratio totalizer, acts as a master controller with the main engine fresh water cooler outlet and by-pass valves as slaves on a similar basis. The steam supply to the fuel oil heater is automatically controlled by way of a VAF Visotherm.

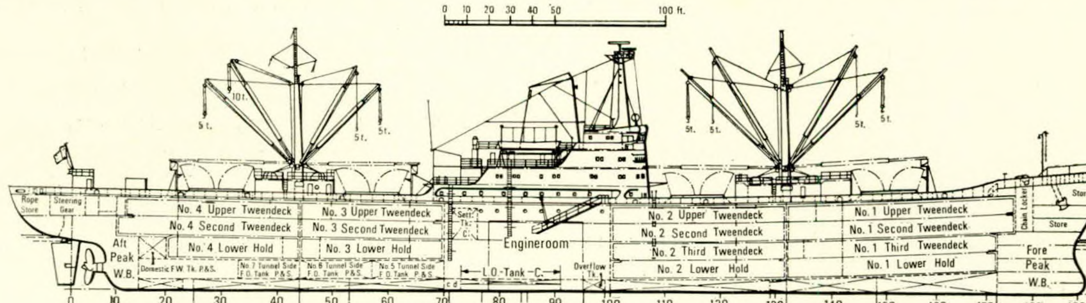
A pressure switch arrangement on main engine, camshaft and turbocharger lubricating oil systems ensures an automatic start of the appropriate stand-by pump in the event of a running pump failure.—*Shipbuilding and Shipping Record, August 1967, Vol. 110, pp. 264-266.*

Frictional Behaviour of Labyrinth Seal and Shroud Material in Steam and Gas Turbines

When labyrinth seals and abradable shrouds are used in steam and gas turbines to control the internal and external leakage of the working fluid, effective sealing requires a small clearance between static and rotating elements. It is often desirable that seal elements rub their own minimum operating clearance and it has been shown that the rubbing compatibility of seals is dependent on the materials and configuration acting together as a system. In this paper the author evaluates specimen seals for rubbing compatibility under conditions simulating service in a steam or gas turbine, presents theories and parameters governing the behaviour and wear of labyrinth seals (wipe-away tooth-type and rub-in seat-type) and abradable shrouds under these operating conditions, and makes suggestions for seal design.

The 'Large Seal and Pack Tester' used to evaluate seals for rubbing compatibility under conditions simulating service in a steam or gas turbine is described. This apparatus permits the use of rubbing speeds of up to 30 000 ft/min with gas at temperatures up to 1110°F (600°C) or with low-temperature steam and enables either stationary or rotating abradable elements to be tested. It incorporates a strain gauge (to record frictional torque) and a differential transformer (to record wear rate). A typical test cycle is described.

The following materials were evaluated: S.G. Ni-Resist, Ascoloy, silver, silver solder, aluminium, fibre metal, phenolic plastics, aluminium/graphite, Hastelloy X, BTH leaded nickel bronze, tin babbitt, metalfoil honeycomb, Type 304 chromium/nickel stainless steel, Type 410 chromium stainless steel, A.I.S.I.



General layout—m.v. Parma

4140 chromium/molybdenum steel and chromium/molybdenum/vanadium steel. The author discusses

1) factors which influence wear;
2) typical wear processes;
3) the different wear processes which can occur with one and the same combination of materials;
4) the design of labyrinth seals and packing.

Foster, W. P., 1967, A.S.M. Metals Engineering Quarterly, May, Vol. 7, pp. 59-64; Nickel Bulletin, Vol. 40, No. 7, pp. 193-194.

Canadian Bulk Carrier

The Upper Lakes Steamship Co., Toronto, has selected the Ruston AO design for a 30 000 dwt, 14-knot, self-discharging bulk carrier to be built by Port Weller Dry Dock Ltd., St. Catharines, Ontario, and due for completion in the autumn of 1968—the first export order for Ruston's medium-speed two-stroke design. The ship is intended to transport coal from Conneaut, Ohio, across Lake Eyrie, through the Welland Canal and across Lake Ontario to a power station near Toronto.

The main machinery installation will comprise two eight-cylinder in-line AO machines with a total rating of 8000 bhp. As well as propelling the ship, the engines will be clutch-coupled to a pair of 2500 kW Brush a.c. generators which will power the self-discharging equipment in port: at all times 1500 sec fuel will be employed. During low-speed manœuvring one of the engines can be disconnected from the propeller drive shaft and the forward-end generator clutched-in to power a 1000 hp bow thrust unit.

Drive from the main engine is through an A.E.I. reduction gear-box to a single KMW controllable-pitch propeller of 18·5-ft diameter and turning at 115 rev/min. This will enable the engines to operate as unidirectional units in normal conditions but because the ship will spend much of its time navigating the busy Welland Canal the owners decided that the small additional expenditure involved in specifying direct-reversing gear would be a prudent investment in case of damage to the propeller servo mechanism. The KMW unit, if damaged, is designed to put the propeller blades in the full pitch ahead position in less than 30 seconds and this will afford sufficient time for the engine room staff to change over the engines to direct reversing operation. All clutch coupling operations for propulsion and power generation can be made from a bridge control position.—*Motor Ship, September 1967, Vol. 48, p. 247.*

Largest Tanker Launched in Europe

The biggest tanker yet launched in Europe and the first of 22 tankers of comparable size being built in six countries and which will greatly reduce Shell dependence on the Suez Canal, is 19 100 dwt *Myrina,* which recently entered the water from the Belfast yard of Harland and Wolff Ltd.

Valued at some £5 million, *Myrina* is probably the heaviest ship to be launched from a slipway in a European yard, her weight with turbines and boilers installed before launching being almost 29 000 tons.

Myrina carries her deadweight capacity of 191 250 tons on a draught of 60 ft 2½ in. Other characteristics of the ship, which is turbine propelled, are:

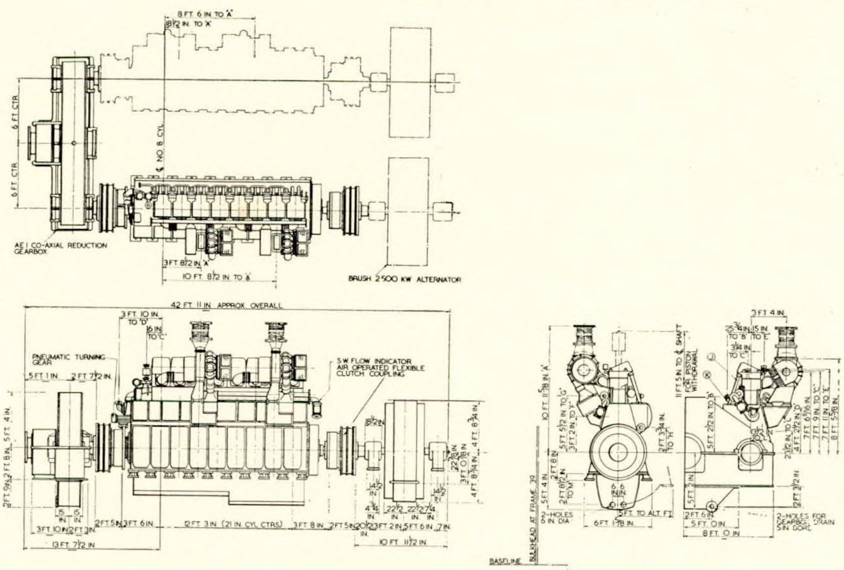
Length, o.a.	1050 ft 0 in
Length, b.p.	1010 ft 0 in
Breadth, moulded	155 ft 0 in
Depth, moulded	77 ft 0 in
Cargo capacity	8 510 000 ft^3
Clean ballast	20 696 ton
Service power	27 000 shp
Service speed	16 knots

Propulsion is by Pametrada turbine with a service rating of 27 000 bhp at 101·5 rev/min driving through double-helical, double-reduction dual tandem articulated type gearing to a Stone Manganese six-bladed propeller.—*Motor Ship, October 1967, Vol. 48, pp. 313-314.*

Hold Ventilation System

Three 6000 dwt cargo ships ordered from Hall, Russell and Co. Ltd. by H. Schuldt of Hamburg have been fitted with complete air conditioning and ventilation systems by Thermotank Ltd. A feature of the mechanical supply ventilation system is the high air-change rate of the hold and 'tween deck spaces—up to 30 changes per hour based on empty hold volume.

Eight axial flow fans, with a total capacity of 150 000 ft^3/min supply the four 'tween deck and cargo hold spaces which have a total grain capacity of 300 000 ft^3. Air is extracted from the spaces by six mushroom-type vents and spray-eliminating jalousies except in the case of No. 3 hold where the required exhaust quantity is extracted mechanically. This is achieved by two 38-in diameter eight hp axial flow fans each having a capacity of 23 500 ft^3/min at ¾ in water gauge.—*Shipbuilding International, August 1967, Vol. 10, p. 21.*



Installation diagram for the Ruston AO-engined propulsion and generator sets in a Canadian bulk carrier

Thyristor Control of Propulsion Machinery

The twin-screw Diesel-electric trawler *Tiko 1* is the first ship to be equipped with a thyristor-controlled main propulsion system.

The main plant comprises three Deutz-AEG Diesel generators, each of 910kVA, 0·8-lbf, 390-V, 50c/s at 600 rev/min. The three generators operate individually or in parallel on the main busbars. They are specially adapted to operate with thyristors and compensation circuits are provided for correct reactive load distribution. The entire system, i.e. including the propulsion motors and trawl winches, is supplied from the 380-V, 50-c/s busbars.

The two propulsion motors are direct-current shunt-wound motors of 810kW, 440-V at 1000 rev/min each. Conversion of the a.c. to d.c. is effected by thyristors, fed via a special transformer in a phase-shifting circuit designed to economize in plate current. The purpose of these transformers is to reduce the overtone or higher harmonics proportion, resulting especially from the driving unit, and so to lessen the static or interference voltage.

The thyristors are split into armature and field sections. Those for the armature feed are connected as a three-phase-current bridge with seven parallel branches. This unit is accommodated in a cabinet with an integral fan which draws the air down from the top.

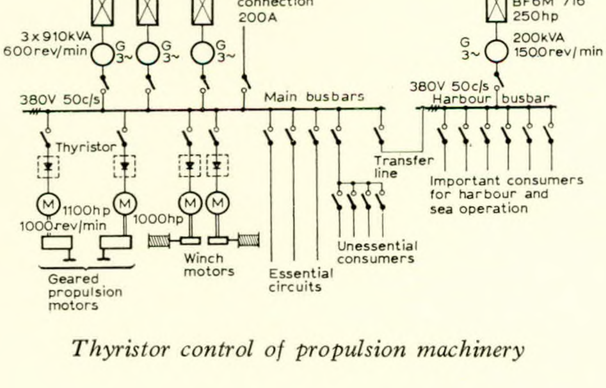
Arranged next to this are the regulator units for armature field and the field thyristors. Other things built into this regulator section include the current limiter, the field attenuation, the speed reversal (field polarity reversion) and the reverse-power limiter for rapid reversing manœuvres.

Should a thyristor fan trip out, the thyristor current is reduced to half its rated value, as also when a fuse blows and when an unduly high air intake temperature for thyristor cooling is reached.

To protect the d.c. circuit (thyristor-motor) a Gerapid quick-break switch has been built in. The release lag of the Gerapid switch lies within the thermal overload capacity of the thyristors in the case of excess current and short circuit. When the generators are overloaded or in the case of partial operation with one or two generators, the rate of power input of the propeller motors is limited or reduced to the input available at the moment. In this way overloading of the control gear is avoided. It is also possible to connect other important consumers such as the trawl winches, as the performance of the propeller motors is simultaneously reduced.

The two propulsion engines are controlled, by twin head telegraph, from the bridge or from the generator room. The telegraphs have a double use as a conventional telegraph from the bridge to the engine room, when the generator room telegraph is used as a speed setting means for the propulsion motors but if control is direct from the bridge, the bridge telegraph operates as the speed-setting agent.

The propeller speed is infinitely variable from nil to maximum. The set number of revolutions can be kept constant by nominal/actual speed comparison. The current limiter acts as a further influence so that neither when accelerating nor in heavy seas can a higher current than the rated one occur. Both propeller motors can be run and reversed independent of one another. There are no reciprocal influences.—*Marine Engineer and Naval Architect, September 1967, Vol. 90, p. 408.*



Thyristor control of propulsion machinery

Performance of Fishing Vessels

The big freeze trawler and the mother ship are such recent developments that it is easy to understand how costs may be reduced by refinement of design and that effectiveness may still be capable of improvement; the revival of interest in the inshore fisheries and the advent of new methods giving increased versatility and flexibility make it desirable to take a fresh look at the design of the classic inshore motor fishing vessel; at the same time means must be sought to increase the effectiveness and reduce the cost of the orthodox deep sea trawlers, many of which have considerable remaining life.

Accordingly, about four years ago an Industrial Development Unit was established by the White Fish Authority. This Unit is charged with the development of equipment and techniques up to the stage at which they are capable of immediate application in the commercial fishing industry. Current projects include development of specialized equipment such as:

1) winch brakes;
2) pneumatic ice conveyors;
3) narrow-beam echo sounders stabilized against the roll of the ship;
4) fishing aids including a system of telemetry from trawl net to the ship;
5) hydraulic transmissions for winches and machines for gutting fish;
6) apparatus for new methods of stowing and unloading the catch and of transferring catches at sea.

All these projects are chosen for their likely beneficial effect on the costs and earnings of the industry and, because this is the object of the work, the Unit also spends a good deal of effort and work aimed at optimizing the design of the vessels themselves.

The performance of the vessels and their machinery has been one of the most significant fields for research and it is this topic which is dealt with in this article.

TABLE I

1) propeller shaft torque, rev/min, thrust;
2) torque and rev/min for power measurement on various shafts on auxiliary machinery;
3) ship speed;
4) wind speed and direction;
5) Warp leads;
6) Electrical power absorbed by main and auxiliary motors;
7) propeller pitch;
8) air and sea temperatures;
9) ship heading;
10) angular motion in pitch, roll and yaw;
11) linear motion along three axes;
12) loads in various cables and other attachments;
13) fuel flow;
14) sea state.

Table I lists most of the quantities that may have to be measured in pursuing the objectives given earlier. Of course, it is not necessary (or practicable) to measure all of these quantities on each project. It is important to recognize, however, that for complete understanding of apparently simple features it may be necessary to mount a complex trial, with measurement of many parameters. For example, in studying the trawl winch performance on any fishing vessel it is necessary to take simultaneous measurements of propulsion power, ship speed, ship motion etc., as the way in which the ship is handled, and the weather, can have profound effects on winch performance.—*Bennett, R., Motor Ship, September 1967, Vol. 48, pp. 21; 23-25; 27.*

Controllable Pitch Propellers for Stern Trawlers

There are two basic types of controllable pitch propeller, ignoring oil transfer or oil distributing boxes as these vary very little from type to type, namely, those with the operating servomotor situated in the propeller hub and those with the operating servomotor situated inboard.

Firstly, with the servomotor in the hub, Fig. 1, the principal advantages are as follow:

a) the facility to contain within the hub the high forces resulting from centrifugal and hydrodynamic twisting forces;
b) the possibility of a smaller shaft diameter than with pushrod-operated designs;
c) greater sensitivity of control due to the fact that the servo piston is adjacent to the pitch changing mechanism;
d) better utilization of space within the hub/pod envelope since hydrodynamic considerations necessitate that a fairing cone be fitted to any propeller;
e) the easy application of a completely independent method of bringing the blades to the full ahead condition in the event of electrical, pneumatic, hydraulic or any other failure.

The principal disadvantage is that when used on a long shaft installation there is a differential expansion resulting from the effect of the hot operating oil in the valve rod and the cold water surrounding that part of the shaftings exposed to the sea. This may give rise to small pitch changes and make the selection of neutral pitch more difficult.

If the servomotor is positioned inboard, Fig. 2, the principal advantages are as follow:

a) the accessibility of the operating mechanism in the event of breakdown. (This is, of course, very rare these days);
b) the decreased frictional loss due to the method of transplanting axial movement of the pushrod to radial movement on the blade root;
c) easier provision for locking the propeller blades in any desired pitch in the event of failures as previously referred to.

The principal disadvantages are:

a) dismantling and operation is more difficult at survey time due to the necessity of uncoupling the pushrod;
b) in heavy loaded propellers the pushrod is subjected to elongation and compression under heavy pitch changing loads.

In no condition is the blade attitude to flow more significant than when efforts are being made to reverse the ship. Tests have shown that the water will approach the reversed fixed pitch propeller at an angle almost normal to the blade surface which will give a completely confused flow regime, the propeller being in complete cavitation and doing nothing

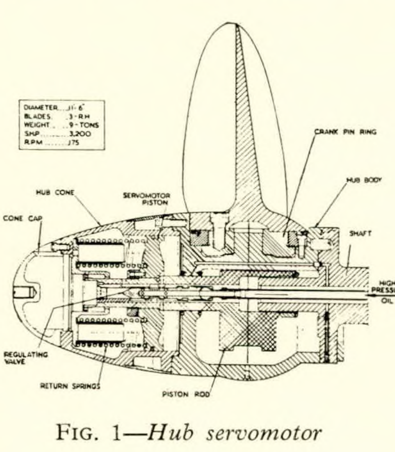


FIG. 1—*Hub servomotor*

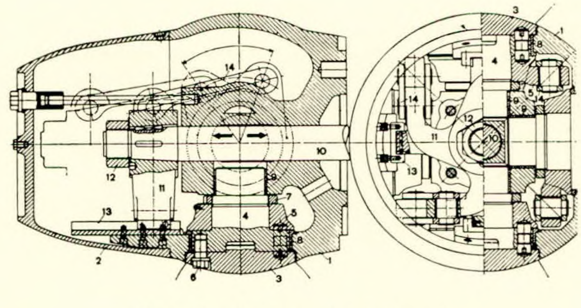


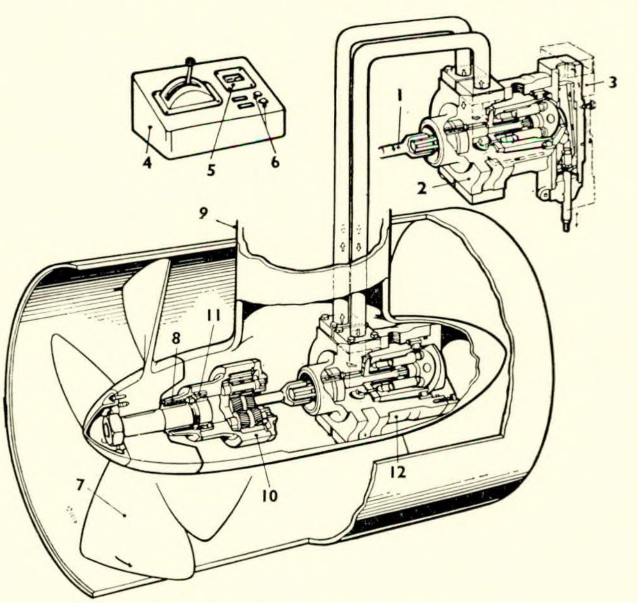
FIG. 2—*Servomotor inboard*

apart from increasing the appendage resistance of the vessel. On the other hand immediately the pitch of the controllable pitch propeller is reduced by a small angle in this case full thrust is achieved and therefore maximum reversing effect. As the speed of the vessel is reduced the pitch of the propeller would be progressively reduced with maximum thrust applying until full astern pitch would be achieved only at full astern speed. Throughout this manœuvre a stable flow regime would be achieved with minimum cavitation. This great ability of the controllable pitch propeller to give high thrusts and manœuvrability at low water speeds is a major advantage for propellers fitted to stern trawlers.—*Parsons, C. G., Motor Ship, September 1967, Vol. 48, pp. 28-29.*

Hydraulically Powered Bow Thrust Unit

Normally, bow thrusters are electrically driven units but a new design, recently introduced by Stone Manganese Marine Ltd., employs a different drive system.

Capable of giving a thrust of up to five tons to port or starboard it is a hydraulically powered unit and is suitable for all types of vessel. The thruster is powered by a constant-speed unidirectional prime mover, either steam, electric or Diesel. The prime mover drives a variable displacement hydraulic pump



1) Prime mover output shaft	7) Propeller
2) Variable delivery pump	8) Shaft seal
3) Servo valve assembly	9) Strut
4) Bridge control unit	10) Epicyclic reduction gear
5) Thrust indicator	11) Thrust and journal bearing
6) Running lights	12) Hydraulic motor

Cut-away section of the Stone hydraulic-powered bow thrust unit through a flexible coupling. The pump, governed by a servo-control which may be operated from the bridge or locally is adjustable to regulate both speed and direction of flow of the hydraulic motor operating fluid. Since the only connexion between the pump and the motor is piping, the pump may be situated in any convenient position. The speed of the hydraulic motor is reduced to a speed suitable for the fixed pitch bronze propeller through an epicyclic gear-box.

The steel tunnel inside which the unit is suspended is fabricated in two sections with the portion surrounding the propeller tips machined to give a small clearance. A flat steel plate attached to the top of the thruster enables the whole unit to be lowered into position through a rectangular hole in the deck. The plate is then jointed and bolted to seal against the ingress of water. When overhauling the equipment it may, in some vessels, be possible to trim by the stem sufficiently to raise the mounting plate above water level and lift the unit and tunnel into the vessel, without the need for drydocking.—*Motor Ship, October 1967, Vol. 48, p. 317.*

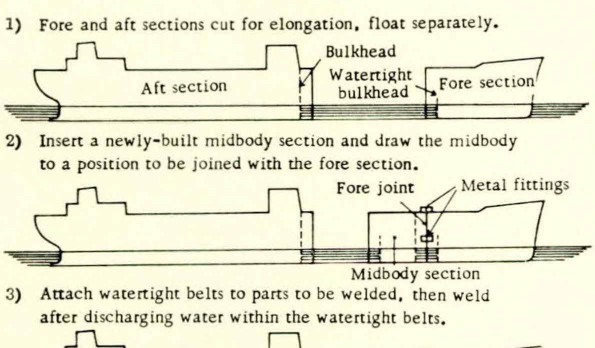
Jumboization Carried Out Afloat

The Former 40 112 dwt tanker *Olympic Runner,* owned by Olympic Maritime, has been increased to 58 900 dwt while afloat. This jumboization, which was carried out by the Yokohama shipyard of Mitsubishi Heavy Industries Ltd. is claimed to be the first of its type to be entirely completed at sea.

Principal particulars of *Olympic Runner* before and after conversion are:

	Before metres	After metres
Length, b.p.	204·00	240·00
Breadth	28·80	28·80
Depth	14·70	17·20
Draught	10·79	12·50
Deadweight (tons)	40 112	58 900

The conversion of *Olympic Runner* was of the cross-type i.e. an increase in both length and depth. The hull was first cut in front of the bridge into two sections. Each section was then increased in depth by about 2·5 m to bring the upper deck level with the existing forecastle and poop decks. A new 'midship body, 36 m long, was inserted between the two sections. All cutting and welding was completed while afloat.—*Motor Ship, September 1967, Vol. 48, p. 270.*



Sequence of cutting and jumboization of the hull of the tanker Olympic Runner *while afloat*

North Sea Automobile Carrier

Where cargoes are to be carried in large quanties regularly it is an economic proposition to construct ships specifically for this purpose hence the development of tankers, bulk carriers, container ships, etc. One of the latest special purpose vessels to enter service is the 1000 grt m.v. *Carway,* which has been specifically designed for the carriage of unaccompanied motor cars and caravans.

Built by the Grangemouth Dockyard Co. Ltd. for Seaway Car Transporters Limited, a subsidiary of Elder Dempster Lines, the vessel will operate between Britain's East Coast and the continent. The hull and superstructure are of all welded steel construction and vehicles are carried on five decks which have the minimum of obstructions. Loading and unloading is facilitated by means of hinged ship-side ramps arranged two on each side of the vessel. The bridge and some accommodation are in the forward deckhouse and further accommodation is arranged aft. Each deckhouse has its own Thermotank ventilating system of the low velocity heating and mechanical ventilating type using a proportion of recirculated air. Steam for the heaters is supplied by a Stone-Vapor generator located in the engine casing.

The car spaces are mechanically ventilated using a system designed to overcome the problem of high carbon monoxide content in these spaces when loading and unloading is being carried out. An interesting feature of this system, also supplied by Thermotank, is that most of the air supply and extraction takes place at deck level. The reason for this is that tests have shown that the concentration of exhaust gases is at its greatest at about 12 in above deck level. Six reversible 2 ft 6in diameter, ten hp axial flow fans with a total output of 106 200 ft^3/min give up to twenty air changes per hour. During loading and unloading all fan units will extract exhaust fumes from car stowage spaces direct to the atmosphere and the clean air supply will be naturally aspirated through the vessel's side doors. At sea certain of the fans act as supply units.

Located at the forward end of the superstructure, the bridge is comprehensively equipped with the latest navigation and radio aids. Consoles are fitted on each side of the wheelhouse and contain the controls for bridge operation of the main engine. A third console is fitted in the engine room for local control, if required.

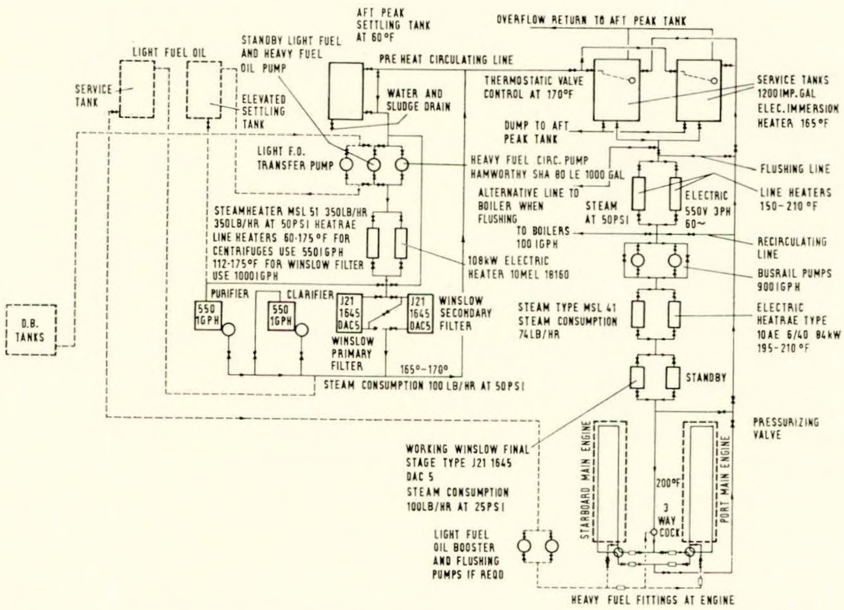
The propulsion machinery is located aft and consists of a Mirrlees direct reversing four-stroke type KLSS DM8 supercharged Diesel engine developing 1864 bhp at 350 rev/min. The drive from the engine is taken through a Twiflex coupling direct to the propeller shaft. Three Laurence Scott d.c. generators are fitted, each unit being driven by a Paxman 6RPHCZ Diesel engine and capable of an output of 200 kW at 900 rev/min.—*Shipbuilding International, August 1967, Vol. 10, pp. 8-9.*

Great Lakes Tanker with Mirrlees K Major Engines

Davie Shipbuilding of Lauzon, Quebec, have delivered the twin-screw tanker *James Transport* to the Hall Corporation of Canada Ltd. She is the first with medium-speed engines burning heavy fuel to operate on the Great Lakes. The leading particulars are as follow:

Length, b.p.	355 ft 0 in
Breadth	55 ft 0 in
Draught	27 ft 6 in
Deadweight	7250 tons
Installed hp	4850 shp
Service speed	13½ knots

The propelling machinery consists of two Mirrlees National six-cylinder KGMR6 Major four-stroke non-revers-



Schematic arrangement of light and heavy fuel systems, showing temperatures maintained in the heavy fuel lines

ing engines, each continuously rated at 2500 bhp at 500 rev/min and connected through a flexible coupling to a Lohmann and Stolterfoht reverse, a 2½ to one reduction gear-box and a fixed-blade propeller. The total weight of the two engines, with the gear-boxes is approximately 106 tons (47½ lb/bhp at the shaft couplings) which is an extremely low figure, even for advanced medium-speed machinery. The engines run on Bunker C fuel of 1000 sec Redwood No. 1 viscosity, although K Major engines have been developed to burn fuel of up to 3500 sec viscosity.

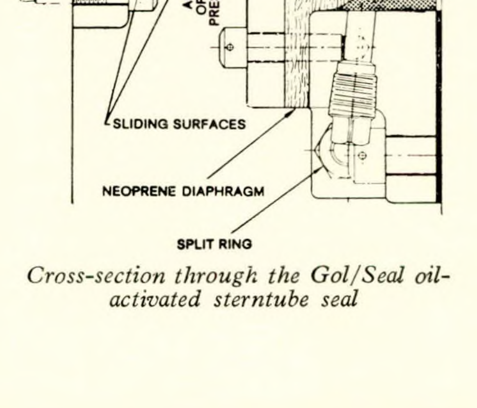
An important innovation is the use of Winslow steam-jacketed filters for heavy fuel treatment in place of normal centrifuges. A purifier and clarifier are installed for the light fuel system but will serve only as stand-by to the Winslow filters for main engine fuel purification. The system operates as follows:

a) Heavy fuel is stored in the after peak bunker tank and maintained at 60°F (15·5°C).
b) Fuel is delivered by positive-displacement transfer pumps through pre-filter electric or steam heaters where the temperature is raised to 175°F (79·5°C).
c) Heated fuel passes through the primary and secondary Winslow filters and enters the 1200-gal heated service tank on demand from the ball float in the tank. Coil heaters maintain the temperature at 175°F (79·5°C). Unused fuel is returned to the pump suction and recirculated.
d) Fuel is then passed through a steam or electric line heater which raises the temperature to 200°F (93·5°C).
e) A bus-rail circulating pump then passes the heated fuel through a final stage Winslow filter and a bus-rail heater which merely maintains the temperature of the fuel at 200°F (93·5°C). The pump circulates three to four times engine requirements around the bus-rail and the unused fuel is returned to the pump section.
f) The engine bus-rail has locally or remotely-operated heavy to light fuel changeover cocks, and the piping on the engine is fully lagged and traced. The high pressure fuel injection lines from pump to atomizer are traced with electric tape to keep the lines warm during shutdown and while manœuvring at low powers.

Jacket water and lubricating oil heaters are also provided, a point worth considering for installations operating in cold climates. The exhaust valve and injector cooling system can also be used as a warning system since a heater is fitted in the expansion tank. A temperature of 180°F (82°C) can thus be maintained at the injector nozzle tips. Hence, even under the most arduous conditions, whether caused by weather or manœuvring difficulties, the engines remain in a state of readiness and, more important, have the inherent ability to operate continuously on heavy fuel for the entire voyage.—*Marine Engineer and Naval Architect, September 1967, Vol. 90, pp. 378-379.*

Oil Activated Stern Tube Seal

The wear-down of propeller tail shafts, liners and bearings associated with the increased powers adopted by the present generation of fast vessels has necessitated further research into the design and maintenance of these components. Golten Marine Co. Inc., has developed an oil-activated springless seal which first entered service on a research vessel of the U.S. Navy. Further research and development has resulted in the Gol/Seal unit which is suitable for all shaft sizes as it claims



Cross-section through the Gol/Seal oil-activated sterntube seal simplicity of construction, ease of installation and ready accessibility for inspection. The design enables the Gol/Seal unit to be fitted to vessels already in service. It comprises two identical seals, one situated inboard and the other outboard. Each seal contains a neoprene diaphragm the outer rim of which is secured to the stern tube and the inner to a bronze running ring. The lapped surface of the ring glides on an anti-friction ring comprising two outer layers of Teflon and a centre layer of neoprene.

The inner diameter of the Teflon anti-friction ring is bored to suit the shaft diameter and to allow a suitable clearance on the shaft. The outer part of the seal comprises a bronze running ring with a lapped contact surface, which is bolted to the propeller boss. The inboard running ring has the same construction as the outboard but is bolted to a split sleeve secured to the shaft. Oil fed from a gravity tank provides the pressure necessary to keep the seal tight.—*Motor Ship, October 1967, Vol. 48, p. 317.*

Norwegian Bulk Carrier with Doxford J-Type Engine

Fernriver and *Fernspring* built for Fearnley and Eger, Oslo, by the North Sands yard of Joseph L. Thompson and Sons Ltd., are among the first ships to be built for export to be propelled by Doxford J-type engines. The engine selected for these vessels is the six-cylinder J-type design, rated at 13 500 bhp at 115 rev/min, and which operated with particular smoothness during trials of *Fernspring.*

Principal particulars of the ship are:

Length, o.a.	708 ft 6 in
Length, b.p.	670 ft 0 in
Length, registered	681 ft 10 1/5 in
Breadth, moulded	96 ft 0 in
Depth, moulded	56 ft 4 in
Draught, summer	40 ft 5¾ in
Freeboard	16 ft 0½ in
Corresponding deadweight ...	49 529 tons
Service speed (approx.) ...	15 knots
Capacities	
Holds (including hatches) ...	2 152 410 ft^3 (grain)
	2 110 450 ft^3 (bale)
Holds, hatches and deep tank	2 202 330 ft^3 (grain)
Ballast	22 442 tons
Bunkers	3147·6 tons
Diesel oil	158·3 tons
Main engine	
Maximum cont. rating ...	15 000 bhp
Corresponding engine speed ...	119 rev/min
Normal service rating	13 500 bhp
Corresponding engine speed ...	115 rev/min

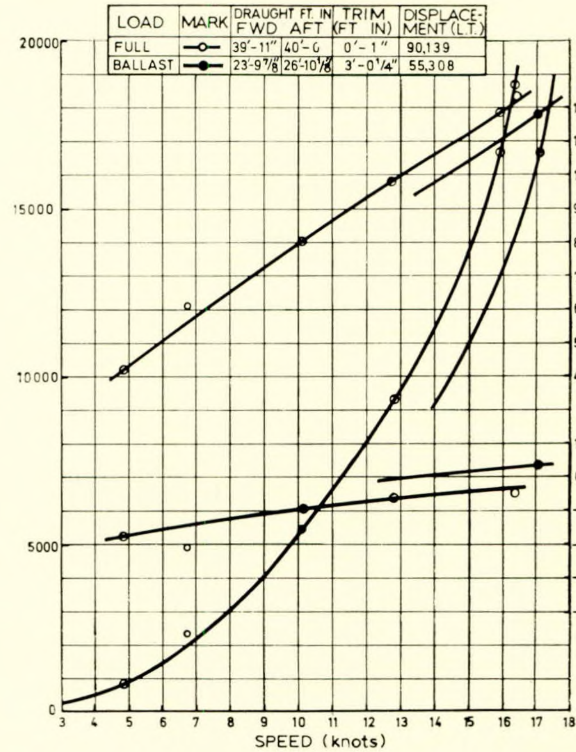
Fernspring has been built to the requirements of Det norske Veritas and carries this society's "F" notation denoting compliance with its fire protection requirements. Construction follows normal bulk carrier practice with longitudinal framing throughout except for side framing in the holds, fore and aft peaks and the engine room double bottom. There is a bulbous ram type bow.—*Motor Ship, July 1967, Vol. 48, pp. 165-167.*

Multi-purpose Carrier

A combination oil and ore carrier has been built by the Kure Shipbuilding and Engineering Co. Ltd. for S.A. di Navigazione Maritima Dorado of Switzerland. This vessel, *Balbina,* is powered by a Diesel engine and has a deadweight of 75 673 tons.

Balbina has been designed and constructed as a single-screw bulk ore/oil carrier, having a single continuous freeboard deck, six tiers of deck houses, bulbous bow, raked stem and Mariner type stern and rudder.

The propelling machinery in *Balbina* consists of a two-stroke turbocharged Ishikawajima-Harima-Sulzer type eight



Multi-purpose carrier—Speed power curves during trials

RD 90 Diesel engine having a normal output of 16 500 bhp at 118 rev/min, and a maximum continuous rating of 18 400 bhp at 122 rev/min. (The bhp figures are in metric units.) The five-blade nickel aluminium bronze propeller has a diameter of 6300 mm.

Principle particulars:

Length, o.a.	834 ft 9 in
Length, b.p.	797 ft 0½ in
Breadth, moulded	119 ft 8 in
Depth, moulded	65 ft 7¼ in
Draught, moulded (designed)	42 ft 3¾ in
Draught, moulded (maximum)	43 ft 11 in
Gross tonnage, Liberian	43 449·80
Deadweight, draught 13·40 m	79 450 ton (L)
Deadweight, draught 12·90 m	75 673 ton (L)
Capacity (100 per cent full)	
Cargo holds, grain	3 398 786 ft^3
Balast water	1 097 625 ft^3
Fuel oil tanks	149 276 ft^3
Machinery output	
m.c.r.	18 400 bhp at 122 rev/min
normal	16 560 bhp at 118 rev/min
Trial speed, draught 40 ft	16·38 knots
Service speed, draught 42 ft 6 in ...	15·0 knots

Steam is generated in an oil-fired boiler and, when the ship is at sea, in an exhaust gas waste heat boiler. The oil-fired boiler is of two-drum water tube type and is fitted with one burner. It is rated at about 47 tons/h at a pressure of 227·6 lb/in^2, 446°F with feed water at 194°F. The forced circulation multi-tube exhaust gas boiler of the La Mont type is rated at 5½ tons/h.—*Shipping World and Shipbuilder, October 1967, Vol. 160, pp. 1227-1232.*

Hydrodynamic Resistance of External Hull Anodes

An investigation was made by B.S.R.A. into the effect on performance of fitting anti-corrosion anodes to the hull of the 18 000 dwt tanker ss *San Fortunato.* In this report the increase in power requirement associated with the anodes was measured by carrying out two series of performance trials on the ship; the first series of trials was made with a set of dummy anodes in position on the hull and the second series was carried out within a few hours, after the dummy anodes had been removed by divers. Furthermore, an attempt was made to calculate the power increase but since there was little information available on the hydrodynamic resistance of anodes, it was necessary at that time to extrapolate resistance data for rectangular sections. B.S.R.A. therefore initiated a series of wind-tunnel tests to obtain data on the resistance of anodes and the results of these tests are presented in this report.

The tests were carried out by the Aerodynamics Division, National Physical Laboratory. Two models of the type of anode fitted to *San Fortunato* were tested, the first model had a smooth surface and the second was coated with Derlex grit to represent the surface of an anode after a period in service. A third model, which represented a second type of anode with a smooth surface, was also tested.

When calculating the increase in resistance due to fitting anodes to a hull, it is recommended that the velocity used in association with the drag coefficients obtained from the tests should be the local velocity in the ship's boundary layer at the outer surface of the anode. The procedure is illustrated in the Appendix by calculating the effect on performance of fitting anodes to the hull of *San Fortunato*. For the ship speed of 14·5 knots, the difference in performance measured on the two series of trials was consistent with an increase in power requirement due to the anodes of the order of 50 shp, and it will be seen that the calculated increase is in good agreement with this.—*Shipping World and Shipbuilder, October 1967, Vol. 160, pp. 1721-1724; 1726.*

Short-sea Roll-On, Roll-Off Ships

Antares, a 1123 dwt "paragraph" vessel, designed to come within the 500 gross ton rules and built by Schlichting Werft, Lübeck-Travemunde for the Argo Reederei Richard Adler und Sohne, Bremen. This is the first of two sisterships—the second of which is *Arcturus,* which was built by Büsumer Werft, a Schlichting Werft subsidiary company. The ships were developed in co-operation with Argo Reederei and are now operating a roll-on, roll-off service between Bremen, Hamburg and Hull in a joint service with Associated Humber Lines Ltd.

In the design of these ships the relevant "paragraph" rules have been taken into account but the vessels have a particularly generous cubic capacity within the 500 gross ton limit, as shown in the following table of principal particulars:

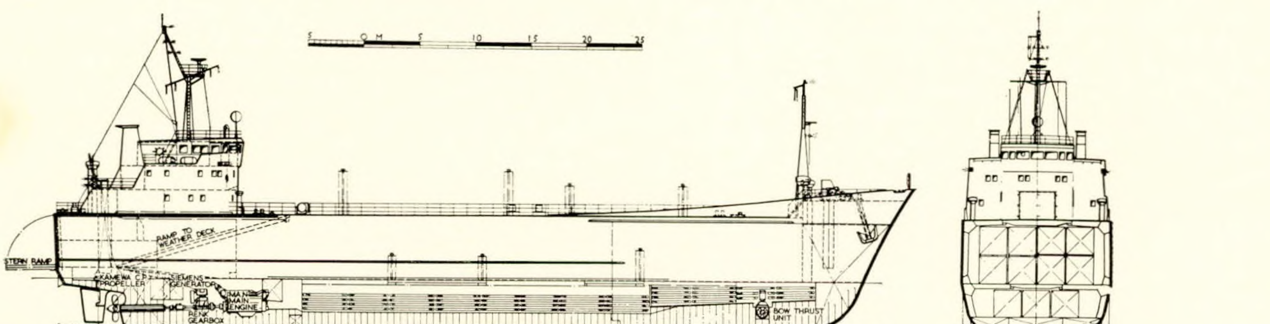
Length, o.a.	76·42 m
Length, b.p.	68·00 m
Breadth, moulded, extreme ...	13·00 m
Breadth, moulded, main deck ...	12·96 m
Depth to shelterdeck	9·92 m
Depth to main deck	4·25 m
Summer draught	4·22 m
Corresponding deadweight ...	1123 tons
Gross register	499·87 tons
Capacity (grain)	5170 m^3
Capacity (bale)	4830 m^3
Containers, under deck	up to 70
Cargo area, lower hold (approx.) ...	306 m^2
Cargo area, upper hold (approx.) ...	600 m^2
Cargo area, shelter hold (approx.) ...	600 m^2
Cargo area, shelterdeck (approx.) ...	580 m^2
Machinery output	2200 bhp at 900/275 rev/min
Full-load speed	14·6 knots
Service range	5000 miles
Classification	Germanischer Lloyd, GL ✠100A4E 1 ✠MCE1

One of the design features which is particularly notable is that *Antares* and her sistership can be loaded through a large stern door and/or through large hatchways in the decks, i.e. both horizontally and vertically.

Propulsion of *Antares* is by a M.A.N. 16-cylinder vee-type four-stroke turbocharged engine of the V8V 22/30 ATL design which is rated at 2200 bhp at 900 rev/min. It is coupled to the KaMeWa controllable pitch propeller via a step-down gear-box of Renk supply and which gives a propeller speed of 275 rev/min. Ship speed will normally be controlled by the propeller pitch because at sea a Siemens 76 kKA, 400 V, 50-cycle a.c. generator is driven by a flat belt from a gear-box lay-shaft. The generator, which is mounted on top of the Renk gear-box, can supply all the normal electrical load at sea but when the bow thrust unit is used, it is necessary to employ a Siemens 162 kVA a.c. generator which is driven by a Deutz BF6M 716 Diesel engine. This unit is arranged for automatic starting in the event of a breakdown of the shaft-driven generator. For use in port when the load is very small and for emergency operation, an air-cooled Deutz F4515 engine coupled to a 48 kVA Siemens generator is housed in a sound-proofed compartment in the casing. Electricity is distributed through a main switchboard of the shipbuilders' own manufacture.—*Motor Ship, October 1967, Vol. 48, pp. 319-322.*

Features of the Automatic Control of the Steam-Condensate Cycle of the Propulsion Plant of Sofia Class Tankers

The automatic regulation system used in the propulsion machinery of SOFIA class turbine tankers (49 000 dwt) are improved versions of those adopted in Leninskii Komsomol class dry-cargo ships and Pekin class tankers (18 000 dwt). The article which is illustrated by a large cycle diagram, describes the control scheme for the condensate system. The main improvement is the unified control for the de-aerator steam space and its heating-steam main, with pressure as the single controlled quantity.—*Shifrin, M. Sh. and Volokov, Yu. P., Sudostroenie, 1967, No. 3, pp. 31-34; Journal of the British Ship Research Association, August 1967, Vol. 22, Abstract No. 25 627.*



Roll-on/roll-off ship Antares

Identification and Measurement of Ultrasonic Search Unit Characteristics

The most important single component of any ultrasonic testing system is the search unit. The sound beam emitted from the search unit determines what can be detected and visualized by the ultrasonic equipment. Any standard programme for ultrasonic testing must logically start with an accurate knowledge and understanding of the beam characteristics. The methods used to analyse the sound beam must provide a high degree of signal purity. The crystal excitation and the amplification of the information must be accomplished without distortion. This paper discusses the approaches to the evaluation of ultrasonic search units.—*McElroy, J. T., Materials Evaluation, June 1967, Vol. 25, pp. 129-137.*

Welding in U.K. Ship Construction

The efficiency of the all-welded ship is still increasing by virtue of design refinement, coupled with the development of tougher, stronger steels and the means of prefabricating and welding them. Shipbuilding is largely an assembly industry and is labour-intensive rather than capital-intensive. Welder labour is still the highest-paid of the fifteen or so separate skills employed in U.K. shipbuilding, and the cost of this labour constitutes over 40 per cent of the total steel labour cost of a ship.—*Richardson, W., British Welding Journal, July 1967, pp. 393-397.*

Steam/Water System Corrosion

The author discusses the premature corrosion failure of four components in high purity water, steam and steam condensate systems. The material of all four components displayed adequate to excellent corrosion resistance when exposed in actual or simulated test environments. In the case histories, the author stresses the significance and proper analysis of design, fabricating procedures and operating conditions in the reduction of corrosion failures.—*Suss, H., Materials protection, June 1697, Vol. 6, pp. 46-48.*

Analysis and Design of Spiral-groove Bearings

The paper starts with a brief description of the history of the spiral-groove bearing. All previous authors based their considerations on a recurrent pattern of parallel straight grooves, for which Whipple gave an approximate solution which has served as the basis for practically all further theoretical work. The agreement between the theory based on this model and the real spiral-groove bearing is rather poor. In the present paper, the author describes how he found a method of calculation which applies directly to a real spiral-groove bearing with logarithmic spirals, working with an incompressible medium. This theory also takes the end effects into account. — *Muijderman, E. A., Transactions of the A.S.M.E.; Journal of Lubrication Technology, July 1967, Vol. 89, pp. 291-306.*

Welding of Copper With Deep Penetration Electrodes

The welding of copper is difficult chiefly because of its high thermal conductivity. An extensive investigation was carried out in the Welding Research Institute of Poland in order to examine the possibility of welding copper without preheat. Following an analysis of the various methods available, the energy of an electric arc for welding of copper without preheating was established. It was found that such energy could be obtained with an arc from suitable penetration copper electrodes.—*Wegrzyn, J., British Welding Journal, May 1967, Vol. 14, pp. 233-238.*

The Use of Pulsed Applied Voltage in the Derivation of Corrosion Rates from Polarization Resistance Measurements

An experimental technique has been developed for the rapid determination of changes in corrosion rates using the well established Stern-Geary equation. The value of the technique was demonstrated with aluminium brass in natural sea water and in sea water containing 0·01 per cent sodium dimethyl dithiocarbamate for which the corrosion characteristics had been established previously. An instrument based on these principles could be developed for a variety of corrosion measurement applications.—*Rowlands J. C., and Bentley, M. N., British Corrosion Journal, May 1967, Vol. 2, pp. 92-94.*

Effect of Dropwise Condensation on the Thermal Efficiency of a Triple Effect Water Distillation Plant

The dropwise condensation promotion of a power station triple effect evaporator with softened water resulted in a significant improvement in the apparent heat transfer coefficients across the effects and a resultant improvement in the net output of 10-15 per cent. This improvement was limited by the thermo-compressor capacity and an improvement of 35 per cent has been calculated if this restriction were removed. Slight condensate contamination by stearic acid occurred, but the quality generally remained acceptable for steam generating plant make-up.—*Poll, A., Potter, C. J. and Powell, A. W. 1967. Submitted to The Institution of Mechanical Engineers for written discussion. Paper P27/67.*

Erosion Between two Parallel Surfaces Oscillating in Close Proximity in Liquids

A disc was vibrated in close proximity to a plane surface while submerged in either water or one of several oils. The specimens suffered surface damage either by subsurface fatigue or cavitation erosion. The type and extent of damage depended upon the thickness of the fluid films and the viscosity of the liquid. Specimens with bearing alloy surface layers showed cracks due to surface shear followed by flaking off of the bearing alloy.—*Endo, K., Okada, T. and Nakashima, M., Transactions of the A.S.M.E.; Journal of Lubrication Technology, July 1967, Vol. 89, pp. 229-236.*

Pitch and Heave with Fixed and Controlled Bow Fins

A method of calculating the effect of bow antipitching fins on the motions of a model is presented and compared in detail to the results of measurements. The agreement is quite satisfactory, both for fixed and controlled fins. Next, this method is applied to a general cargo ship of the Sixty Series equipped with fixed and with activated fins, respectively. The activated fins are controlled by a nonlinear feedback signal of the pitch velocity. The absolute and relative ship motions in regular and irregular waves are computed and compared to the motion without fins.—*Vugts, H. V., International Shipbuilding Progress, May 1967, Vol. 14, pp. 191-215.*

Reversing Normal Strains by Rolling Contact Load

Attempts have been made to correlate some characteristics of the stress field produced by rolling contact loads with the location of the origin of the rolling contact fatigue failure process. Analysis of the stress field of a cylinder and torus under contact load reveals the existence of reversing normal strains in certain directions at points in the material. Research work indicates this condition to be a requirement for large plastic deformations in high cycle fatigue.—*Lyman, J., Transactions of the A.S.M.E.; Journal of Lubrication Technology, January 1697, Vol. 89, pp. 76-80.*

Control of Corrosion at Mechanical Joints

Control is defined as the reduction of corrosion risks to an acceptable level by methods incurring an acceptable cost. Choice of fasteners and protective finishes for fasteners are considered, and methods of preventing corrosion at joints in steel, aluminium, and non-metallic structures are discussed. It is emphasized that the fastener must be considered in relation to the other components of the joint and to the condition of service.—*Layton, D. N., and White, P. E., British Corrosion Journal, March 1967, Vol. 2. pp. 65-70.*

Open-water Tests on Nozzle Rudders

After mentioning some advantages of nozzle propellers and nozzle rudders and the scarcity of design data relating to them (particularly to nozzle rudders), the authors present a detailed account of systematic open-water model-tests (in ahead and astern motion at various nozzle-rudder angles) which form the first part of an investigation intended to provide such data. The present tests were confined to seven simple Shushkin-type nozzles, including a slotted nozzle and one fitted with various types of stabilizing fin; the same three-bladed propeller (a modification of the Wageningen B3-35 design) was used throughout (some tests were run with no propeller).—*Gutsche, F. and Schroeder, G., 1966. Schiffbauforschung, Vol. 5, No. 5/6, pp. 185-208; Journal of the British Ship Research Association, May 1967, Vol. 22, Abstract No. 25 312.*

Mechanisms of Noise Generation in a Compressor Model

The authors report on a study undertaken in order to gain a better understanding of how compressor noise is produced. To facilitate mathematical analysis, the noise-generating mechanisms of axial-flow compressor blades have been investigated using flat blades. Analytical expressions are given for calculating the compressor noise due to blade thickness, loading and vortex shedding. Measured values of compressor noise show good agreement with analytical predictions. It has been found that the lift or loading noise dominates the blade thickness noise. Rotor-stator spacing is an important parameter in rotor noise generation.—*Hulse, B. T. and Large, J. B., Transactions of the A.S.M.E.; Journal of Engineering for Power, April 1967, Vol. 89, pp. 191-198.*

Erosion Resistance of Coatings

The authors define cavitation erosion and discuss several methods used by the U.S. Naval Applied Science Laboratory to test its effects on protective coatings. The methods described are:

1) rotating disc apparatus;
2) high speed nozzle apparatus;
3) magnetostriction apparatus;
4) piezoelectric transducer equipment.

Illustrations are provided to show the effects of each on various generic coatings.—*Lichtman, J. Z. and Kallas, D. H., Materials Protection, April 1967, Vol. 6, pp. 40-45.*

Aluminium Anodes in Sea Water

The authors describe the effect of various alloying elements on the laboratory performance of aluminium anodes. Among these elements are mercury, tin, gallium, indium, zinc, magnesium, cadmium, barium, and bismuth. A combination of aluminium/mercury and zinc delivers 1290 amp h/lb of metal consumed at a potential of 1·05 V (saturated calomel reference). — *Reding, J. T., and Newport, J. J., Materials Protection, December 1966, Vol. 5, pp. 15-18.*

Corrosion of Mechanical Joints in Aluminium and Aluminium/Steel Structures

This paper is primarily concerned with the problem of poor performance of mechanical joints, the main reason for which is inadequacy of published information on joint design, construction procedures and maintenance. This contention is illustrated by discussion of corrosion problems that arise with mechanical joints, particularly with aluminium/steel joints which are commonly used in shipbuilding. The need for close co-operation among designers, constructors and corrosion specialists, is strongly emphasized. Some methods of making practical corrosion information available to industry are suggested.—*Booth, F. F., British Corrosion Journal, March 1967, Vol. 2, pp. 55-60.*

Cathodic Protection

The author briefly outlines several major points that the engineering beginner should know about cathodic protection. He then explains how cathodic protection works, what it can and cannot do, what it may do that is undersirable, how much it will cost, how much it will save, and how it can be presented and sold to management.—*Parker, M. E., Materials Protection, December 1966, Vol. 5, pp. 9-12.*

Scale Modelling

Most physical systems can be studied by means of miniature scale models whose behaviour relates in a known way to that of the prototype. The problem is to obtain a valid scaling law that displays this similarity accurately. One way of going about the task is the "parameters approach", where all the variables concerned are grouped into meaningful dimensionless quantities by means of the Buckingham "Pi" theorem. This method assumes that nothing is known of the equations governing the system. If these equations are known, then the scaling law can be deduced by the "equations approach" where the equations are manipulated so as to reveal the significant dimensionless groupings.—*Soper, W. G., International Science and Technology, February 1967, No. 62, pp. 60-62, 64, 66-69.*

Optimum Seal Performance

The most important aspects of seal installation to ensure successful operation are covered, with special emphasis on certain considerations that are too often overlooked or not recognized. Such things as careful aligment of the fixed face, cleanliness, cooling, lubrication, gasketting, shaft deflexion and end play, balance, arrangement, etc. are discussed. With appropriate attention to these aspects, mechanical seals can be relied upon to perform for long periods of uninterrupted service under very difficult conditions.—*Dolman, R. E., Lubrication Engineering, November 1966, Vol. 22, pp. 438-441.*

Principles of Merchant Ship Optimization Calculations

Although a knowledge of the relevant economic principles is essential for the study of the optimum design of merchant ships, those concerned do not always possess this knowledge. The author therefore explains these economic principles and a critical examination of some criteria and calculating methods which have been used or proposed is included. A procedure is suggested which gives special consideration to the conditions peculiar to any capital investment and the effectiveness of optimization studies is brieffy discussed.—*Aass, H. L., Forschungshefte Schiffstechn, November 1966, Vol. 73, pp. 139-144; Journal of the British Ship Research Association, June 1967, Vol. 22, Abstract No. 25 410.*

Recent British Work on Behaviour of Warship Structures

Entirely rational elastic or plastic design procedures for surface ship structures have not been achieved. During the past 15 years, considerable advances and development both in the understanding of the mechanics of ship structures and in the application of digital computers to ship problems have been made. This is a report on research in progress to obtain information on loadings at sea, with regard to both extreme and repeated cyclic loading.—*Clarkson, J., November 1966. Ship Structure Committee Special Rep. SSC-178.*

Practical Applications of Corrosion-testing Apparatus under Heat Transfer Conditions

Methods for practical measurement of the effects of heat transfer on corrosion are discussed and the use of the following types of testing equipment is described: a cooling-water rig, an air-cooled rig for long-term constant temperature testing in flue gases, a drier simulating apparatus and several designs of on-line apparatus including heated tubular probes fitted in pressure glands or sight glasses, a multi-specimen probe representing steam-heating coils and a condenser for simultaneous tests on different materials.—*Moore, P. T. and Smith, S. H. British Corrosion Journal, July 1967, Vol 2, pp. 143-149.*

Hot Tensile Properties of $\frac{1}{2}$ chromium $\frac{1}{2}$ molybdenum $\frac{1}{4}$ vanadium and $2\frac{1}{4}$ chromium/molybdenum Steam Pipe Material

The high temperature properties of chromium/molybdenum/vanadium and $2\frac{1}{4}$ chromium/molybdenum steam pipe have been determined over a range of conditions. To compare the influence of two extreme thermal conditions experienced in the heat-affected zone of a welded joint, material was tested in the normalized condition, and after oil quenching from 1350° C. The main series of tests were carried out at 650, 700 and 750° C and at strain rates between 0·01 per cent/min and one per cent/min; additional tests were carried out at an intermediate strain rate at temperatures of 450, 500, 550, and 600° C. — *Barr, W. and Siverns, M. J., British Welding Journal, May 1967, Vol. 14, pp. 238-243.*

Effects of Applied Magnetic Fields on Welding Arcs

An investigation was undertaken to determine the visual and microscopic effects of a transverse magnetic field applied to the gas tungsten/arc welding process. The effects of magnetic fields on welding arcs were studied, with special attention to the appearance of the bead welds.

It was found that application of an optimum magnetic field to a welding arc provided a possibility of greater flexibility in welding techniques at increased speeds on both magnetic and nonmagnetic materials.—*Hicken, G. K. and Jackson, C. E. Welding Journal, November 1966, Vol. 45, pp. 515s-524s.*

Profile Modification of Helical Gear Teeth

The object of the investigation was to find out the effect of the profile modification upon the dynamic properties of helical gears and furthermore to derive a method for determining the optimum amount of profile modification.

Both non-crowned and crowned helical gear teeth were dealt with. It was found that the vibration caused by gear mesh was reduced by giving a suitable profile modification to the teeth or both non-crowned and crowned helical gears, and the optimum amount of profile modification could be determined from tooth deflexion under working load.—*Kugimiya, H., Bulletin of J.S.M.E. (Japan Society of Mechanical Engineers), 1966, Vol. 9, No. 36, pp. 829-841.*

Application of Gunpowder to the Removal of Keel Blocks

The authors describe a new method developed for the removal of keel blocks by means of gunpowder. Safety and reliability of the method is claimed to have been confirmed by actual experiments carried out in a dock. The new method is said to reduce the labour cost to one tenth of that recorded for conventional methods.—*Watanabe, S., Kotsubaki, M. and Sato, H., Journal of Zosen Kiokai (Society of Naval Architects of Japan), June 1966, Vol. 119, pp. 281-288.*

Cost Relations of the Treatments of Ship Hulls and the Fuel Consumption of Ships

By comparing the total costs of several painting schemes and the costs of drydocking over four years, it has been found that the use of better paint systems has economic advantages. Investigations have been made for cargo vessels, passenger vessels and tankers concerning the condition of the ship's hull as a result of the difference in protecting properties of the paint system and its influence upon fuel consumption for voyages in several periods of service.—*Lageveen-van Kuyk, H. J., International Shipbuilding Progress, July 1967, Vol. 14, pp. 292-311.*

Propeller Maintenance—Propeller Efficiency and Blade Roughness

Barring macroscopic changes in form and spacing, it is only the increasing roughness of the propeller which causes its decreasing efficiency in service. Parameters influencing the character of the surface are summarized and a study of actual surface characteristics in the same way as in the production of high class gears is recommended. A definition of permissible undulation of the surface as employed in gear technology, might also be introduced.—*Broersma, G., and Tasseron, K. International Shipbuilding Progress, September 1967, Vol. 14, pp. 347-356.*

Radioactive Tracer Techniques for Studying the Efficiency of Technological Measures for Increasing the Wear Resistance of Marine Engine Components

The author gives details of tests carried out at the LIVT Radioactive Isotopes Laboratory on the effects of various materials, coatings, fuels of different sulphur contents, lubricants and operating conditions on the wear rates of Diesel engine components. The use of radioactive tracer techniques has been shown to have considerable technical and economic advantages. The test engine had an output of 10 hp at 1500 rev/min and drove an electric generator. Small consumable radioactive sources were mounted in the surface of the part to be studied.—*Tochilnikov, D. G., Sudostroenie, 1966, No. 11, pp. 48-52; Journal of the British Ship Research Association, August 1967, Vol. 22, Abstract No. 25 620.*

Additive Against High Temperature Corrosion by Residual Fuel Oil Ash

Metallic heating surfaces may suffer from high temperature corrosion if they are subjected to inorganic ash components of heavy fuel oil at temperatures above 580°C. The possibility of using additives to reduce corrosion has been investigated. Favourable experience with gas turbines fired with heavy fuel oil initiated the use of SiO_2 (Aerosil) in the form of a pure coagulated aerosol in boiler plants. The reactions of this additive with the ash components, its introduction into the heavy fuel oil and the results on a practical boiler plant are described.—*Hansen, W., Journal of the Institute of Fuel, August, 1967, Vol. 40, pp. 348-351.*

The Future of Plastics in Ships

This paper projects the applications of plastics in ships today into the future to show the probable developments and trends. It summarizes the principal advantages on which these applications will be based and the limitations where further development is unlikely or impossible. It discusses the use of plastics for structural purposes the rise of the custom moulder, the possibility of the all-plastics ship and various major uses.—*du Plessis, H. 1966. Paper presented at the Technical Symposium of Ship's Gear International. Paper No. 9/3.*

Influence of Intake Air Temperature on Smoke Emission in Diesel Engine

Tests carried out on a four and a two stroke Diesel engine, are discussed. Inlet temperature variations range from 74 to 253°F. Smoke intensity is shown as a function of inlet air temperature with constant engine but under different sets of operating conditions (fuel and air consumption, air/fuel ratio, output) and as a function of these parameters at different constant intake air temperatures. Variations in running parameters, influenced by air inlet temperature, for constant smoke intensity are also presented.—*Gross-Gronomski, L., Wacholder, E., Rotstein, D. and Kabin, D., Journal of the Institute of Fuel, August 1967, Vol. 40, pp. 352-357.*

Developments in Side Loading Transporters and Deck Auxiliaries

This paper gives a brief investigation into the economics of present cargo handling techniques and running costs suggesting the reduction of these by means of improved cargo handling equipment. This leads to a full description of the structure and application of a side-loading transporter as produced to date. New ideas for overcoming future problems of cargo handling are explained, including a short section on self-discharging coastal bulk carriers.—*Hepburn, D., and Gibson, I. B., 1966. Paper presented at the Technical Symposium of Ships' Gear International. Paper No. 10/2.*

Structural Air Leakage Test Method Using Neo-Foamer

The authors report the development of a high-accuracy leakage detection method for ships' hulls with the use of a novel detecting agent. By employing this method, leakages in ships tanks can be detected more accurately than by conventional hydraulic test procedures. When Neo-Foamer is applied to the defective part of the tank, it foams as soon as it comes into contact with leaking air and forms a lasting solid foamy body. Neo-Foamer can be applied for detecting air leakage in airtight structures of various kinds as long as they have sufficient mechanical strength to withstand the air pressure. —*Hirota, N., and Onojima, Y., Technical Review, Mitsubishi Heavy Industries, 1967, Vol. 4, No. 1, pp. 1-7.*

Patent Specifications

Passive Stabilizers for Oil Tankers

Parts of a ship adapted according to the invention show the following features: Fig. 1 is a plan view, Fig. 2 is a cross-section and Fig. 3 is a longitudinal section. The drawings show the application of the stabilizer to one section of a tanker.

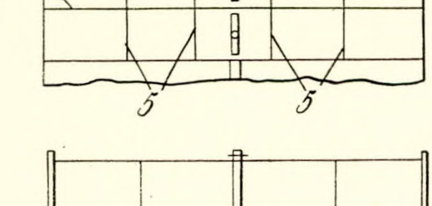


Fig.1

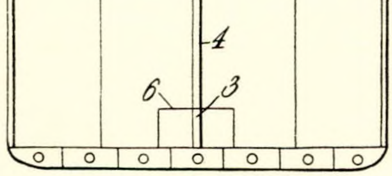


Fig.2

The section shown is divided into five compartments by means of four transverse bulkheads (1). There is a centre dividing bulkhead (2) running fore and aft from deck to keel, having five openings (2a) between the bulkheads which can be closed as required by doors (3) which slide vertically, controlled from rods (4) operated by mechanisms on the deck.

Additionally, vertical baffles (5) can be fitted as required to avoid surging of the liquid in the transverse direction. These baffles may be provided with large holes so that the fluid can flow readily on each side. The centre plate, however, only has the openings already described, preferably near the bottom.

In one particular construction, the openings may be divided by suitable transverse and top plates to form the short channels (6) between the two halves of the tank. The object of such channels is to promote the flow of liquid from one half to the other. The length of such a channel is chosen according to the characteristic flow required. One, two or more such sections may be provided.

In operation, the number of sections utilized for stabilization will depend upon the loading of the vessel and its cor-

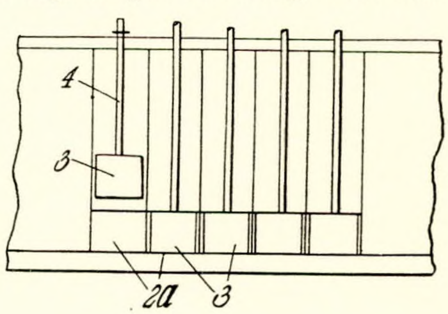


Fig.3

responding righting moment, and the tuning of individual sections is regulated by opening or closing the appropriate number of channels.—*British Patent Specification No. 1 068 466 issued to Muirhead and Co. Ltd. Complete specification published 10th May 1967.*

Apparatus for Pumping Fish

This invention relates to improvements in systems for transferring fish from a location in water into a hold.

Referring to Fig. 1, fishing vessel (V) is shown equipped with suitable net-hauling means such as the power operated device (10). The unit is mounted on the end of the boom (12) and is raised to an elevated position over the deck in order to haul in the purse seine net (14). A skiff (16) may be used to control the float line so as to provide an adequate opening for initial lowering of the submersible pump unit (18) into the net. Once the unit is submerged in the net, there is no further need for keeping the net open at the surface during the transfer of the catch to the vessel.

The submersible pump (18) is mounted at the lower end of a pressure conduit or hose (20) to which its volute or discharge side is connected through a coupling. The hose (20) extends upward from the net and over the side of the vessel, being suspended on a saddle (24) from an auxiliary boom (26). A line (36) carries the submersible pump (18) together with associated elements for raising, lowering, positioning and shifting it about in the net.

The net is progressively strapped or dried up alongside the vessel as the brailing progresses, using strapping line (15) in order to compress the fish into a sufficiently small space within the net so that the submersible pump (18) will reach them.—*British Patent Specification No. 1 076 674 issued to Marine Construction and Design Co. Complete specification published 19th July 1967.*

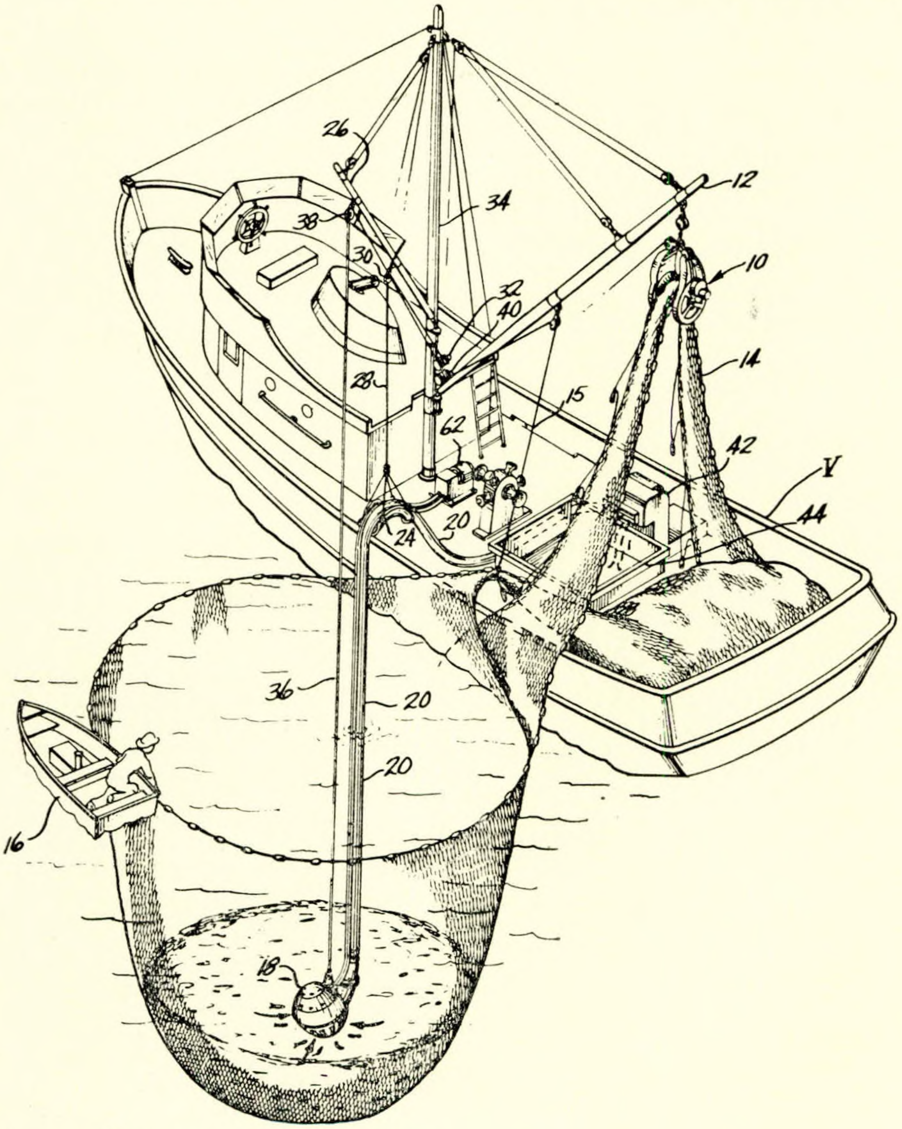


Fig. 1.

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