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Machinery Aft *versus* Amidships.

READ

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CHAIRMAN: Mr. T. R. THOMAS, B.Sc. (Member of Council).

Synopsis.

DURING recent years, marine engineers and naval architects have jointly effected great improvements both in propulsive performances and speed-keeping capabilities, as well as in the general design of the ship itself. This paper examines the possibilities of effecting further improvements in overall economic efficiency, by investigating the advantages and disadvantages of fitting propelling machinery aft, instead of amidships.

The primary considerations and factors affecting the problem are discussed, and the reasons are given for confining the investigation to one representative type of ship and machinery, and also for the selection of this type. This is followed by some general observations on modern cargo ship design for the purpose of outlining the qualities of design which are most likely to be improved by fitting propelling machinery aft, and which may still further increase the overall economic efficiency of the modern cargo tramp as an instrument of commerce.

The manner in which greater efficiency in the carrying, stowing, loading and discharging of cargo may be obtained in consequence of the amended disposition of cargo compartments resulting from fitting machinery aft is then discussed and analyzed. The general particulars of the ship and machinery used for this investigation are then given, together with sketches of the general arrangements, comparisons of weights, capacities, centroids, also of trim, and stability in various conditions, with explanatory notes.

The paper concludes with a general survey and summary of the results of this particular investigation, followed by remarks of general interest on some other aspects of the problem. Endeavour has been made to deal with every important factor affecting the problem, and the subject has been treated in a thoroughly impartial manner throughout.

Primary Considerations and Factors Affecting the Problem.

The problem of investigating the advantages and disadvantages of fitting propelling machinery aft instead of amidships involves so many factors that it is not possible within the confines of this paper to deal with other than a typical example. Further, there are many types and sizes of ships in which it would not be advantageous to fit the propelling machinery aft.

The modern cargo tramp, that popular and efficient instrument of sea transport, of which so large a proportion of our tonnage is composed, is probably as representative a type as any to use for the purpose of this investigation. A ship of this type with a deadweight of 8,000 tons and average service speed of 10 knots has therefore been used.

Two outstanding and possibly the principal disadvantages of fitting propelling machinery aft in ships of this type and size are:—

(*a*) The change of trim from the loaded departure condition resulting from consumption of fuel.

(*b*) The draughts and trim for departure and arrival when the vessel is in ballast conditions.

It is apparent that type of machinery, kind of fuel, and length of voyage, are important and variable factors affecting the foregoing as well as other aspects of the problem.

Since there are so many variables, even in the case of one ship, it is not possible to illustrate the general problem, and the investigation has therefore been confined to a typical and representative case, namely, ordinary triple-expansion engines, with coal-fired boilers, and a non-stop voyage of 12,500 nautical miles. This selection should illustrate in marked fashion the disadvantages (*a*) and (*b*).

Of the three basic types of machinery, namely, steam reciprocating, geared turbine, and internal combustion, the type selected is probably most typical of present-day practice for the type of ship under review.

This arrangement will also cater for the other two basic types of machinery since it covers the worst aspects of the principal disadvantages previously mentioned, it being obvious that they would be simplified with oil-fuel fired boilers or internal combustion engines.

The problem is also affected by the vessel's fineness of form and the shape of her after sections in determining the length of the machinery space.

The worst aspect of the problem as affected by these factors has therefore been catered for in this investigation by using a form, representative of the latest ideas as to degree of fineness, with sections of normal shape in association with a position of centre of buoyancy approaching the forward limit usually adopted in cargo ships of this type with machinery amidships.

It may be mentioned that it is often possible to reduce the length of machinery space by modifying the shape of the after sections without any alteration of resistance, but in order to maintain strict impartiality throughout the investigation, this artifice has not been adopted, and the lines of the ship have been kept precisely the same for machinery aft and amidships.

The foregoing remarks will serve to emphasize what is fairly obvious, namely, that the large number of possible variations in machinery, hull, fuel, and length of voyage will usually necessitate an investigation of each individual case in order to determine whether machinery aft or amidships is the better proposition.

General Observations on Modern Cargo Ship Design.

Ship design is usually a compromise between primary and other essential requirements, and the measure of success of the ship depends upon the nearness with which each requirement approaches its ideal apportionment.

Formerly, an owner's primary requirement in cargo ships was deadweight, and keen competition used to prevail between shipbuilders as to who could produce the smallest ship capable of carrying the most deadweight on the limiting draught, while ensuring that the specified speed could be obtained.

Under these conditions, the resulting forms were of full formation, and sometimes not conducive to the obtaining and maintenance of speed in an economical manner. The naval architect had little scope for exercising his skill in producing a form of low resistance, bearing in mind, also, that ship and propeller model experiments, together with the numerous devices now in operation for improving the performances of ships, were then unknown. The engineering contractors were often confronted with an even more difficult problem than the naval architect, and extravagant, as distinct from economical propulsion was sometimes unavoidable.

Despite these difficulties, however, it should be remembered that many excellent performances were obtained by some of these "old timers", a striking tribute to the skill of the combined efforts of the designers who had perforce to work from what were almost "rule of thumb" methods, coupled with an accumulation of practical experience, intelligent observation, and sound judgment.

Present-day design requirements, both for hull and machinery, are more extensive and in some respects more exacting than formerly obtained, but it may also be observed that designers now have greater opportunities and facilities for satisfying the higher standard of requirements demanded by owners.

A design requirement which appears to have recently become of increasing importance is cubic capacity, and owners now almost invariably specify a deadweight together with a cubic cargo capacity, and while deadweight was formerly the main factor in determining the dimensions of cargo ships, it now sometimes happens that cubic capacity governs the dimensions.

There have also been substantial reductions in the value of the block co-efficient, partly for the purpose of reducing hull resistance and also for improving the speed-keeping capabilities of the vessel under average service conditions at sea. In consequence, for a given deadweight, draught and speed, the modern cargo vessel is often larger than her prototype of twenty or thirty years ago, notwithstanding the recent substantial economies in weight of hull and machinery.

There is at present considerable diversity of opinion as to the most suitable dimensions and block co-efficient to satisfy given conditions of deadweight, cubic capacity, speed and speed-keeping capabilities, and since these conditions are conflicting, a compromise must often be adopted.

Since owners nowadays seldom place restrictions on dimensions (apart from draught) and the keen rivalry between builders as to producing the smallest-sized ship capable of performing the specified duties appears to have abated, there are often appreciable variations in the size and form of cargo ships designed for the same duties.

Recent improvements in propulsive performances have been effected by progress in the design of ship forms and stern appendages, and the reduction of air resistance, as well as by the increased efficiencies of propelling installations, auxiliaries, and propellers. In some instances, the improvements in propulsive performances have also been accompanied by reductions in the weights and lengths of propelling installations in addition to the economies in the weight and space required by bunkers.

Great progress has also been made in the simplification of ship structure by eliminating all redundant material and improving the distribution of material contributing primarily to structural strength, and, in consequence, reductions in weight of structure have been realized.

Small economies in the weight of some of the items comprising the ship's outfit and fittings have also been effected, and the increasing application of electric-arc welding to fittings and to parts of the structure not subjected to important stresses, has also resulted in some saving of weight, but these economies are usually offset by the increased weight occasioned by the more elaborate and extensive nature of a modern cargo ship's outfit and fittings.

In general, the developments in the design of cargo ships have recently been directed more towards satisfying individual requirements than in the production of standard ships.

The foregoing general observations on modern cargo ship design may be summarized and considered broadly from two aspects:

(*a*) Efficiency from the point of view of ease and economy of propulsion and speed-keeping capabilities.

(*b*) Efficiency from the point of view of carrying, stowing, loading and discharging cargo (the function for which the ship is designed).

These considerations indicate:—

(1) That while the "overall" efficiency of the modern cargo ship is undoubtedly greater than that of her prototype of twenty or thirty years ago, this increase has been largely brought about by improvements in (*a*) and

(2) That in many cases, a compromise must be made between (*a*) and (*b*) since an increase in (*a*) is often accompanied by a decrease in (*b*).

The author is of opinion that by fitting the propelling machinery aft it may be possible still further to increase the overall efficiency of the modern cargo vessel as an instrument of transport, by increasing (*b*) while maintaining (*a*).

Arrangement and Subdivision of Cargo Compartments.

The arrangement and subdivision of cargo compartments is an important factor arising from fitting propelling machinery aft instead of amidships.

An ideal arrangement of cargo compartments would be in the form of a rectangular box, but the locating of machinery amidships eliminates that portion of the ship which would be of most value in approximating to this ideal. By fitting machinery aft, the cargo compartments are grouped together in an approximately box-like formation, and the amount of broken stowage obtaining in the after hold with machinery amidships is minimized, that abreast the shaft tunnel is deleted, and the shape of the hold spaces generally is improved, particularly for the carriage of bale cargoes.

Considering now the manner of subdividing the cargo space, it is well known that the usual conventional manner in which the cargo space of ships with machinery amidships is divided into compartments of appreciably different capacities, has often been the subject of discussion. In this connection, reference may be made to a *paper by Mr. R. I. Dodsworth, O.B.E., on "Loading and Unloading Facilities on Board Ship and on Land". Mr. Dodsworth observes that the "main hold" idea (one of the surviving traditions of the sailing ship age) perpetuating as it does an entire absence of balance as between the different divisions of the ship, is in a large measure responsible for the retardation of "port speed", namely, the rate at which a vessel is capable of discharging or loading her cargo. He also makes an estimate of the loss in port speed resulting from improper subdivision, by using data in respect of seventeen different classes of vessels operated by one company which give the following averages for hold capacity:—

No. 1 hold	...	24 per cent. of gross capacity.
„ 2 „	...	37 „ „
„ 3 „	...	22 „ „
„ 4 „	...	17 „ „

Averaging these seventeen vessels at 8,000 tons cargo capacity, and allowing a rate of discharge for

* Trans. N.E.C. Inst. of E. & S., Vol. XLIII.

average cargoes of thirty tons per hatch per hour, gives $266\frac{2}{3}$ gang hours as the time necessary to discharge an 8,000-ton ship, which apportioned over the various holds in the above ratios, gives the following results:

No. 1 hold	...	1,920 tons at 30 tons per hour	=64 hours	= 8 eight-hour working days
„ 2 „	...	2,960 „ 30 „	$=98\frac{2}{3}$ „	$=12\frac{1}{3}$ „ „
„ 3 „	...	1,760 „ 30 „	$=58\frac{2}{3}$ „	$= 7\frac{1}{3}$ „ „
„ 4 „	...	1,360 „ 30 „	$=45\frac{1}{3}$ „	$= 5\frac{2}{3}$ „ „

Mr. Dodsworth then compares these figures with what would obtain if the holds were of identical capacity, and all the cargo appliances contributing to the same effort. That is to say, each hold would contain 2,000 tons of cargo, which, at the same rate of discharge as before, namely 30 tons per hatch per hour, would give $66\frac{2}{3}$ gang hours for each of the four hatches. The whole cargo would thus be discharged in $8\frac{1}{3}$ eight-hour working days as compared with $12\frac{1}{3}$ eight-hour working days for the unbalanced subdivision of holds, the latter being an increase of time of nearly 50 per cent.

An apparent method of overcoming the loss in port speed caused by the unbalanced subdivision of holds in vessels with machinery amidships, is to provide cargo-handling appliances pro-rata to the capacity of each hold.

While this can seldom be done throughout, it is customary in this type of ship to fit a supplementary cargo hatch of as large a size as space permits to the after end of the main (No. 2) hold, together with two derrick posts, derricks, and a steam winch in order to work the cargo at the after portion of the hold. If this additional cargo hatch and cargo-handling appliances are not fitted, the cargo in the after portion of this hold is difficult of access and expensive to work in view of its distance from the after end of the hatch.

These additional cargo-handling appliances at the after end of No. 2 hold either do not appear to have been fitted or taken into account in the example given by Mr. Dodsworth, as otherwise, the rate of discharge of this hold would have been greater than 30 tons per hour. If their effect could be considered as increasing the total rate of discharge of this hold up to 45 tons per hour, the whole of the vessel's cargo would then have been discharged in about $65\frac{2}{3}$ hours, say $8\frac{1}{4}$ eight-hour working days, instead of $98\frac{2}{3}$ hours, or $12\frac{1}{3}$ eight-hour working days.

It is doubtful, however, whether the rate of discharge of this hold would have been increased from 30 to 45 tons per hour by fitting these additional cargo-handling appliances. The length of the additional hatch as well as the derricks is appreciably less than the others, the derricks are often of reduced lifting capacity, and are operated from the extended ends of a winch. It seems probable, therefore, that these factors, together with the adverse effect of the rather cramped nature of this locality in hampering the activities and limiting the number of men who could be fully employed, would not result in the rate of discharge of this hold being increased by 15 tons per hour.

If the holds of a cargo ship with machinery amidships are made of the same or even approximately the same capacity, the resulting large differences between the lengths of the end holds and the midship holds do not admit of a satisfactory disposition of hatches and arrangement of cargo-handling appliances, and also involve additional outlay.

A further aspect of the problem also arises when vessels with machinery amidships are loading into and discharging from lighters alongside. Additional cargo-handling facilities will not compensate for a lack of a useable length of side of ship available for the accommodation of lighters, the forward and particularly the after hold causing difficulties in this respect and reducing the speed of operating.

Owners occasionally require No. 2 hold to be of a specified length in order to accommodate certain classes of cargo, but for the average cargo tramp carrying general cargo and bulk cargo, it seems desirable from every point of view to have the holds of equal capacity, and this can be readily accomplished by fitting the propelling machinery aft.

General Particulars of Ship and Machinery.

The vessel is a typically modern cargo tramp of the open shelter deck type, namely, single deck with complete superstructure deck, tonnage opening, and forecastle.

Ship.

Length 395ft. B.P. × 55ft. 6in. mld. ×
{ 35ft. 3in. depth mld. upper deck.
{ 25ft. 3in. depth mld. second deck.

Lloyd's highest class, hull and machinery.

To good plain specification.

The 'tween deck height of 10ft. was adopted in order to give a stowage capacity for the cargo portion of the deadweight of $66\frac{1}{2}$ cubic feet per ton, excluding the forecastle.

Horse power and coal consumption.

For 10 knots in average weather at sea—estimated i.h.p. 1350. With coal at 14,000 B.Th.U.'s per pound, the consumption (all purposes) is $17\frac{1}{2}$ tons per day at 1·20 pounds per i.h.p. per hour.

For a non-stop voyage of 12,500 nautical miles at 10 knots, the length of passage is 52 days.

Total bunkers required is thus... 910 tons.

Add 3 days margin, say... ... 970 tons.

Machinery.

Triple expansion engines 20in., 33in., 55in., by 45in. stroke capable of developing 1,500 i.h.p. at 74·5 revs. I.h.p. 1,350 at 67 revs. for average ser-

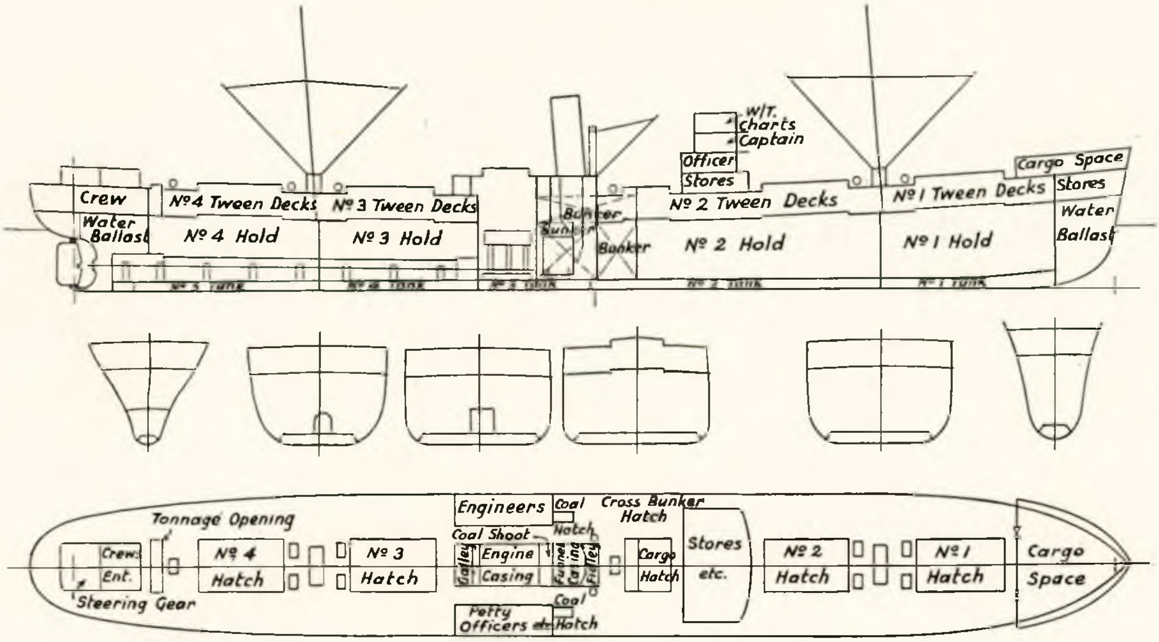


FIG. 1.

vice speed of 10 knots. Two single-ended boilers, 14ft. 6in. dia. by 12ft. long. Coal burning. Total heating surface, 4,700 square feet. Three furnaces per boiler, 3ft. 6in. diameter. Total grate area 115 square feet. Working pressure 200 pounds per square inch. Superheated to total temperature of 600° to 650° F. Forced draught. Pre-heated air supply.

The outline general arrangement of the vessel with machinery amidships is shown in Fig. 1. and is a typically conventional arrangement for this type.

It is customary in this type of ship to arrange the position of the machinery, and longitudinal centre of buoyancy, to give an even keel draught or a trim by the stern up to about two feet when the vessel is fully loaded with a homogeneous cargo, bunkers, fresh water, stores, crew and effects. In this example, the vessel has been designed to float on an even keel in this condition.

There are six watertight bulkheads and four cargo holds and hatches, an additional small cargo hatch with two derrick posts, derricks, and a steam winch being fitted as customary in this type of ship for reasons previously given, the after portion of this hatch serving the cross bunker.

The following are the lengths of the compartments :—

After peak	29ft.
No. 4 hold	65ft.
No. 3 hold	60ft.
Machinery space	45ft.
Cross bunker	15ft.
No. 2 hold	92½ft.
No. 1 hold	65¾ft.
Fore peak	22¾ft.

The total length of the cargo compartments is thus 283¼ feet. The 'tween deck space abreast the engine casing not being required for bunkers is thus available for cargo, but is not of course fitted with hatches or cargo-handling appliances. Bunkers are stowed in the cross bunker hold and 'tween decks, at the sides of the boilers, abreast the boiler casing in the 'tween decks, and in the coal shoot.

The outline general arrangement of the vessel with machinery aft is shown in Fig. 2. The after peak has been kept the same length as before, namely 29 feet, but the length of the machinery space has been increased to 50 feet. This length is ample for the purpose, and allows comfortable working clearances throughout. Sections through the machinery space are shown in Fig. 3.

The depth of the double bottom has been made 2 feet deeper than rule requirements throughout the whole length of the machinery space, instead of (as is customary in ships with engines aft) only for the length of the engine room. This gives increased water ballast capacity for a small increase in weight of structure. The tank top plating in the machinery space has been extended to the ship's side, a drainage well being formed at the forward end of the machinery space, in addition to the usual well aft. This additional well is formed by continuing No. 4 tank at its normal depth one frame space into the machinery compartment as shown, No. 4 tank being sounded from the machinery space in the usual manner.

Referring to the sketch, it will be seen that there are six watertight bulkheads, four cargo holds and hatches as before, but that the additional small cargo hatch with its accompanying derrick posts,

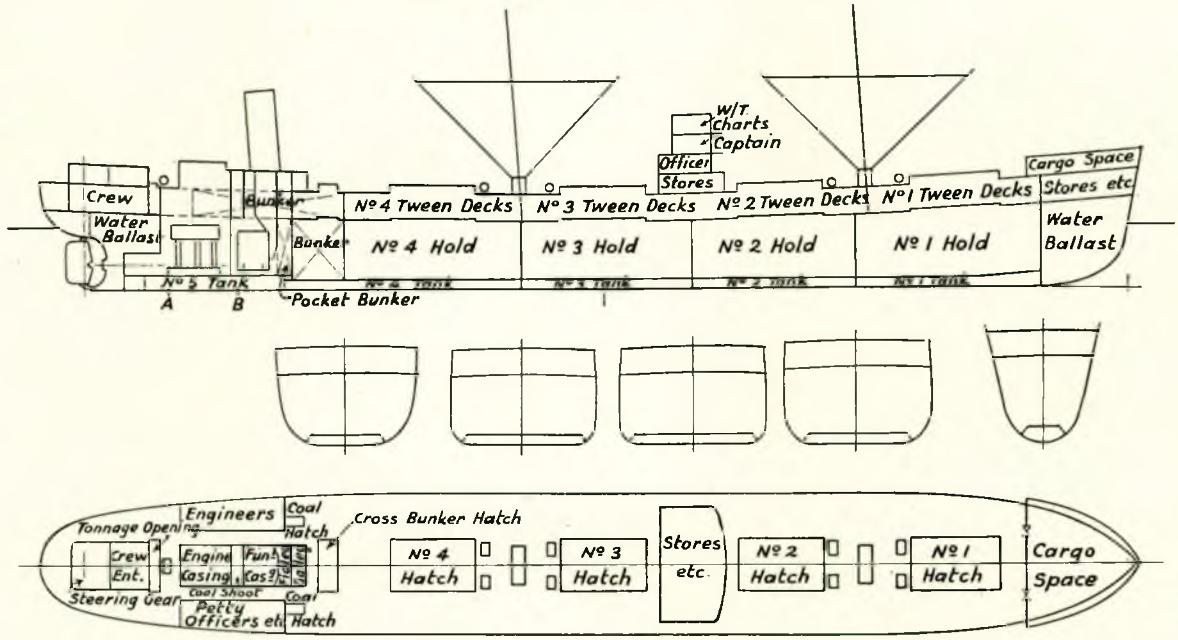


FIG. 2.

derricks and winch as fitted in Fig. 1 are not necessary.

In order to provide the necessary bunker capacity, the length of the cross bunker has been increased to 20 feet, since it is not possible to fit bunkers at the sides of the boilers as with machinery amidships. Pocket bunkers two frame spaces in length are fitted in the wings at the fore end of the boiler room, also 'tween deck bunkers abreast the boiler casing and abreast part of the engine casing, and in the coal shoot.

The length of the fore peak has been increased to 31½ feet in order to provide increased water ballast capacity for voyages in the ballast condition, and the lengths of the cargo compartments have been arranged (to the nearest frame space) to give equal capacities.

The following are the lengths of the compartments :—

After peak	29ft.
Machinery space	50ft.
Cross bunker	20ft.
No. 4 hold	67½ft.
No. 3 hold	65ft.
No. 2 hold	62½ft.
No. 1 hold	69½ft.
Fore peak	31½ft.

The total length of the cargo compartments is thus 264½ feet, or 18¾ feet shorter than with machinery amidships.

Table I shows a comparison of capacities for machinery amidships, and aft.

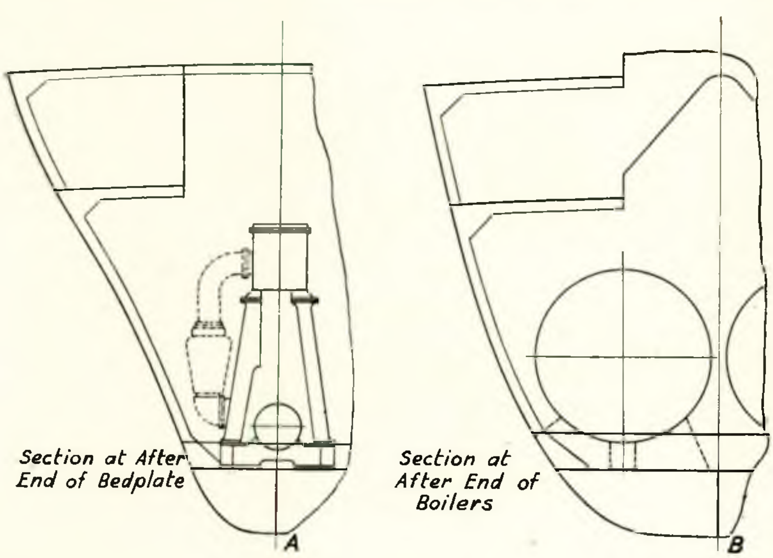


FIG. 3.

It will be noticed that despite the reduction of 18¾ feet in total length of cargo compartments, the vessel with machinery aft has a slightly greater total cubic cargo capacity, namely 4,600 cubic feet, than with machinery amidships.

The hold capacity of the vessel with machinery aft is 11,700 cubic feet greater than with machinery amidships, but the 'tween deck capacity is less since the space abreast the engine casing cannot be utilized for carrying cargo when machinery is fitted aft.

Differences in Weight and Cost of Hull and Machinery, and in Vertical Centres of Gravity of Hull, Machinery, Cargo, and Bunkers.

Hull.

By fitting the machinery aft, the shaft tunnel, tunnel stools, and a

TABLE I.

COMPARISON OF CAPACITIES.

Compartment.	*Machinery amidships.*	*Machinery aft.*
Cargo Compartments (Grain measurement).	*Cubic feet.*	*Cubic feet.*
No. 1 hold	70,800	81,000
No. 2 hold	116,500	79,500
No. 3 hold	68,500	79,800
No. 4 hold	53,500	80,700
Total holds	309,300	321,000
No. 1 'tween decks ...	32,000	36,000
No. 2 'tween decks ...	52,500	37,700
Abreast engine casing ...	7,900	—
No. 3 'tween decks ...	32,500	36,600
No. 4 'tween decks ...	30,000	37,500
Total 'tween decks...	154,900	147,800
Total holds and 'tween decks ...	464,200	468,800
Forecastle	8,900	8,900
Bunkers	970 tons	970 tons
Water Ballast	*tons*	*tons*
Fore peak	200	425
No. 1 C.D.B.	130	170
No. 2 C.D.B.	455	260
No. 3 C.D.B.	180	280
No. 4 C.D.B.	205	295
No. 5 C.D.B.	100	120
After peak	220	220
Total water ballast	1,490	1,770

watertight door are deleted, also a portion of the side bunkers, together with a steam winch, two derrick posts, two derricks and gear, and the length of the double bottom in No. 1 hold is reduced. The total saving of weight thus effected is 35 tons.

Additional weight is involved by the increased depth of double bottom in the machinery space, and the larger fore peak tank. These increases amount to 10 tons.

The nett saving in weight of hull due to fitting the propelling machinery aft is thus 25 tons, and the resulting effect on the centre of gravity of the hull is to raise it by 0·10 of a foot.

The saving in cost of hull due to fitting the propelling machinery aft is approximately £850.

Machinery.

The saving in weight of shafting, plummer blocks, platforms, etc. due to fitting the propelling machinery aft is 20 tons, and the effect of this saving in weight, together with the effect of the increased depth of the double bottom under the machinery is to raise its centre of gravity by 2·00 feet.

The saving in cost of machinery due to fitting it aft is appproximately £2,000.

Cargo.

By fitting the propelling machinery aft, the common centre of gravity of the cargo compartments is lowered by 0·86 of a foot.

Bunkers.

The common centre of gravity of the bunkers is raised 5·00 feet due to fitting the propelling machinery aft.

Fitting the propelling machinery aft thus increases the deadweight by 45 tons, and incidentally it will be noticed in Table I that there is also additional cubic cargo capacity for stowing this extra deadweight.

Weights of hull and machinery are as follows :

	Machinery amidships. Tons.	*Machinery aft. Tons.*
Weight of hull	2,395	2,370
„ machinery ...	385	365
Light weight	2,780	2,735
Deadweight	8,000	8,045
Load displacement... ...	10,780	10,780
Load draught	23ft. 5in.	
Block co-efficient	·735	

Longitudinal centre of buoyancy is 6·93ft. forward of amidships.

A comparison of trim and stability in various conditions of loading is given in Table II.

TABLE II.

COMPARISON OF TRIM AND STABILITY IN VARIOUS CONDITIONS.

Condition.		*Machinery amidships.*	*Machinery aft.*
(1) *Builders' Light Condition.* Vessel fully equipped, and ready for sea. No cargo, bunkers, fresh water or stores on board.			
Displacement		2,780 tons	2,735 tons
Draught aft		9ft. 0½in.	11ft. 6½in.
„ forward ...		5ft. 2½in.	2ft. 5½in.
„ mean... ...		7ft. 1½in.	7ft. 0in.
Trim		46in. by stern	109in. by stern
Metacentric height ...		16·7ft.	16·8ft.
(2) *Loaded Departure Condition.*		*tons*	*tons*
Vessel fully loaded with a homogeneous cargo, bunkers, fresh water, stores, crew and effects.	Cargo ...	6,980	7,025
	Bunkers ...	970	970
	Fresh water	30	30
	Stores, etc.	20	20
	Total D.W.	8,000	8,045
Load displacement ...		10,780 tons	10,780 tons
Deadweight		8,000 „	8,045 „
Draught aft		23ft. 5in.	24ft. 5in.
„ forward ...		23ft. 5in.	22ft. 5in.
„ mean... ...		23ft. 5in.	23ft. 5in.
Trim		Even keel	24in. by stern
Metacentric height ...		1·50ft.	1·50ft.
(3) *Arrival Condition*, from (2).		*tons*	*tons*
Vessel fully loaded with a homogeneous cargo, bunkers 50 tons, fresh water 5 tons, stores, crew and effects 15 tons. (Water ballast in after peak and Nos. 5 and 4 tanks for machinery aft only).	Cargo ...	6,980	7,025
	Bunkers ...	50	50
	Fresh water	5	5
	Stores, etc.	15	15
	Water ballast	nil	635
	Total D.W.	7,050	7,730
Displacement		9,830 tons	10,465 tons
Deadweight		7,050 „	7,730 „
Draught aft		21ft. 4½in.	22ft. 5in.
„ forward ...		21ft. 9½in.	23ft. 3in.
„ mean... ...		21ft. 7in.	22ft. 10in.
Trim		5in. by head	10in. by head
Metacentric height ...		1·40ft.	2·60ft.

(4) *Ballast Departure Condition.*		*tons*	*tons*
Cargo nil, bunkers 970 tons, fresh water 30 tons, stores, crew and effects 20 tons. (Water ballast in fore peak and Nos. 1, 2 and 3 tanks, and 400 tons of dry ballast in No. 1 'tween decks in the case of machinery aft).	Cargo ...	nil	nil
	Bunkers ...	970	970
	Fresh water	30	30
	Stores, etc.	20	20
	Water ballast (all tanks)	1,490	1,135
	Dry ballast	nil	400
	Total D.W.	2,510	2,555
Displacement		5,290 tons	5,290 tons
Deadweight		2,510 „	2,555 „
Draught aft		15ft. 1in.	15ft. 3in.
„ forward ...		9ft. 11in.	9ft. 9in.
„ mean... ...		12ft. 6in.	12ft. 6in.
Trim		62in. by stern	66in. by stern
Metacentric height ...		9·20ft.	6·10ft.

(5) *Ballast Arrival Condition*, from (4).			
Cargo nil, bunkers 50 tons, fresh water 5 tons, stores, crew and effects 15 tons. Water ballast in all tanks in each case. (400 tons of dry ballast in No. 1 'tween decks in the case of machinery aft).	Cargo ...	nil	nil
	Bunkers ...	50	50
	Fresh water	5	5
	Stores, etc.	15	15
	Water ballast (all tanks)	1,490	1,770
	Dry ballast	nil	400
	Total D.W.	1,560	2,240
Displacement		4,340 tons	4,975 tons
Deadweight		1,560 „	2,240 „
Draught aft		12ft. 9in.	12ft. 10in.
„ forward ...		8ft. 2in.	10ft. 10in.
„ mean... ...		10ft. 5½in.	11ft. 10in.
Trim		55in. by stern	24in. by stern
Metacentric height ...		12·70ft.	9·60ft.

Explanatory Notes on Table II.

Machinery Amidships.

The results for the various conditions are typical, and do not require any comment.

Machinery Aft.

Condition 1.—This is a hypothetical and not a sea-going condition. The large trim by the stern and draught aft may require to be adjusted by means of water ballast for handling the vessel in rivers, wet-docks, etc., and certainly for the purpose of dry-docking.

Conditions 2 and 3.—The vessel has been designed to trim two feet by the stern in this loaded departure condition, a very suitable sea-going trim.

It may be mentioned that the vessel would have a trim of 91 inches by the head at the end of the voyage, due to the consumption of bunkers, fresh water and stores. This information is only given by way of interest, it being apparent that such trim is not practicable and must be reduced.

While the filling of water ballast tanks at sea is not an uncommon practice, it is sometimes not a prudent one, and may be dangerous in cases where a vessel has not a sufficient margin of stability to cover the transitory loss caused by the effect of the free-surfaced water during the period of filling a tank.

In this example, the vessel leaves port with a metacentric height of 1·50 feet and a trim of two feet by the stern. After ten days at sea, some 190 tons of bunkers, fresh water and stores will have been consumed, her trim being then approximately even keel, and metacentric height 1·60 feet. If then No. 5 double bottom tank (120 tons) is filled, she will trim 14 inches by the stern, and the metacentric height will become 1·80 feet. The maximum loss of metacentric height during the process of filling this tank is negligible, being only 0·05 of a foot.

Proceeding on her voyage for another 15 days, namely 25 days after departure, a total of some 480 tons of bunkers, fresh water and stores will have been consumed, the trim then being 18 inches by the head, and metacentric height 2·10 feet. If then No. 4 double bottom tank (295 tons) is filled, she will trim 3 inches by the stern, and the metacentric height will be increased to 2·60 feet. This tank has the largest value of moment of inertia of free surface of any of the three tanks which are filled on the voyage, and the maximum loss of metacentric height during the process of filling is 0·20 of a foot, there being thus an ample margin of stability.

The metacentric height has increased during the voyage due to the consumption of bunkers and the filling of Nos. 4 and 5 tanks, and the trim during the remainder of the voyage may safely be adjusted when desired by admitting the appropriate amount of water ballast to the after peak.

It may be mentioned that the maximum loss of metacentric height during the process of filling the after peak never at any time exceeds 0·20 of a foot, which again leaves an ample margin of stability. The middle line division of all the double-bottom tanks, with the exception of No. 1, is watertight, and the after peak is fitted with a middle line wash plate in the usual manner, and this plate consequently does not reduce the moment of inertia of the free surface.

It is scarcely necessary to mention that care must be taken to ensure that Nos. 4 and 5 tanks are *completely* filled so as to leave no free surface.

The vessel arrives at her destination with a metacentric height of 2·60 feet, and a trim of 10 inches by the head, these values being quite satisfactory.

Conditions 4 and 5.—It may be mentioned by way of interest that if in the ballast departure condition given in Table II, the dry ballast be omitted, the vessel would have a trim of 124 inches by the stern. Dry ballast (coal could be used) is thus necessary in order to obtain a suitable trim in the departure condition.

The departure draughts and trim are almost the same, both for machinery amidships and aft, but the draught aft leaves much to be desired from the point of view of insufficiency of propeller immersion in each case. The reduced value of the metacentric height of the vessel with machinery aft is desirable from the point of view of obtaining an increased period of roll in a seaway, and has been obtained by stowing the dry ballast in the 'tween decks. Incidentally, the pitching period of this vessel will also be greater than in the case of machinery amidships, due to the increase in radius of gyration caused by the distribution of weight towards the ends of the ship.

If the fore peak and Nos. 1 and 2 tanks are emptied during the voyage, the vessel would arrive at her destination with a trim of 57 inches by the stern. This is quite satisfactory so far as trim alone is concerned, but the resulting draughts of 11ft. aft and 6ft. 3in. forward would not be conducive to good propulsive performance and seaworthiness, and also, since the filling of double-bottom tanks is a quicker and cheaper process than emptying them, it is preferable to fill Nos. 4 and 5 tanks and the after peak during the voyage, the resulting draughts and trim being shown in Table II. It is not necessary to discuss the question of loss of stability during the process of filling the tanks when on ballast voyages.

General Summary of Advantages and Disadvantages.

The investigation and comparison of differences in technical qualities resulting from fitting the propelling machinery aft instead of amidships show that satisfactory conditions of trim and stability can be obtained and maintained throughout a long non-stop voyage, provided that water ballast be admitted during the loaded and ballast voyages, and dry ballast be carried on the ballast voyage.

The advantages and disadvantages of fitting the propelling machinery aft instead of amidships in this particular example may now be summarized.

Avantages.

(1) *Deadweight.*

An increase of 45 tons deadweight is obtained.

(2) *Cubic cargo capacity.*

An increase of 4,600 cubic feet of cargo capacity is obtained, this being ample for stowing the additional deadweight.

(3) *Arrangement and subdivision of cargo compartments.*

The cargo compartments are grouped together and located in the portion of the ship most suitable for carrying cargo, broken stowage is reduced to a minimum, the compartments approximate in shape to the ideal, and are well suited for the carriage of all kinds of cargo, and particularly bale cargoes.

The holds are all of the same capacity, and all are fitted with precisely the same cargo-handling appliances, thus eliminating any possible retardation of port speed resulting from an unbalanced disposition and arrangement of hold capacities and cargo-handling appliances. The arrangement should result in an acceleration of port speed as compared with the vessel having machinery amidships, but to what extent it is difficult to say.

The hatches and cargo-handling appliances are all symmetrically disposed, every portion of each hold is easily accessible and workable, and the arrangement is particularly well adapted for loading into and discharging from lighters alongside the ship. The loading and unloading operations being grouped, should be more readily supervised and controlled than in the case of the vessel with machinery amidships.

Referring to the remarks previously given under the heading of arrangement and subdivision of cargo compartments, the cargo capacities of the vessel with machinery amidships are :—

No. 1 hold	22·9 per cent.	or	No. 1 hold and 'tweens	22·1	per cent.	of the respective total capacities.
„ 2 „	37·7	„	2 „	36·4	„	
„ 3 „	22·1	„	3 „	23·5	„	
„ 4 „	17·3	„	4 „	18·0	„	

Using the latter values since they are a better criterion and are substantially the same as for holds alone, and working on the same basis as before, gives the following results :—

No. 1 H and T	1,543 tons at 30 tons per hour	=51·4 hours	= 6·4	eight-hour working days
„ 2 „	2,540 „ „	=84·7 „	=10·6	„ „
„ 3 „	1,640 „ „	=54·7 „	= 6·8	„ „
„ 4 „	1,257 „ „	=41·9 „	= 5·2	„ „

With machinery aft, each hold and 'tween deck contains say 1,755 tons of cargo, which at the same rate of discharge as before, namely 30 tons per hatch per hour, gives 58·5 gang hours for each of the four hatches. The whole cargo would thus be discharged in 7·3 eight-hour working days as compared with 10·6 eight-hour working days in the case of the vessel with machinery amidships, the latter being an increase of time of 45 per cent. These figures are of interest in that they substantially confirm those given by Mr. Dodsworth. If, as before, the rate of discharge of No. 2 hold and 'tween decks of the vessel with machinery amidships, could be considered as being 45 tons per hour, the whole of the vessel's cargo could be discharged in 56·4 hours, say 7·0 eight-hour working days, instead of 84·7 hours, or 10·6 eight-hour working days. This assumption, however, is doubtful for reasons previously discussed.

(4) *Structure.*

Structurally, the arrangement of the vessel with machinery aft has much to commend it on account of simplicity. There is continuity of homogeneous structure throughout the midship half-length of the vessel (the more important part), the change of section caused by increased scantlings in the machinery space, together with the deck openings for machinery and bunker hatches, being transferred to a part of lesser importance. There will also be slightly reduced hogging stresses in loaded conditions, but no useful purpose would be served in investigating these, as they are of small amount.

(5) *Hull.*

A saving in capital cost of some £850 is realized, and the operating expenses for loading and discharging will also be reduced due to eliminating the cargo-handling appliances at the after end of No. 2 hatch. Bearing in mind the many advantages resulting from the improved arrangement and subdivision of cargo compartments already discussed in item (3) of this summary, the efficiency of the vessel from the point of view of carrying, stowing, and particularly loading and discharging of cargo, is undoubtedly greater than with machinery amidships.

(6) *Machinery.*

A saving in capital cost of some £2,000 is realized, and there should also be some slight amount of saving in supervision, etc., since seven plummer blocks have been eliminated.

The transmission losses between the engine and propeller will also be reduced.

Disadvantages.

The disadvantages are almost entirely confined to the question of trim.

(1) *Light condition.*

The disadvantages of the increased draught aft, and large trim by the stern, have already been discussed.

(2) *Loaded departure and arrival conditions.*

The draught aft in the loaded departure condition is one foot greater than with machinery amidships, and may be a disadvantage.

The change of trim from the loaded departure condition resulting from the consumption of fuel, etc., and the necessity for admitting water ballast during the voyage for the purpose of counteracting this change of trim, are undoubtedly disadvantages.

Since salt-water ballast does not cost anything, and the double-bottom tanks together with a portion of the peak tank can be filled by the action of gravity, little time or labour is involved in filling Nos. 4 and 5 tanks, and in adjusting the quantity of water in the after peak during the voyage. The latter operation will be the most troublesome, but should not involve much difficulty as calibration particulars will be supplied for the purpose.

There is an ample margin of stability to cover the transitory loss caused by the free-surfaced fluid during the process of filling a tank, even in the event of a mistake being made by filling two tanks at the same time. Nos. 4 and 5 tanks are sounded from the machinery space, and there should not be any difficulty in ensuring that they are completely filled, even under heavy weather conditions.

The after peak tank must necessarily contain free-surfaced water for about one-half of the duration of the voyage, and the noise caused by the movement of this water may possibly be troublesome, but the risk of any structural damage is negligible.

It may be mentioned that in this type of ship, the loaded departure and arrival conditions with a homogeneous cargo are usually the most exacting of any conditions from the point of view of stability, but it will be seen that ample stability is provided and maintained throughout the voyage.

The vessel with machinery aft has some 320 tons greater average displacement on voyage, but the effect on speed and consumption is trifling.

The frequent use of the double-bottom tank under the machinery space for the carriage of water ballast, will necessitate special care being taken to guard against the effects of corrosion. On completion of the voyage, the expense of emptying the tanks is incurred with possibly a resulting loss of time.

(3) *Ballast departure and arrival conditions.*

In these conditions, the disadvantages are greater since it is necessary to carry some 400 tons of dry ballast in addition to admitting water ballast during the voyage. The necessity for carrying dry ballast is the principal disadvantage arising from fitting propelling machinery aft in this particular example.

A voyage from the United Kingdom to Australia in ballast is unfortunately not uncommon in these days, and while the vessel with machinery amidships can undertake a voyage of this duration with water ballast alone, it is necessary to incur the additional expense and loss of time in loading and discharging dry ballast in the case of the vessel with machinery aft.

(4) *Hull.*

The lengths of the machinery space, cross bunker, and fore peak, have been increased for the reasons given, but the weight and cost involved have already been discounted.

The distribution of weight and buoyancy in the ballast conditions may possibly result in slightly increased stresses as compared with the corresponding conditions with machinery amidships, but as before, no useful purpose would be served in determining quantitative values as the increases are of small amount.

A minor disadvantage is that whereas all the double-bottom tanks, with the exception of No. 1, can be entered when the vessel with machinery amidships is fully loaded, it is only possible under similar circumstances to enter Nos. 4 and 5 tanks when the machinery is fitted aft.

The arrangement of accommodation is the same in each case, but the galley of the vessel with machinery aft is much further from the amidship accommodation than in the case of machinery amidships, and this is undoubtedly some disadvantage.

Other Aspects of the Problem.

Some further aspects of the problem may be of interest.

Deep Tank.

Deep tanks, while not being uncommon in vessels of this type and size, cannot be considered as being a regular feature, and in consequence a deep tank has not been adopted in this example. In the case of the vessel with machinery amidships, a deep tank could be arranged to give increased bodily immersion as well as increased propeller immersion, thus improving her weatherly and navigable qualities and propulsive performance.

If a deep tank were fitted in the vessel with machinery aft in this example, it would eliminate the necessity for carrying dry ballast (the principal disadvantage) and also increase the cubic cargo capacity since the fore peak could then be made of normal length, the deadweight of course, being reduced. It would not, however, be of any help in giving increased bodily or propeller immersion, since it would, for purposes of trim, require to be placed in the fore body.

While no detailed comparison has been made, it may be mentioned that if the design of the vessel with machinery amidships were retained, that is to say without a deep tank, and a deep tank were fitted to the vessel with machinery aft, the latter would still be the cheaper ship to build, notwithstanding the increased cost of the deep tank.

Tonnage.

The question of obtaining the usual propelling power allowance as a deduction from gross tonnage arises in consequence of fitting the propelling machinery aft, but in this example the same amount of deduction as with machinery amidships is obtained.

In view of the great progress made in propelling installations and spaces, there seems to be justification for a revision in the scale of allowance for deduction from gross tonnage.

Watertight subdivision.

The question of bulkhead spacing in so far as the safety of the vessel after underwater damage is concerned, is of some importance, and the disposition of bulkheads in the vessel with machinery aft gives a better subdivision from the point of view of safety than in the case of the vessel fitted with machinery amidships.

Steering gear.

The steering engine in each case is fitted in the after deckhouse and operated by telemotor control. The distance from the navigating bridge to the steering engine is about ten feet less in the case of the vessel with machinery aft, the arrangements thus being practically identical. A steam winch with extended ends is fitted forward of the after deckhouse in each case, for the customary purpose of acting as an independent means of steering and also for warping purposes.

Machinery.

Adequate space for comfortable access to all parts of the machinery has been provided in each case.

Feed water has purposely been omitted in this investigation in view of the conflicting opinions as to policy of carrying it in vessels of this type. If required, it would be carried as usual in the tank under the engines, and its consumption would have a slightly adverse effect on trims of the vessel with machinery aft.

The questions as to whether there is increased vibration with propelling machinery aft, and also as to whether there is greater liability of cracking and fracture of the propeller shaft, are of such a nature as to necessitate an independent and exhaustive investigation and cannot be dealt with in this paper.

The smoke nuisance, and risks of fire would be somewhat lessened in the case of the vessel with machinery aft.

Concluding Remarks.

The investigation of this particular example shows that the principal disadvantages of fitting propelling machinery aft can be overcome, and satisfactory conditions of trim and stability be obtained and maintained throughout a long non-stop voyage.

The efficiency of the vessel for carrying and stowing cargo, and particularly in respect of the loading and discharging operations, has undoubtedly been increased by fitting the machinery aft, and the standard of seaworthiness has been maintained.

These improved technical qualities are accompanied by a reduction in capital cost, and while expense is involved in handling the dry ballast required for long voyages in the ballast condition, economies in operating expenses have been effected in other directions.

Many factors of differing degrees of importance are involved in an investigation of this nature, and while the merits and demerits of some features are difficult to assess, both technically and commercially, it seems reasonable to conclude that the overall economic efficiency of this particular vessel would be increased by fitting the propelling machinery aft.

Discussion.

Mr. E. F. Spanner, R.C.N.C., ret. (Member of Council), opening the discussion, said it was most important that they should find the very best way of arranging the machinery in a ship. To-day, competition was very keen and no point should be neglected. Incidentally, it was advisable to watch carefully what was being done on the Continent.

Throughout the paper the author said nothing

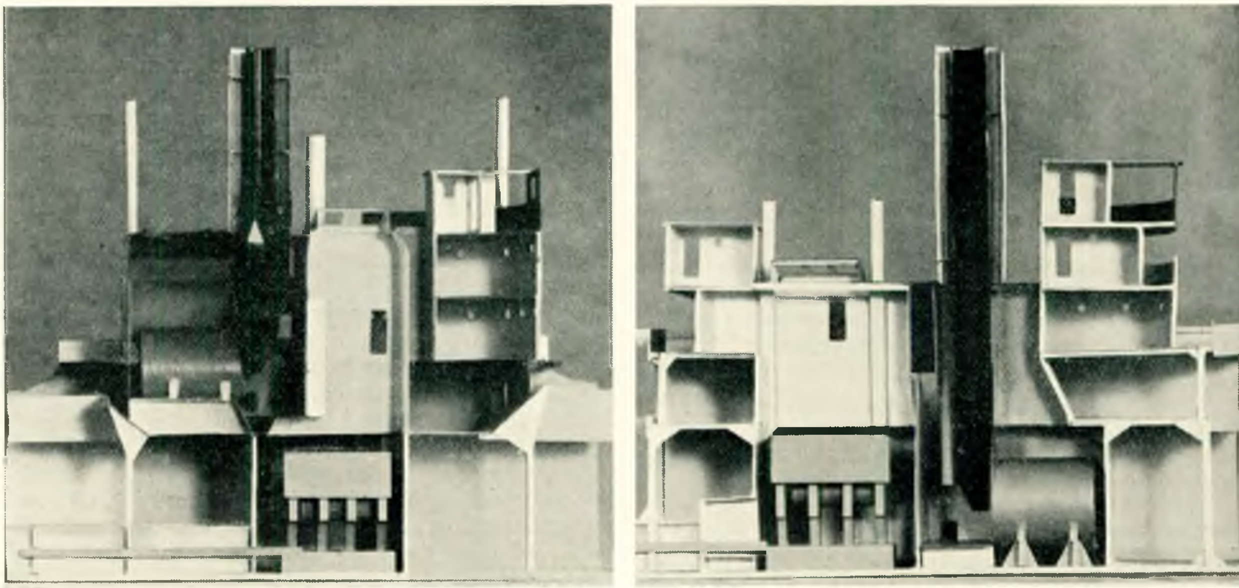
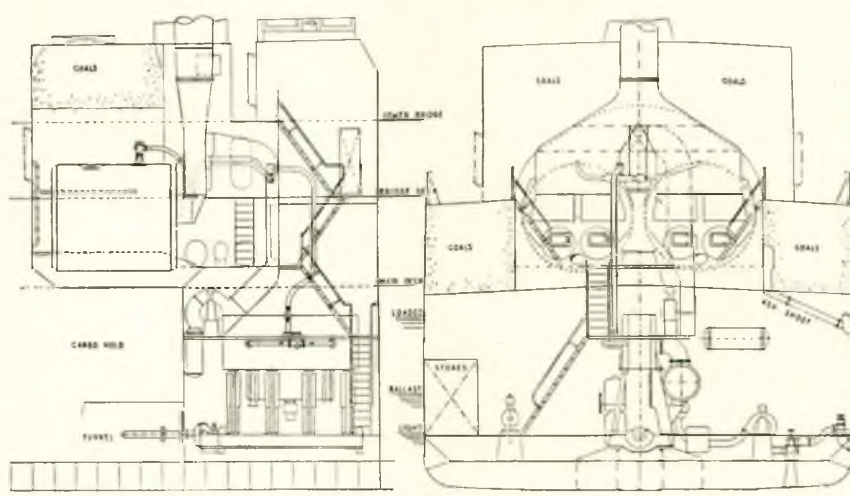


Fig. 4.

about oil tankers. As he (the speaker) read the paper, it seemed that the author's principal reason for starting this argument was to put forward the view that if the machinery was placed aft, a ship handier for cargo working was obtained. Those responsible for oil tankers already agreed with the author in putting the machinery aft, but obviously this must be for reasons other than cargo handling —as discussed in the paper—and he felt that the author should include an analysis of the oil tanker aspect of the question, in order that those reading the paper might have as full information as possible.

The author had taken a short cut; suggesting that by dealing with one particular installation there was no need to argue about any other. This proposition could not be accepted, however, for while it was certainly admitted that the "middle cut" was the best in a ship, as in a fish, it also followed that the smaller the middle cut, i.e. the smaller the midship space occupied by the machinery, the less advantage was to be obtained from removing the machinery from amidships to the after end.

In reviewing the author's paper it was quite clear that the obstruction offered by the shaft tunnel was not only a nuisance, but an expensive nuisance as regards cost in construction, cost in tail shafting, and cost in cubic space lost. He (the speaker) was puzzled to know why it was that progress had not been made more rapidly with the adoption of the scheme of placing the propellers amidships together with the machinery. So far as he could understand there was a very great deal to recommend this system, whatever technical difficulties might suggest themselves in the early stages. So much was to be gained by eliminating the shaft tunnels, simplifying the construction and clearness of the holds at the after end, cutting down machinery weight and costs, eliminating a long line of shafting, reducing vibration, obtaining better propeller immersion conditions, and so on, that it seemed well worth while tackling this proposition in a practical manner, by actually building a ship to see whether this system



F.M.V. ARR. OF ENGINE AND BOILER
.SUPER CUBIC'
Fig. 5.

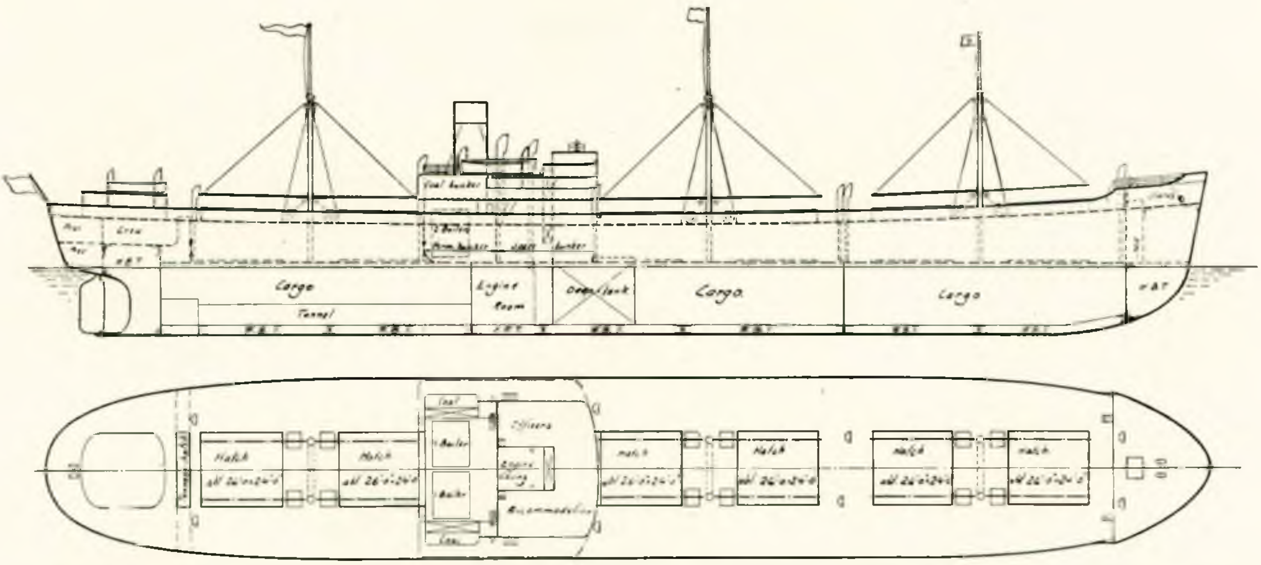


FIG. 6.—Cargo steamer of about 7,200 tons. Dimensions approximately 358ft. 0in.×57ft. 0in.×23ft. 6in.; depth moulded to shelter deck 35in. 0in.; coefficient of displacement about ·76; coal and oil fired; i.h.p. 2,500 maximum, 1,850 normal; 21-22 tons of coal per day; normal speed loaded 11 knots; bales cubic about 450,000 cu. ft.; grain cubic about 485,000 cu. ft.; perm. bunkers 300 tons coal, spare bunkers 350 tons coal, and extra spare bunkers 150 tons coal; net registered tonnage about 2,120.

did not provide a perfectly sound answer to many propulsion problems arising, particularly in recent years, e.g. excessive vibration, tail-shaft fractures, singing propellers, etc. He was convinced that practical exploration of this line of development might well result in a very marked improvement in ship design generally, and he hoped that someone with courage would be forthcoming to build the first ship with propellers amidships.

Next to having the propellers and propelling machinery wholly amidships, it was of advantage to cut down the length of midship space occupied by the machinery, and in this connection the work which was being done by Mr. K. G. Meldahl in the development of what he termed super cubic ships was bearing excellent fruit.

It would be remembered that Mr. Meldahl's objective, as indicated by the name he gave his ships, was the obtaining of very large cubic space on given dimensions, which objective was one of the main points aimed at by Mr. Scott in his design. Mr. Meldahl solved the problem by lifting the boilers to a position above and abaft the engines, thereby (1) utilising upper deck and superstructure space which was not normally of great value; (2) restricting the overall length of the deck erections; (3) providing for bunkering and ballast requirements in an ingenious manner which avoided complications on service in respect of trim, and finally (4) releasing hold space for the reception of cargo

FIG. 7.

Table of Comparison.

	Steamer of 8,045 tons d.w. according to Mr. Scott.	*Super-cubic steamer of 7,200 tons d.w.—one of two recently ordered—with guaranteed contract figures.*
Length	395ft. 0in.	358ft. 0in.
Breadth	55ft. 6in.	57ft. 0in.
Depth to main deck	25ft. 3in.	23ft. 6in.
Depth to shelter deck	35ft. 3in.	35ft. 0in.
Draught loaded	23ft. 5in.	22ft. 3in.
Displacement	10,780 tons	9,900 tons.
Cu. ft. grain, ex f'cle	468,800	485,000
Ratio cu. ft./d.w. Ts.	58·3	67·3
Speed	10 knots.	11 knots.
I.h.p. 1,350; max. 1,500, perhaps more.		1,850; max. 2,500-2,600.
Triple expansion 20in. × 33in. × 55in. × 45in. stroke.		Double compound 415 mm. × 1,015 mm. × 930 mm. stroke.
Two boilers, 200lb., 14ft. 6in. × 12ft. 0in.		Two boilers, coal and oil fired, 220lb., 15ft. 0in. × 12ft. 1in.
Weight of machinery, 365 tons.		340 tons.
Number of hatches, 4 large and 1 small.		4 forward, 2 aft = 6 of about 27ft. 0in. length.
Winches, 10.		12.
Net register tonnage, ?		About 2,120.
Dry ballast recommended, 400 tons.		Deep tank, 1,000 tons.
Radius of action, coal: 12,500 m.		Radius of action, Oil: 15,000 m.

For the same d.w. the elevated boiler ship was not more expensive to build, thus for instance no ash hoist needed.
For the same cubic capacity the *elevated boiler ship would* be about *3 per cent. cheaper* to build and drive.
The elevated boiler ship offered considerably better sanitary conditions for the stokers, particularly in the tropics.
The excess ballast-stability was considerably reduced in the elevated-boiler ship.

under conditions which made the space easily usable and very valuable.

Fig. 4 showed diagrammatically comparative arrangements according to Mr. Meldahl's ideas and according to standard practice. Fig. 5 was a drawing showing the arrangements a little more clearly. Fig. 6 illustrated a ship arrangement for a vessel of 7,200 tons d.w., incorporating Mr. Meldahl's boilers, and Fig. 7 was a photograph of the "Harpefjell" which indicated that there was nothing at all abnormal in the appearance of these super cubic ships.

To enable the author to consider a particular case in comparison with the one he had chosen himself, Mr. Meldahl had sent the above particulars, and it would be very interesting to know how Mr. Scott regarded these in comparison with his own suggested design.

Whatever conclusion the author might reach with regard to the arguments for the super cubic ship as against his own proposal, it was worth remarking that Mr. Meldahl had been extremely successful with his proposals, the present position being that he had eight ships running satisfactorily, a ninth just launched, and nine more recently ordered. Of these, two were of 7,200 tons d.w. capacity, 11 knot speed, and 485,000 cubic ft. grain capacity, as shown in the foregoing table.

One important incidental feature of the designs had been the great improvement of the conditions under which the stokers had to work, the stokehold now being lit by daylight; also the improvement in the lot of the engineer on watch, seeing that the machinery and boilers were more closely under his control. Factors advantageously affecting the personnel had become of increasing importance during recent years.

No doubt, in his reply, the author would deal with the oil tanker question, also with the centre propulsion proposals, and the super cubic ships, in as thorough a manner as he had his own proposals, in which case an already valuable paper would become greatly increased in importance.

Mr. J. Hamilton Gibson, O.B.E., M.Eng. (Vice-President) said that in his opinion, as a mere engineer, Mr. Scott had made out an excellent case for machinery fitted aft, though he must say that from the æsthetic point of view he was no admirer of vessels with the funnel on the stern. But, especially in tramp tonnage, appearances must give way to utility and earning capacity, and the author had given facts and figures to prove this.

The question of vibration occurred to him. Years ago at Birkenhead they built two small vessels 180ft. by 42ft. by 9ft. draft as meat-barges to bring cargoes down the River Plate to ocean-going refrigerated liners loading at Buenos Ayres. They had twin-screw compound engines 15in. and 32in. by 21in. stroke of 850 total i.h.p. at 136 r.p.m., and two single-ended boilers—all situated aft, and the vibration was very bad until they fitted two longitudinal bulkheads in way of the machinery space. It would appear that special care would be required in all such designs to minimize vibration.

He supposed they were all agreed that, with the engines aft, the lighter the machinery the better. In this connection he remembered reading a description of some vessels built in America five or six years ago with turbine machinery aft, and water-tube boilers. The boilers were, he believed, actually aft of the engines on a raised flat. This would remind them, as would the previous speaker's remarks, that in Scandinavia steamers were now being built with boilers on deck, and abaft the engine room. In these vessels the machinery was amidships. Would the author consider such an arrangement feasible with machinery aft?

Mr. C. J. Hampshire (Member) said that the paper contained a lot of points in favour of fitting the machinery aft. This arrangement obviated a long length of shafting and tunnel trouble due to hot bearings, etc. He thought, however, that in pinching the machinery aft, this would give a cramped engine room, especially in the layout of auxiliaries. During the late war he viewed many engine rooms of Government oilers, and that conveyed to him the cramped conditions.

With regard to cargo handling, no doubt the machinery aft arrangement gave a clear run from the forward end of the boiler room bulkhead which was very useful for cargo handling, but from the point of view of a man who regarded a ship as something beautiful, machinery fitted aft could only be considered an atrocity.

Mr. Spanner referred to boilers being fitted high up—from the fireman's point of view a most excellent arrangement — but he thought that the lower one got the weight, the better it was for rolling and seaways. He had seen the vessels in question, but it seemed to him that the arrangement would have a deleterious effect on stability. Perhaps he was wrong, but he considered it better to keep the weight as low as possible in the ship.

They were so accustomed to seeing machinery fitted amidships. When one saw a tanker running light with her bow up in the air, it was more like a barge or lighter! Mr. Scott made out a very good case, but he (the speaker) looked at the problem from an æsthetic point of view rather than from that of a shipowner.

The Chairman said that the author deserved the thanks of the members of The Institute for a most interesting paper, which had the advantage that it dealt with problems of naval architecture of considerable interest to the marine engineer in a manner which could be easily appreciated.

He said that before passing to detailed comments, he would draw the author's attention to the design of vessels sailing on the Great Lakes of Canada. This was of interest in view of the paper because these ships had machinery aft for the special purpose of facilitating the loading and discharge of bulk cargoes.

In these particular ships the fact that the machinery was placed aft had proved of no disadvantage from the point of view of the structural strength of the ships, but the service on which they were engaged was not so severe as would be encountered by ocean-going vessels. He suggested that the author had dismissed the matter of the effect of the disposition of machinery on the structure of the ship rather too lightly.

In oil tankers the effect of the concentration of the cargo weight amidships was to cause these vessels to be liable to excessive compressive stresses in the deck plating when compared with the cargo ship with machinery amidships and, although it was admitted that the weight of cargo per cubic foot was greater in the oil tanker, there was a possibility that the fitting of machinery aft would result in the normal cargo ship of average scantlings being liable to severe stresses in the sagging condition.

The speaker had dealt with this aspect in a paper read before the Institution of Engineers and Shipbuilders in Scotland, and suggested to the author that in view of the approach of present scantlings to a minimum compatible with absence of structural weakness he should give the matter careful consideration.

With regard to the question of the effect of considerable trim by the stern on the ship's structure, it was known that small ships on ocean-going service were liable to recurrent damage at the forward end, due to slamming. The stiffening of the structure against this was not easy, although it could be successfully accomplished, but he was afraid that a vessel 400ft. in length with machinery aft on the North Atlantic service would suffer this kind of damage unless careful arrangements were made to make the structure of the bottom forward fully effective under what must be very severe conditions.

Mr. W. A. Christianson (Member) said that in Fig. 1 where the machinery was amidships, the crew was housed amidships, but in Fig. 2 with the machinery aft the crew was accommodated aft. In the second case, why not put the crew amidships where they would be more comfortable and away from the noise of the machinery and propeller?

Mr. J. Stileman (Member) asked the author where the auxiliaries were housed in the case of the ship with the engine room aft.

Mr. F. A. Hunter (Member) said that he was interested in the question of vibration in connection with Diesel-engined coasting vessels varying in length from 120 to 200ft. Taking, for instance, two of these vessels fitted with similar Diesel engines running at 300 r.p.m. and of the same power, one with the machinery fitted amidships and the other aft, he had found that the ship with the machinery fitted aft suffered more from vibration. Was this due to the design of the ship or to the scantlings?

It should be remembered that the engine was better water-borne when the machinery was fitted amidships, but he assumed that it was much better with the machinery aft in the case of a vessel in light condition, especially with shallow draft ships in bad weather, because the propeller did not rise as it did in the case of a vessel on even keel.

Mr. Wm. McLaren (Member) asked if the ships of the present time which were specialised were really advantageous? Forty years ago ships went anywhere and loaded anything.

In these specialised ships, and more especially those with machinery fitted aft, there were some advantages. The distance between the stern tube and the thrust block was shortened, and this was an advantage in drawing in the tail-end shafting. But taking the machinery aft arrangement as a whole, he did not favour it. He thought the naval architect would be inclined to make it a full trim ship. Was that an advantage from the speed-keeping aspect of the problem?

Another point was that when running before a wind and the ship was turned round, he did not know what would happen to the boiler fires.

Had the author any experience in the maintaining of the water level near to what one could gauge in the boiler? The period of pitch would be much longer than with engines fitted amidships. Then again there would be such a lash in the Scotch or cylindrical boilers. One could imagine the boiler water flying from one lash to another.

Did the author consider that maintenance would be less in the case of the engines fitted aft as compared with amidships?

The author referred to an increased weight of 10 tons. What allowance had been made for the windlass, cable, etc., because it occurred to him that much more cable would be required when anchoring in midstream, sometimes in very difficult weather.

He wished to stress the point, were they getting away from the useful ship?

On the proposal of **Mr. J. Hamilton Gibson, O.B.E., M.Eng.** (Vice-President) a hearty vote of thanks was accorded to the author.

By Correspondence

Mr. E. G. Warne (Member) wrote that in any consideration of Mr. Scott's paper, special thought must be given to the ships the author had in mind. He was dealing, of course, with the shipowners' and naval architects' attitude towards placing the machinery aft in vessels which were yet to be built. The facts which had been so clearly presented by Mr. Scott did not, unfortunately, apply to about 80 per cent. of the tonnage under construction. Of this tonnage, 60 per cent. would be propelled by oil engines and of the remaining 40 per cent. roughly one half would be fitted with the coal-fired boilers and steam engines on which the author had based his conclusions. He (Mr. Warne) suggested that even the ingenuous proviso in the paper for catering for the "worst aspect of the problem" scarcely put the author's calculations on a desirable basis.

It was very difficult indeed to understand how, in view of the present shipbuilding situation, the author could claim as he did on the second page of the paper, that his "investigation has been confined to a typical and representative case", when the example selected did not refer to one-quarter of the tonnage now on the stocks. Was not Mr. Scott asking them, in effect, to consider what could have been done with what he called a "popular and efficient instrument of sea transport", namely, the 10-knot coal-fired tramp—which was now neither popular nor any more efficient than the laws of thermodynamics would allow—rather than what might be done in the case of orders for ships which the majority of owners preferred to build?

Dr. J. Bruhn, Oslo, in a letter addressed to the Editor, "Lloyd's List", which was published in the issue of that Journal dated 29th December, 1936, stated: "In your issue of 9th December you quote Mr. Scott's paper read at the Institute of Marine Engineers on the subject of machinery aft. With regard to safety it is stated that 'the standard of seaworthiness had been maintained by fitting the machinery aft'. This is no doubt the case, but superficial observers assert that such vessels are less seaworthy than those with the machinery amidship. They arrive probably at this conclusion by looking only at the relative percentage of ships lost with machinery aft and with it amidship. It is, however, clear that these figures alone give a misleading picture of the case. The average size of ships with machinery aft is, apart from tankers, very much less than the average size of ships with the machinery amidship, and the equipment of the former with officers, etc., is generally not quite of the same standard as that of the larger vessels. The hatchways are as a rule relatively much larger in the ships with the machinery aft than in the ordinary case when it is amidship. Moreover, there is as a rule no midship erection in the vessels with machinery aft, which affects the seaworthiness to a considerable extent. The cargo which vessels with machinery aft carry, and the trade they are employed in, are also on an average more trying from the safety point of view than the general average. It is therefore to be expected that vessels with the machinery aft should appear to be less satisfactory than others with regard to seaworthiness".

The Author's Reply to the Discussion.

The author, in reply, thanked the members of The Institute for the reception given to his paper, and for the excellent discussion and criticism it provoked.

With regard to Mr. Spanner's comments on oil tankers, there were, as he suggested, reasons other than those of cargo handling for fitting the machinery aft in these vessels, and the author had purposely omitted any reference to this standard practice as he did not consider it necessary to question such an arrangement or discuss its pros and cons.

Oil cargoes were officially classed as dangerous, and bulk oil carriers must conform to special regulations, and it was therefore, in the first place, a prudent practice to isolate completely such cargoes from the propelling machinery space. Further, since classification societies required cofferdams to be fitted at the forward and after ends of the oil cargo spaces, it was obviously more economical to fit the propelling machinery aft since two additional cofferdams would be required in the case of machinery amidships.

The shaft tunnel, tunnel stools, tunnel shafting, plummer blocks, etc., were deleted by fitting the machinery aft with resulting economies in cost, weight, cubic capacity, etc.

An important point to note in connection with the shaft tunnel in oil tankers with machinery amidships was that it was a potential source of danger in view of the ever-present possibility of leakage of oil and accumulation of explosive gas in a confined space, and in consequence classification societies required it to be isolated from the engine room, entered by a separate trunkway from the deck, and provided with a large ventilator at each end. All of these disadvantages were eliminated by fitting the propelling machinery aft.

It should also be noted that since oil pump rooms were required by classification societies to be enclosed by oil-tight bulkheads, and to have no direct communications with the machinery space, it was clear that this also resulted in additional cost and weight of structure, piping, etc., in a tanker with machinery fitted amidships.

Fire danger, resulting from sparks, had been reduced since the inception of the oil-fuel burning tankers, and was minimised by fitting the propelling machinery aft.

The foregoing were some of the reasons why those who were concerned with or responsible for oil tankers were of opinion that machinery aft was the better proposition, and it should also be noted that while there was no ruling to the contrary, Lloyd's Rules for the construction of vessels intended to carry petroleum in bulk were drawn up on the definite assumption that the propelling machinery was situated at the after end of the ship.

Mr. Spanner could not accept what he termed the short cut taken by the author in dealing with one particular installation, but the author was of opinion that this procedure and his particular selection was justified since it undoubtedly covered the worst aspects of the principal disadvantages of fitting machinery aft while retaining the conventional machinery arrangement, Mr. Spanner's comments on the "middle cut" being, of course, indisputable.

The author agreed with Mr. Spanner's observations on the scheme for placing the propellers amidships together with the machinery, but it was obviously not possible for him to accede to Mr. Spanner's request to deal with centre propulsion proposals in this reply. The author suggested that Mr. Spanner with his well-known capacity for originality and ingenuity could, with advantage, undertake an investigation of this problem.

The author was already acquainted with Mr. Meldahl's scheme and his paper "Steamships with Main Boilers on Deck"*, and thanked Mr. Spanner for showing the lantern slides illustrating these ships and endorsed his observations as to their merits. As a matter of fact, the author when preparing this paper had sketched out a preliminary arrangement for the purpose of ascertaining how Mr. Meldahl's arrangement would work out in the case of the vessel under review, but did not proceed further with this alternative on account of the difficulties occasioned by the stowing and trimming of the large quantity of bunkers required in this particular example.

The author thanked Mr. Meldahl for sending particulars of one of his super-cubic steamers for purposes of comparison with the author's machinery aft proposal, but pointed out to Mr. Meldahl and Mr. Spanner that his paper was prepared expressly for the purpose of comparing the advantages and disadvantages of fitting machinery aft instead of amidships, and while the result of this particular investigation indicated that machinery aft was the better proposition, the author did not imply that he was an advocate of this arrangement or that it was the best possible. The author was of opinion that on given dimensions and form, Mr. Meldahl's arrangement would give a greater cubic capacity than would be obtained by fitting the machinery aft and maintaining its conventional arrangement. Mr. Spanner, in his table of comparison, observed that for the same deadweight, the elevated-boiler ship was not more expensive to build, and that, for the same cubic capacity, would be about 3 per cent. cheaper to build and drive. It would require a detailed investigation of the technical qualities, capital costs, and running expenses of these two vessels in order to assess their respective overall economic efficiencies with the necessary degree of accuracy, and the author regretted that he could not undertake this investigation in view of his present commitments, and also observing that the large differences between the dimensional relations and block coefficients of the two vessels, together with several other factors, would invalidate the reliability of any approximate comparison.

It appeared to the author that great difficulty would be experienced with regard to the stowing and trimming of the coal bunkers required for a non-stop voyage of 12,500 nautical miles in the case of the super-cubic ship, and he noted that while the vessel with machinery aft had 970 tons of permanent coal bunkers, the super-cubic ship only had spaces allocated for 300 tons of permanent bunkers plus 350 tons of spare bunkers; mention was also made of 150 tons of extra spare bunkers but the drawing did not show where these extra spare bunkers were stowed.

A further point was that the block coefficient of the vessel with machinery aft was ·735 on a length of 395 feet and for a speed of 10 knots, whereas the super-cubic ship had a block coefficient of ·76 in a length of 358 feet for a speed of 11 knots. The differences in block coefficients alone accounted for a substantial portion of the increased cubic cargo capacity obtained by the super-cubic ship, and the author was also of opinion that the propulsive performance and speed-keeping capa-

* Trans. I.N.A., Vol. LXXVII.

bilities of the latter vessel in average weather at sea would not be so good as in the case of the vessel with machinery aft, it being interesting to note that Mr. J. L. Kent in his paper "Ship Propulsion under Adverse Weather Conditions"*, stated in his conclusion that "to ensure the best speed performance at sea in adverse weather, the fullness coefficient of the ship should not exceed ·74". The author congratulated Mr. Meldahl on his novel and excellent scheme, and was pleased to hear that it had been extremely successful and was being still further developed.

The author agreed with Mr. Hamilton Gibson's comments on the problem of the vessel with machinery aft from the æsthetic point of view and that appearance must give way to efficiency. He also agreed with Mr. Hamilton Gibson's opinion about the necessity for exercising special care in order to avoid vibration troubles in lightly-built, shallow-draft, twin-screw vessels, an occurrence not uncommon in vessels of this type and size.

Replying to Mr. Hamilton Gibson's query about the feasibility of adapting Mr. Meldahl's arrangement to vessels with machinery aft, the author was of opinion that there were cases in which this arrangement could be adopted with a still further increase in the high standard of efficiency already attained by Mr. Meldahl's designs.

With regard to Mr. Hampshire's comments on the engine room of the vessel with machinery aft being cramped, particularly in the layout of auxiliaries, the author had sketched out the machinery arrangement while preparing the paper, and arranged for comfortable working clearances and easy accessibility throughout, but there was not of course as much space available as in the case of machinery amidships. The author was not surprised at Mr. Hampshire's observations on the appearance of vessels with machinery aft and was in general agreement with him. The author assured Mr. Hampshire that Mr. Meldahl's arrangement had no deleterious effect on stability.

The author was in agreement with the chairman's comments on the structural strength aspect of the problem as affected by the disposition of machinery, and suggested that in view of the chairman's remarks as to the approach of present scantlings to a minimum compatible with absence of structural weakness, it would be advisable in the case of cargo vessels of this size with machinery aft to reinforce the deck structure. A very effective and economical manner of obtaining this additional strengthening would be by fitting girders on top of the deck in line with the hatch coamings, the disposition and arrangement of the deck openings as shown on Fig. 2 being admirably suited for obtaining the most effective development of this reinforcement. Since this additional strengthening would not involve an expenditure of more than £400, the capital cost of the vessel with machinery aft would be some £2,450 less than that of the vessel with machinery amidships.

With regard to the chairman's remarks as to the effect of considerable trim by the stern on the ship's structure, the author agreed that this factor was always a possible source of fore end damage due to slamming in all ocean-going vessels, particularly when in ballast or partially loaded conditions, but the author could not agree that the vessel under review in any of her service conditions and trims was more liable to damage from this cause than the vessel with machinery amidships. The author endorsed the chairman's opinion as to the necessity for providing effective stiffening of the bottom forward in all ocean-going vessels.

The author was not quite clear as to Mr. Christianson's remarks about the crew being housed amidships in Fig. 1, and aft in Fig. 2, as the drawings showed their accommodation aft in each case. Possibly, and perhaps not unnaturally, Mr. Christianson was thinking of the engineers, in which event there was no particular reason why they should not be accommodated in the lower portion of the midship deckhouse where they would derive the advantages mentioned by Mr. Christianson, but it might also happen that the remoteness of their accommodation from the machinery space in the vessel with machinery aft, might be a disadvantage in an emergency, particularly under severe weather conditions.

In reply to Mr. Stileman's query, the housing of the auxiliaries in the vessel with machinery aft did not present any difficulties, seatings being built where necessary on the sides of the ship in the same manner as in oil tankers, and the author had taken special care (as mentioned in his reply to Mr. Hampshire) to ensure that all the auxiliaries, including the forced draught fan, could be arranged satisfactorily.

With regard to Mr. Hunter's question as to vibration in Diesel-engined coasting vessels varying in length from 120 to 200 feet, the author replied that ship vibration was always a complex problem, and particularly in cases like those cited by Mr. Hunter. The problem did not at present admit of solution with the necessary degree of precision, even by the most exhaustive mathematical treatment, observing that the many assumptions involved were derived from recorded data, of which none, so far as the author was aware, had been obtained from vessels of the type mentioned by Mr. Hunter.

Differences in the longitudinal distribution of weight, and of rigidity, of the two vessels might probably have accounted for some of the difference referred to by Mr. Hunter, but these were only two of the many factors involved, and while the author could advance several reasons which might have accounted for the difference, he could not do so with any degree of confidence. He was of opinion, however, that Mr. Hunter's query as to scantlings

* Trans. N.E.C. Instn. of E. & S., Vol. LIII, Part 2.

might be discarded, provided the vessels were of precisely the same type, dimensions, and form.

It might be mentioned that the longer shaft in the vessel with machinery amidships would have greater facility for absorbing and dissipating the effects of shock and unevenness of torque than the short shaft in the vessel with machinery aft, and this might possibly have been one of the contributory causes of the difference noted.

Mr. McLaren raised several points of interest, and replying to his first question, the author agreed that while the ships of forty years ago went anywhere and loaded anything, the number of specialised ships at present under construction was an indication that they were advantageous.

The author was not familiar with the expression "full trim" ship, but if it implied a large trim by the stern, he was of opinion that a trim by the stern of, say, two to three feet in the vessel under consideration, had a slight advantage from the speed-keeping aspect of the problem in view of considerations of propeller immersion with reduced risk of breaking surface. The author regretted that he could not answer Mr. McLaren's query as to what would happen to the boiler fires in the event of the ship being turned round when running before a wind.

The author had no experience in the maintaining of the water level in boiler gauges, but appreciated Mr. McLaren's remarks in this connection, and was of opinion that it would be more difficult to ascertain and maintain the correct level in the gauges of the vessel with machinery aft when in a seaway.

The cost of maintenance referred to by Mr. McLaren would, in the author's opinion, be less in the case of the vessel with machinery aft.

With regard to Mr. McLaren's question about the windlass, cable, etc., the author replied that the classification societies' rules required exactly the same length and size of cable, anchors, etc., in the case of each vessel in this example, and he had consequently not allowed any additional cable in the vessel with machinery aft. Mr. McLaren might have had in mind the question of wind effect on the different dispositions of superstructure and funnel as this might possibly have some bearing on the question he raised. Replying to Mr. McLaren's last query, the author did not think they were getting away from the useful ship; changing conditions of trade must be accompanied by changes in ship design.

With regard to Mr. Warne's remarks, the author emphasised the fact that he had given in his paper explicit reasons for his selection of the type of machinery and fuel most suitable for the purposes of this investigation, and was of opinion that this selection was amply justified since it served the particular purpose for which it was intended.

The author, before commencing his paper, was fully aware of the relative proportions of cargo ship tonnage propelled by the three basic types of machinery, and his particular choice was not made because he considered it to be either the most efficient or popular, but solely because it undoubtedly was the most suitable type of machinery and fuel to use for the purpose of illustrating the outstanding disadvantages resulting from fitting propelling machinery aft instead of amidships. If, for example, the author had used internal combustion engines for this investigation, he doubtless would, and with every justification, have been criticised adversely for selecting machinery which would only cater for the simplest solution of the problem.

As mentioned in the paper, it was not possible to illustrate the general problem, and it was surely axiomatic that if the most difficult aspect of the problem admitted of satisfactory solution, there would not be any difficulties with its simpler aspects. It was obvious that while Mr. Warne's criticism of the author's use of the expression "the investigation has therefore been confined to a typical and representative case" was justified when considered from the point of view of building statistics, it had absolutely no bearing or effect on the problem.

Mr. Warne's observations on the laws of thermo-dynamics were of course indisputable, and in reply to his query as to what might be done in the case of orders for ships which the majority of owners preferred to build, the author suggested that Mr. Warne would find the answer in the first paragraph of the second column of the second page of the paper.

The author very much appreciated Dr. Bruhn's observations on the question of seaworthiness in ships with machinery aft and with which he was in complete agreement, and was glad that so eminent an authority on this subject confirmed the author's statement that the standard of seaworthiness of the vessel of the size, type and design reviewed in the paper had been maintained by fitting the machinery aft.

INSTITUTE NOTES.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, 4th January, 1937.

Members.

James Alexander Aldcroft, 3, Carlton Court, 2295 1st Avenue West, Vancouver, B.C., Canada.

Frederick Alexander Chamberlain, 20, Ellington Road, Ramsgate, Kent.

Douglas Stuart Esdon, Marley, Southdown Road, Cosham, Hants.

Douglas Horsburgh, 80, New Cavendish Street, London, W.1.

Ernest Dillon Hughes, Glen Rosa, Hendre Road, Ashton Gate, Bristol.

Norman Ernest White, 28, Grange Street, Port Talbot, South Wales.

Companion.

William Henry Pilmour, Denfield, Northumberland Avenue, Forest Hall, Northumberland.

Associates.

Thomas Frederick Paddon, 12, Onslow Road, Peverell, Plymouth, Devon.

Horace Ernest George Saffin, 5, Kendal Way, Milton Road, Cambridge.

William Wright, 46, Crossley Terrace, Newcastle-on-Tyne, 4.

Student.

Edward Fred Barton, 7, Madeira Road, Leytonstone, E.11.

Transfer from Student to Associate.

Richard Edward Knowles, Ermelo, Ashburnham Road, Pembrey, Carmarthenshire.

Harry Wilcox, Oakside, Eagle Lane, Snaresbrooke, E.11.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

Lloyd's Register of Shipping Rules and Regulations for the Construction and Classification of Steel Vessels.

"The Application of Diesel Engines to Rail Traction", by T. Hornbuckle, B.Sc. Diesel Engine Users Association.

Munro's Engineer's Manual, 1937. James Munro & Co., Ltd., 16, Carrick Street, Glasgow, C.2, 2s. 6d. net.

"The Shipbuilder and Marine Engine-Builder", Vol. XLIII, January-December, 1936.

Proceedings of The Institution of Mechanical Engineers, Vol. 132, containing the following papers :—

- "The Future of Steam Propulsion". Thomas Lowe Gray Lecture, by Johnson.
- "James Watt", by Beare.
- "Exhaust Steam Turbines for Marine Propulsion, with special reference to the Rowan-Gotaverken System", by Sneeden.
- "Wrapping Machinery", by Grover.
- "Fuel Injection Equipment". Symposium of papers.
- "Methods of Testing Internal Combustion Engines and Comparative Fuel Economy of Engines on Test and in Service". Symposium of papers.
- "Recent Developments in Turbo-Blowers and Compressors", by Kearton.
- "The Effect of Specimen Form on the Resistance of Metals to Combined Alternating Stresses", by Gough and Pollard.

"Heating and Air-conditioning of Buildings", by O. Faber, O.B.E., D.C.L., D.Sc., and J. R. Kell. The Architectural Press, 434pp., illus., 25s. net.

This book should prove of immense value to architects and others who are responsible for the decisions regarding the principles affecting the design and layout of heating and ventilating plants for buildings.

All systems of heating, domestic hot water supply, ventilating and air conditioning are fully described and their advantages and disadvantages concisely discussed without prejudice. The particulars given of the running costs of all the modern systems are unique, and as they are taken from actual practice can be used with confidence by anyone who has to decide between the vexed question of coke, coal, oil, gas, or electricity for heating purposes. Hitherto, the published figures have mostly been hypothetical and their source of origin not altogether disinterested. The costs tabulated in this book are all the more valuable as obviously the authors have had no axe to grind.

Electrical thermal storage is described and its merits discussed, but one point regarding the cost appears to be missed. Most undertakings which want off-peak loads are prepared to quote special rates for lighting and cooking and to other power users if thermal storage is installed; the savings thus made should be credited to the cost of electrical heating.

The design of the plants described is not dealt with exhaustively, but sufficient information is given in a very lucid manner to enable anyone interested to understand the principles involved.

It is regrettable that the book suffers an irritating failing common to most textbooks in that it is often necessary to turn the page to refer to the illustrations and this could largely have been avoided. A good index is provided and the sequence of the chapters leaves nothing to be desired.

Although no mention is made of ships, the information given should be invaluable to those responsible for the hotel amenities in passenger liners, and marine engineers employed ashore on such work will also find the book very useful.

There is a paucity of English literature on the subject and this volume is a welcome addition to the works already published on modern heating and air-conditioning methods which are only in their infancy in this country. Public demand is already stimulating an interest, and buildings not brought up-to-date in this respect are bound to become obsolete in the not far distant future.

"Electric Arc and Oxy-Acetylene Welding", by E. A. Atkins, M.Sc., and A. G. Walker. Sir Isaac Pitman & Sons, Ltd., 3rd edn. 394pp., illus., 8s. 6d. net.

The publication of this issue so quickly after that of the second edition is an indication that this practical handbook is appreciated by operators and designers interested in the various forms of fusion welding, which has now developed into one of the most important of all metallurgical processes.

The opening chapter deals with methods of metal jointing, from riveting to various types of welding. Chapters II to IV deal with the advantages of electric arc welding, wiring diagrams, equipment, preparation and type of joints and diagrams showing arc stream movement when welding from various positions. Chapter V contains practical hints for the operator, and it is noted that arc flash and eye protection are dealt with at some length. The arc welding of cast-iron might be more fully treated, particularly methods of preheating and cooling, the advantages of free edges and curved surfaces against tied edges and flat surfaces, the reinforcing of heavy duty castings with steel plates, and the use of Monel metal where machineable cold welds are required, also slow stringing to allow for even distribution of contraction stresses. Valuable and interesting "Don'ts" for electric welders are given in Chapter VI.

Chapters VII to X deal fully with oxy-acetylene high, medium and low pressure processes, together with their manipulation and technique, and Chapter XI with "Don'ts" valuable to the gas welding operator. Gases used by welders are described in Chapter XII, and metal cutting in Chapter XIII.

The expansion and contraction of metals and the resulting effect of welding, together with interesting sketches comprise Chapter XIV. Chapters XV and XVII are devoted to the testing of welds, together with a large number of interesting micro-photographs which show the reader most clearly the structure of different metals in various conditions and forms of crystallization. Data and tables of metals, also their properties, are clearly given in Chapter XXI.

Chapter XXII deals with the training of welders, and this is followed by a series of examination questions of interest to encourage the beginner to go further, and to assist the operator who has the flair, touch and welding sense which are essential to make up the skill he must apply to produce the right job. The authors are to be congratulated on this most practical handbook, and the reviewer cordially recommends it to those interested in welding and its application.

"The Performance and Design of Alternating Current Machines", by M. G. Say, Ph.D., M.Sc. and E. N. Pink, B.Sc. Sir Isaac Pitman & Sons, Ltd., 552pp., 373 illus., 20s. net.

This is intended as a companion volume to Dr. Clayton's book "Performance and Design of Direct Current Machines", one of Pitman's Engineering Degree Series. There is no doubt that the combination of performance and design into a single volume has definite advantages for the student of heavy electrical engineering, whether he intends or not to specialise later in machine design. The disadvantage in this case lies in the fact that in a.c. engineering the range of machinery is so vast that no adequate treatment in the manner suggested could be contemplated within the covers of one book of normal proportions, hence the authors have been compelled not only to condense the text but also to limit the scope of the book to the three principal types of a.c. machines, namely, transformers, three-phase induction motors and synchronous machines. Other types of lesser importance are left for treatment in a subsequent book.

It should be clearly understood that the book is not intended to teach commercial design. It is a book for advanced students of heavy electrical engineering who are taking their final B.Sc.(Eng.) or similar examination in the subjects dealt with. It may also be recommended as a thorough groundwork for all who later intend to specialise in machine design, and for all of these we cannot commend the book too highly. It will also be found invaluable as a book of reference for those already practicing in some specialised branch of electrical engineering connected with the sections under consideration.

The general plan throughout the work is to give in each of the sections (the transformer, induction motor, synchronous motors and generators) an outline of the simple theory of each type, together with details of construction, operation, control, testing and design. The reviewer has nothing but praise for the manner in which this plan is developed throughout the book. In all sections, excellent examples from modern practice are utilized for explanation and illustration. Other brief chapters are devoted to the theory, operation, performance and control of various types of converting machinery.

The great value of the book lies in the wide scope and general treatment of the principles involved. The production of the work is excellent, the paper and printing leave nothing to be desired, whilst the numerous illustrations, graphs, etc., although conservative of space, are both excellent in choice and presentation.

"The Protection of Electric Plant", by P. F. Stritzl, D.Sc. Sir Isaac Pitman & Sons, Ltd., 200pp., illus., 18s. net.

There is at the present time little possibility of the apparatus described in this book being used on board ship. The book is written for information on the methods of protection of large electrical networks, and as such is very good.

If and when alternating current systems are used on board ship, then the information on several of the protective devices for cables may be useful to the marine electrician, while the numerous marine engineers already employed ashore on such plant will find the book of great value.

Briefly, this work can be recommended within its appropriate sphere, and if for no other reason whatever, merits approval for the chapter on "air blast" and other oil-less circuit breakers. The remainder of the book is concerned mainly with relay protection of high voltage alternating current networks and the protection of transformers and alternators.

"Power Wiring Diagrams", by A. T. Dover. Sir Isaac Pitman & Sons, Ltd., 3rd edn., 216pp., 272 illus., 6s. net.

Mr. Dover has gone to great trouble in compiling a variety of diagrams covering a very big percentage of electrical apparatus with which a person responsible for electrical repairs and maintenance is likely to come into contact. The diagrams are so clear and well marked that it is impossible for them to be misunderstood, and the instructions appertaining to the various diagrams are very instructive.

The author goes very thoroughly into the question of direct current, and although d.c. current installations are on the decrease, there is a large amount of this kind of plant still in use. There was a time when it was possible for any one interested in the electrical side to be able to get diagrams and drawings of the various apparatus from the different manufacturers. The practice seems to have been discontinued however, and this book certainly fills the gap. Its handy form for reference is also to be commended.

The marine engineer, who may not be too well acquainted with this class of work, should find the connections for generators both shunt and compound of great service. The charging equipment section is exceptionally good, especially in view of the great prominence to which electrical vehicles and trucks have now risen. Charging by means of rectifiers is very good, showing both half and full way of rectification.

Now that electric welding is coming into its own, this section is valuable, as it shows the various connections and methods of forming the arc. The a.c. starter section is thoroughly dealt with from the simple tumbler switches for factional horse power to the various equipment capable of handling hundreds of horse power.

In section seven which deals with power transformers and static balancers, the various connections supplied are exceptionally good and far in excess of what the reviewer has seen in many books which deal solely with transformer connections. The tap changing diagrams are well placed, showing the latest methods. The section on instruments is very interesting, especially the part referring to the Watt hour meter, an aspect usually neglected in the average textbook. Fig. 221 showing the connections for determining phase rotation on three phase supply merits special attention, and the reviewer would recommend this to all maintenance engineers, especially as by slight variation the lamps can be used for testing many circuits.

The chapter on protective system has been thoroughly dealt with and is worthy of note. Indeed, this book is a most useful addition to the library of every person interested in electrical wiring, from the manager down to the young apprentice.

"Theory of Elastic Stability", by Professor S. Timoshenko. London and New York: The McGraw-Hill Publishing Co., 518pp., illus., 36s. net.

This book is published with the aid of certain American Engineering Societies as being one which, although adjudged to be of value to engineers, is not likely to be published commercially because of too limited a sale. It may be said at once that, unless the reader has not only had a reasonably good technical training, but is accustomed to the reading and use of mathematical formulæ, he will find some difficulty in digesting the contents without a good deal of application. This, however, does not affect the fact that the book is of a kind which one rarely meets.

because it deals most completely with a subject of which the average engineer's knowledge is inclined to be sketchy.

Many seagoing engineers will have seen the failure of a long strut or thin deck plate by compression because of its inability to maintain its original shape, or to buckle. Because a deck plate has buckled under compression it has not necessarily failed entirely to perform its function, and this is a simple case of the kind of examination which Professor Timoshenko deals with in his book.

The book is essentially for specialists, and it would hardly be fair to suggest that the average seagoing engineer would use it often, but for anyone engaged or intending to engage in design it would be most valuable as practically every form of buckling of beams, straight and curved, and plating is dealt with, and the author has not, as might be supposed from what has already been said, omitted to discuss the practical application of his methods.

The book is very well produced and printed, and the reasoning of each case is well set out and is as easy to follow as the nature of the problems permits.

"Vibration on Shipboard", by E. H. Smith. "The Journal of Commerce", Charles Birchall & Sons, Ltd., Liverpool, 132pp., illus., 7s. 6d. net.

Vibration on shipboard is a subject which has occupied the minds of engineers for many years. Hitherto attention has been concentrated on the problem of balancing a single engine, shaft and propeller, but it is now more clearly recognised that the characteristics of the hull, the interaction between hull and propellers, and the heterodyne effects of multiple engines and propellers are factors of at least equal importance.

In this book stress is still laid on the dynamic characteristics of the single shaft line, and the greater part of it deals with the general theory of engine vibrations. Admittedly much remains to be done before a ship can be designed and guaranteed to be free from vibration, but much more has been done than the book indicates. For example, the cyclic variations of propeller resistance are mentioned as giving rise to torsional vibrations only; the cyclic impulses communicated to the plate work, the propeller brackets and shafting are ignored. Anyone who has stood in the tunnel of a ship at sea will be aware that the elucidation, control and possible elimination of these impulses is probably the most important investigation yet to be carried out in the sphere of ship vibration.

As an introduction to the subject the book is very useful, but one would have welcomed a more complete presentation of the difficulties yet to be overcome and some mention of the methods tried and untried whereby these difficulties may be attacked.

"Sea Trading and Sea Training". Being a short history of the firm of Devitt & Moore by Clement Jones, C.B. Edward Arnold & Co., 192pp., illus., 7s. 6d. net.

It is seldom that a reviewer becomes so absorbed in a book that he reads it from cover to cover. That, however, has been the result in this case and it is with some regret that this very readable account of a century of the activities of this well-known London firm is returned to its rightful place—the Library of The Institute to which the publishers have kindly presented a copy. There was a singular appropriateness in this act, for Sir Thomas Lane Devitt, whose biography pervades the long period 1860-1920, was President of our Institute in 1913-14 at the time when the present building was erected. Older members on perusing the book will be pleased to see a fine reproduction of Sargent's portrait of that grand old man as the frontispiece.

The author traces the fortunes of the Devitt family from 1836 when Thomas Henry Devitt, a shipping clerk of 18 years' service, ventured to ask his employers for a rise and, being refused, started on his own with Joseph Moore, a discontented fellow clerk. At first they acted as managing agents, loading ships on commission, but soon they had a fleet of sailing vessels of their own and in 1866 had their first ship built specially for the Australian emigrant trade. She was the "Parramatta", 1521 tons, three-masted, full rigged, and did good service until 1873 when she was sold to a Norwegian owner. Then follow accounts of more trading ships written as only a sailing-ship lover could describe them; and the remainder of the book deals with a succession of training ships, the firm being convinced that the training of lads *at sea* was the right way to ensure a steady supply of real sailors. Eventually, during the anxious years of the Great War, Pangbourne College was founded under the auspices of the Royal Navy and the Merchant Navy and, as the author points out, if the reader cares to see a lasting monument of the pioneer training system introduced by Messrs. Devitt & Moore, let him go to Pangbourne and look around the Nautical College there.

Mr. Clement Jones's book is so full of good things that it is impossible to enumerate them here, but a word of praise should be accorded to the excellent illustrations of some ten famous sailing ships, both "trading" and "training", and several portraits of the principal characters, including typical master-mariners of the old school.

"Graphical Helical Spring Calculations", by W. R. Berry, M.Sc., A.I.C. Emmott & Co., Ltd., 22pp., 7 illus., 1s. net.

The curves and nomograms in this pamphlet are offered to enable engineers to determine, by a single direct reference to a simple graph, the size of wire which must be used with a given outside or inside diameter of spring to carry the required load and generate a stress which will be a definitely known proportion of the torsional elastic limit of the particular size and type of wire, allowing for the latest corrections for the displacement of the neutral axis of the wire due to the curvature of the spring. Reference to the appropriate nomogram then gives, by the intersection of two straight lines, the complete data of the spring without any calculation whatever.

The examples cover (1) a normal compression spring, (2) a tension spring with initial tension, (3) special compression spring with the load in the open position and definite working closure the dominant factors, (4) chrome-vanadium steel spring, (5) phosphor bronze spring. It is believed that the intelligent use of these charts will reduce the labour of spring designing to a minimum, and eliminate many of the failures at present written off as inexplicable or too readily attributed to faulty wire or manufacture.

"A Survey of the Present Organisation of Standardisation—National and International". Central Office of The World Power Conference (36, Kingsway, W.C.2), pp. viii + 55, 3s. net.

A copy of the above survey has been presented to The Institute, which is represented on the British National Committee of the World Power Conference, and it has been placed in the Library for the use of members.

This publication records the activities as regards national standardisation of some 33 countries, and by bringing these under one purview, it is hoped to prevent duplication and overlapping. At the same time it is emphasized that the World Power Conference has no intention of acting itself as a standardising body or of engaging in any standardising activities. Through the courtesy and co-operation of the different international organisations, however, it has been possible to include the latest information on international standardisation.

Turning to Great Britain we read that in establishing national and British standards the underlying principles are that they shall be in accordance with the needs of industry and fulfil a generally recognised want, that the community interest of producers and consumers shall be maintained throughout the work, that periodical review and revision shall be undertaken to prevent crystallisation and keep the work abreast of progress, and that there shall be no coercion whatever by one section of the community over another section, standardisation being arrived at by general consent.

The general principles, it is hoped, will apply to all countries and, it may be added, the British Standards Institution endeavours to ascertain the views of all other countries concerned before issuing its final specifications. Up to the present 561 British standard specifications have been issued and over one and a half million copies have been distributed throughout the world.

"British Empire Shipping, 1936". H.M. Stationery Office, Adastral House, Kingsway, W.C.2, or through any bookseller, 5s. net, postage 4d. extra.

This valuable publication comprises a large scale map of the world on which is indicated the distribution of British Empire shipping of and above 3,000 tons gross on the 7th March, 1936, and the percentage of certain important commodities obtained by the United Kingdom from the principal regions supplying them in 1934. The map is accompanied by a tabular statement of these commodities, which consist largely of foodstuffs and the chief raw materials, reference to which will enable the student rapidly to determine the total quantity in tons imported, or the quantity and percentage of any of these commodities supplied by any particular country.

Apart from the high general educational value of this work, it will naturally be of special interest to those engaged in the shipping industry, particularly the statisticians.

"Kent's Mechanical Engineers' Hand Book, Vol II, Power", edited by R. T. Kent. London: Chapman & Hall; New York: John Wiley & Sons, 11th edn., copiously illus., 25s. net.

The aim of the editor has been to present a reference book which, whilst not purporting to be a textbook on any particular subject, does contain a sufficiency of basic information to the general mechanical engineer on practically all the subjects likely to come under his purview.

Glancing through the pages of this work one is struck with the great amount of information on each of the subjects covered. That the information is reliable is proved by the list of collaborators whose names represent some of the best engineers in the U.S.A. The arrangement in sections and indications at the top of the pages enable a ready reference to be made to each subject without the need of searching through the whole book for information required. In addition there is a very well arranged index at the back of the book. Very careful attention appears to have been given in bringing each section right up to date.

In making use of the work it must be remembered that it has been specially written for America, and in consequence scantlings, valve sizes, test codes, fuels, etc., apply particularly to that country. It may be, therefore, that whilst such information can be taken as approximately correct some modifications would be required to bring it into line with codes and rules on this side of the Atlantic. Apart from this the volume forms a very useful addition as a reference book to the general mechanical engineer's library, and were it written specially for the United Kingdom would be found very acceptable indeed in this country. Perhaps in the future the publishers will issue such a version of this valuable work. The absence of any advertising whatever in the book, with the consequent loss of revenue from this feature, is an indication that the book will pay the publishers purely on its editorial merit.

"Technical Drawing", by James D. Chalmers. Robert Gibson & Sons (Glasgow), Ltd., 51pp., copiously illus., 1s. 10d. net.

To regard this book purely from the viewpoint of the engineer is to do it an injustice, since in both subtitle and preface the author disclaims any intention of favouring any particular trade. In any case, this book is merely the first of a projected series of three, so that judgment of it as a unit might be unfair. In the main, the subject matter is geometrical, and the chief emphasis, as is only to be expected in a book aiming at School Certificate standard, is on the geometrical constructions and problems arising out of practical work. Hence it should form a sound foundation for any branch of draughtsmanship which the student may wish to pursue later. Building construction, architecture, engineering, surveying, etc., are all touched upon. The volume is well produced, with clear diagrams and careful explanations of the principles involved. Some minor departures from the recommendations of the British Standards Institution on sheet 5 and the rather unusual proportions of the packing gland on sheet 15 need not be taken too seriously at this stage.

"Workshop Drawing", by H. A. Darling and F. C. Clarke, A.R.C.S., B.Sc. Blackie & Son, Ltd., 138pp., copiously illus., 3s. 6d. net.

There is sometimes a tendency to regard a "Workshop Course" as one in which the wind of advanced theoretical work is duly tempered to the shorn lamb—the student. The authors of this very useful book apparently have no such idea, since they not only touch upon practically every construction in plane or solid geometry that can be needed in drawing office work but carry many of their theorems to advanced stages. In the twenty or so chapters will be found a great deal that would be useful to the student or teacher of practical geometry as distinct from machine drawing. The book is full of interesting and valuable examples, many of which reach an advanced stage, especially where developments and curves of interpenetration are dealt with; and there is a good chapter on sketching, a branch of drawing too often neglected by the aspiring draughtsman. Some of the diagrams and sketches are rather small, but the clear printing and get-up of the work in a measure make up for this. The book is well-produced and bound and should prove a valuable addition to the library of anyone engaged in the study or teaching of either geometrical or machine drawing.

"The Preservation of Iron and Steel by Means of Paint", by L. A. Jordan, D.Sc., A.R.C.Sc., F.I.C., and L. Whitby, Ph.D., M.Sc., F.I.C. The Research Association of British Paint, Colour and Varnish Manufacturers, Paint Research Station, Waldegrave Road, Teddington, Middlesex, 68pp., 2s. 6d., postage 2d.

This interesting booklet issued by the Research Association of British Paint, Colour and Varnish Manufacturers should commend itself to all engineers. It covers a great deal of ground in a relatively small space, and a perusal of its pages must lead one to reflect on the enormous advance that has been made in the last few years in the methods of protecting metals from corrosion, since the modern industrial chemist has tackled this problem. From the first few pages of the treatise the reader will realise how varied and numerous are the causes of corrosion, and it follows that the means of protection are of the utmost importance to the engineer in considering the safeguarding of the machinery under his charge against the ravages of rust and corrosion generally.

At one time, one coat of paint was considered as good as another, but the authors of this booklet have set out in technical detail the results of scientific research which have exploded this old theory. It will, of course, be difficult for an engineer, already fully occupied with the major problems of his own craft, to appreciate all the highly technical matter contained in the treatise, but in a general summary on the last four pages a very comprehensive digest is made of the various protective pigments usually employed, together with a description of each, giving its outstanding characteristics.

The authors are to be congratulated on producing a remarkably instructive treatise which should find a permanent place in the reference library of all practical engineers.

"Ship's Lifeboats", by C. W. T. Layton. Brown, Son & Ferguson, Ltd., 77pp., illus., 6d. net.

The author has put together in this small booklet practically all the information and knowledge required by candidates for Board of Trade Certificates in Lifeboat Efficiency. In the last paragraph of the foreword the author expresses a desire for "standardisation of the orders given". In the text he has made a good contribution towards achieving this end.

On the whole the diagrams in the book are good, excepting those on pages 23 and 29, where more details of the chocks and skids could have been given or a separate diagram could have been given to show these very important fittings.

"A Textbook of Physics", by Charles A. Culver. The Macmillan Company 816pp., illus., 17s. net.

The author, Professor of Physics in Carleton College, U.S.A., has produced an omnibus book for students of science and engineering, including in its 800 or so pages mechanics, heat, light, electricity and magnetism and sound compressed into 55 chapters.

Presupposing an elementary knowledge of trigonometry and calculus, each section commences with an historical introduction and a reference to the fundamental concepts and laws, and carries the reader rapidly to the very modern theories involved. For example, the section on heat commences with a history beginning with Plato, and continues through a quick survey of thermometry, calorimetry, expansion of solids, liquids and gases, changes of state, critical temperatures and pressures, refrigeration and transfer of heat, the quantum theory, thermodynamics, Carnot cycle, steam engine, steam turbine, mercury vapour engine, and the internal combustion engine, all in the compass of 110 pages.

In most cases a passing reference suffices, and the steam engine is dismissed in two pages while the internal combustion engine is completed in four.

The result of this condensation is a regrettable reduction in the number of useful illustrative analytical problems in the text, and a sparsity of questions at the end of each chapter.

The book, however, should be an excellent reference work for students up to the intermediate degree standard, particularly in the sections of light and electricity and magnetism. It is written in a very easy and readable style, well illustrated throughout with very clear diagrams, and presents the subject of physics in a very attractive manner.

JUNIOR SECTION.

Film Display.

On Thursday evening, December 17th, 1936, a series of technical films was displayed to a meeting of the Junior Section in the Lecture Hall of The Institute. Mr. J. H. Graves (Associate Member) occupied the Chair.

The first film, "Cathode Ray Oscillograph", produced with the collaboration of the Radio Research Board, gave a highly interesting demonstration of this latest refinement in electrical measuring devices and its use in radio research and direction finding.

The second film "Propeller Making" showed the manufacture of propellers at a Works in Deptford, where those for the largest liners, including the "Queen Mary" and "Normandie", were made. This, like the first, was a sound film.

The third item, a sound film entitled "Hull Design," depicted a very good study of the marine research work of the National Physical Laboratory in testing prospective vessels by means of 10ft. wax models made in exact detail from the naval architect's plans. It was shown how these models are fitted with electric motors and tested in 600-ft. tanks in which the water surface can be varied to represent sea conditions while the action of the model is recorded by graph on a revolving drum.

The fourth film "Apparatus for Cutting; Cutting a Ship in Two; Oxygen Cutting by Automatic Machine", was shown by courtesy of The British Oxygen Co., Ltd., and illustrated the various types of oxygen cutting apparatus manufactured by this well-known firm. Of particular interest were the extraordinary efficiency of the automatic cutting machines and the use of hand manipulated apparatus to remove completely a section from the centre of a ship in dry-dock for a shortening operation.

The final item on the programme was an excellent two-reel sound film entitled "'Broomwade' Pneumatic Production Plant—Precision Produces Perfection" kindly loaned by Messrs. Broom & Wade, Ltd., who specialise in the production of a range of portable air compressors delivering 55, 80, 170, 255 and 340 cu.ft. of free air per minute at 100lb. per sq. inch working pressure, with either petrol or diesel engine drive, stationary compressors of capacities up to 4,750 cu.ft. per minute, and a wide range of pneumatic tools. The film included interesting views of the foundry and machine shop, the assembly shop, and modern methods of heat treatment. It also depicted the Company's plant and tools in operation in engineering works, crane erection, road works, and quarry drilling.

A hearty vote of thanks for the provision of these instructive films was accorded to the above Companies at the conclusion of the meeting.

ABSTRACTS.

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

Operating Results and Experiences of the Three Asiatic Fast Steamers of the Norddeutscher Lloyd.

By Oberingenieur Schneider, Bremen.

The following interesting extracts are taken from a paper read by the author in Berlin before the Schiffbautechnische Gesellschaft, whom we have to thank for permission to publish.

"The Steam Engineer", January, 1937.

In consequence of the putting into service of the three fast steamers, "Scharnhorst", "Potsdam" and "Gneisenau", during 1935, the Eastern Asiatic service of Norddeutscher Lloyd has been developed in the manner required by friendly competition with other nations.

The three ships represent the peak of German ship- and engine-building design. The bold step of fitting high pressure steam plants has greatly contributed to the improvement of the ships' engines.

In Table I the most important data regarding the boilers and machinery of the three ships are set out side by side. The normal designed power of the shafts is 26,000 shaft horse-power in all three ships, for a ship's speed of 21 knots.

Table I.

	"Scharnhorst".	"Potsdam".	"Gneisenau".
Type of drive	Turbo-electric AEG—Deschimag.	Turbo-electric SSW—Blohm & Voss.	Geared turbine Deschimag.
Shaft power: Shaft h.p. ...	2×13,000	2×13,000	2×13,000
Designed speed, knots ...	21	21	21
Steam pressure of turbine, atmos.	45	80	45
Steam temperature of turbine, deg. C.	455	470	455
Main boilers	Four water-tube boilers, Wagner-Deschimag.	Four Benson boilers, Blohm & Voss.	Four water-boilers, Wagner-Deschimag.
Boiler heating surface, sq. m.	4×650	4×590	4×607
Oil firing	Per 2 burners, Saacke-Deschimag.	Per 4 burners, Blohm & Voss.	Per 2 burners, Saacke-Deschimag.
Combustion air	Closed firebox, pressure blower.	Open firebox, suction and pressure blower.	Closed firebox, pressure blower.

In s.s. "Scharnhorst" and s.s. "Gneisenau" the steam is generated at a working pressure of 50 atmospheres (gauge pressure) by each of four Wagner water-tube boilers. The boilers are fitted with Saacke oil burners, which atomise the fuel oil by centrifugal force. On s.s. "Potsdam" four Benson boilers are erected, each being fitted with pressure and suction blowers. The fuel oil is supplied to the boilers by oil burners having pressure atomisation, of Blohm & Voss design.

The boiler and engine plant on s.s. "Potsdam" (Fig. 1) presents approximately a similar arrangement to s.s. "Scharnhorst".

Unlike the other two ships, s.s. "Potsdam" was equipped with a Benson boiler plant, consisting of four units having open combustion chamber and suction and pressure blowers (Fig. 2). From the drawing can be clearly seen the disposition of the tube systems in the Benson boiler. This arrangement has been designed on the strength of experience collected in recent years from the Benson marine boilers already in use. The boilers have double casing, through which the air for combustion is supplied. This ensures effective heat insulation, so that the radiation of heat is almost avoided.

The air preheaters have the form of plate preheaters, Hartmann design. The feed pumps are of the greatest importance in the operation of these boilers. Two Balke piston pumps are fitted in the form of a twin unit, and there are also two turbo-feed pumps by Klein, Schanzlin & Becker. During the first trip the cast steel valve chests of the plunger pumps gave rise to trouble in operation. At the high pressure of up to 130 atms. porous parts were found during the continuous working, so that much leakage occurred with considerable loss of water. The cast steel valve chests had to be replaced by homogeneous iron blocks. This measure secured the necessary safe working of the pumps.

The oil furnace built on the Blohm & Voss system, having four pressure atomisers per boiler, is distinguished by regular working. The new type of supply of the thoroughly preheated air from the plate preheater to the burners ensures a uniform combustion mixture, which is dependably ignited by an electrical ignition device. The combustion is smokeless, and in consequence the deposition of soot is small, so that the plant can be kept clean without difficulty.

The engine plant of the s.s. "Potsdam", built by the Siemens-Schuckert Works, consists of (*a*) two two-housing excess pressure condensation turbines (Fig. 3); (*b*) two rotary current generators with air coolers each 10,000 kv.a., 6,000 v., 3,200 r.p.m., 53⅓ cycles; and (*c*) two rotary current synchronous screw motors with air coolers, each 13,000 effective h.p., 6,000 v., 160 r.p.m., 53⅓ cycles. The condensers are accommodated beneath the low-pressure turbine and rigidly joined to the latter's housing. The cooling tubes were united to the tube plates by a special mandrelling process. The heat stresses occurring are taken up in the jacket by an expanding fold.

All auxiliary machines, with the exception of

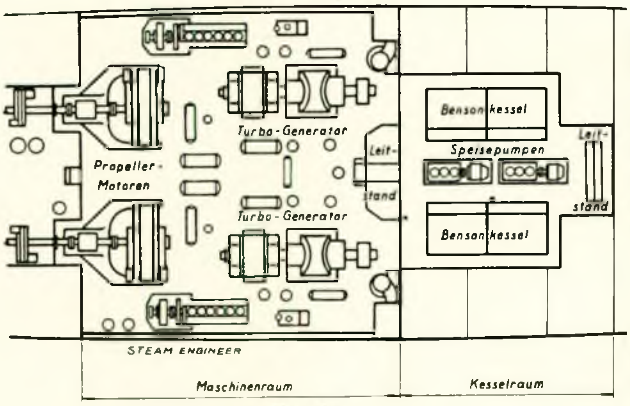


Fig. 1.

Speisepumpen—Feed pumps.
Bensonkessel—Benson boiler.
Leitstand—Control stand.
Propeller Motoren—Screw motors.

the two reserve boiler feed pumps, have electrical drive. For the generation of current for the auxiliary machines and for deck use, four turbo generators and two Diesel generators are available.

Now that the two ships "Scharnhorst" and "Potsdam" have each made four circular trips and s.s. "Gneisenau" three circular trips to Eastern Asia, sufficient operating data are available to enable an opinion to be formed regarding these ships.

The following Tables* give separately for each ship the principal particulars regarding the operating results actually obtained. In considering these data it must be taken into consideration that the figures given regarding the consumption of fuel oil represent not only the total consumption of the main engines, including the auxiliary engines necessary for their operation, but also the consumption of all other auxiliary machines and gear for the general operation of the ship, such as lighting, ventilation, heating, kitchens and refreshment purposes, and, in addition, for the operation of the very extensive stores and cargo refrigerating plant. The proportion of these auxiliary ships' machines amounts to from 8 to 10 per cent. of the consumption of fuel oil. The consumption of fuel oil relates to fuel of 9,700 to 9,800 heat units. For purposes of comparison with the usual basis of 10,000 heat units, from 2 per cent. to 3 per cent. should be deducted from the fuel oil consumption figures given in the Tables.

*Tables for "Potsdam" only included.

In the case of s.s. "Potsdam" the data for the first trips are also below the normal values (Table 2). The third trip had to be covered at greater speed and also shortened in order to make up a great delay caused by damage. The higher Diesel oil consumption is due to the fact that on this boat, unlike the "Scharnhorst" and "Gneisenau", the auxiliary Diesels are used at sea more extensively for the generation of power.

Table II. ("Potsdam").

	1st trip.	2nd trip.	3rd trip.	4th trip.
Displacement ... tons	20,000	20,410	19,830	20,290
Speed at sea ... knots	19·11	20·46	21·04	20·04
Slip ... ... per cent.	14·6	14·4	14·8	12·1
Engine power, shaft h.p.	—	20,650	22,500	20,450
Days steaming at sea ...	61·12	56·63	52·98	56·98
Driving oil, total tons	168	170	83	84
Fuel oil, total ... „	9,307	9,585	9,148	8,639
Fuel oil at sea ... „	8,625	8,871	8,741	8,231
Fuel oil at sea, tons per day	141·1	156·6	165	144·5
Fuel oil, kilos per shaft, h.p. hour	—	0·316	0·306	0·294
Fuel oil at sea— Carrying capacity × speed $\frac{\text{kilos per hour}}{\text{tons} \times \text{knots}}$	—	0·0266	0·0273	0·0250

In order to produce a faultless distillate with the evaporators originally installed by the Atlas-Werke, Bremen, constant conscientious control and supervision of this plant by trained staff were necessary, and in addition it was important not to overload these evaporators. It was not always possible to comply with both conditions, in consequence of the large requirements of distillate and the initial overworking of the operating crew.

Owing to these circumstances and the occa-

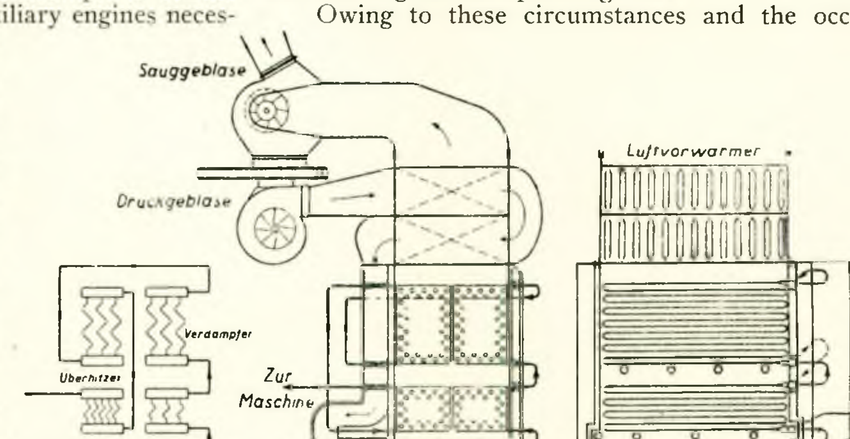


Fig. 2.—Benson Boiler arrangement on the "Potsdam".

Sauggebläse—Suction blower.
Druckgebläse—Pressure blower.
Verdampfer—Evaporator
Überhitzer—Superheater.
Strahlungsteile—Radiation parts.
Luftvorwärmer—Air preheater.
Zur Maschine—To the turbine.

sional feeding of mains water, an accummulation of salt in the boilers and in the whole feed circulation system was unavoidable.

The next result was the priming of the boilers, and the steam supply pipes therefore conveyed dirt to the sensitive regulating valves of the main and auxiliary turbines, which gave rise again to more extensive disturbances in operation.

In order to overcome these difficulties in operation it was found necessary to evolve a sea-water evaporator plant which would be insensitive to variations in working and require little attention. For reasons of economic working and the difficulty of obtaining supplies of fresh water *en route* to the Orient, it was not possible to dispense with sea-water evaporation.

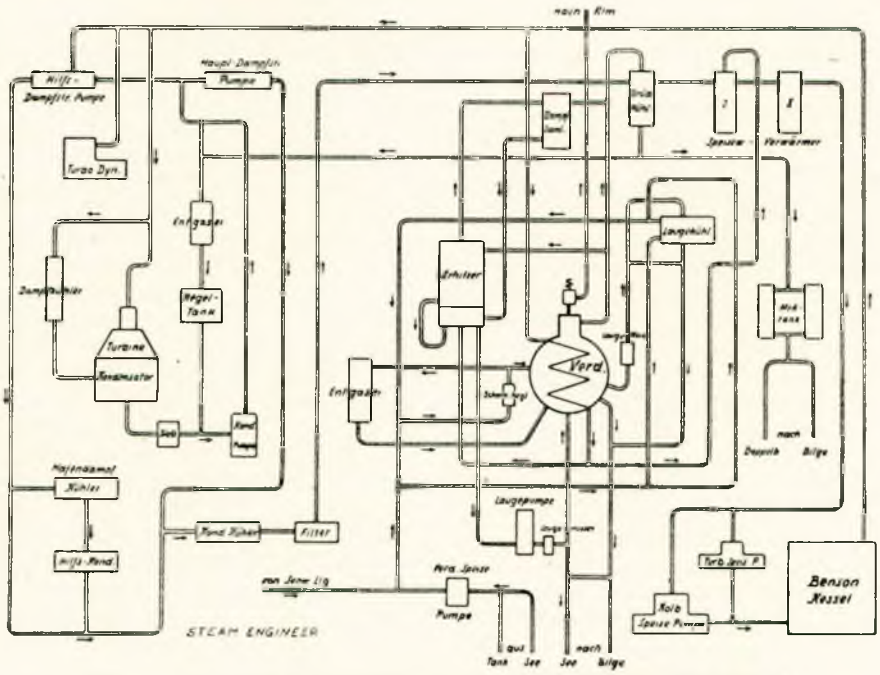


Fig. 4.—Feed water circulation for Benson boilers on "Potsdam".

Hilfs Dampfstr. Pumpe	— Auxiliary steam flow pump.
Haupt Dampfstr. Pumpe	— Main steam flow pump.
Nach Atm.	— To atmosphere.
Dampfkühler	— Steam cooler.
Turbine Kondensator	— Turbine condenser.
Hafendampf Kühler	— Port steam cooler.
Hilfs Kond.	— Auxiliary condenser.
Entgaser	— Degasifier.
Regel Tank	— Regulating tank.
Kond. Kühler	— Cond. cooler.
Speisew.-Vorwärmer	— Feedwater preheater.
Mess.-Tank	— Measuring tank.
Turb. Speise P.	— Turbine feed pump.
Holb. Speise Pumpe	— Plunger feed pump.
Verd. Speise Pumpe	— Evaporator feed pump.
Laugepumpe	— Lye pump.
Verd.	— Evaporator.
Schwim. Regl.	— Float regulator.
Kond. Pumpe	— Cond. pump.

The problem newly arising was solved in the case of s.s. "Scharnhorst" and s.s. "Gneisenau" by the Atlas-Werke, Bremen, in a perfect manner, as the plants then converted into two-stage rotary evaporators comply with all requirements hitherto imposed. On the alteration of the sea-water evaporators, it was also necessary to improve the whole feed-water circulation system and fit it in such a way that the good quality of the additional and feed water would be constantly ensured, which is checked by a constant control.

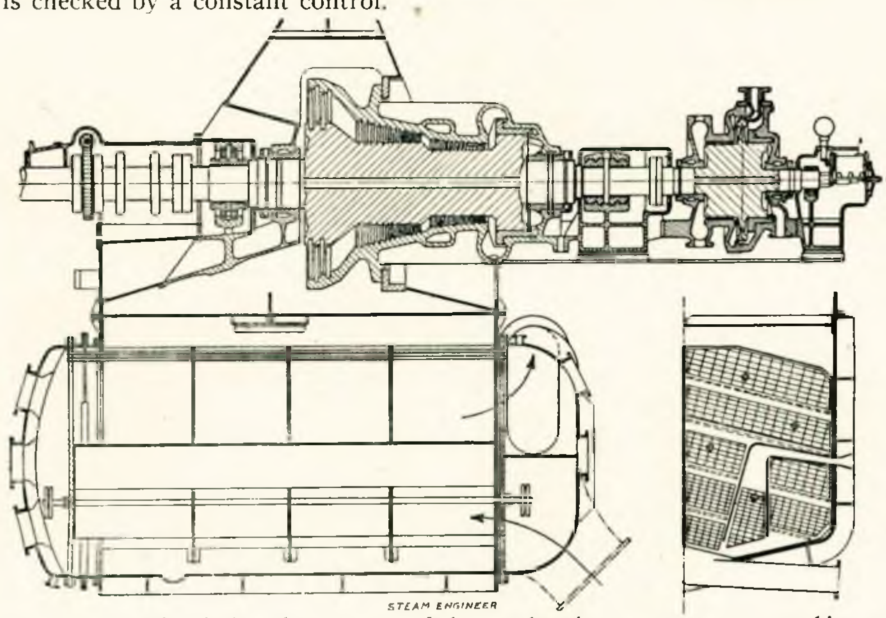


Fig. 3.—A sectional view through one of the two-housing excess pressure turbines.

At all points where a forced entry of sea water can occur electric lamps are fitted as control units, lighting up immediately the slightest salt content makes itself felt in the circulation. The boiler water present in the circulation is made alkaline by the direct addition of caustic soda and tribasic sodium phosphate into the boilers.

Owing to pipe cracks, which occurred not only in the radiation part, as already described, but also at various other parts of the boilers and superheaters, further disturbances occurred during the first period of operation.

These pipes cracked, owing partly to insufficiently good quality of the boiler water, but in various cases defects in material were also conclusively proved. Pipes were fitted which had drawing grooves, which, after some time, burst open in the longitudinal direction. In other pipes the lack of uniformity in the wall thickness led to cracking. After the experience obtained in operation in the three ships, it can be said that the manufacture of the high pressure boiler tubes must be improved in such a way that disturbances through defective material no longer occur.

The s.s. "Potsdam" was the second ship to be put into service. The combustion is good in the boiler plant of this ship, and the firing plant therefore remains clean for long periods.

The boilers gave rise to certain disturbances in operation in this ship also. The causes were found to be :—

(1) Impurities, such as hammer scale or the like, in the pipe system. Before being put into operation—particularly in the case of the Benson boiler plant, since it is based on the through-flow principle and is built without a drum—the plant requires to be thoroughly cleaned where all internal pipe walls are concerned, as small, solid particles of dirt can give rise to trouble in the flow at the throttle parts, at the transition points from the distributor cylinders into the pipes.

(2) In various cases defective material in the same form, as in the case of s.s. "Scharnhorst" was the cause. In order to ascertain these defects before the boilers are put into operation, it is advisable to have the whole pipe systems, during the water pressure test, stand under full pressure for a period of from four to six hours. Longer experience in operation shows that disturbances in the boilers are becoming continually less frequent; since all defective points that have given rise to pipe cracks have in the meantime been eliminated by welding in new pipe ends.

(3) Everything that was said regarding the boiler water replacement in the case of s.s. "Scharnhorst" also applies to s.s. "Potsdam". Initial difficulties arose, these being principally caused by the high water losses in the plunger feed pumps, which have already been mentioned in the discussion of these pumps.

The safety of the Benson boiler operation requires to a high extent pure oxygen-free feed-water. On the strength of the experience gained in the first trip, the firm Schmidt & Söhne, Hamburg, converted the evaporator supplied by them into a two-stage rotary evaporator.

The evaporators now supply from sea water a perfect additional water, which ensures the safe working of the plant. Tribasic sodium phosphate and sodium sulphite are supplied in dosed quantities to the feed-water circulation system. In the plan the whole circulation system is shown (Fig. 4).

It should be mentioned here that since the conversion of the evaporator plants of the three ships, the soiling and formation of deposit in this plant have fallen off quite considerably; for example, after three months' continuous working there is no longer any noteworthy soiling or formation of crust.

After overcoming the initial difficulties it can be said of the operation of these high pressure, high temperature steam plants, that the dependability in operation is completely ensured and that these plants have effected a considerable improvement in the economy of the operation of the ship.

A mention must be made here of the self-sacrificing co-operation of the crews, whose conscientious study of the novelty of the plants has contributed to the rapid elimination of these initial difficulties.

The ships were immediately put into service on routes involving very long journeys. The faith shown by the shipowners and builders in the new machine plants has been fully justified by the results.

In conclusion, it can be said that the ships "Scharnhorst", "Potsdam" and "Gneisenau" represent an important addition to the German mercantile fleet, and the fullest recognition must therefore be paid here to their makers.

Vibration of Steam Pipes Connected to Engine Cylinders.

By A Canadian Correspondent.

"The Steam Engineer", January, 1937.

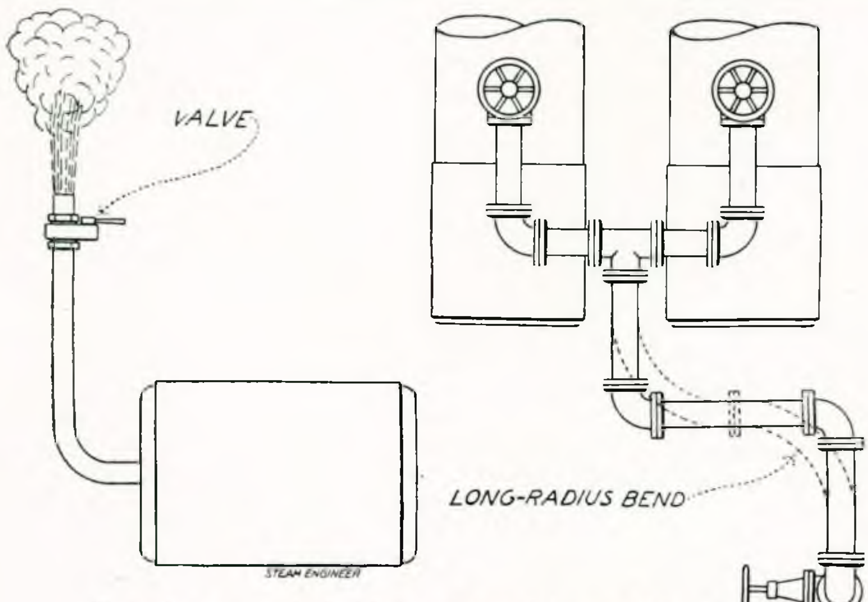
More or less vibration of the piping will inevitably attend the transmission of steam from a boiler to an engine cylinder. The vibration is due to the pulsating flow of the steam, caused by the opening and closing of the engine valves for admission and cut-off. The degree of vibration in any case depends largely on the way the pipe-lines have been laid out and erected. Excessive and dangerous vibration generally may be charged to poor judgment in attending to these matters.

The figure at the left in the accompanying sketch shows a closed cylinder containing a fluid under constant pressure and discharging through a quick-closing valve on the end of a pipe bent at right angles. The tension of the escaping fluid will diminish progressively during the passage through the pipe. Assume the constant cylinder pressure to be 50lb. per sq.in. and the constant drop at the outlet to be about 1lb. Then the bent pipe will continue steadily in a fixed position.

Suppose now that the valve be suddenly closed. Then the cylinder pressure of 50lb. instantly will be impressed on the vertical section of the pipe. The force of impact against the valve disc will be transmitted to the right-angled turn and will be expended in an effort to straighten the pipe. The instant effect will be a straining of the vertical section toward the left, followed immediately by a return to the original form. This action constitutes a vibration, and if the valve be opened and closed at very brief intervals, as in the operation of engine valves, there will be a rapid series of such vibrations.

Two boilers, piped as shown by the figure at the right in the sketch, were used alternately at weekly intervals to supply a high-speed engine. When the boiler at the left was in use the vibration was excessive, particularly when the engine was carrying a heavy load, but when the right-hand boiler was in service the vibration diminished somewhat.

This difference in the vibratory effect was attributed to the fact that when the left-hand boiler was



Illustrating cause of vibration. An unsatisfactory piping lay-out.

in service the zigzag course of the steam was in the same general direction. Thus the straightening impulse at the turns was cumulative in its effect. But when the right-hand boiler was in use, the effect of impact against the walls of the pipe contiguous to the first and second turns from the boiler was partly neutralised by the reactions near the third and fourth turns. Thus the vibrations set up at the third and fourth turns counteracted in some degree the vibrations set up at the first and second turns.

The trouble was remedied by substituting long-radius bends for the sharp turns, as indicated by the dotted lines in the sketch. The long curves permitted the steam current to strike the wall of the pipe at a more oblique angle, and so diminished the vibratory effect.

Vibration of a steam pipe supplying an engine may be abated by installing a large receiver-separator in the line near its connection with the engine. The comparatively large volume of steam in the receiver will act as a buffer in absorbing the ramming effect of the steam current at cut-off. The reaction due to suddenly arresting the flow will be expended in compressing the steam in the receiver, and the momentum of the current coming from the boiler likewise will be dissipated. Thus the pulsating flow through the pipe will be changed to a comparatively steady flow.

Impulse Turbine Fundamentals.

The Use of the Mollier Diagram simply explained.

By Sydney D. Scorer.

"The Steam Engineer", January, 1937.

The reciprocating steam engine was for many years the principal type of prime mover used for the production of mechanical and electrical power. In its most complicated form its essential working cycle was simple and easy to grasp, so that any falling off in efficiency was readily traced by those responsible for its operation. The indicator diagram was of great assistance in this respect; the conception of pressure and volume changes allowing of a visual record of performance. The advent of the steam turbine, however, has led to the gradual displacement of the reciprocating steam engine for all but moderate powers. It has left those entrusted with the efficient working of turbine plant without any but indirect means of assessing the significance of the various steam changes taking place in the interior of the machine.

The cycle of operations employed in the steam turbine is, of course, similar to that adopted in the steam engine; water being used as the vehicle for the necessary thermal energy. The cycle consists essentially of the provision of a supply of heat at the turbine stop valve, the conversion of this heat into mechanical work, and the rejection of the unused heat to the condenser or other receiver. Briefly, the process may be summarised as the reception of heat by the water from the feed-water heater, boiler and superheater, accompanied by change of state to steam; the expansion of the steam in the turbine, together with the performance of work on the blades; and the removal of the waste steam, accompanied by a reversion to its initial state as water.

While it is quite possible to show this cycle of operations graphically in the form of a pressure-volume diagram similar to that of the steam engine, a much more satisfactory method—and one that allows of a greater scope for investigations—is to use a diagram in which the co-ordinates are expressed in terms of heat units. Since the complete design of a steam turbine is intimately related to thermal and steam velocity calculations, the advantages of a diagram of this nature will be appreciated.

To derive full benefit from the diagram, an understanding of the term "entropy" is required. When 1lb. of water at a temperature of T° F.

absolute is given a small quantity of heat, h, its total heat and temperature are increased by a correspondingly small amount. Since this change is of a low order, the temperature T will be sensibly constant during the addition of h B.Th.U. Then the increase of entropy is given by the result h/T. By plotting a diagram in which the ordinates represent the absolute temperature, T, and the abscissæ, the entropy units, it will be seen that an area under the curve will give at once the total heat contained in the water or steam at a given temperature. Thus if h B.Th.U. are added to water at a temperature T, then this will be derived from the temperature-entropy diagram by the product of T × increase in

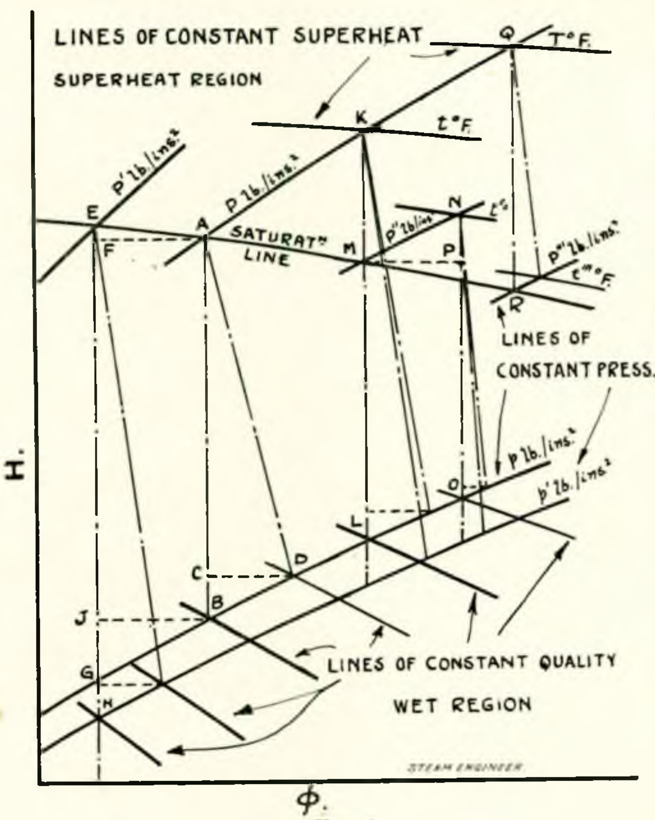


FIG. 1.

entropy. Similarly, if an amount of heat, L (equal to the latent heat required to form steam at a temperature T), is added to the water at T° F., then the increase in entropy is L/T.

The diagram may be extended to show the relationship between the temperature and entropy (usually denoted by the symbol φ), for water, saturated and superheated steam, but it has the disadvantage that a calculation is always necessary to arrive at the total heat of the water or steam for any given conditions. A much more convenient method is to replace the T units on the diagram by the total heat at various points, and to plot these against entropy as before. This diagram—due to Dr. Mollier—is usually referred to as the Mollier diagram, and is of considerable assistance in solving steam turbine problems.

A sketch of a Mollier diagram is shown in Fig. 1, and it will be seen to consist of a number of pressure lines running diagonally across the paper, intersected by other constant superheat lines or constant quality lines. The various curves are obtained by plotting the total heat of steam at, say, P lb. per sq.in., against the entropy value for different conditions of dryness and superheat, the resultant points, when joined, forming lines as shown. Thus, in order to determine the total heat of 1lb. of steam at any given temperature and pressure, it is only necessary to move along the pressure line up to the point where it cuts the temperature line; the total heat may then be read off from the vertical scale, and the entropy from the lower. The saturation line on the diagram intersects each pressure line at a point where the steam is dry and saturated; points above the saturation line being superheated, and those below indicating that the steam is slightly wet.

Turning now to a consideration of the changes actually taking place in an impulse turbine, one finds that advantage is taken of the fact that if steam is expanded adiabatically, viz., without gain or loss of heat to external bodies, in a specially formed nozzle, its velocity is increased considerably and the momentum of the steam may be utilised in rotating a disc provided with suitable vanes. In passing through the nozzle the heat energy of the steam is partly converted into kinetic energy, so that at the exit the total heat contained in 1lb. of steam is less than at entry, the difference (in a frictionless nozzle) representing the quantity of heat transformed into velocity energy. It is obvious that some relation must exist between the reduction in total heat (or heat drop) and the velocity of the steam leaving the nozzle, and it may be shown that $V = 223{\cdot}8\sqrt{H}$; where V is steam velocity at exit, and H is the heat drop in B.Th.U. Moreover, since no heat is added to or taken from the steam during its expansion, the entropy will be constant from the point of entry to that of discharge, the above facts being of importance when considered in conjunction with the Mollier diagram.

Take the case of 1lb. of dry, saturated steam expanding adiabatically from a pressure p lb. per sq. in. to p lb. per sq. in. A (Fig. 1) is the starting-point, and the expansion proceeds at constant entropy down to B, where it meets the p lb. per sq. in. line. The steam is now in the wet region and its dryness fraction is given by the value of the constant quality line which cuts the p line at B. The total heat of the steam at A is H′, and that at B is H″, so that the heat used in increasing the steam velocity is $H' - H'' = H$, the heat drop. From the expression given above, the velocity at exit will be $V = 223{\cdot}8\sqrt{H}$ ft. per sec., and the area of the nozzle at exit will be $A = w.q.v./V$; where w is the weight of steam flowing in lb. per sec., q is the dryness fraction at B and v is the specific volume of steam at p lb. per sq. in.

In practice no nozzle is frictionless, so that a percentage of the available heat drop is converted into frictional heat, which results in the adiabatic line being diverted to D, owing to the reheating of the steam. The point D may be determined when the efficiency, AC—AB of the nozzles or combination of nozzles is known. It will be seen that as a result of reheating, the final condition of the steam is slightly dryer than at B, but the amount of heat left in the exhaust is increased. The heat drop, however, is decreased.

The effect of raising the initial steam pressure of a turbine is shown in Fig. 1, by moving the *starting-point along* the saturation line until it coincides with the intersection of a higher pressure, P', line. The increase in the theoretical available heat drop is given by the sum of EF and JG, assuming the expansion to be carried down to the original p line. When the lower exhaust pressure is also reduced to a pressure, say, p′ lb. per sq.in. absolute, there is a further increase of available heat drop represented by GH; the effect of the lower condenser pressure being to reduce the amount of heat passing away to waste in every lb. of steam. Since the power obtainable per lb. of steam is proportional to the adiabatic heat drop shown on the diagram, it is obvious that any method of increasing the heat drop, while preserving turbine efficiency, must result in increased power per lb. of steam.

The gain derived from superheated steam is indicated in Fig. 1, where steam at the pressure P lb. per sq. in. is superheated to a temperature, t° F., at K. The expansion line is given by KL, and when the lower vacuum is used the gain in heat energy is plain. In large power stations an effort is often made to increase the overall thermal efficiency of the station by extracting the steam from the turbine at a predetermined stage and reheating it by means of waste gases, etc. The effect of this is shown at MN, the steam being withdrawn when it is dry and saturated as at M, at a pressure P″ lb. per sq. in. The reheating raises the steam temperatures at constant pressure P″ to t″° F. and the expansion through the turbine is then resumed down the line N.O. The extra heat given to the steam is NP B.Th.U. and the general effect is to increase the available heat drop and to dry the steam at exhaust.

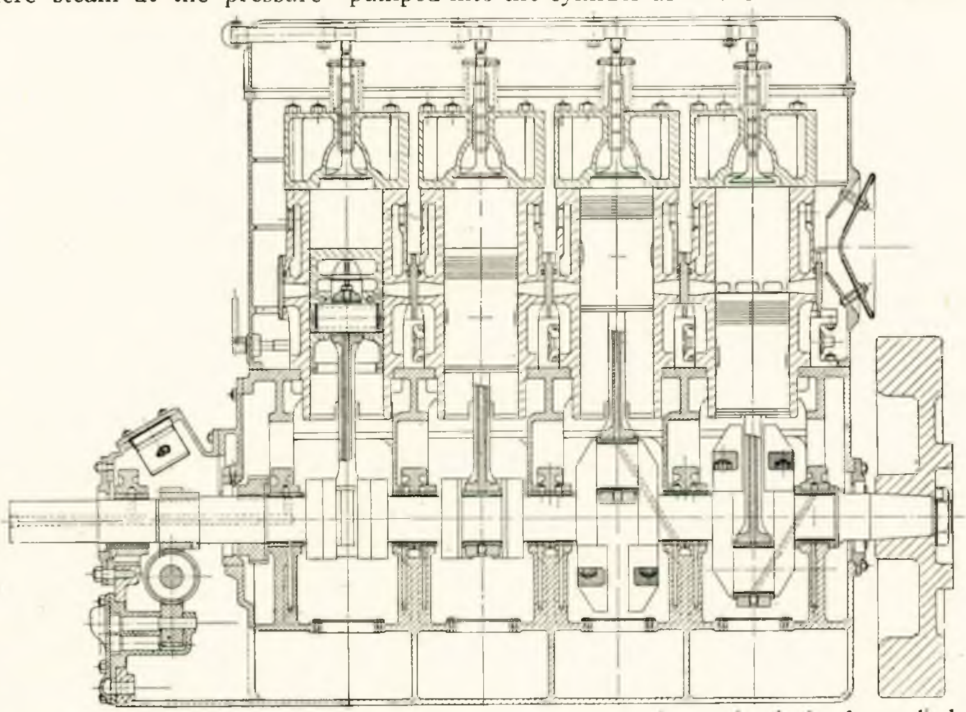
Maximum thermal efficiency, however, is obtainable by the use of a back-pressure turbine. If steam at P lb. per sq. in. be heated to a superheat temperature T° F., as at Q, and expanded down until it is at a pressure P‴, dry and saturated, then the effect of frictional reheat will be to make available for process work steam at P‴° F. The back-pressure turbine is designed for maximum efficiency under the given conditions, and the heat used for process work brings up the total thermal efficiency of a plant of this type to from 65 to 75 per cent.

The extraction turbine is a variation of this principle, as it consists of a primary back-pressure turbine exhausting into a condensing turbine in series with it, process steam being removed at the intermediate stage. It is very interesting and instructive to plot the expansion of steam in a turbine of which one has the various stage pressures and temperatures.

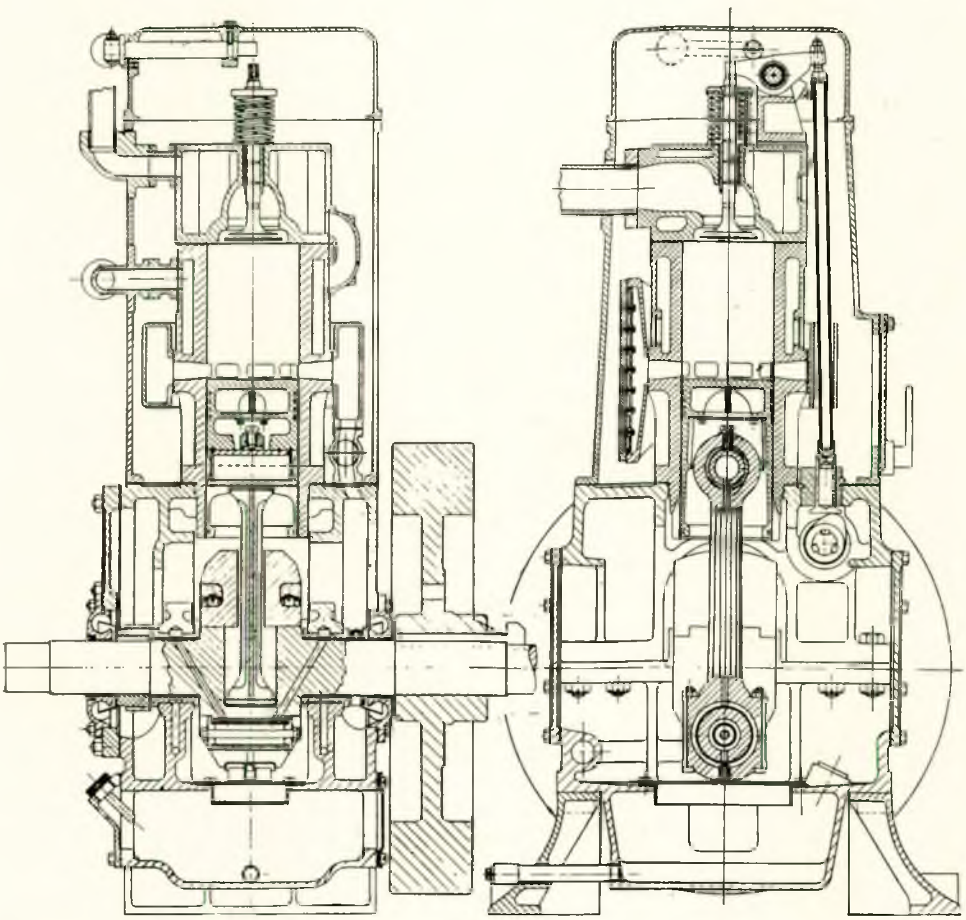
Petter Harmonic-induction Diesel Engine.

"Gas and Oil Power", December, 1936.

The Petter harmonic-induction engine is the successful application of a principle which has been known to engineers for many years. The intended interpretation of the word "induction" is that the fresh air which is required to re-charge the cylinder before each stroke of the engine instead of being pumped into the cylinder as in the case of a normal



Longitudinal section through the new Petter harmonic-induction engine in its four-cylinder form. The large exhaust valve in the cylinder head is operated through rocker gear from a gear-driven camshaft.



Transverse and longitudinal section through a cylinder of the harmonic-induction Diesel engine.

two-stroke cycle engine, is drawn or sucked in by means of a vacuum which is produced as a result of the wave motion in the exhaust pipe.

Research into the phenomenon of the wave motion in the exhaust pipe of an internal combustion engine commenced as early as 1893, but it was not until 1922 that the first experiments were carried out by Petters Ltd., on this system. The results obtained then were not considered very promising, and work was discontinued until recently, when a new series of experiments was conducted, from which remarkable practical results have been obtained. These latter experiments were carried out on a two-stroke cycle engine, the air inlet ports being arranged circumferentially around the cylinder bore at the lower end of the piston travel. The exhaust valve was situated centrally in the cylinder head, thus the air entered the cylinder at one end, was compressed by the piston to the other end of the cylinder, and was ejected from the cylinder at the end to which it was compressed, thus providing means for keeping the air flowing in one direction through the cylinder.

When the exhaust valve in the engine opens, the sudden ejection of the burnt products of combustion from the cylinder into the exhaust pipe sets up a wave motion in this pipe. This motion is similar to the motion of the waves produced in an organ pipe, the initial compression wave being formed by this sudden ejection into the exhaust pipe. Immediately following this compression part of the wave, there is a vacuum or rarefaction part which completes the wave cycle. This rarefaction is transmitted from the exhaust pipe through the exhaust port into the cylinder, and at exactly the right moment the ports in the cylinder connected to the atmosphere are opened, thus connecting the vacuum in the cylinder to the pressure in the atmosphere, the result of this being that the clean air rushes in from the atmosphere and fills the cylinder completely, thus the cycle of operations in the cylinder may be repeated.

As is well known in the design of organ pipes, the frequency of the waves in the exhaust pipe, *i.e.*, the number of waves per second, is governed by two factors: the length of the pipe and the speed of sound in the medium in the pipe. As the latter of these is fixed by contingencies which are not under the control of the engine designer, it is important that the right length of pipe is used in order that the waves in this pipe are timed correctly so that they coincide with the opening of the exhaust valve and the opening of the air ports; that is, at the moment that the air ports of the engine open, it is necessary to have the vacuum in the cylinder, therefore it will be seen that for any particular speed of operation of the engine there is a definite length of exhaust pipe required. Fortunately, once the length of exhaust pipe has been fixed, the speed of operation of the engine is not absolutely rigid, and a certain amount of flexibility is obtainable. Furthermore, although the length of the pipe is so important the actual shape does not matter, the wave motion being unaffected by bends. The result of this method of filling the engine cylinder with fresh air at each stroke of the piston is that it is possible to do away with all the usual methods of re-filling an engine cylinder with air, namely, the idle strokes of a four-stroke cycle or the auxiliary compressor of a two-stroke cycle engine.

The engines which were demonstrated by Petters Ltd., in London, at the beginning of this month illustrated the design as applied to four-, twin-, and single-cylinder units. So far only the single-cylinder unit is in production, although it is anticipated that the rest of the range will be available in the near future. It is of interest to note that it *is possible to* connect the exhaust from two cylinders into one pipe, as the functions in the pipe take place at an interval of 180°, and it is possible to coincide the motions in the two pipes to work together. The multi-cylinder engines are of monobloc construction with separate cylinders which are easily removable for re-boring.

The exhaust valve already referred to which is situated in the cylinder head, is operated from the camshaft, which is gear-driven from the main crankshaft. The fuel injection nozzle has a single hole, centrally placed, which is of relatively large diameter, and therefore remarkably free from the danger of being choked by carbon deposit. Since the wave motion in the pipe only functions above a certain speed of the engine, there is an auxiliary device whereby air is supplied to the engine for starting from the crankcase, but once the engine has run up to speed the automatic scavenge system operates of its own accord.

The advantage claimed for this method of scavenging is that not only are all exterior methods of supplying air to the engine removed, but more complete scavenging of the engine is effected than is usually obtainable in a two-stroke unit, so that approximately 50 per cent. more power is developed per cylinder volume than in a standard two-stroke engine. This has the effect of lowering the power weight ratio of the unit. In addition, of course, the fact that the two-stroke cycle is adopted makes for a high cyclic regularity.

Constructionally, the design is on sound, robust lines, cast iron being used extensively. The cylinder is cast integrally with the water jacket, resulting in a strong, light and simple assembly. The cylinder head has a symmetrically machined combustion chamber; the piston is of aluminium alloy. White metal-lined main bearings with gun-metal shells are used, the big-end bearings being similarly lined. The camshaft is supported in three sets of ball bearings and is gear driven from the crankshaft.

The lubrication of the engine is by force feed throughout. A gear-type pump, located in the crankcase, forces oil to the connecting-rod bearings, the main bearings, the camshaft gear and the exhaust valve rocker bearing. The oil pipes and ducts are all enclosed in the engine, except one external pipe which is fitted in the system so that an oil cooler may be provided in tropical climates where necessary. After lubricating the various parts the oil is collected and drained back to the sump, whence it is passed through a filter before being used again.

As regards general performance, the new engine starts very easily and runs sweetly, with very little vibration. The normal speed range is from 600 to 1,100 r.p.m. and the torque variation over this range some 15 per cent. The rated b.m.e.p. is 62lb. per sq. in. The exhaust is clean at all loads and the engine has a fuel consumption below 0·4 pint per B.H.P. per hour at full load; this figure remains practically constant over a wide range from half load to ten per cent. overload. The lubricating oil consumption is equally low, being less than 0·004 pint per B.H.P. per hour. As will be seen from the accompanying illustrations, the engine has a remarkably clean external appearance, all components being totally enclosed and moulded to form a compact, businesslike unit.

Stewit Combustion System.

"Gas and Oil Power", December, 1936.

For a number of years now Stefan Witkowski, a prominent Polish engineer, at present living in Switzerland, has been experimenting with problems relating to injection engines. As a result of the success of his work he has now evolved an entirely new combustion chamber design which is claimed equally suitable for high and low compression engines depending on compression or spark ignition.

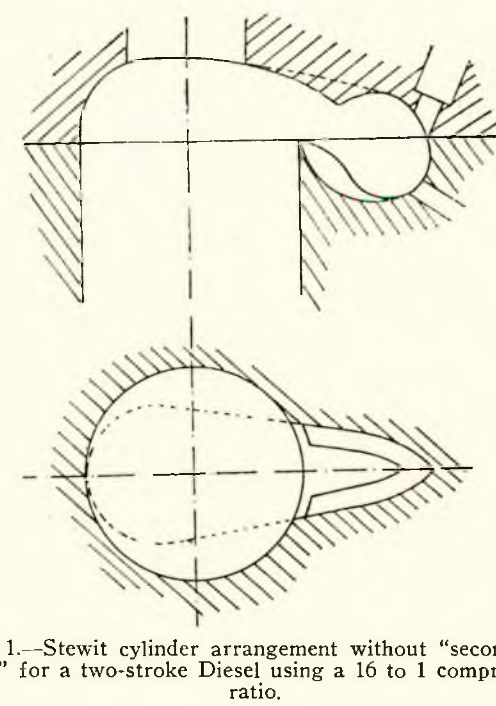


Fig. 1.—Stewit cylinder arrangement without "secondary" head" for a two-stroke Diesel using a 16 to 1 compression ratio.

The nature of the system employed in the Stewit design (the name by which the principle is to be known) is not altogether new, according to an article in *Motor and Sport,* the idea being to create the highest possible turbulence and mixing of the fuel and air, in conjunction with a directional swirl past the atomiser nozzle. The point of interest, however, is the way in which all this is carried out and the highly unconventional cylinder head form that is used. In passing, it may be mentioned that special types of atomisers and fuel injection pumps have also been devised, which, besides being light and small in size, are intended to deal equally well with light fuels such as petrol and paraffin or heavier grades such as gas-oil or soya-bean oil. Between the top of the cylinder block and the cylinder head, what is known as a secondary head is interposed, which takes the form of a ring of metal with a noselike

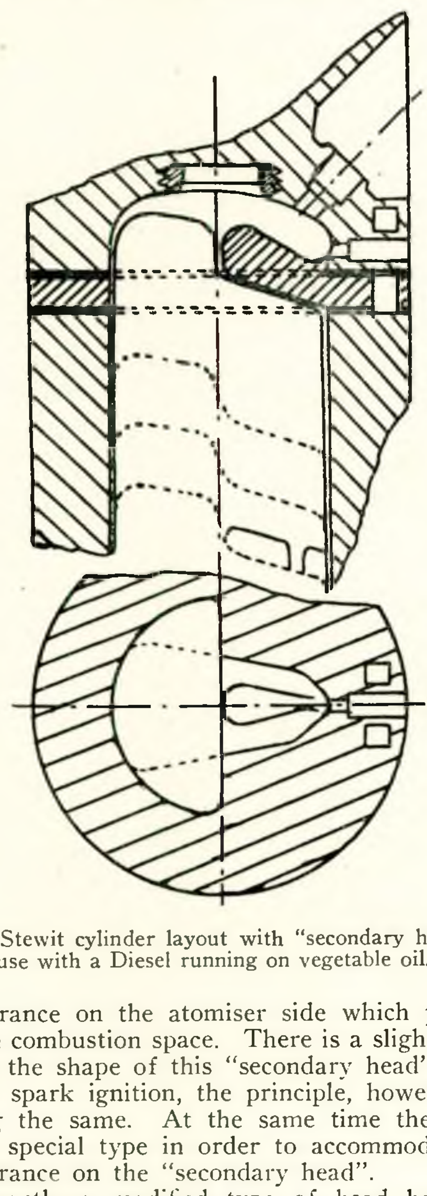


Fig. 2.—Stewit cylinder layout with "secondary head" for use with a Diesel running on vegetable oil.

protuberance on the atomiser side which projects into the combustion space. There is a slight difference in the shape of this "secondary head" in the case of spark ignition, the principle, however, remaining the same. At the same time the piston is of a special type in order to accommodate the protuberance on the "secondary head".

Recently a modified type of head has been

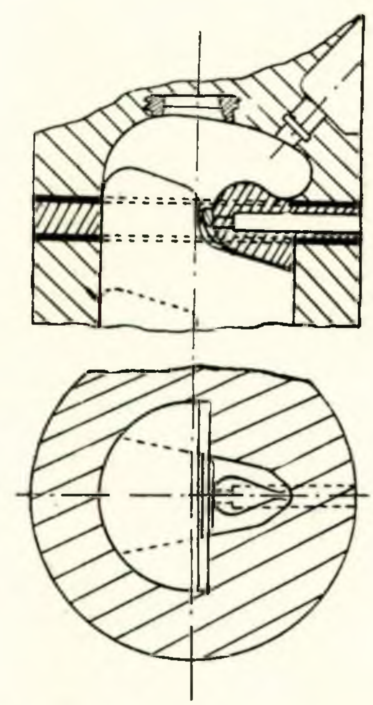


Fig. 3.—Stewit cylinder head for low compression (4·8 to 1—7·4 to 1 compression ratio) engine fitted with spark ignition.

developed retaining the main features of the original design but obviating the use of the secondary cylinder head. The system as applied to a two-stroke diesel engine using a 16 to 1 compression ratio is shown in Fig. 1. In this instance the ante-chamber is contained within the cylinder block casting and a normal type of piston is employed. The combustion chamber is beak-shaped, the atomiser spraying from top to bottom at a slight angle to the vertical. A single-cylinder two-stroke test engine of 105 mm. bore and 115 mm. stroke (swept volume 994 c.c.) fitted with this head and using a 16 to 1 compression ratio develops 46 B.H.P. at 3,400 r.p.m. The fuel consumption at the same power output, burning good quality gas-oil, is 0·375lb. per B.H.P. per hour and the exhaust temperature 170° C.

Fig. 2 shows the Stewit cylinder head with "secondary head" for use with a diesel engine burning vegetable oil. Owing to the nose-like projection the combustion chamber is broken into two parts. The atomiser is located in the ante-chamber and sprays towards the projection, which is also the direction in which the air is circulating. With a similar test engine to the one above the power output at 2,000 r.p.m., using ordinary fuel oil, was 26·2 B.H.P., and using soya-bean oil, 23·6 B.H.P. The corresponding fuel consumption figures were ·378 and ·481lb. per B.H.P. per hour.

In Fig. 3 the arrangement is shown when applied to low-compression spark-ignition engines.

Fuel.	Stewit cylinder head with Secondary head. Comp. ratio 4·8 to 1		Normal turbulent head. Comp. ratio 4·8 to 1	
	Power output: B.H.P.	Fuel: lbs. per B.H.P. hour.	Power output: B.H.P.	Fuel: lbs. per B.H.P. per hour.
No. 1 Petrol	8·30	·492	8·10	·510
Alcohol blend	8·10	·495	7·90	·513
95% Alcohol	7·80	·549	6·10	·715
Gas oil	8·00	·512	—	—
Soya-bean oil	7·80	·550	—	—

Here the atomiser is taken right through the secondary cylinder head, thereby allowing the fuel to be preheated before injection. In order to compare the performance of a normal turbulent-head and one employing the Stewit design, tests were carried out on two engines of 94 mm. bore by 110 mm. stroke (swept volume 763 c.c.) the same compression ratio of 4·8 to 1 being used in both cases. The results are shown in the accompanying table.

Further interesting data were obtained in the spring of 1936 at a Swiss motor-cycle track using a standard single-cylinder 500 cc. Motosacoche machine fitted with a Stewit cylinder head. With a compression ratio of 5·6 to 1, 27·4 B.H.P. was developed at 2,000 r.p.m., the fuel consumption figures being ·480, ·473 and ·492lb. per B.H.P. per hour for gas-oil, No. 1 petrol and alcohol respectively. Under exactly similar conditions, but with a 13 to 1 compression ratio, the output was 26 B.H.P. and the fuel consumption ·362lb. per B.H.P. per hour, using gas-oil.

White-engined Steamship "Llanashe".

"The Marine Engineer", January, 1937.

The single-screw cargo steamship "Llanashe", built by Bartram & Sons, Limited, for the Clarissa Radcliffe Steamship Co., Ltd. (Evan Thomas Radcliffe & Co., Ltd., managers), of Cardiff, ran a series of loaded ship trials on the Hartley mile, off Whitley Bay, a few weeks ago. The vessel's dimensions are 410ft. length between perpendiculars, 56ft. 7in. breadth moulded, and 36ft. 2in. moulded depth to shelter deck; she carries 9,200 tons deadweight on 25ft. 0½in. draught.

The hull form is closely similar to one specially tested at the National Physical Laboratory, and which has been developed by the builders during many years' experience of tank-tested models. The vessel has the modern design of fore-end with raked stem and a cruiser stern; she is fitted with a double plated rudder with fin of the builders' own design, the bronze propeller was specially designed by the builders in collaboration with the N.P.L. staff.

Machinery.

The propelling machinery consists of a White Economy steam engine built by White's Marine Engineering Co., Ltd., Hebburn-on-Tyne. In this machinery, as is now well known, a double-compound high-speed reciprocating engine works in conjunction with a low-pressure exhaust steam turbine, both being geared to the same propeller shaft.

The coal-burning boiler installation comprises two three - furnace Scotch boilers provided with Howden's latest forced draught and turbulent flow air heaters, while Sugden's superheaters are fitted in the combustion chambers of both boilers.

Conditions at the time of the trial were considered to approach general service conditions, there being a heavy swell and a half gale blowing across the course, the wind force being Beaufort scale 7. The coal used was unscreened mixed North country coal, calorific value 13,850 B.Th.U.'s which had been ordered by the owners for their ordinary use, and included a fair percentage of slack.

Fires were cleaned at the end of each watch as usual, and the trials were run as near as possible to service conditions.

After eight runs over the mile to establish the relation between speed and revolutions, the highest average speed attempted being 10·7 knots, the vessel underwent a consumption trial. This was originally intended to be of eight hours' duration, but the Owners' representatives indicated their entire satisfaction after six hours. During that time the average revolutions were 56·2 per minute, giving a speed of 9·99 knots, with boiler pressure of 230lb. per sq. in., and a final steam temperature of 640° F. The total consumption of coal over the six hours running for all engine room purposes was 66¼ cwts., equivalent to 13¼ tons per day, or approximately 0·9lb. of coal per I.H.P. per hour, establishing what is claimed to be a record consumption for a fully loaded 9,200-ton cargo steamship running at 10 knots. The fact of this performance being made under conditions which approximated those encountered in service makes the result all the more important.

The main engines are of the White patent combined type, designed to develop about 1,800 I.H.P. at full power with steam of 230lb. per sq. in. pressure and 680° F. total temperature. The reciprocator is a high-speed, totally-enclosed, balanced, force-lubricated, double-compound engine and is geared directly on to the main gearwheel through a single pinion; the exhaust turbine transmits its power through double-reduction gears. The turbine exhaust is led direct to the condenser, which is of the latest regenerative type. The h.p. and l.p. valves in the reciprocating engine are of the piston type; the h.p. exhaust steam is reheated on its passage to the l.p. steam chest from the high-pressure steam on its way to the h.p. valve chests. The engine exhaust to turbine is also reheated by the auxiliary steam before it passes to the auxiliaries. When running astern, the reciprocator exhaust is passed direct to the condenser, and live steam is admitted to an astern impulse turbine. T. & K. mechanical lubricators are fitted.

The reciprocating engine was built at the Hebburn works of White's Marine Engineering Co., Ltd., the gears were supplied by the Power Plant Co., Ltd., West Drayton, and the turbine by R. & W. Hawthorn, Leslie & Co., Ltd., St. Peter's, Newcastle-on-Tyne. The condensing plant has been designed to maintain a high vacuum with maximum sea temperatures, circulating water being delivered to the condenser through an independent circulating pump. Other auxiliaries include an independent air pump and augmentor, feed pumps, feed heater, and evaporator.

The two coal-burning main boilers are 13ft. in diameter by 11ft. 6in. long, and have Sugden superheaters fitted in the wing combustion chambers. For harbour use, there is an auxiliary boiler 12ft. in diameter by 10ft. 6in. long; this is also arranged for 230lb. working pressure, but operates under natural draught conditions.

On a loaded run from the Tyne to Gibraltar, the vessel's speed in normal weather was over 10 knots, but the three days' heavy weather which she encountered reduced the average speed for the entire run to 9·56 knots. The consumption was 15 tons per day of unscreened North Country coal having an ash content of 14 per cent. The accompanying table gives fuller particulars.

TABLE.—VOYAGE RUN, "LLANASHE"—TYNE TO GIBRALTAR.

Day and Date. Dec., 1936.	Boiler Pressure.	H.P. Chest Pressure.	Vacuum.	Average Speed, Knots.	Average Slip. %	Coal per Day.	Sea Temp., °F.	Feed Temp., °F.	Weather Changes.	Mod.	Heavy.
			Ins.								
Tues. 1	225	207	$29\frac{1}{4}$	10·14	0·1	8·05	51	214			Mod. Gale.
Wed. 2	230	215	„	8·66	14·6	15·00	50	216	Head Wind.		24 hrs.
Thurs. 3	230	220	„	7·9	20·03	15·00	55	220	Head Wind.		24 hrs.
Fri. 4	230	225	„	9·73	6·09	15·00	56	224	Weekly Wind (Bow).	8 hrs.	16 hrs.
Sat. 5	230	225	„	10·26	3·69	15·00	58	„	Following Wind.	12 hrs.	12 hrs.
Sun. 6	230	225	„	10·33	2·59	15·00	60	„	Following Wind.	24 hrs.	
Mon. 7	230	225	„	10·00	6·67	15·00	62	„	Head Wind.	12 hrs.	12 hrs.

Mean draught—Sailing = 24′ $11\frac{1}{4}$″
Mean draught—Arriving = 24′ $6\frac{3}{4}$″

Average r.p.m. = 55·37.
Average speed = 9·561 knots.
Average apparent slip = 7·894%
Average daily coal consumption = 15 tons.

There are now six new cargo vessels and one trawler fitted with this type of machinery, and all are giving highly satisfactory service results; several orders are in hand, including three for repeat installations.

These consumptions and speeds have been consistently maintained on all voyages.

Kort System of Propulsion.

By KURT HELM.

"The Marine Engineer", January, 1937.

Shipbuilding literature for the last few years has contained quite a number of publications dealing with the theory of Kort propulsion. In this article, the first part of which appeared in last month's issue of "The Marine Engineer", the author deals with the practical considerations associated with the application of the Kort nozzle to tugs and trawlers.

Trials, which were carried out on a model of the trawler "Volkswohl", revealed that on bollard tests with the engine developing 500 *S.H.P., a gain of* 32 *per cent. in pulling power was possible after the nozzle had been fitted. Furthermore, it is claimed for this system of propulsion that it considerably increases a vessel's speed in a seaway, the same test ship, having a speed of* 3·1 *knots in a sea, with waves of* 160*ft. wave-length, without the nozzle and* 3·5 *knots under similar conditions with the nozzle fitted.*

Last month's contribution concluded with a reference to the action of the nozzle with regard to the pitching movement of a vessel when steaming in a rough sea.—ED., M.E.

In order to find out whether such action of the nozzle takes place, the dipping and pitching movements of the model were measured continuously by moving picture photos showing, by means of indicators, the extent of the dipping and pitching motion of two intermittent time lights. One of these time lights flashed every half second, while the other flashed every time a wave-crest passed the bow of the ship. (The records thus obtained were re-read picture by picture and the results worked out and plotted as shown in Figs. 6 and 7).

The value of a given shape in seaway depends on the one hand on the seaway, the propeller and the ship's speed, and on the other hand on the following factors, which may be influenced to a certain extent by change of the ship's shape:

(*a*) The extent of the dipping movement.

(*b*) The extent of the pitching movement.

(*c*) The combination of (*a*) and (*b*) and the position of the pitching centre depending thereon.

(*d*) The relative positions of ship and wave to each other at various stages and the consequent varying position of the propeller.

It is known that dipping movements have the greatest influence on the amount of power required for a certain speed. This has been investigated by many model tests in seaways independent of these particular tests, with the result that it is known that the loss of speed is greatest when there are comparatively large dipping movements and practically no pitching movements; as soon as this dipping movement, however, is turned into a pitching movement by a small alteration of the length of the wave, the speed of the ship with the same H.P. is increased considerably. Nevertheless, apart from the dipping movement, the pitching movement also calls for an increase in H.P. in order to maintain a given speed, since constant energy is required to destroy the forces set up by the pitching action.

The loss of speed finally depends on the specific load on the propeller and the amount of air sucked in when pitching, both tending to decrease the propulsive efficiency. The greatest loss of propeller efficiency exists where the propeller has the greatest emersion from the water.

The pitching angle and the amount of pitching movement found during the tests are given in Fig. 6. On an average these angles were ± 4° for the ship without Kort nozzle and ± 3° 55′ for the ship with Kort nozzle. The Kort nozzle therefore has little or no benefit on the size of the pitching movement.

The extent of the dipping movements cannot be read directly from Fig. 6, as the curves of the dipping movement depicted on the diagram show the movements of the midship section only. It is therefore necessary to find the position of the pitching centre longitudinally and vertically. For this purpose various longitudinal positions of the ship were drawn up for each of the two lengths of wave which passed the model. In each case, *i.e.*, without and with nozzle, one wave was chosen which produced a large, and another which produced a small dipping movement, in order to find out the upper and lower limits of these movements (see Fig. 6, I and II).

The waves which were generated were divided up into 10 parts of equal length. It was assumed that the ship was in a state of rest and the wave passed along the ship. At each of the 10 different divisions of the wave the ship took up 10 different angular positions as compared with the position of her water line with the water at rest. These angular positions are shown on Fig. 7 and 8; in these figures the longitudinal dimensions are made half of the vertical dimensions. As a result of the foregoing tests the following limits were found:

(*a*) Ship without Kort nozzle:
Pitching centre about 2ft. 1½in. behind midship section. Height of dipping movement between 24in. and 12in., average 18in.

(*b*) Ship with Kort nozzle:
Pitching centre about 7ft. 4in. behind midship-section. Height of dipping movement between 16in. and 8in, average 12in.

The comparison shows, that the ship with the Kort nozzle has a much smaller dipping movement and this means as was explained before, a reduction of the ship's resistance in favour of the nozzle and, in consequence, a saving of H.P. for a given speed.

The comparison shows furthermore that the pitching centre is moved considerably further aft. This means, that for the same wave length and speed there is less emersion of the propeller and less suction of air, both improving the propulsive efficiency and thereby causing a saving in H.P.

In Fig. 8 various typical positions of the ship shown in Fig. 7 are drawn

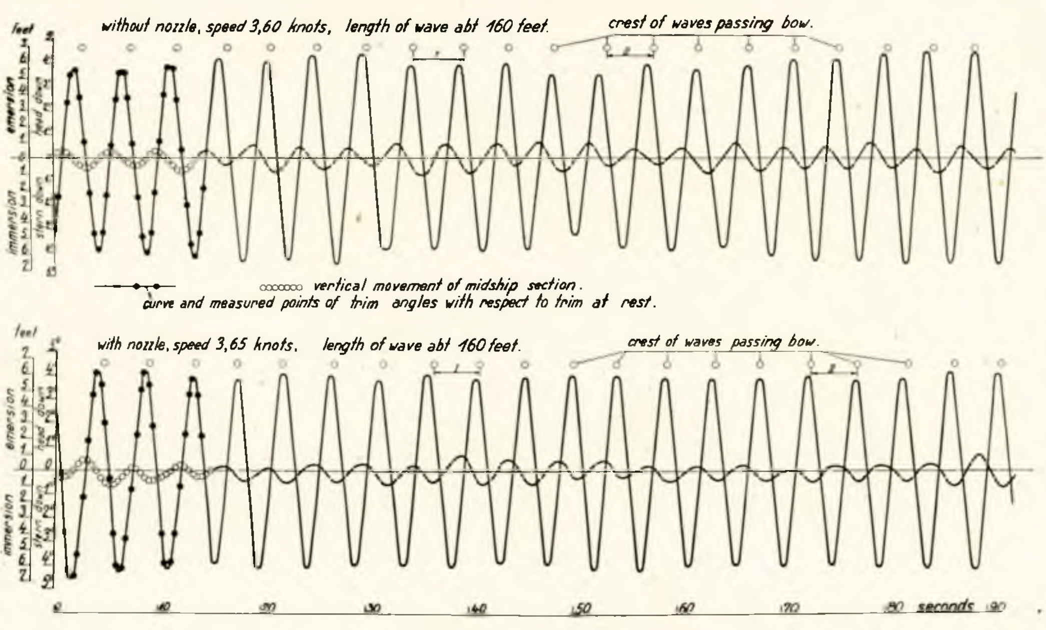


FIG. 6.—Graphs showing extent of pitching and dipping motion in a seaway from model tests of the trawler "Volkswohl"

into the outline of the corresponding wave contours showing for the various stages the longitudinal position with regard to the ship. The dotted lines indicate the movements of the uppermost point of the propeller tips with regard to the wave surface.

It will be seen that on the ship without Kort nozzle the dotted curve repeatedly intersects the waterline showing that the propeller tips emerge above the water while on the ship with the Kort nozzle the propeller tips are at no time even touching the water surface.

This does not necessarily mean that it is impossible for air to enter the propeller; the air may enter when there is still some water above the tips in those cases where the specific load on the propeller is high. It was observed that on the ship with nozzle some air was drawn in, though the quantity was considerably less. These remarks are fully confirmed in Fig. 8. When in addition to the nozzle the inlet tunnel is fitted, the entrance of air was avoided almost entirely and this is the reason why the propulsive losses were furthermore lessened by the tunnel.

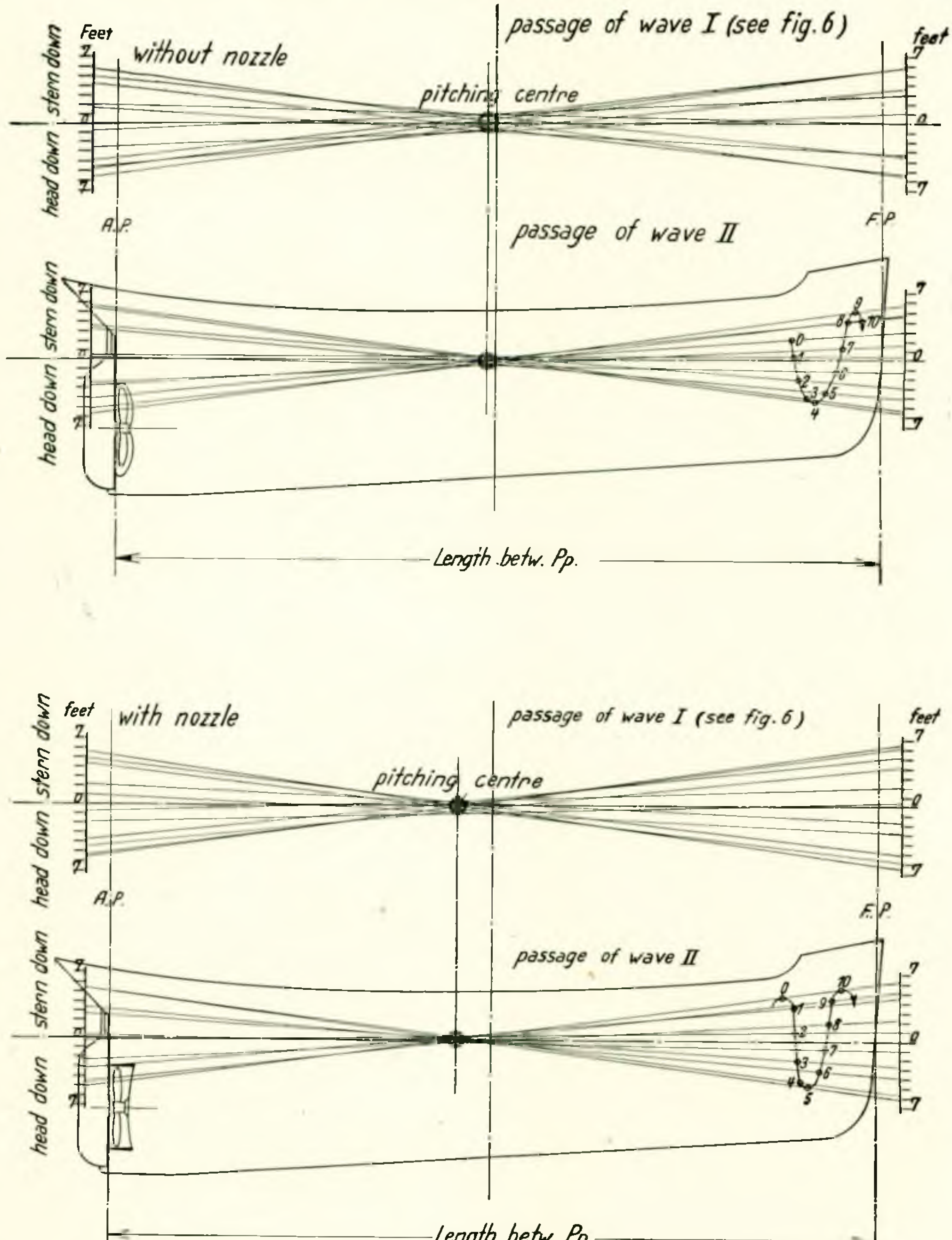


FIG. 7.—Angles of trim and centre of pitching during the passage through one complete wave from model tests of the trawler "Volkswohl".
Maximum wave movement (1)
Minimum wave movement (2)

To sum up: The results of the readings of the pitching and dipping movements prove that on a ship running in a seaway there is, in addition to the direct action of the nozzle (increased pushing power by avoiding the jet contraction) an indirect action (influence on the ship's movements) resulting in a reduction of the resistance of the ship and diminishing the amount of air which is sucked into the propeller, thereby increasing the propulsive efficiency. The indirect action of the nozzle explains why the results of the seaway trials were so much better than the results in smooth water.

In order to analyse the conditions to be expec-

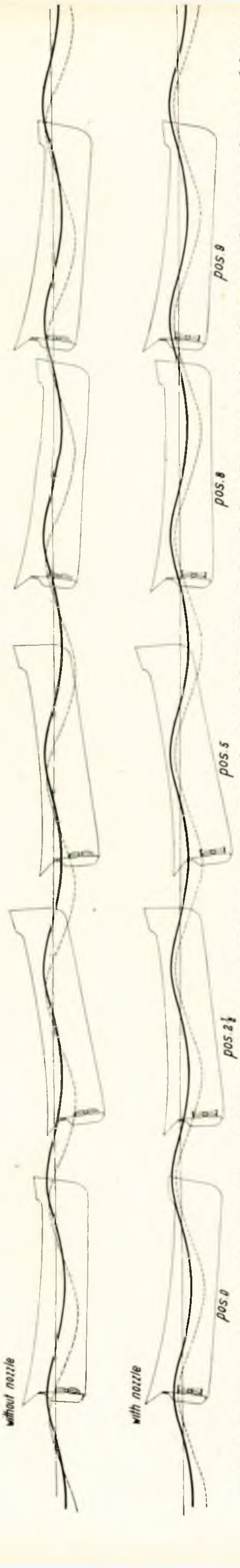


FIG. 8.—Various relative positions of ship, height of propeller tips and contour of waves developed from Fig. 7, i.e., during the passage through one complete wave, from model tests the trawler "Volkswohl".

ted when trawling in seaway, some pulling tests were carried out with the model. The wave used during these trials had a length corresponding to 154ft. and a height corresponding to 5ft. 6in. The trials were carried out for the speed 0 (mooring test) and 3·2 knots. The results are shown in Fig. 9. In these tests also a considerable improvement due to the application of the nozzle was found, namely, about 40 per cent. increase of pulling power at the bollard test and more than 45 per cent. at 3·2 knots. At these trials the influence of the inlet-tunnel was not tested. It is, however, correct to assume that the further advantages found by the application of the tunnel (reduced pitching movements and less air to the propeller) will make themselves felt to their full extent in this case also.

The model trials have thus shown that the application of the nozzle brought advantages for every one of the conditions under which the ship was tried and the results were so convincing that in April, 1935, two trawler firms, the Nordsee Deutsche Hochseefischerei Bremen-Cuxhaven A.-G. and Ludwig Janssen & Co., Wesermünde, decided to have their trawlers "Kassel", "Jane" and "Jeverland" converted to Kort Nozzle Drive by the shipyard Schiffbau Gesellschaft Unterweser A.-G., Wesermünde-Lehe.

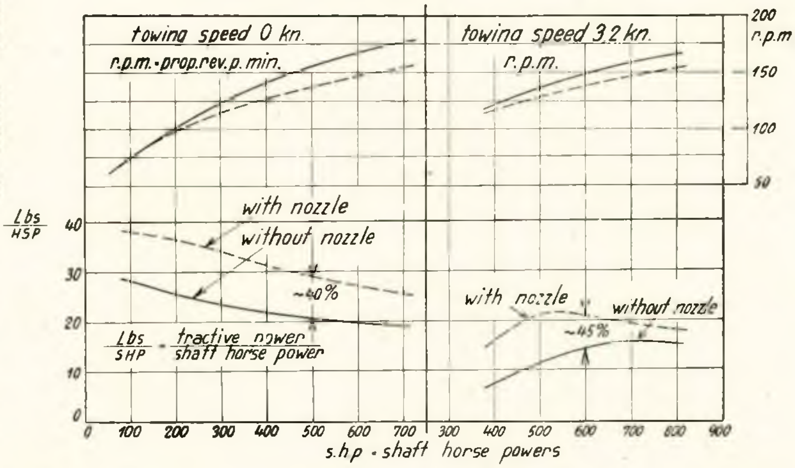


FIG. 9.—Tractive power per s.h.p. and corresponding r.p.m. with various horsepowers in both the moored and towing conditions at 3·2 knots—all taken in a seaway from model tests of the trawler "Volkswohl"—waves 154ft. length 5ft. 7in. height.

The first of these ships, the 400 I.H.P. trawler *Kassel*, has been converted at the time of writing (see Fig. 10). The results of her trial trips before and after conversion measured in co-operation between the owners and the shipyard, are given on Fig. 11.

The speed running free over the measured mile on the lower Weser River, taking the average between the two courses up and down the river, was 10·5 knots before and after conversion. The engine power required was 387 I.H.P. without the nozzle, and 379 I.H.P. with nozzle, *i.e.*, a saving of 2 per cent. of engine-power. The r.p.m. were practically the same at both trials. The comparison of the mooring tests showed that at the same H.P. the pulling power was increased by 35 per cent. in favour of the nozzle. These actual results agree closely with the results of the tests of the model of the "Volkswohl". It was found, furthermore, that the loss of revolutions at high loads (*e.g.*, when trawling) was a good deal less with the nozzle than without. In practice this amounts to a further appreciable advantage in favour of the nozzle, as with the same torque on the shaft, that is, with the same cut-off of steam in the engine, a greater engine power is available for towing. It is therefore possible on a trawler fitted with the Kort nozzle to use the available boiler plant to better advantage when the ship is trawling or is held up by wind or sea.

At the mooring test of the "Kassel" with maximum cut-off on the engine and full boiler pressure the propeller r.p.m. were 79 before and 90 after the nozzle was fitted. The corresponding engine powers were 280 and 330 respectively and the corresponding pulls rose from 4·42 tons to 6·7 tons. As there is always plenty of steam under towing conditions this gain of more than 50 per cent. of pulling power is always fully available for towing purposes though, of course, at the same time the engine power also is increased somewhat, namely by about 18 per cent.

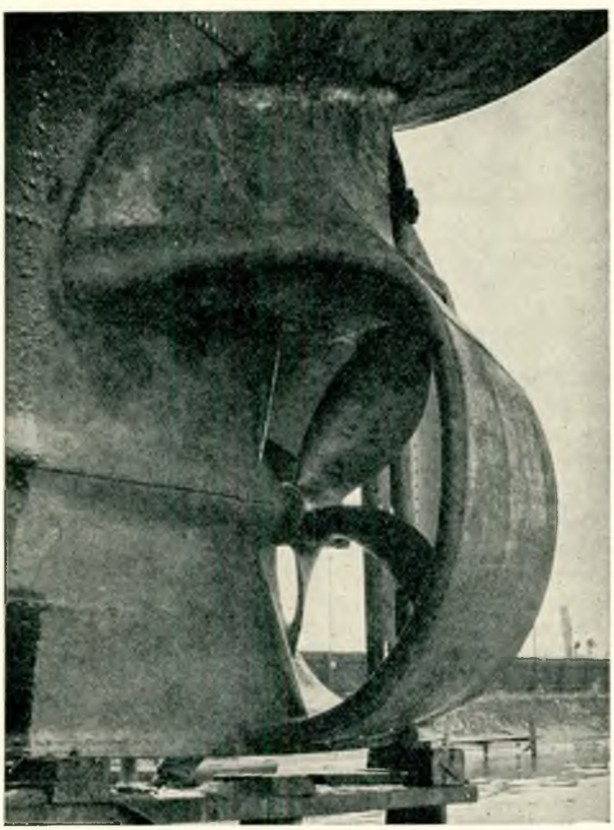


FIG. 10.—Stern of the Kort-nozzle-propelled tug "Kassel".

Based on the experience of years of model practice and the close agreement between the model tests and the performance of an actual ship for the mooring test measurement, it is correct to assume that for all intermediate speeds, *i.e.*, between speed

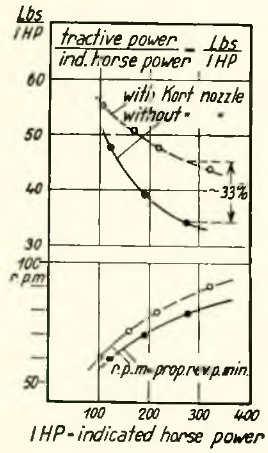


FIG. 11.—Tractive power per I.H.P. and corresponding r.p.m. at mooring post. Trials taken before and after the fitting of a Kort nozzle to the trawler "Kassel" (actual tests, not tank results).

0 at the bollard and the running free condition, the pulling power will decrease in a similar way as that found for the model of the trawler "Volkswohl". On the "Volkswohl" the decrease in pulling power between the bollard and trawling speed was about 30 per cent., which means that the pulling power of the "Kassel" with nozzle at a mean trawling speed of 3·5 knots will be 35-30 per cent. more, with 18-13 per cent. more I.H.P. Assuming the resistance of the trawl net increases directly as the square of the speed the increased pulling power will be capable of increasing the trawling speed by 0·4 to 0·5 knots.

It is safe to anticipate that the "Kassel" will prove a good practical success, when judged by the results of the model experiments described above. There are already to hand most satisfying reports on experience gained in practice with the sea- and harbour tug "John Hamilton", fitted with the Kort nozzle. She is stationed at Falmouth on the western outlet of the English Channel, a district well known for very rough weather.

Reviewing once more the model trials for the trawler "Volkswohl", the practical trials with the trawler "Kassel"—as far as they are available—and the proved seaworthiness of the "John Hamilton", there is sufficient evidence to say that the application of the Kort nozzle to ships of this size and type must necessarily bring a noteworthy improvement of the towing and sea-going performances.

Recent Marine Engineering Progress.

"The Marine Engineer", January, 1937.

Since our last issue an important new marine steam engine development—a Rankin & Blackmore product—has been announced and technical details of the new Petter harmonic-induction diesel have been made available; both are discussed in this short article.

The Rankin & Blackmore triple-expansion engine is an interesting step forward without using untried ideas. It is compact in overall dimensions, accessible, practical, and appears to be cheap to build and easy to maintain.

The arrangement adopted, as the illustration on this page shows, enables vertically-operated individual steam and exhaust valves to be fitted to all three cylinders. There is one steam and one exhaust valve at top and at bottom of the high-pressure cylinder (which faces forward) and of the m.p. cylinder, which faces aft; this is, of course, the usual arrangement with such valves. In the case of the l.p. cylinder there is one steam valve and two exhaust valves at the top and at the bottom. The valves are of the Andrews & Cameron type. The usual Stephenson link motion gear operates the cam rocking shafts direct for the h.p. and m.p. cylinders; for the l.p. engine it works through a bell-crank to a single cam on the starboard side for the steam inlet valves and to double cams on the port side for operating the two exhaust valves.

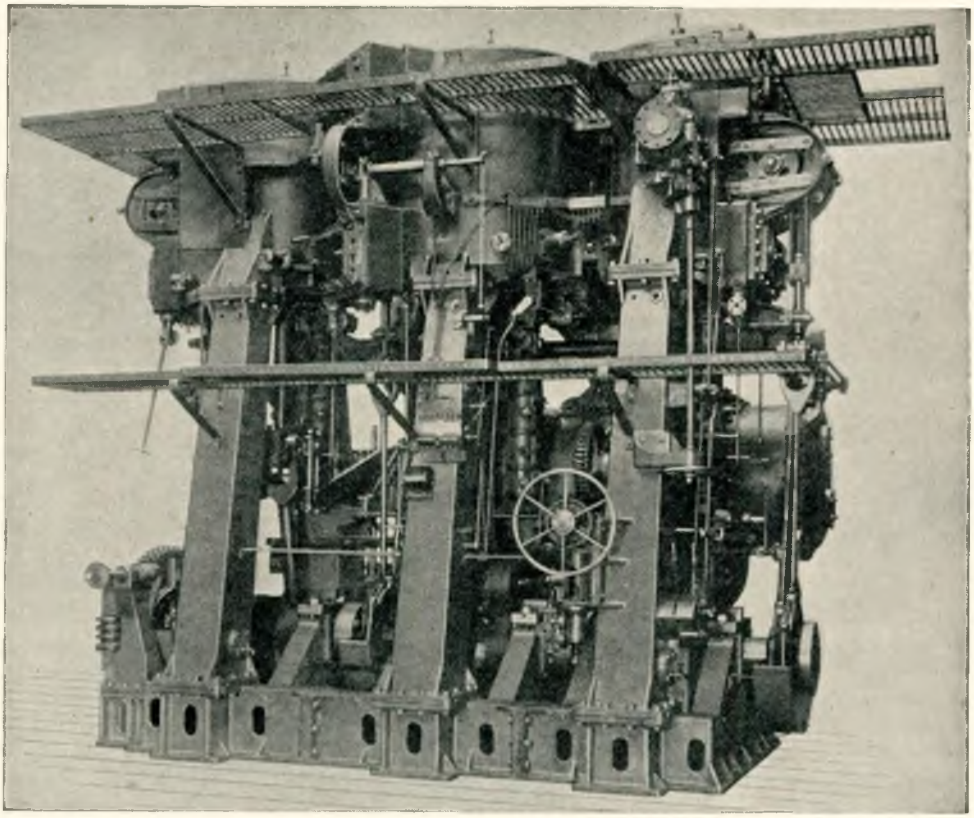


FIG. 1.—Rankin & Blackmore triple-expansion engine has separate steam and exhaust valves for all three cylinders.

The design and arrangement adopted permits of a very short overall length, and at the same time affords maximum accessibility to all valves, valve gear, etc. Immediate inspection of any of the valves can be made direct from the platforms by removing the small door over the valve. All the valves used are of the latest quadruple-opening balanced type.

The engine shown has cylinders 17in., 28in., and 50in. by 33in. stroke, and has been fitted in the cargo vessel "Dotterel". Steam is supplied from forced draught Scotch boilers at a pressure of 220lb. per sq. in. and the boilers are fitted with superheaters of North Eastern make; Kirkham lubricators attend to the cylinder lubrication. On trials an average of six runs brought out 101·5 r.p.m. at 1,232 I.H.P. and gave the ship a speed of 12·9 knots.

White Engine Progress.

The large cargo steamship "Adderstone", noteworthy as the first vessel to be fitted with White combination machinery, continued to give a satisfactory account of herself during the year; for a new and untried installation her machinery has proved singularly free from teething troubles, while her Sugden combustion chamber superheaters (also new at that time) have proved excellent. The appended table shows a comparison over a number of voyages of the "Adderstone" before and after conversion, these data having been furnished by the owners.

	Before Conversion.	After Conversion.
Steaming time, days	262¼	332½
Distance, nautical miles	63,868	72,885
Total oil consumed, tons	7,430	4,430
Average oil per day, tons	28·43	13·2
Oil per I.H.P. per hr., average ...	1·05	0·68

$$\text{Saving} = \frac{1{\cdot}05 - 0{\cdot}68}{1{\cdot}05} = 35 \text{ per cent.}$$

New Winton Injection Arrangements.

One of the most interesting recent diesel developments of the year was announced just as we closed for press by Winton Engine Company, of Cleveland, Ohio. It is known as the unit injector system and operates without the use of long individual pipe lines, or rails, to the individual cylinders. This achievement resulted from the successful operation of the latest diesel-driven streamlined trains now being run throughout America, although, of course, the unit system has wider applications. From this field Winton have developed a comparative unit for smaller engines suitable for the average pleasure craft. These unit injectors are now installed in the Model 233-A, 200 B.H.P., and Model 241, eight-cylinder engines which are to be exhibited at the 32nd annual National Motor Boat Show in Grand Central Palace, New York, January 8 to 16.

Through the unit system, individual injection in each cylinder under what is declared to be an absolutely even pressure is attained. This, it is declared, produces complete atomization. "The application of this unit fuel injection system to Winton's latest marine engines is the greatest single advance ever effected in building marine engines for modern pleasure craft", said George W. Codrington, president of the Winton Engine Company. "By smoothing out the fuel injection difficulties frequently encountered in conventional engines, this unit injector now provides for pleasure-boat owners a character of diesel engine performance never before available in this field". The new Winton models, instead of having the long pipe-lines running from the high-pressure pump which may develop a form of pressure lock because of the inability to maintain an absolute evenness under any and all speeds of the engine, use the new unit system which delivers the fuel at an even injection in exactly the right amount at all times.

Another feature of these units, which are installed separately in each cylinder head, is that instead of a maximum pressure of 10,000lb. per sq. in. permissible in some conventional airless-injection systems, a pressure of 20,000lb. or more may now be used. This, it is claimed, eliminates the uneven flow due to choking, and also permits better atomisation.

Attached much like a sparking plug in an ordinary petrol engine, these injector units operate through a sort of double check valve. The valves are actuated much as are those in an ordinary overhead valve diesel or petrol engine—through a push rod and rocker arm. This assures opening and closing the nozzle at exactly the correct instant. With the high, even pressure behind the nozzle, the charge of fuel is sprayed into the combustion chamber in every direction, thereby covering every part and assuring clean, even burning. Another factor in the use of these unit injectors is that should a nozzle become fouled or clogged in any way, it may be removed, cleaned and replaced in the same manner as a sparking plug would be renewed in a petrol engine, although in this respect the Winton engine is not unique.

Among the yachts already powered with the new type engines are the 101ft. "Gem", owned by William Zeigler, Jr.; the "Consort IV", a 90-footer owned by T. Munroe Dobbins; the "Alma F", a 75-footer owned by Alfred J. Fisher; the 65ft. motor sailer "Devshir", owned by Louis E. Emerman; the "Helen H", a 74ft. yacht owned by E. A. Hughes, and a new 92½ft. yacht recently launched for a prominent Eastern States yachtsman.

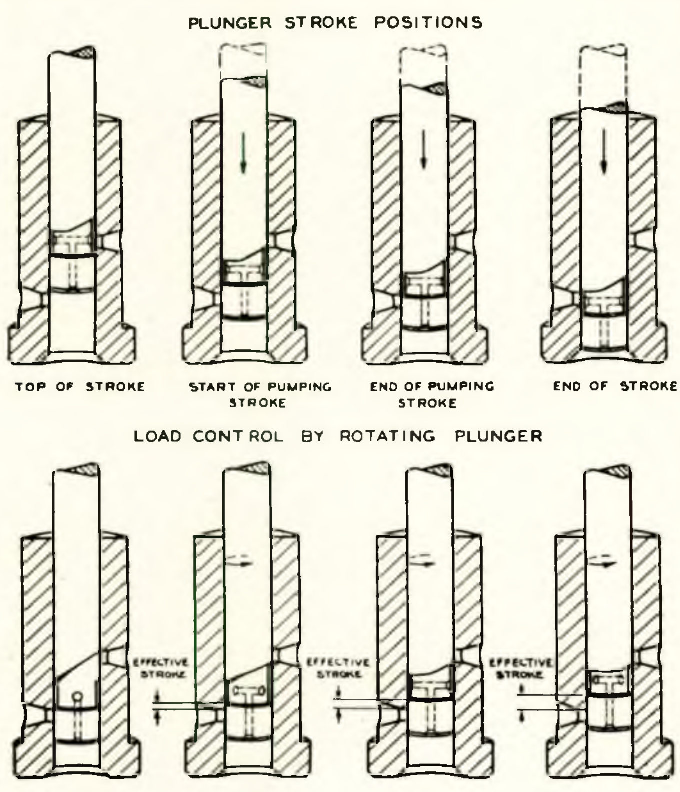


FIG. 2.—Operation and control diagram.

Operation of the Injector.

Fuel oil is supplied to the injector at a pressure of about 20lb. per sq. in. and enters near the top on the left side of the body. After passing through the filter in the inlet passage, the fuel oil fills the annular supply chamber around the bushing. The surplus fuel supplied by the pump flows out of the annular supply chamber through the outlet passage on the right side of the body. The fuel pressure in the injector is maintained by discharging the overflow fuel through a small hole in a restriction plug, which sets up the required resistance. This plug is placed in the outlet end of the drain manifold.

Injection stroke.—From the description of the injector and its parts, it is evident that the plunger has two motions, reciprocating motion to pump the fuel and a rotary motion to vary the amount of fuel according to the load. The sectional diagrams of Fig. 2 indicate these motions. The upper diagrams show the reciprocating or plunger-stroke positions, and the lower diagrams show the plunger-rotary or load control positions. The upper series of diagrams of Fig. 2 show in detail how the start and end of the pumping stroke are controlled by the upper and lower lips on the plunger. These diagrams make it evident that the total downward stroke of the plunger is divided into three parts. The first or upper part of the stroke allows the plunger to be accelerated to the required velocity before pumping begins. The second or pumping part of the stroke controls the quantity of fuel injected. The third or over-travel part of the stroke slows down the plunger velocity to the end of the stroke.

Load and timing control.—Fig. 2 shows that the pumping stroke is controlled by the upper and lower lips on the plunger passing over the ports. The lower set of diagrams in Fig. 2 show how the distance from the lower lip to the lower port is varied by the rotating of the plunger and the resulting variation in the effective pumping stroke. The method of rotating the reciprocating plunger by means of a gear and rack is shown in cross-section drawing Fig. 3. These diagrams, Fig. 2, show that the pumping part of the stroke begins when the helical upper lip on the plunger covers the lower edge of the upper port. Rotating the plunger, so as to increase the effective pumping stroke, also makes the effective pumping stroke

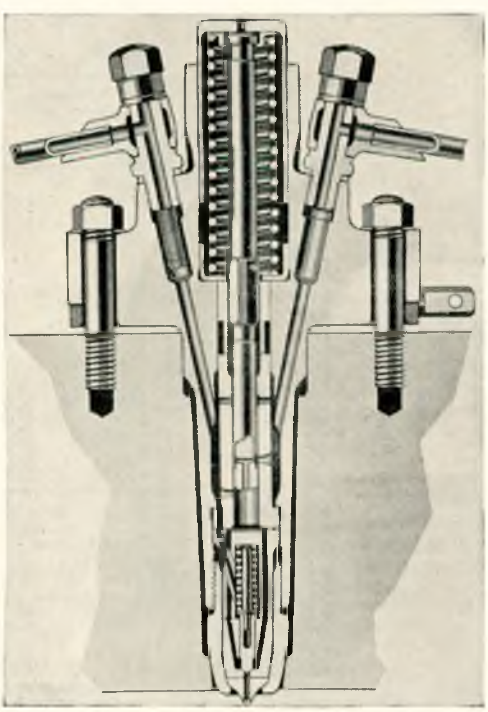


Fig. 3.—Section through the Winton unit.

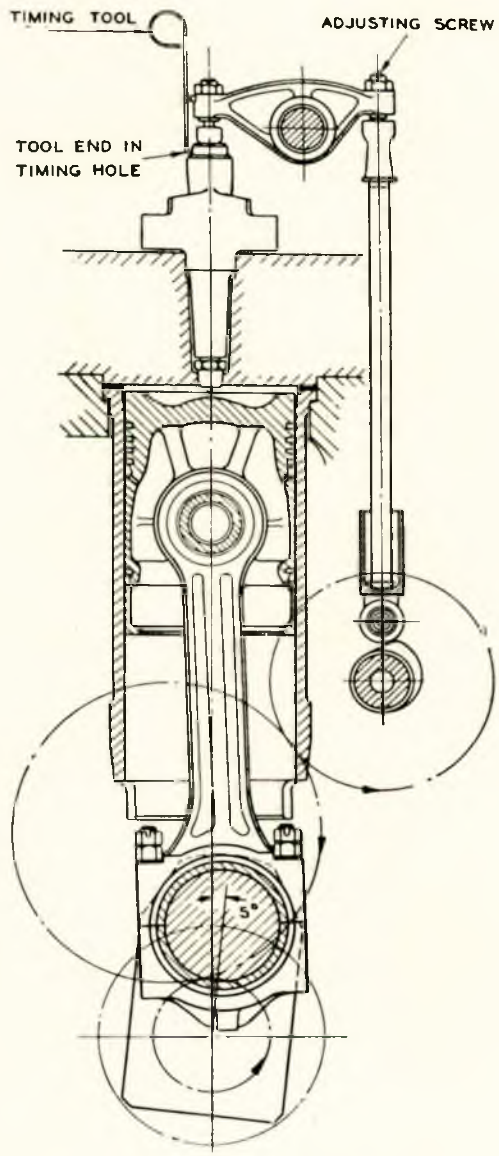


Fig. 4.—Injection setting.

start earlier during the cycle. When the load is increased, the plunger rotation automatically advances the beginning of injection.

Automatic fuel valve.

Fuel enters the annular space around the valve seat and when the fuel pressure, acting on the stepped area of the valve needle, has been built up high enough to compress the spring, the needle is lifted from its seat. Fuel is admitted to the spray tip and is forced through the spray orifices into the cylinder. Due to the high velocity of the plunger at the full speed of the engine, and due to the restrictive action of the small spray holes, the final oil pressure is built up to a much higher value than the pressure at which the needle valve opens.

The spring-loaded needle valve performs three important functions in the operation of the injector. First, it serves as a check valve between the combustion chamber and the injector. Second, it gives positive control for the start and stop of the fuel spray into the cylinder. Third, it provides the necessary atomisation of the fuel for prompt ignition at low speeds. Atomisation is a function of the relative velocity between the fuel and air, or, it may be said, a function of the velocity of the fuel through the orifices. Since the needle cannot open until the fuel pressure has been built up high enough to compress the spring, it follows that the initial fuel spray velocity is always sufficient for good atomisation, even at low speed and light load. This fine atomisation of the first part of the spray insures prompt ignition of the fuel, so that the remainder of the fuel spray burns as it enters the cylinder. This makes it possible to control the combustion pressure by the shape of the cam which operates the injector plunger.

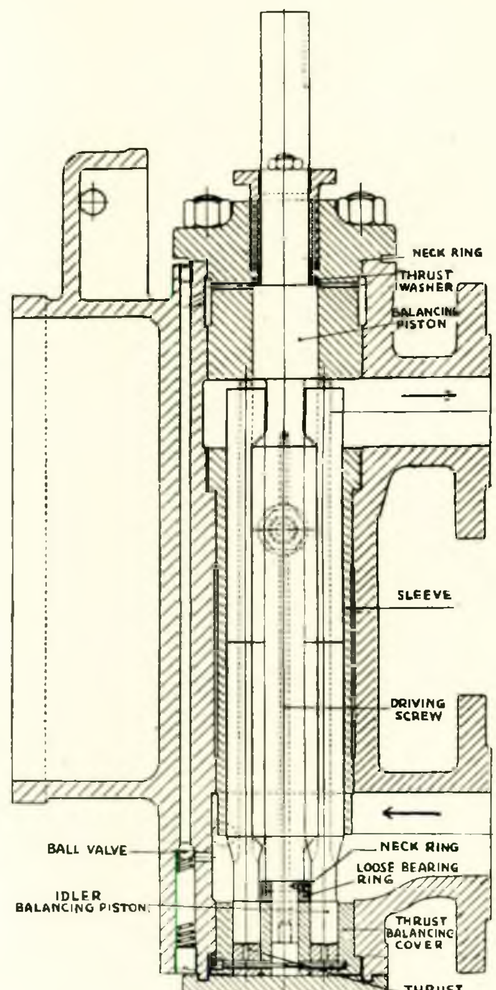
Complete cycle of operation.

Referring to Fig. 3, the complete cycle of operation of the injector is as follows: As the plunger is moved downward by the rocker arm, fuel in the bushing chamber is first displaced through the lower port into the supply chamber around the bushing until the lower edge of the plunger closes this port. Fuel in the bushing chamber is then displaced through the central and transverse holes in the plunger and through the upper port into the supply chamber. Further downward movement of the plunger causes the helical upper lip to cover the upper part, and the fuel in the bushing chamber is then forced down through the passages in the spring cage and the needle guide to the annular space around the spring-loaded needle valve.

The fuel oil pressure, acting on the stepped area of the needle valve, lifts the valve needle off the seat, and the fuel passes in the spray tip and is forced through the orifices into the cylinder. Injection continues until the lower lip on the plunger uncovers the lower port in the bushing, and then the fuel by-passes upward through the holes in the plunger and through the lower port into the supply chamber. This lowers the pressure of the fuel remaining in the bushing chamber until the needle valve spring closes the valve. On the return stroke, the upward movement of the plunger fills the bushing chamber with fuel oil which flows from the supply chamber, through the lower port.

Yacht installations embodying this fuel injection system have proved highly satisfactory, and, unquestionably, this engineering advance will receive wide discussion in the marine field. The three Winton diesel marine engines to be displayed at the 1937 National Motor Boat Show, Grand Central Palace, New York City, will have this system of fuel injection and its behaviour in service will be watched with interest.

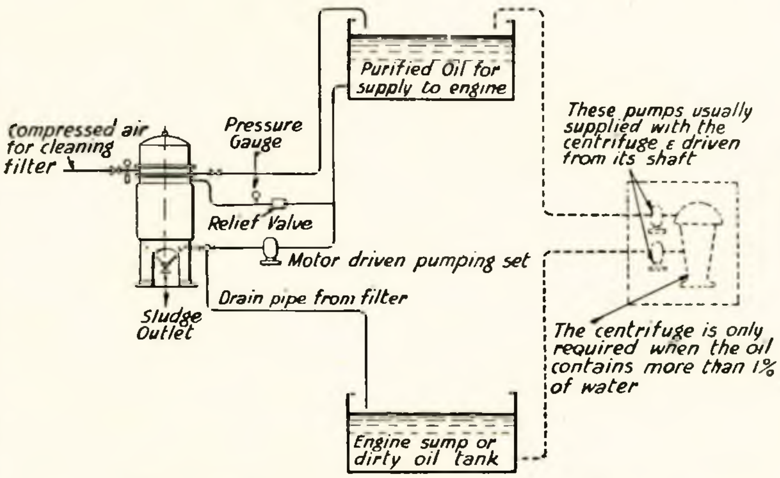
The R.N. high-speed diesel engine is a design that has enjoyed popularity since its introduction about six years ago. The original combustion chamber design was, and still is, ingenious and efficient, and has been used without modification until comparatively recently. In the early R.N. head patent, which is used by various licensees of Russell, Newbery & Co., the injector is placed vertically in the head, and the "off-set" cylindrical combustion chamber has flat ends. In the latest patent head the injector is set at an angle, so that the last traces of injected oil are deflected off the hot turbulence block into the turbulent concentrated air stream, thereby greatly assisting combustion and preventing the formation of carbon deposits in the combustion chamber at light loads. A further R.N. patent covers the curvature of the ends of the combustion chamber whereby the valves have a more effective opening and the volumetric efficiency is increased. The modifications are said to result in quieter and cleaner running, an increased power output of approximately 10 per cent., and a reduced fuel consumption.



Mirrlees-Imo marine pump.

Auxiliary Developments.

The Imo pump, which is shown in the sectional view on page 190, has been used extensively on the Continent of recent years and is now being built by Mirrlees, Bickerton & Day, Ltd., of Stockport, who are sole licensees for the British Empire, excluding Australia and Canada. The pump consists of a power or driving rotor, with two idler or sealing rotors which are placed symmetrically and rotate in a sleeve. They rotate and propel the surrounding *medium axially in* a perfectly continuous flow. The threads act as a continuous piston which always moves in a forward direction. The medium is not brought into rotation, but flows smoothly without turbulence or pulsation.



Layout of the Stream-Line filter for marine service. The filter, it will be seen, is used in conjunction with a centrifuge.

The chief characteristic of the pump is the shape of the thread faces. A detailed analysis of the form of the latter shows that it is possible to calculate the dimensions mathematically so as to obtain a perfect fit. It is also possible to manufacture the rotors exactly in the theoretically correct shape. This thread shape is protected by several patents.

Among the claims made for the Imo pump are simplicity, efficiency (a figure of over 90 per cent. has been registered with small pumps and motors of about 10 H.P. running with lubricating oil), small no-load losses, high working speeds, silence and light weight. In passing it may be mentioned that both the Swedish and Norwegian Navies have Imo installations on a number of their vessels.

While the Imo system of rotors lends itself particularly well to the construction of pumps, it should be pointed out that it is equally suited for use as a motor. These machines, which are made in various sizes up to about 50 H.P., are insensitive to heat and mositure and may be immersed in water. A number of steering gears are being operated successfully with these motors, other uses being for anchor windlasses, winches and capstans.

It must have become increasingly clear to followers of marine engineering progress during the past two or three years that the Stream-Line filter is being adopted for many marine installations. For instance, the recently-built Coast Line motorships, the "Silverlarch" and "Silverpine", the 18 new vessels of the British Tanker fleet, and those of the Burmah Oil Company, are all provided with Stream-Lines for lubricating oil treatment. Furthermore, in the last few months 34 filter installations have been supplied to Dutch owners alone.

The accompanying diagram shows how the filter is used on shipboard. It will be observed that it is complementary to the centrifuge, the Stream-Line unit not being capable of effectively handling oil containing more than 1 per cent. of water. When this amount is exceeded the oil is first centrifuged.

Cylinder-Liner Wear With Pressure-Charged Engines.

"The Motor Ship", January, 1937.

Proof of the fact that, as mentioned in another note, supercharged four-cycle engines run with a degree of reliability equal to that of the unsupercharged type, was afforded in a paper which Mr. John Lamb read before the Society of Consulting Engineers and Ship Surveyors recently. He stated that the practice of supercharging had no effect on the wear rate of cylinder liners and piston rings, and cited two examples which had recently come to his notice. In one case a pressure-charged engine with a cylinder diameter of 630 mm. and operating at a mean pressure of 120lb. per sq.in., showed, after four years' service, a maximum wear on the four cylinders, which were opened up for examination, of 2·75 mm., 2·71 mm., 2·75 mm. and 2·24 mm. The average maximum wear per 1,000 hours worked out at 0·11 mm., or a little over 0·004in. In the second vessel, the wear on three cylinders, also after four years' running, was 2·90 mm., 2·14 mm. and 2·01 mm. respectively. These figures are equivalent to an average maximum wear per 1,000 hours of 0·096 mm., or 0·0038 in. On an average, cylinder liner renewal is necessary when the wear reaches about 6 mm., so that on this basis the life of the liners is in the neighbourhood of nine or ten years.

Experience With Trunk-Piston Engines and Gearing.

"The Motor Ship", January, 1937.

Little information has hitherto been available concerning the operating results, from the shipowner's point of view, of vessels equipped with two-stroke single-acting trunk piston engines in conjunction with gearing. One of the first vessels so equipped was the "Sofia", owned by the Deutsche Levante Linie, which has now been two years in service. She has two two-stroke single-acting trunk-piston engines driving a single propeller shaft through gearing, and the engines are of the same type and cylinder dimensions as those being installed in numerous German geared Diesel ships, also in the various Diesel-electric passenger liners and cargo vessels now being built for the Hamburg-Amerika Line.

In a lecture before the General Meeting of the Schiffbautechnische Gesellschaft in Berlin a short time ago one of the directors of the Deutsche Levante Linie spoke on the subject of the performance of these ships. He stated that during the course of the two years at sea the results had been highly satisfactory and that the low weight and small dimensions of the engine parts had proved advantageous from the standpoint of supervision and maintenance.

The noise which is experienced with such machinery is generally considered to be great, but the author remarked that, as a result of some interesting experiments, this pressing question of machinery noise had been satisfactorily solved. The manœuvring capacity was stated to be excellent, and one advantage claimed for the system was that voyages could be made at reduced speeds, when desired, with only one of the Diesel engines in operation, resulting in substantial economies in fuel and lubricating oil.

Navy Engineering Sixty Years Ago.

"The Engineer", 20th November, 1936.

Following the accession to office of the Disraeli Government in 1874, "an almost unparalleled series of disasters" befel the British Navy. The "Iron Duke" collided in a fog with, and sank, the "Vanguard"; there was a disastrous boiler explosion in the "Thunderer"; a stop valve exploded in the "Hydra"; a compressed air chamber blew up in the "Vesuvius", and the engines of the "Shah" failed to work satisfactorily in service. Certain organs of the daily Press attributed these mishaps to the malign influence of a Conservative Government. In our issue of November 24th, 1876, we did not trouble to controvert this ridiculous assertion but passed straight to the real cause, inefficient machinery and laxity of control. In past years, we said, the engine-rooms of warships were not unduly cramped and the engines were designed with liberal proportions. When Mr. E. J. Reed became Chief Constructor conditions changed. He introduced ships short in length and great in beam, which of necessity demanded increased power for their propulsion. The marine engineers of the country responded but with each new ship they found that they were being allowed less and less room for their engines and boilers. Cramped for space they were forced to resort to expedients which militated against the attainment of trustworthiness. As a result, we stated, a successful trial trip had become a rare event. We warned the Chief Constructor—Mr. Barnaby by that date—that unless he paid attention to the advice of the engineers who supplied him with his engines the failures and disasters would continue. A second factor contributing in our view to the mishaps was the custom of transferring engineers and engine-room staff from one ship to another and sending them to sea without the slightest opportunity of studying the idiosyncrasies of the machinery placed in their charge. We gave examples to show that marine engines had their individual peculiarities and that each required special attention for its successful operation. No doubt admirable reasons could be advanced why each ship could not have a permanent chief and second engineer appointed to her but there was, we said, really no more difficulty in such a scheme than in appointing a permanent man as manager of a blast-furnace. A third cause of trouble lay in the fact that there was at that date no Engineer-in-Chief of the British Navy. There was an engineer-in-chief at each of the principal ports but no harmony existed between them. So marked was the disagreement between those authorities that what was right at Chatham was all wrong at Portsmouth. At one dockyard for example contractors would be informed that all feed pipes were to be fitted so as to be visible throughout their length while at another they would be told that they were to be hidden beneath the floor plates. Ludicrous instances were known in which pipes fitted one way had been refitted later the other way. An illuminating instance of the effects of the lack of control was revealed in a recently published parliamentary paper concerning the "Vanguard". At the court-martial which followed her loss it was disclosed that ventilating holes had been cut in her watertight bulkheads. Neither Mr. Barnaby nor the Admiral Superintendent at Devonport knew anything about these holes. They had been made at the order of the chief engineer at that dockyard for ventilation purposes following a gas explosion in the bunkers of the "Devastation". Fifteen ships all told had had their bulkheads rendered incapable in a similar manner of fulfilling their primary function. The Admiralty expressed its disapproval of this procedure in severe terms and ordered the holes to be stopped up.

Navy Engineering Sixty Years Ago.

"The Engineer", 27th November, 1936.

In our issue of December 1st, 1876, we returned to the discussion of the repeated disasters which were befalling the machinery of British warships and pressed once more for the appointment of an Engineer-in-Chief to the Navy. Even since our previous issue in which as noted last week we had broached the subject, a fresh mishap had occurred. The "Alexandra", possibly the most powerful man-of-war then afloat, had returned from her first trial trip with a defective crank pin. Later she had damaged one of her propellers during a trial in harbour. Then when all had been repaired she proceeded on a six hours' steaming trial but it had to be abandoned because a crack developed in one of her cylinders. It was true, we said, that certain ships were running very well with cracked and mended cylinders and it was just possible that if the "Alexandra's" cylinder were repaired it might be stronger than before. Still a cracked cylinder was a very serious defect and no chief engineer with one in his charge however skilfully it had been mended would hear the order to go full speed ahead without trepidation. We did not blame the builders of the engine for the breakdown but fastened responsibility for it upon the Admiralty. Engines of increased power were being demanded at the same time as the space within which they were to be housed was being decreased. The marine engine builders to whom the design and construction of the engines were entrusted knew that they could not meet the official requirements concerning power, size and weight without cutting down the margin of safety to a very low figure. They knew that to build engines for the Admiralty was a speculation and that they would be fortunate if they could get through the measured-mile run and the six hours' trial without a breakdown. Yet so long as they enjoyed the patronage of the Admiralty their mouths were sealed. We however were free to speak the truth and the truth was that we were living in a fool's paradise. Our policy in naval construction was radically wrong from first to last and if followed much further would infallibly lead up to some great national disaster. The remedy which we advocated was the appointment of an Engineer-in-Chief to the Navy whose duty it would be to supervise the provision of machinery for our warships and to ensure that the Chief Constructor's department was not allowed to enforce impossible conditions on the engine builders. The great shipping companies had each a superintendent engineer and it was rare to hear of machinery failures in their ships. Great as would be the responsibility which the Engineer-in-Chief of the Navy would have to bear, his task would not be beyond the powers of one man after the existing chaos had been cleared up. It would not be greater than that of the locomotive superintendent of a leading British railway. We expressed the opinion that nothing but disappointment would result if the Engineer-in-Chief were chosen from the ranks of existing naval engineers. The heads of the engineering departments of the dockyards were one and all so imbued with respect for the existing system of Admiralty management that they would find it impossible to shake off their official fetters. The appointment to the post of a competent engineer untainted by official prejudice would, we concluded, be celebrated by a grand festival accompanied with illuminations at all the principal marine engine building establishments throughout the kingdom.

Changing from Sail to Steam.

Naval Engineering 100 Years ago.

From a Correspondent.

"The Times", 6th January, 1937.

For engineers in the Royal Navy the year 1937 marks the centenary of more than one interesting development in their branch of the Service. Engineers in 1837 were raised from the position of civilians to the rank of warrant officers, and for the first time the engineering branch had a representative at Whitehall. Because of the Post Office steam packets being placed under the Admiralty the number of steam vessels in the Navy List was almost doubled, and on August 8, 1837, the first steam frigate, H.M.S. Gorgon, was launched at Pembroke.

Steam vessels had first appeared in the Navy List in December, 1827, when the names of the "Echo", "Lightning", and "Meteor" were included: by December, 1836, there were some 29 such vessels shown, including the earliest steam war vessels, the "Rhadamanthus", "Dee", "Phoenix", "Salamander", and "Medea", the last of which in 1837 was doing excellent work in the Mediterranean. Several other steam vessels were engaged in carrying the mails from Falmouth to Malta, Alexandria, and elsewhere. It was partly the good service given by these ships that led to the Admiralty being made responsible for the cross-Channel mail service. *The Times* of December 20, 1836, quoting from the *Observer*, noted that "all the necessary arrangements for transferring to the Board of Admiralty the packet establishment of the Post Office have been finally completed and the transfer will immediately take place".

First Engineer-in-Chief.

At that time the headquarters of the steam department of the Royal Navy were at Woolwich Dockyard, the responsible engineer being Peter Ewart, an old friend of James Watt, who in 1835, at the age of 68, had by Order of Council been appointed Chief Engineer and Inspector of Steam Machinery. The real working head of the branch, however, was a much younger man, Thomas Lloyd (1803-1875), who in 1847 became the first Engineer-in-Chief of the Navy. With the addition of the Post Office packets to the Fleet and the increase in the size and number of steam war vessels, the Admiralty came to the conclusion that the Department ought to be represented at headquarters, and an Order in Council, dated April 19, 1837, was promulgated respecting the "Appointment of a Comptroller of the Steam Machinery and Packet

Department of the Navy". The choice of the Admiralty fell on Captain (afterwards Admiral) Sir William Edward Parry (1790-1855), who already had distinguished himself as an explorer, hydrographer, and administrator. It may be surmised that he was generally liked, and in the *Proceedings* of the Institution of Civil Engineers it is recorded that on February 19, 1839, he was elected an honorary member of the Institution, "amongst whose members he had rendered himself extremely popular by the kindness of his manner and his accessibility while holding the position of Director of Steam Machinery, the duties of which he performed with singular uprightness and skill".

On July 19, 1837, the day, incidentally, that Brunel's Great Western was launched at Bristol, regulations were issued for "Engineers and engineers' boys". By these engineers became warrant officers on the same footing as gunners, boatswains, and carpenters; a first-class engineer getting £9 12s. 1d. a month, a second class £6 16s., and a third class £4 18s. Superannuation was provided for, but the conditions left much to be desired, and almost immediately the engineers began their long agitation for improved status and remuneration. The two dates, April 19 and July 19, 1837, however, are landmarks in the rise of the naval engineer and in the history of an important department of a great Service.

BOARD OF TRADE EXAMINATIONS.

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

Name.	Grade.	Port of Examination.
For week ended 3rd December, 1936 :—		
Duke, Cecil A.	2.C.M.	Belfast
Geddes, Douglas M.	1.C.	Glasgow
Guthrie, John	1.C.	"
Cahill, John C.	1.C.	Liverpool
Duncan, John...	1.C.	"
Jackson, George W.	1.C.	Liverpool
Tomlinson, William	1.C.	"
Peat, Reginald	1.C.M.	"
Moore, Phillip S.	1.C.S.E.	"
Marsh, Thomas E.	1.C.M.E.	"
Hunter, Oliver R.	1.C.M.E.	Glasgow
Gillespie, David	1.C.M.E.	"
Gauld, Archibald L.	1.C.M.E.	"
Deans, George	1.C.M.E.	"
Beck, John R.	1.C.	Newcastle
Bolton, Ronald R.	1.C.	"
Dixon, Robert A.	1.C.	"
Sample, Walter	1.C.	"
Carmichael, Robert	1.C.S.E.	"
Baxter, James F.	1.C.M.E.	"
Bennett, Arthur C.	1.C.M.E.	"
For week ended 17th December, 1936 :—		
Strain, John W.	1.C.	Belfast
Donald, Alexander	2.C.	Glasgow
Esslemont, William T.	2.C.	"
Love, Andrew	2.C.	"
Roy, Lessels	2.C.	"
Sillars, Malcolm M.	2.C.	"
Whyte, James	2.C.	"
Douglas, James F.	2.C.M.	"
Hinds, William	2.C.M.	"
Herrick, Grahame B.	2.C.	Liverpool
Lloyd, John L.	2.C.	"
Dunn, Robert J.	2.C.M.	"
Kneale, John V.	2.C.M.	"
Nicholls, Wilfred E. G.	2.C.M.	"
Nicholson, Robert M.	2.C.M.	"
Trelford, Lawrence J.	2.C.M.	"
Ferguson, George S.	2.C.	Newcastle
Ferguson, John G. S.	2.C.	"
Grant, Michael	2.C.	"
Keel, William	2.C.	"
McAnelly, Thomas M.	2.C.	"
Purdie, Hugh D.	2.C.	"
Thornton, Joseph L.	2.C.	"
Acheson, William	2.C.M.	"
Brown, James	2.C.M.	"
Edbury, Charles	2.C.M.	"
Innes, Andrew	2.C.M.	"
Ramsay, James B.	2.C.M.	"
Bowman, James	2.C.	London
Clay, Leslie C.	2.C.	"
Overy, Aubrey S. J.	2.C.	"
Wetherilt, James E.	2.C.M.	"