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VOLUME XXXVII.

Motorship Progress in 1925.

A Retrospective Survey of a Year's Work and Development,

BY A. C. HARDY, B.Sc. (Assoc. Member).

READ AT

THE SHIPPING EXHIBITION, OLYMPIA,

On Tuesday, December 1, *at* 8 *p.m.*

CHAIRMAN: MR. R. S. KENNEDY (Vice-Chairman of Council).

LLOYD'S Register shipbuilding returns for the quarter ending September 30th, 1925, show that the total tonnage of motorships under construction in the world exceeds 99 per cent. of the total steamship tonnage. This is an increase of 39 per cent. over the returns for the quarter ending December 31st, 1924 and an increase of 64 per cent. over the corresponding quarter of 1923. For Great Britain, the tonnage of motorships under construction for the quarter ending September 30th, 1925, is 55 per cent. of the steamship tonnage, an increase of $12\frac{1}{4}$ per cent. over the corresponding figures for the end of last year and of just 25 per cent. for the final figure of 1923. These points will be noticed on referring to Tables 1 and 2 and Figs. 1 and 2†, from which it will also be noted that the above per-

† These Figures are intended to be purely diagrammatic.

centages in each case have risen from a zero figure quoted in the returns for December 31st, 1913. In twelve years, therefore, the motorship, from being a negligible quantity, has increased in importance until it now occupies nearly half of the tonnage under construction in the world and nearly a quarter of the tonnage building in the world's premier ship constructing country. It seems not without interest, therefore, to make a brief retrospective survey of the present year's work in the field of marine internal combustion engineering, noting, at the same time, any historical milestones along a road of steady progress.

TABLE 1.

MOTORSHIPS AND STEAMSHIPS UNDER CONSTRUCTION IN THE WORLD.*

Quarter ending.	Steamers.	Motorships.	% Motor/Steam.
	Gross Tons.		Round Figures.
Dec. 31, 1913	1353098	None recorded separately	—
Dec. 31, 1923	1793579	634027	35
Dec. 31, 1924	1530885	923738	60
March 31, 1925	1357834	1021631	75
June 30, 1925	1212525	1129912	93
Sept. 30, 1925	1090456	1088888	99·8 app.

*Including Great Britain.

TABLE 2.

MOTORSHIPS AND STEAMSHIPS UNDER CONSTRUCTION IN GREAT BRITAIN AND IRELAND.

Quarter Ending.	Steamers.	Motorships.	% Motor/Steam. Round Figures.
	Gross Tons.		
Dec. 31, 1913	1,952,814	None recorded separately.	—
Dec. 31, 1923	1,065,770	323,641	30·3
Dec. 31, 1924	976,134	320,137	$32\frac{3}{4}$
March 31, 1925	800,848	359,920	45
June 30, 1925	687,607	399,070	58
Sept. 30, 1925	646,410	356,480	55

A detailed examination of the figures quoted in Tables 1, 2 and 3, and shown diagrammatically in Figs. 1, 2 and 3, indicates that, as far as world figures are concerned, although there has been a slight drop in the motorship tonnage under construction for the quarter ended September 30th (1,088,888 gross tons as against 1,129,912 gross tons) in comparison with the quarter ended June 30th, there has been a drop also in steamship figures—1,090,456, as compared with 1,212,525. The rate of drop for steam, however, is considerably steeper than that for motors, which helps to account for the gratifying or alarming—according to the point of view from which it is regarded—increase in motorship tonnage under construction. In British shipyards, the increase of motorship construction, although gradual, has not been anything like so spectacular and in the complete year from December 31st, 1923, to December 31st, 1924, the percentage of motor to steam construction only shows an increase of 2·45 per cent. It is worthy of

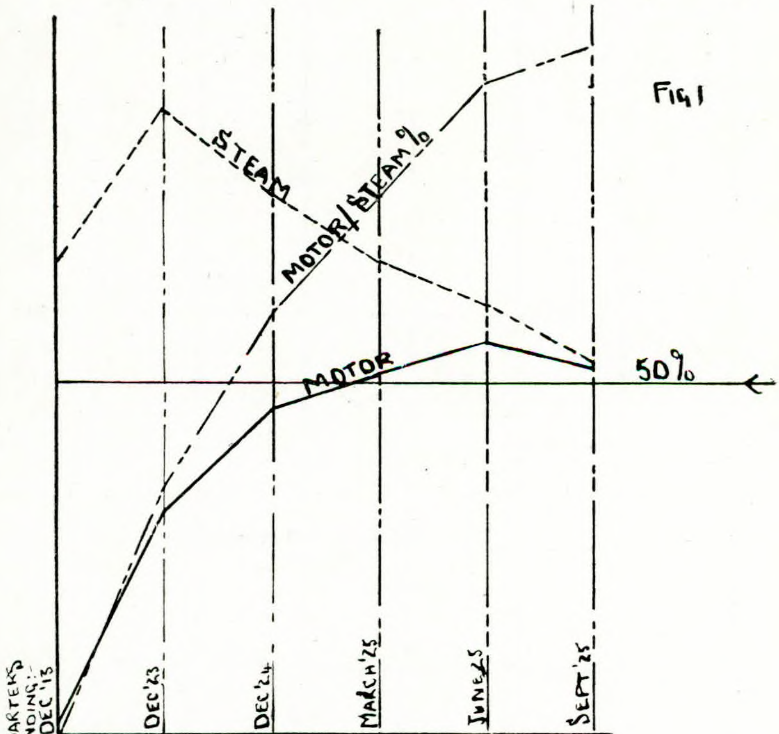
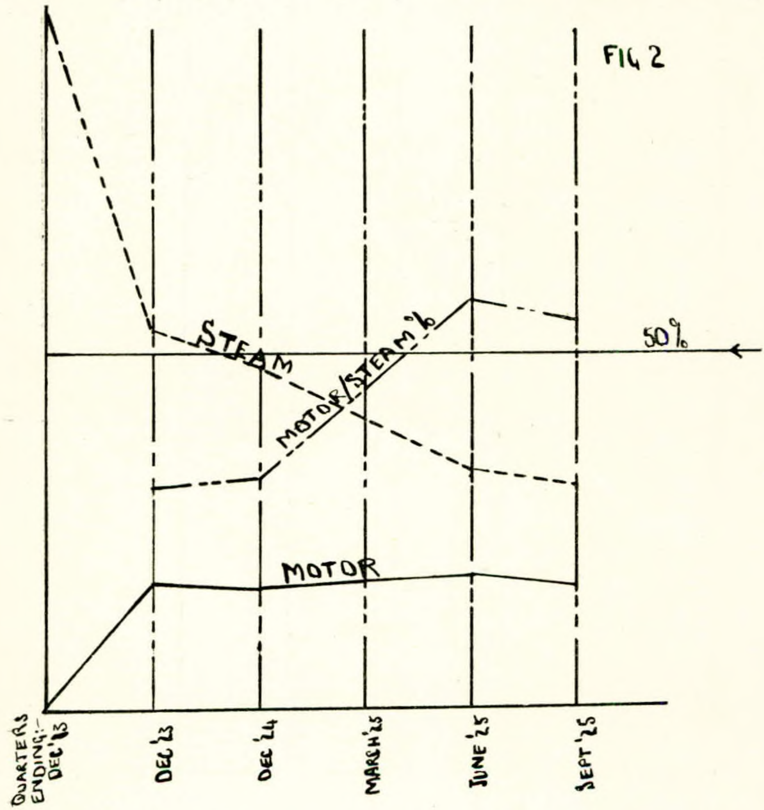


Fig 1

note, however, that in the period from December 31st, 1924, to September 30th of this year the percentage of motor to steam construction shows an increase of 22·25 per cent. This fact is not so much due to an abnormal increase in motorship construction (actually there were 42,590 gross tons of motorships less under construction for the quarter ended September 30th than for the quarter ended June 30th) as to a drop of some 329,724 tons in steamship construction during the present year.

As far as foreign countries are concerned, I have selected three of the Northern European countries most interested in the internal combustion engine, and in Table 3 and Fig. 3 is shown the comparative development of steam and motor tonnage. Denmark* and Sweden* are, of course, small shipbuilding countries when compared with Great Britain or with Germany.



Moreover Denmark was among the earliest champions of the motorship, as well as being the home of the Burmeister and Wain engine and of ship-owning firms like the East Asiatic Company, who have, in the course of the last twelve or fourteen years, replaced practically the whole of their steamship's fleet by motorships. Both Denmark and Sweden have been the

* Denmark has 10, and Sweden has 11 establishments capable of turning out ocean-going motorships and steamships and their machinery.

marine internal combustion engine's staunchest supporters from the beginning, and for these reasons it is not so surprising to find that the motorship returns for the period under review easily outweigh the steamship returns. The motorship construction for Denmark at September 30th of this year, was just over 17 times the steamer construction, although the September returns show a proportionately greater motorship drop than is

TABLE 3.

MOTORSHIPS AND STEAMSHIPS UNDER CONSTRUCTION IN SELECTED COUNTRIES.

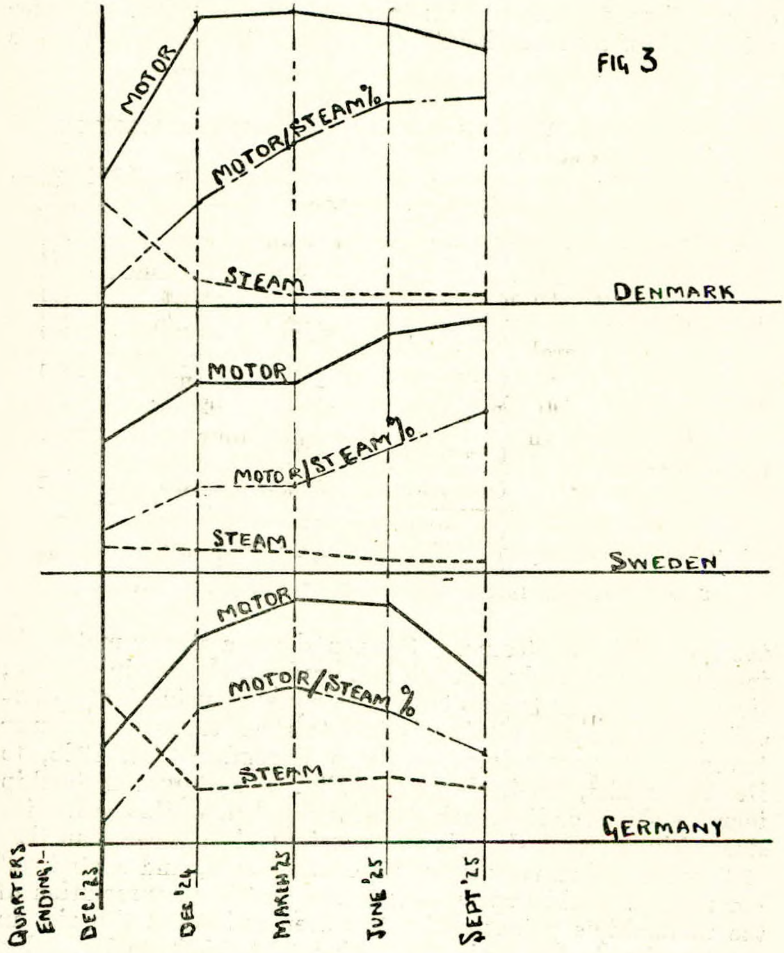
Quarter Ending.	Country.	Steamers. Gross Tons.	Motorships. Gross Tons.	% Motor/Steam. Round Figures.
Dec. 31, 1923	DENMARK	28,109	34,087	121
	SWEDEN	7,584	35,300	464
	GERMANY*	187,823*	135,561	72
Dec. 31, 1924	DENMARK	9,428	75,400	800
	SWEDEN	7,180	50,400	700
	GERMANY	78,539	274,071	350
March 31, 1925	DENMARK	6,210	77,084	1,240
	SWEDEN	7,180	50,400	700
	GERMANY	80,321	324,155	403
June 30, 1925	DENMARK	4,250	73,511	1,730
	SWEDEN	5,730	61,100	1,066
	GERMANY	92,217	313,309	342
Sept. 30, 1925	DENMARK	3,900	66,860	1,710
	SWEDEN	5,130	66,450	1,300
	GERMANY	88,951	217,675	245

*N.B.—Under construction in all German yards at Dec. 31, 1913, 541,626 tons gross.

the case with the steamer. Sweden shows a steady motorship increase and a steady, though less gradual, steamship decline; the returns for September 30th of this year showing that motorship tonnage now building is just thirteen times the steamer tonnage. A year's increase, from December 31st, 1923, to December 31st, 1924, shows (see Fig. 3) a steeper motorship increase slope for Denmark than for Sweden, while the Danish steamship decrease slope is also considerably steeper than that of Sweden. Germany is an interesting case, and a study of her returns would appear to indicate that her appreciation of the motorship's potentialities has been swift and the rise in construction in the period December 31st, 1923, to December 31st, 1924, is some 138,510 tons. In other words, in a year it almost doubled, and it should also be remembered that on December 31st, 1923, the steamship tonnage exceeded the motorship tonnage by 52,262 tons. The latest figures for

German shipyards indicate a distinct downward tendency in motorship tonnage under construction as well as a slight fall in steamer tonnage. Of course, even allowing for the present abnormal state of depression of shipbuilding throughout the

FIG 3



world, the German shipyards are not operating at anything like their pre-war output and the present total (steam and motor) output, 306,626 tons gross, is some 245,000 tons short of the output for the last quarter of 1913. When the history of the motorship is written, Germany will always be cited as the champion of indirect or transmitted drive and more particularly in its hydro-mechanical interpretation. The present year has seen two ships go on service in which single screws are driven by two sets of 4-stroke cycle high speed crosshead engines through the medium of single mechanical reduction gearing and Vulcan hydro-mechanical clutches.†

The Italian Shipbuilding Boom.—Italy presents rather an interesting case as regards increase of motorship construction, as Table 4 and Fig. 4 show. In one year—from December 31st, 1923, to December 31st, 1924—the tonnage under construction in Italian shipyards to be fitted with internal combustion engines increased from 13,000 to nearly 61,000 gross tons with a corresponding decrease in steamship construction of 14,787 tons, the percentage of motor to steam tonnage in this period increasing from 12·3 to 67·3. The present year, however, has witnessed an almost unprecedented boom in Italian shipbuilding generally, and although in the three-quarters of the current year under review, the steamer tonnage has decreased from 90,290 tons at December 31st, 1924, to 75,894 at September 30th of this year, the motorship tonnage under construction in this period has increased from 60,800 gross tons to 192,512 gross tons. In other words, whereas in December, 1924, Italian motorships in course of construction represented just over 67 per cent. of the steamships, at the end of the last quarter, they amounted to over two and a half times the steamship tonnage. This tremendous increase, and indeed the boom in Italian shipbuilding generally, is due largely to the fact that Italian shipbuilders are being assisted financially by the Government, and also much of the tonnage and some of the engines are being built under the terms of the Reparations Agreement.

Large Passenger and Mail Liners.—All categories of merchant ships are represented in the above Italian motorship figures, but foremost among them is a ship of whose construction Italian marine engineers and naval architects must be justly proud, and that is the passenger and mail liner *Augustus* of 33,000 tons gross, particulars of which will be found in Table 7. This vessel, which is intended for transatlantic service, was ordered during the present year from the Ansaldo Company by the Navagazione Generale Italiana Company and she is, at the time of writing, the most powerful motorship in the

† See December Issue.—J.A

TABLE 4.

MOTORSHIPS AND STEAMSHIPS TONNAGE UNDER CONSTRUCTION IN ITALY.

Quarter ended.	Steamers.	Motorships.	% Motor/Steam.
Dec. 31, 1923	105,077	13,000	12·3
Dec. 31, 1924	90,290	60,800	67·3
March 31, 1925	77,486	84,137	108·0
June 30th, 1925	76,593	134,255	175·0
Sept. 30, 1925	75,894	192,512	253·0

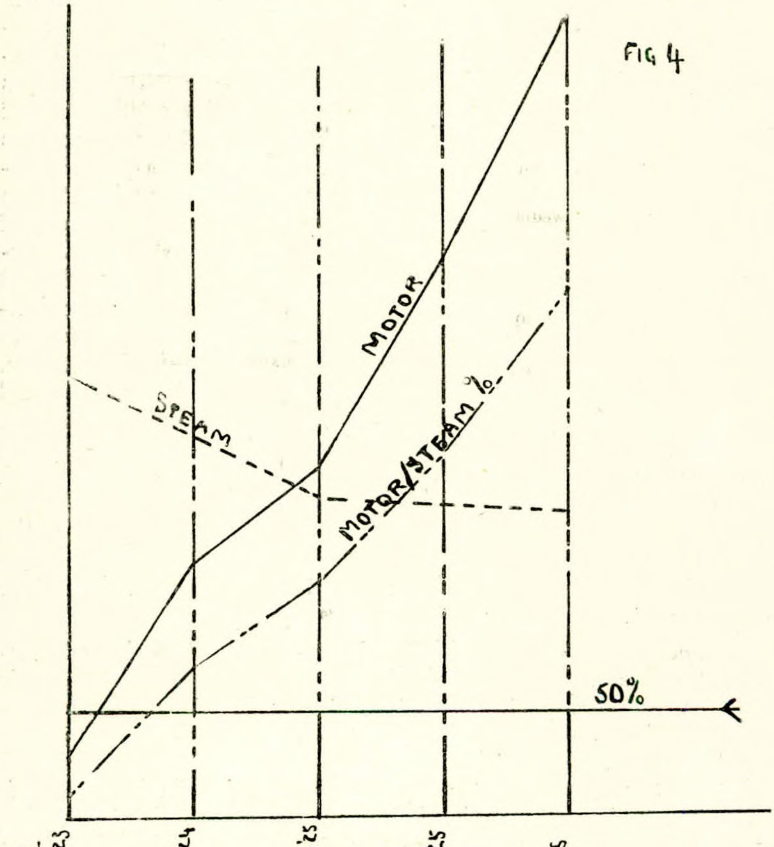


TABLE 7.

POWERING DETAILS OF TYPICAL MOTORSHIPS OF 1925.

Type and Duty. Name.	Tonnage. Nationality.	Power of Machinery (Total), No. and Type of Engine, Cylinder Dims.	Other Particulars, Auxiliary Drive, Cyls. per Engine.
Passenger Liner for Atlantic Service. *Augustus.*	33,000 Gross. Italian.	28,000 shaft. 4 sets 2 str. cycle M.A.N. double acting engines. 700 mm. × 1200 mm. str.	Ship under construction. All electric auxiliaries. 6 cyls. per engine.
Passenger Liner for S. American Service. *Asturias.*	22,000 Gross. British.	20,000 indicated (at 125 r.p.m.) 2 sets 4 str. cycle H. & W. Burmeister & Wain double acting engines. 840 mm. × 1500 mm. str.	Ship due for completion. All electric auxiliaries. 8 cyls. per engine.
Ore Carrier for U.S.A.— S. America. *Swaland.*	20,600 Dwt. Swedish	6,400 indicated (at 110 r.p.m.) 2 sets 4 str. cycle A.E.G. Burmeister & Wain single acting engines. 740 mm. × 1200 mm. str.	Power can be increased to 7,800 I.H.P. by super-charging. All electric auxiliaries. 8 cyls. per engine.
Refrigerated Ship for Australian Service. *Port Hobart.*	10,800 Dwt. British.	6,000 indicated (at 95 r.p.m.) 2 sets 2 str. cycle Doxford opposed piston engines. 540 mm. × 1080 mm. str.	First twin-screw Doxford engined ships. All electric auxiliaries. 4 cyls. per engine.
Oil Tanker for American Coast. *J. W. Van Dyke.*	7,500 Dwt. American	2,300 shaft. (at 100 r.p.m.) 1·750 volt d.c. motor taking current from 2 600 K.W. d.c. generators driven by 6-cycle Ingersoll Rand solid injection engines. $19\frac{1}{2}$ in. × 24 in. str.	Conversion from steam. 2,400 S.H.P., S.R. geared turbine. All electric auxiliaries.
Cargo Vessel for Far Eastern Trade. *Dinsburg.*	9,500 Dwt. German.	4,100 shaft (at 79 r.p.m. of propeller) 2 sets 4 str. cycle M.A.N. single acting, driving 1 shaft Uno vulcan hydro-mechanical clutch engine, speed 210 r.p.m. 640 mm. × 700 mm. str.	Vulcan clutch. Steam and electric auxiliaries. 8 cyls. per engine.
General Cargo Carrier. *Raby Castle.*	8,000 Dwt. British.	3,000 indicated (at 92 r.p.m.) 1 set 4 str. cycle North-Eastern Werkspoor single acting engine. 730 mm. × 1300 mm. str.	First North-Eastern Werkspoor modified engine with A framing. All electric auxiliaries. 8 cyls.

world, exceeding in power the Royal Mail Steam Packet *Asturias* by some 8,000 horse-power. She is specially interesting in that she will be propelled by 2-stroke cycle double-acting engines of German (M.A.N.) make, driving four screws, each engine having six cylinders of 700 mm. diameter by 1,200 mm. stroke. The 4-stroke cycle engines of the *Asturias*, now practically completed, have each eight cylinders 840 mm. in diameter by 1,500 mm. stroke. In the *Asturias* a maximum of 10,000 I.H.P. per shaft is developed with eight cylinders on each of two shafts and in the *Augustus* about 7,000 S.H.P. on each of four shafts with six cylinders.

The present Italian motorship construction programme includes various types, as has been indicated, but mention should specially be made of the fact that certain companies, such as the Cosulich Line of Trieste, have put in hand the experiment of what I may call selective powering, or the fitting of two different makes of engine—one 2-stroke cycle and the other 4-stroke cycle—into two ships of exactly the same hull form and dimensions. This experiment, which incidentally has been carried out by a Dutch firm—the Royal Packet Navigation Company* of Amsterdam, and by a Japanese firm, should enable shipowners to obtain first hand an appreciation of the relative merits of the two rival working cycles.

Bunker Coal Export Figures.—Table 6 shows the bunker coal exports from British ports for each month of this year up to September. It shows also the monthly average export figures for the last four years and from these it will be seen that there has been a gradual fall in the monthly total export figures, not only in the period under review, namely, from January to September of this year, but also in the monthly average of total export figures for the past four years. This latter has been a very gradual drop representing a difference (for a nine monthly average) of some 159,951 tons between this year and the year 1922. All this would seem to suggest that, in spite of the present chaotic state of the British coal industry, and in spite of the enormous monthly increases in the use of oil both in internal combustion engines and under boilers, the bunker coal trade has not suffered abnormally. There are, of course, various contributary causes towards the present depressed state of the coal industry, some political and some economic, but there is very little doubt that

* Engaged exclusively in Far Eastern Trade.

TABLE 6.

SHOWING BUNKER COAL EXPORTS UP TO SEPTEMBER 30th, 1925.

Month, 1925.	Total Export Tons.
January ...	1,441,163
February	1,393,942
March	1,418,265
April	1,335,561
May	1,379,281
June	1,292,714
July	1,427,770
August ...	1,215,067
September	1,354,198
Total	12,257,961
Monthly average	1,361,995

MONTHLY AVERAGES BUNKER COAL EXPORTS.

Year.	Total Export Tons (Monthly Average Figures)
1922	1,521,586
1923	1,513,182
1924	1,474,075
1925 (9 months)	1,361,995

TABLE 5.

STEAM AND INTERNAL COMBUSTION ENGINES UNDER CONSTRUCTION IN GREAT BRITAIN AND SELECTED COUNTRIES AT SEPT., 30th, 1925.

Country.	Steam Engines.		Oil Engines.
	Recip. I.H.P.	Turbines S.H.P.	I.H.P.
Great Britain	282,361	143,359	216,510
Germany ...	38,610	23,300	131,770
U.S.A.	8,100	35,200	21,545
Denmark ...	3,300	—	102,900
Sweden	3,300	2,550	63,070
Holland	38,610	3,000	49,930

the enormous inroads made by oil have a great deal to do with the question. And this has led many farseeing people to ask the question, what are we going to do with our surplus coal if the demand for and the use of oil goes on increasing to the same extent that it has done of recent years? I do not, frankly, attach a great deal of importance to the pessimists who state that the oil supply of the world is limited in quantity, but it only seems wise to do everything possible with a view to fostering experiments and furthering schemes for obtaining oil from the destructive distillation of coal. If the demand for oil goes on increasing the demand for coal must inevitably decrease and it may be in time that only some proposition of this nature will help to restore a complete economic balance*. Table 5, extracted

* A society is being formed to study this question in all its bearings.—J.A.

from the latest Lloyd's Register Quarterly Shipbuilding Returns, is a new and interesting feature, showing the horse-power of different types of marine prime movers under construction in various countries. In Great Britain the total power of oil engines is only 65,851 below that of steam reciprocating engines, the turbine being considerably below either. Germany has more oil engines under construction than either of the two steam types, while in Denmark the turbine is not represented at all, the steam reciprocating engine being a mere 3,300 I.H.P. In all the other countries listed, the progress of the motor engine is marked.

High Power Installations and Double-acting Engines.—The foregoing has dealt with progress generally in terms of statistics. It is now of interest to cover briefly some of the more detailed matters of interest, and Table 6 should be studied in this connection, since it shows noteworthy motorships of different categories added to the world's mercantile fleets during the period under review. As far as passenger liners are concerned, no noteworthy vessel has been actually completed for service, if we except the transpacific *Aorangi* which left Southampton for her station early in January. Actually, however, this vessel was completed in 1924. One important vessel was launched and is now rapidly nearing completion—the 22,000 ton gross *Asturias*, constructed by Harland and Wolff, Ltd, for the Royal Mail Steam Packet Co.; one important vessel would have been completed earlier than she actually was but for the fact that the construction of her main propelling machinery was delayed by a strike—the 17,000 ton gross *Gripsholm*, constructed by Armstrong, Whitworth and Co., Ltd., for the Swedish-America Line; and the largest motor passenger liner in the world has been laid down—the 33,000 tons gross *Augustus*, an Italian vessel, to which reference has been made already. These three ships all represent a triumph for the double-acting internal combustion engine, a type of prime mover about which so many doubts were expressed initially. The first two are propelled by two 8 and 6-cylinder, 4-stroke cycle units, aggregating about 20,000 and 15,000 I.H.P. respectively and the third is to be fitted with four sets of 2-stroke cycle units aggregating 28,000 S.H.P., and in each case the power per cylinder developed is slightly over 1,000. The engines of the Italian ship have slightly smaller cylinder dimensions than those of the 4-stroke cycle units, but the rates of revolution are about the same. This represents a notable advance, when it is considered it was only in 1922 that the first practical sea-going double-acting marine internal combustion engine ran test bed trials, and only last year that the first mercantile vessel propelled by such an engine went on service. This was the 2-stroke cycle North British engine with the sliding cylinder, rated for about 660 B.H.P. per cylinder unit. The end of 1924 saw the advent of the large motor passenger and mail liner with approximately 16,000 B.H.P. in four shafts of the *Aorangi*, which was a triumph for the 2-stroke cycle, single-acting engine. The end of 1925 will see progress pushed a stage further in the construction of a vessel with 28,000 S.H.P.—nearly double the *Aorangi's* power—on four shafts, which will be a triumph for the 2-stroke cycle double-acting engine, and which brings us considerably nearer the high power requirements sketched out in my paper read before this Institute in March last*, and in my recent book**. It does not seem likely, however, that vessels of *Mauretania* type will be powered by internal combustion engines for many years, although there is a gradually increasing number of motor passenger liners of more moderate power. The 2-stroke cycle double-acting engine is in many ways superior to its 4-stroke rival, and with external scavenging higher power can be compressed into a smaller space and generally with smaller cylinder dimensions. There are also less moving parts, an important factor in a large mass of moving machinery like a double-acting internal combustion engine.

Single-Acting Engines.—The single-acting engine, just as much as the double-acting engine, has gone through stages of development in the period under review, and the line this has taken has been one of increasing the power developed per unit rather than of the introduction of new types. A study of engines completed during the year shows that there is a general tendency towards simplicity of construction and standardisation, so that, as Lord Inverforth reminded us recently in his Presidential Address, there may be a ready interchange, not only of parts, but also of personnel. It is only by such means that a Diesel-engined fleet can be maintained in a state of high efficiency, and the engine for cargo vessels of the future will undoubtedly be a slow-running light-weight engine standardised down to the last bolt and nut. Last year the Werkspoor Co., it will be recalled, re-arranged its engine's exhaust-manifold,

* "Motor Passenger Liners." (See August Transactions).

** "Motorships," By A. C. Hardy, B.Sc., Chapman & Hall. 15s. net.

altered the framing of the engine and re-arranged the cylinder castings. This year the North Eastern Marine Engineering Co. have finished their first engine of this type, an 8-cylinder unit developing 3,000 I.H.P. at 92 r.p.m. fitted in the 8,000 tons dwt. cargo vessel *Raby Castle*. This 4-stroke cycle engine it is extremely interesting to compare with two sets of A.E.G.—Burmeister and Wain 4-stroke cycle engines, completed for a 20,600 ton dwt. ore carrier (one of two vessels) built in Hamburg for Swedish owners for ore carrying from Chile to North America. This ship is one of the largest motor cargo vessels in the world and each of the main engines is an 8-cylinder unit rated for 3,200 I.H.P. at 110 r.p.m. As Table 7 shows, the cylinder diameter of the Burmeister engine is 10 mm. greater than that of the Werkspoor engine, while the stroke is 100 mm. less. These two engines, and a 2-stroke cycle unit*, of six cylinders (cyl. dia. 760 mm. by 1,340 mm. stroke) rated for 3,600 B.H.P.** at 90 r.p.m. are the largest single-acting Diesel engines in existence, and are all products of this year's work.

Refrigerated Motorships.—Another type of ship to which the internal combustion engine has been applied is the refrigerated vessel designed for the carriage of meat, and in this direction the Commonwealth and Dominion Line, Ltd., have been to the fore with two ships, the *Port Hobart* and *Port Dunedin* of 10,800 tons dwt., which took their maiden sailings to Australian and New Zealand ports via Panama, this year. These ships are interesting as the first twin-screw opposed piston-engined ships, and they have also an extraordinarily complete equipment of electric auxiliary machinery, the refrigerating machines, themselves two in number, being driven by 110 B.H.P. motors, direct coupled. The main engines themselves are four-cylinder Doxford units, having cylinders 540 mm. diameter with a piston stroke of 1,080 mm. Scavenging is carried out on each engine by a crank on the main crankshaft between each pair of cylinders. These two ships can be bracketed with two other refrigerator motor meat ships of somewhat larger size, fitted with 2-stroke cycle machinery of Sulzer type built by John Brown and Co., Clydebank (hull by W. Hamilton and Co., Port Glasgow), and the Fairfield Shipbuilding and Engineering Co., Ltd., for the Union Steamship Company of New Zealand, Ltd., and the Houlder Lines Argentine Service, respectively. The

* Constructed by Sulzer Bros , for the *Bintang*" an ex-steamer owned by the Netherland Steamship Co.

** Overload 4,390 B.H.P. at 96 r.p.m.

former—the *Limerick*—has a deadweight capacity of 11,450 tons and two 6-cylinder engines (680 mm. cyl. dia. by 1,200 mm. stroke) designed for 3,000 B.H.P. per engine at 100 r.p.m. The latter—the *Upwey Grange*—has a refrigerated capacity of 500,000 cubic feet and two 6-cylinder engines of approximately the same size and power as those constructed for the *Limerick*.

Indirect Drive.—The only motor refrigerated ships constructed in this country prior to the two mentioned above were two vessels, of an original three, completed last year by Cammell-Laird and Co., for the United Fruit Co., of Boston. These ships had electric drive, current being supplied from generators driven by Cammellaird-Fullagar opposed piston engines. Two of these were completed as designed but the third had her original machinery taken out and steam reciprocating engines and boilers substituted. These ships represent nevertheless the only examples of the Diesel electric drive for sea-going ships constructed in this country, and the present year has been quite blank, as far as Great Britain is concerned in this system of propulsion. America has made considerable progress in this direction, and sea-going oil tankers (see Table 7) side wheel ferries, tugs and dredgers may all be cited as ship types in which internal combustion engines have been fitted, driving generating sets which in turn drive propelling motors. Germany on the other hand, has favoured the fitting of high speed engines in pairs, driving a single screw through the Vulcan hydro-mechanical clutch, and two 9,000 ton dwt. cargo vessels are now in regular operation (see Table 7) employing this system of drive. The characteristics of this form of drive* have been discussed from time to time in considerable detail and it is not necessary to go over these points again, except to say that the Vulcan hydro-mechanical clutch does permit of an ease of manœuvring which is not easily approachable with any other form of internal combustion drive. In all probability it is more costly both initially and in fuel, but the performance of the two German ships now on service will prove this and it will be interesting to see whether any further orders of a similar nature are placed. The British shipowner does not seem to regard indirect drive schemes with any measure of favour.

A New Cast Iron.—It has often been suggested that one of the limiting factors in internal combustion engine pro-

* See also Chap. 8. of "Motorships."

gress is the question of metallurgy and the production of castings which will successfully stand up to the heat and other stresses to which they are subjected, and from this point of view, one of the most important developments of this year is the introduction into Great Britain of a process for the manufacture of cast iron which has been in use for some time on the Continent. The patent rights have been acquired by the British Perlit Iron Co., London, and a prominent Diesel engine building concern as well as a well-known shipowning firm interested in Diesel engine progress, are represented on the board of directors. The Perlit process of manufacture, in brief, aims at homogeneity of structure in the casting, and the production of a cast iron with the characteristics of steel, of uniform composition throughout irrespective of section and shape. An ordinary casting of varying section, on cooling, changes in composition, density and strength at various parts, being pearlitic in one part while in the other it may be ferritic or cementitic. The Perlit system claims to make the most complicated casting wholly pearlitic and homogeneous, and of uniform strength. It will be interesting to note to what extent the process is adopted in this country.

Conclusion.—The foregoing remarks have sketched, in brief, the present position of the motorship. The year now passing has been characterised by steady development and by a steady general increase in the number of motorships laid down. Two prominent shipowners, Lord Kylsant and Lord Inverforth have publicly, and in no half-hearted manner, declared their confidence in and satisfaction with the running of motorship fleets, which they evidently regard as the fleets of the future. Pessimists say that the widespread adoption of the motorship will spell even greater ruin to our coal industry, while optimists maintain that it will end in giving us a period of greater general prosperity. In the meanwhile, those of us who are enthusiastic about the internal combustion engine can look forward to another year which will certainly not be blank as far as development is concerned.

The vote of thanks proposed by Mr. R. H. Pinn was cordially carried.

———o———

Pulverised Fuel Firing.

BY E. KILBURN SCOTT, M.I.E.E., A.M.I.C.E.

READ

On Tuesday, December 8, at 6.30 p.m.

CHAIRMAN: Mr. G. J. WELLS (Member of Council).

Development of Industry.—During the past two years the extent to which coal is burnt in pulverised form has come as a surprise to many people, for, although the method was experimented with in this country 50 years ago, its practical development has been principally in America within the last 10 years.

In the present year about 25 million tons of coal are being pulverised, of which about 8 millions are used in the cement industry; the percentages used for various purposes being about as follows:—

	Per cent.
Portland Cement Manufacture	40
Metallurgical Furnaces, Ferrous	20
Metallurgical Furnaces, Non-ferrous ...	17
Generation of Electric Power	13
Miscellaneous Steam Raising, etc. ...	10

Pulverised fuel is used in this country for boilers in the electric power stations of Birmingham, Derby, St. Pancras, Poplar, The North Metropolitan Power Company, Philadelphia, Durham, Hammersmith, Peterborough, Runcorn and Dover.

It is also being used for boilers in many industrial plants, including Blaina Colliery, and Guest, Keen and Nettlefold, Ltd., in South Wales; Stewarts & Lloyds' Works, Glasgow; York Street Flax Spinning Co., Ltd., Belfast; Synthetic Ammonia & Nitrates, Ltd., Billingham-on-Tees.

The extraordinary rapid increase in its use for boiler firing is shown by the following figures for boilers in U.S.A.:—

	Heating Surface (Sq. feet).
1916	10,000
1918	90,000
1920	280,000
1922	680,000
1924	1,700,000

Experiments on Ships.—Very little has been done in the direction of utilising pulverised fuel firing on vessels, partly because of lack of interest, and partly because the equipment developed for power station boilers is not suitable for restricted spaces on ships.

Experiments with pulverised fuel were made in 1915 by the Pacific Coast Steamship Co., on steamers plying between San Francisco and Puget Sound, but the results were not made public.

One of the first experiments was in 1916 on patrol ship *Gem*, U.S. Navy; pulverised fuel burners being fitted to one of the two oil fired boilers, and the fuel ground to necessary fineness at a shore station.

The boat is said to have attained the same speed with one pulverised fuel fired boiler as was made with two oil fired boilers, but unfortunately, owing to restricted dimensions it was difficult to maintain the refractory lining of the combustion chamber.

In the same year an Australian ship, the *Skylark*, was fitted with a pulverised fuel plant and semi-lignite coal was successfully burnt, but here again the upkeep of the furnace presented difficulties.

Pulverised coal is now under test on a Stinnes steamer on the Rhine in Germany, and in this case the coal is pulverised on board by means of a unit machine, which supplies the fuel to the boiler as it is prepared.

It will be observed that the principal difficulty is in finding room for the combustion chamber and as a result, many minds are at work on the problem of reducing size of furnaces and this will be referred to later.

Colloidal Fuel.—There are possibilities for pulverised fuel for marine work by mixing it with thick fuel oil to form what is known as *Colloidal fuel*. Experience with such fuel with land plants has shown that if the pulverised fuel does not exceed 40% of the mixture there is little tendency for it to separate out. By reason of the fact that coal is a much cheaper fuel, reckoned on a B.Th.U. basis, a colloidal mixture is cheaper than oil alone.

During the last big coal strike, colloidal fuel was tried in various places, including for locomotives by the Great Central Railway, and it was found possible to use it in burners in much the same way as oil; and to store it without risk of oxidation or spontaneous combustion. Because of greater viscosity, the mixture is not so liable to leak from tanks as ordinary oil, and as it can be stored easily there is no reason why the present oil stations should not be fitted with pulverising plants, and supply a colloidal mixture in place of oil.

Good Combustion.—The superior combustion obtained with pulverised fuel firing can be explained in the following way:—A piece of pure carbon, exactly one inch cube, having a surface of six sq. inches, requires for complete combustion $6\frac{3}{4}$ cubic feet of air, which air occupies a cubic space measuring $22\frac{1}{2}$ inches along each side.

Now assume that the one inch cube is powdered into particles, each of which measures 1/100th in. cube, then there will be one million of them and their aggregate surface will be 600 square inches, that is to say, one hundred times greater than the surface of the one inch cube.

It is now easy to see that if the million particles are blown into a furnace so that they can distribute themselves equally through the $6\frac{3}{4}$ cubic feet of air, each particle will be surrounded by a cube of air measuring quarter of an inch. This obviously is the condition for perfect combustion.

Although coal is not pure carbon, the argument holds good, indeed it is stronger if anything, when one considers the ash in coal, because the ash particles becoming incandescent, radiate heat; in other words a dirty flame is better than a clean one for steam raising.

CO_2 and CO Gases.—With pulverised fuel firing it is easy to maintain the CO_2 at about 15% or 16% by adjusting the excess air at about 20 to 25% above that for theoretically perfect combustion; also there is practically no formation of carbon monoxide.

With mechanical stokers, on the other hand, it is difficult to keep the CO_2 up to about 13%, and there is always some CO due to the imperfect combustion.

If the melting point of ash is low it is not possible to avoid a considerable number of particles of coke and coal being shut in by molten ash, and as the oxygen cannot get access they remain unburnt.

With mechanical stokers another loss is due to the particles being blown off the grate, for in order to burn fine coal containing a high percentage of ash, and low volatile, air has to be forced through the coal, and a number of particles are thus blown away with the gases. Some pieces clog up the boiler and economiser, leaving clinker as a result of slow dry distillation, whilst the finer particles pass up the chimney.

Refuse Fuel.—For many years it has been the practice to tip refuse fuel at collieries, and as a consequence there are millions of tons of fuel waiting to be used, particularly in old colliery districts such as South Staffordshire.

At the Nechells power station, Birmingham, fuel from the pit heaps is being burnt which contains below 9,000 B.Th.U.'s, up to 20% of ash, and costs only about 7/- a ton delivered.

Largely because of the possibility of burning such low-grade fuel in a complete way without causing a nuisance, four boilers in that particular station have been equipped for pulverised fuel firing, and an order given for equipping more boilers.

At the Philadelphia power station in Durham, a waste material called "Splints" containing up to 30% of ash is burnt in pulverised form in a boiler that was changed over from mechanical stoker firing, and the engineer in charge says he is very satisfied with its performance.

When coal is undercut by machines the percentage of cuttings to the total coal cut depends on the depth of the seam and whether the cut is made in the coal or in a band of shale, *e.g.*, in a seam of coal 40 inches thick, if the undercut is in the coal and four inches deep, then the amount is about 10%.

By bringing the cuttings out of the mines, the workings are made much safer, and less stone dusting is required to make non-explosive the fine coal dust that remains in the workings.

The Pelton Colliery Company, Limited, has recently applied turbo-pulverisers to five boilers in order to burn cuttings, etc., which contain 10 to 30% of ash, 30 to 50% of carbon, and which have calorific values ranging from 8,000 to 12,000 B.T.U.

When the cuttings arrive at the surface, they are fed through sheet iron chutes to turbo-type pulverisers, which are fitted with a series of discs having manganese steel, flat-faced beaters. Each pulveriser has a capacity of 1,400 lbs. of coal per hour and is driven at 1,750 r.p.m. by a 25 h.p. three-phase motor.

A fan propels the powdered fuel through a six inch galvanized iron pipe to the combustion chamber of the boiler. Two boilers give 15,000 lbs. of water per hour, and three give 8,000 lbs. per hour.

The three 8,000 lb. boilers have had the combustion chambers increased by 533 cubic feet, and of the two 15,000 lb. boilers, by 1,040 cubic feet, and the extra brickwork has been strengthened by channel girders, and the sides of the furnace encased by steel plates.

The boilers were originally fired with coke oven gas, the steam pressure being 80 lbs. per square inch, but when the coke ovens were discontinued, they were hand-fired for a time. With pulverised fuel the pressure is now 120 lbs. per square inch.

With hand firing the best unscreened coal was used having a calorific value of 12,000 B.T.U.; but with pulverised coal firing the coal cutter cuttings have a calorific value of only about 10,500 B.T.U. and yet they give a higher evaporation.

Lopulco System.—One cannot talk about pulverised fuel without referring to the Lopulco system, for the simple reason that it is the method most used for firing large power station boilers.

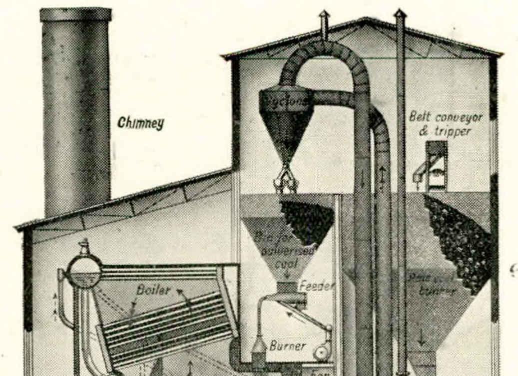


Fig. 1—Typical lay-out of Boiler House, with Lopulco Plant, shewing relative positions of Dryer, Raymond Mill, Cyclone, Feeder, Burner, and the U-shaped Flame.

Fig. 1 shows a typical lay-out, and the following is a brief description :—The coal is dried in a dryer of which one type is shown in Fig. 2, and is then ground in a Raymond roller pulveriser, until it is so fine that 85% will pass through a wire mesh having 10,000 holes to the square inch.

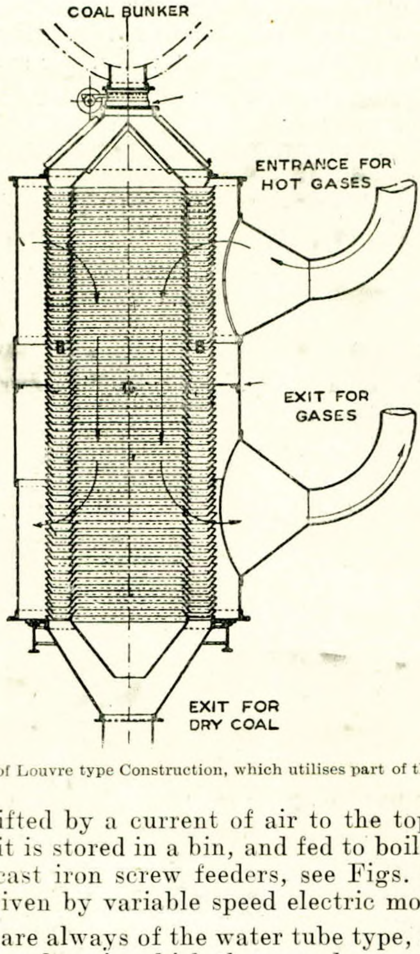


Fig. 2.—Dryer of Louvre type Construction, which utilises part of the Flue Gases.*

It is then lifted by a current of air to the top of the boiler house, where it is stored in a bin, and fed to boilers as required by means of cast iron screw feeders, see Figs. 3 and 4. The feeders are driven by variable speed electric motors.

The boilers are always of the water tube type, and have large combustion chambers in which there are burners, of which one is shown in Fig. 5, to project the fuel downwards.

* Other dryers utilise steam, and one called the carpenter, of which a lantern slide was shown, utilises centrifugal action.

The pulverised fuel is lighted up in the same way as lighting gas, and the flame returns on itself, the gases passing upwards through the tubes of the boiler and thence to the chimneys. The temperature at the centre of the flame is usually at about 2,700 degrees Fahr.

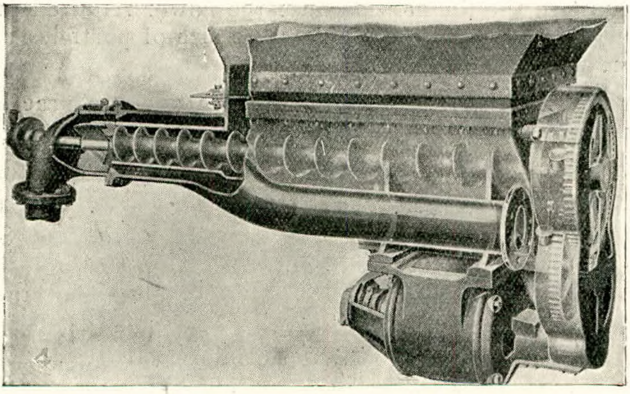


Fig. 3.—Section through Lopulco Feeder of Screw Type, showing Motor Drive and the Pipe for Supplying Carrying Air.

The ash particles from the coal fall in a fine rain to the bottom of the combustion chamber, and are there cooled by a hearth screen of tubes, set a foot apart. The water of the boiler circulates through these tubes.

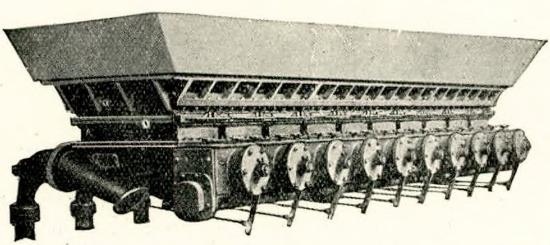


Fig. 4.—Group of 10 Lopulco Screw Feeders, driven by one Electric Motor.

Fineness of Grinding.—The fineness of pulverisation depends on the amount of volatile matter contained in the fuel; thus good bituminous coal, having high volatile content does not require to be ground so fine as a fuel which has a low percentage, the ideal being to get just that degree of fineness necessary for efficient combustion by using the least amount of power.

No advantage is gained by having larger percentages to go through the finest sieve, but combustion is reduced if particles are too large to go through a coarser sieve. There is a technical limit to the fineness because the power required for pulverising increases very rapidly as the size of particles become smaller.

The following is an attempt to state average practice for various kinds of coal:—

Name of Coal.	Approx. per cent. of volatiles.	Uses.	Coarse Sieve. All passes through.	Fine Sieve. 85°/₀ passes through.
Anthracite ..	3 to 7	—	60 mesh	200 mesh
Semi-Anthracite	7 to 12	Hard steaming	60 ,,	200 ,,
Semi-Bituminous	12 to 25	Good ,,	50 ,,	150 ,,
Bituminous ..	25 to 35	Smoky ,,	40 ,,	100 ,,
Highly-Bituminous	30 to 45	Gas and Coking	40 ,,	100 ,,
Lignite ..	45 to 60	—	40 ,,	100 ,,

Grinding Mills.—The Raymond is the most used of the roller mill types and is usually built with four to six rollers, each one representing about one ton of bituminous coal per hour, ground to a fineness such that 85% will pass through a 100 mesh.

Mills of this type to grind up to fifteen tons of lignite coal per hour have just been ordered for the new power station in Berlin and larger ones are being projected.

The Fuller Lehigh mill has several large grinding balls which are pushed round a race, and as the balls are loose there is practically no internal lubrication. Some of these mills have screens for separating out the fine dust, but as screens are liable to wear and get broken, a better method is to use air for separating the fines.

For grinding anthracite and especially coke it is well to use a very robust type such as the Hardinge ball mill and these are built in sizes which will grind up to twenty-five tons per hour.

Cost of Grinding.—St. Louis Company had a tube mill installation to grind low-grade bituminous screenings, and as it required 200 h.p., it was replaced by two Raymond roller mills, each of which took 85 h.p. to produce a similar amount, but of finer and more uniform quality.

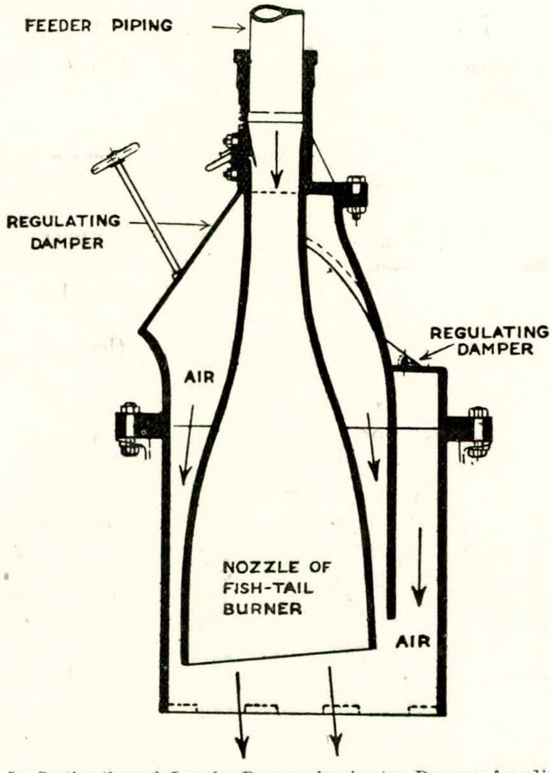


Fig 5.—Section through Lopulco Burner, showing two Dampers for adjusting the amount of Cooling Air.

The actual cost of grinding with the Raymond mills, including depreciation, interest on first cost, labour and maintenance and electricity at $1\frac{1}{2}$d. a unit was 15d. per ton of coal pulverised, and the total cost, including drying and conveying, as well as pulverising, was under 2/- a ton.

For quick calculations, grinding costs are often given as a percentage of the cost of the coal, *e.g.*, with coal of 13,000 B.T.U. the figure of $1\frac{1}{2}\%$ has been quoted and for coal having 9,000 B.T.U. about $2\frac{1}{2}\%$.

At the Lakeside Station at Milwaukee, Mr. Anderson gives the following costs per 1,000 lb. of steam from and at 212° F., for a labour rate of 75 cents per man hour; a coal cost of 22 cents per million B.T.U.; and a boiler rating of 175%.

Operating Labour	·023
Maintenance Labour	·010
Maintenance Material	·019
Supplies and Expenses	·011
Lubrication	·001
Fuel for Steam	·224
Total	$0·278

This includes maintenance of boiler and pulverising room fixtures, and the coal for banking, which is included in the "Fuel for steam," but it does not include interest or fixed charges.

A Fuller Lehigh push ball mill grinding dried anthracite coal of about a buckwheat size to a fineness such that 54%

Fig. 6.—Section through Lopulco Furnace Wall, showing Hollow Construction and the Supports for Holding Tiles to allow for Vertical Movement when the Wall Expands and Contracts.

passed through 200 mesh, cost 2/- per ton. The electric power was half-penny per Kw. hour, and labour 16½ pence per hour. When the fineness of grinding was such that 85% passed through 200 mesh the cost was 3/- per ton.

Construction of Wall.—A typical wall section of the Lopulco system is shown in Fig. 6, and it will be seen that it is constructed in such manner that it is free to expand and contract without the brickwork getting out of line or binding.

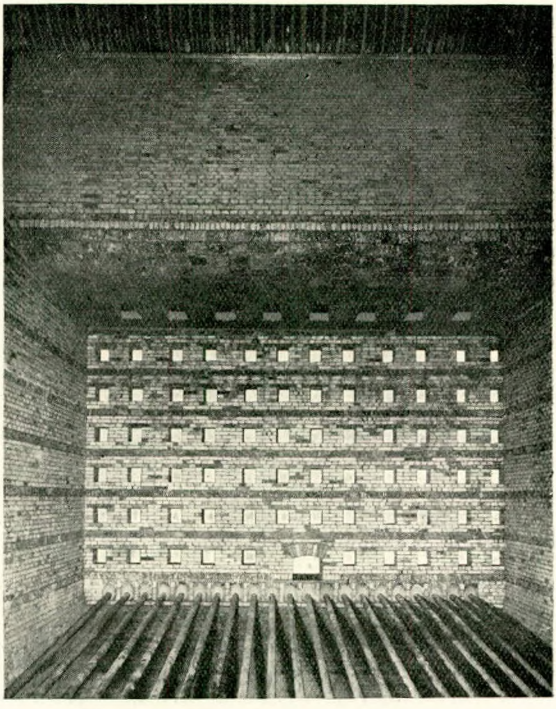


Fig. 7.—Interior of Lopulco Furnace, showing Holes for eight Burners in the Flat Suspender Arch, 70 Ducts for Secondary Air in Front Wall, and the 4-inch diameter Tubes of the Water Screen at bottom.

Secondary air passes through the hollow walls and absorbs heat from the brickwork and this heat passes again into the furnace. The air enters the furnace through openings in the front wall as shown in Fig. 7.

The amount of air circulated is controlled by doors located in the side walls, which are actuated by a single hand wheel, the adjustment being such that the correct amount of air for complete combustion enters each zone of the flame.

The chamber is built upon a steel cage or framework with a steel plate lining, and the walls filled in with sections of refractory brickwork, and each section has only to withstand the stress due to its own weight.

The layers of refractory tiles act as binders and slide freely up and down on cast iron clips or hangers attached to the main steel girders of the furnace, and these metal clips or hangers are similar to those used for suspended arches. By this method the walls can be built vertically.

Size of Furnace.—A striking feature of a modern boiler working with pulverised fuel is the large size of the combustion chambers, and the reason for it is to keep down the temperature of the walls to a figure which ordinary refractory bricks and tiles can withstand.

The capacity of a boiler working with pulverised coal depends upon the size and shape of the furnace, but good results are obtained when coal is burned at a rate of about $1\frac{1}{2}$ lbs. per cubic foot of combustion space per hour.

The draught is arranged so as to get a turbulent flame which will wander on the tubes, and it is usual to have a slight vacuum in the hopper, no pressure in the middle zone, and a slight positive pressure at the first pass of the tubes.

A boiler, to evaporate say 50,000 lbs. of water per hour, may require about 6,000 lbs. of coal per hour, and if the coal contains 15% of ash, then the actual carbon burnt will be 5,000 lbs. Each pound requires about 180 cubic feet of air for its complete combustion.

Assuming the initial temperature of the mixture at say 450° F. and the temperature of the flame at 2,700° F., or six times the initial amount, also the average velocity of gases through the combustion chamber at five cubic feet per second, then the cross section of the chamber works out at 300 square feet.

$$\frac{5{,}000 \times 180 \times 6}{60 \times 60 \times 5} = 300 \text{ square feet.}$$

Banking.—Boilers for pulverised fuel firing can be banked overnight or over a week-end without any coal being fired, and as the air ports of the flues are closed, heat can be held in the brickwork and thus loss of steam pressure is relatively small.

The rapidity with which a boiler can be brought to full steam is shown by a test made by Mr. Kreisinger at the station of the West Penn Power Company. He states that after a certain boiler had been banked for five hours, during which time no coal was fired, it was operating at 300% of rating within four minutes of starting up.

If an old type boiler with solid walls had been fired up with such rapidity, the inner portion of the wall would have been brought to a high temperature with consequent expansion, before the outer portions of the wall had absorbed sufficient heat to expand proportionately. This causes spalling and cracking of the bricks.

Arches.—These have to be flat because of great width of furnace and each refractory block has to be suspended separately, so that any one can be renewed when burnt out.

The best known types of suspended arches are the Detrick and the Liptak, and in each case the blocks are made in standard sizes and suspended from a metal structure. The Liptak has the refractories in two layers as shown in Fig. 8.

Shape of Flame.—There are various ways of arranging pulverised fuel flames, but by a general concensus of opinion the U-shaped flame is the most commonly used.

The burners are placed in a row on a flat suspended arch at the top of the combustion chamber and the fuel with a small amount of carrying air is projected downwards at good velocity. The draught causes it to return on itself and rise up to the boiler tubes, which are usually at a higher position and to one side of the burners.

When particles of bituminous coal are blown into the combustion chamber, each one bursts into flame, and there is a considerable heat near to the burners, but after the volatiles have been burnt out, the particles are carried forward and continue to burn as carbon.

Flame conditions for anthracite and coke are different because these fuels do not ignite so easily owing to lack of volatiles, therefore the particles burn as carbon for the whole course of their travel, with no burst of flame near to the burner.

Air of Combustion.—With pulverised fuel firing the amount of air required for combustion is only about 20% to 25% in

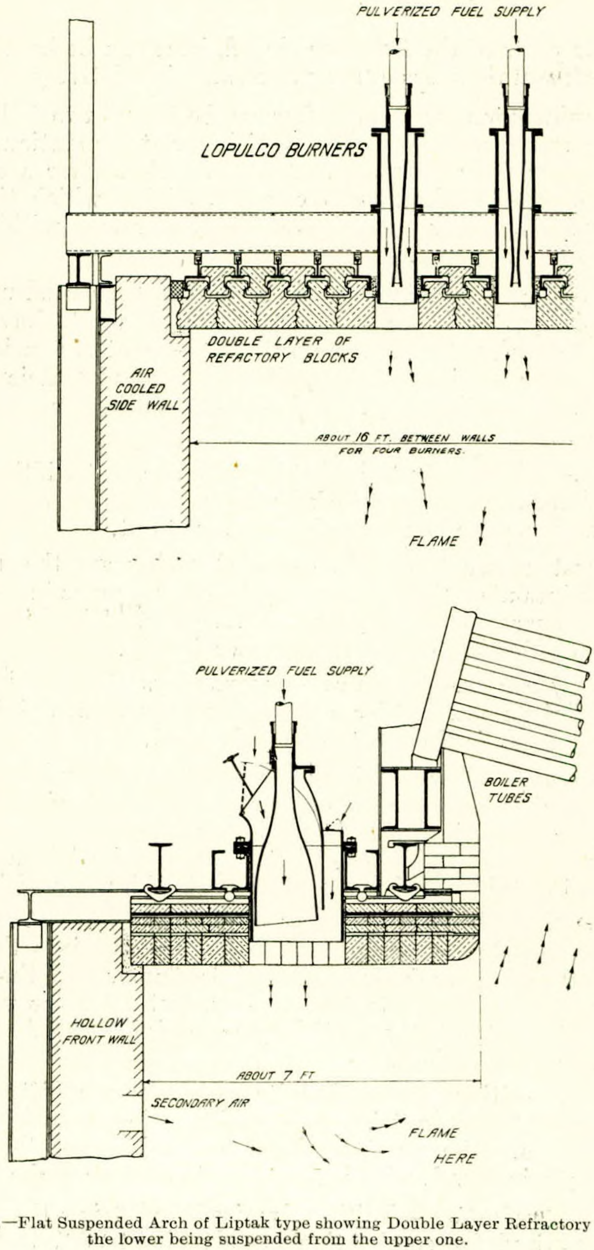


Fig. 8.—Flat Suspended Arch of Liptak type showing Double Layer Refractory Blocks, the lower being suspended from the upper one.

excess of the theoretical amount which would be required for perfect combustion if such a thing were possible.

In the Lopulco system three separate quantities of air mix with the fuel, and they are:—

First.—Carrying air which is mixed with the pulverised fuel when it is in the feeders; this is pre-heated by passing it through passages in the sloping walls of the ash hopper. Its purpose is to prevent packing of fuel due to moisture.

Second.—Air induced through passages in the burner, the amount of which is controlled by small dampers; this air is cold because its purpose is to keep the burner nozzle cool. It is useful to help combustion when first starting up.

Third.—The balance, about 80%, is called secondary air; and it is pre-heated by passing it through ducts in the side walls, after which it enters the combustion chamber through numerous openings in front wall.

Highly pre-heated air improves the boiler efficiency and it throws more evaporation on to the front tubes of the boiler.

Anti-Slag Screen.—The water or anti-slagging screen is an important feature of the Lopulco System, and exclusive to it, one of its functions being to prevent slag forming at the bottom of the combustion chamber.

It consists of seamless steel tubes, four inches diameter, set nearly horizontally across the bottom of the combustion chamber and at about 14 inches pitch. The tubes are expanded into forged-steel headers at front and rear of the chamber. These headers are connected with the boiler by down-take and riser tubes.

As the particles of ash settle out of the combustion chamber they pass between the tubes, and being chilled below fusing point fall to the bottom of the furnace as fine dry particles, which are easy to remove through the hopper doors.

The absorption of heat by tubes is at the rate of over 30,000 B.T.U. per hour per square foot of heating surface, and this is due to their being exposed to direct radiant heat from all parts of the combustion chamber.

Without the water screen there is the choice of having the combustion chamber so large that the lower portion is cool enough to cool the ash below fusing; or on the other hand, to rely on the furnace temperature being sufficiently high to fuse all the ash so that it can be discharged in fluid condition.

With the latter, if the furnace temperature should be a little too high the fused ash may flux away the furnace lining, and it may build up in sticky masses at the bottom.

New Boilers.—The success of pulverised fuel firing has brought into prominence defects in the present design of boilers, and we are on the eve of big developments in new types.

At one time water tube boilers were made with many sets of baffles, so that the gases had to pass several times across the tubes, but with the advent of the Stirling boiler it began to be recognised that it would be a good thing to cause the gas to pass along the tubes, and to reduce in number of baffles.

Later, it was shown that practically all the work of steam raising was done by the first rows of tubes which caught the radiant heat, thus two-pass, and even one-pass boilers have come into use.

The introduction of the Lopulco water screen to get over the fused ash difficulty, brought into notice the fact that such a screen at the bottom of the combustion chamber, was a very useful addition to the boiler heating surface.

The next step was to continue the tubes up the back wall to protect the wall from the pulverised fuel flame, and add still more heating surface to the boiler, in a position to catch the rays of radiant heat.

Murray Tubes.—Fin tubes were first tried on the side walls of boilers at Hell Gate power station, New York, and as a result those interested in the Lopulco system of pulverised fuel firing took up the patent rights.

There must be some distance between tubes in order that they may be expanded into the headers and plain tubes spaced at the minimum distance apart would necessitate refractory brickwork between them. This is objectionable because of the tendency for clinker to adhere to the brickwork and bridge across the tubes. Therefore fins were introduced.

Fig. 11 shows a section through a number of fin tubes forming part of a furnace wall, and it will be seen that projecting fins are arranged to overlap. Radiation losses from the external casing of the combustion chamber are rendered negligible by placing insulating brick between the tubes and casing.

It has been found that the conductivity of steel is so greatly in excess of the rate at which heat can be absorbed, that fins welded on to a water tube transmit the heat with such rapidity that the fin cannot become overheated.

Following the development of power plant practice, by which boiler feed water is pre-heated by bleeding turbines, the use of air pre-heaters for recovery of heat contained in the flue gases has become general, and higher furnace temperatures by use of pre-heated air are now possible.

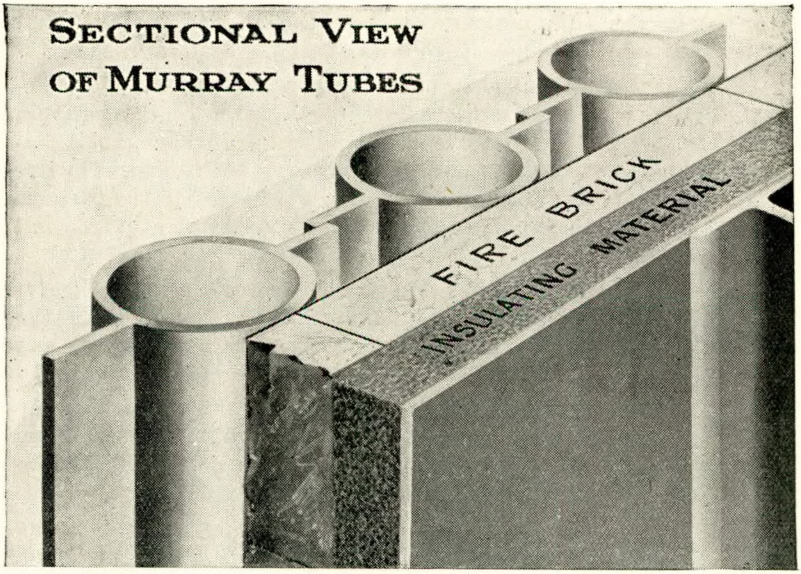


Fig. 11.—Murray Tubes showing the Fins overlapping to give continuous metal surface, also Insulation to prevent radiation of heat.

A test made at the Waterside power station, New York, on a B. & W. boiler, which exposed about 140 sq. ft. of tube surface to the radiant heat in the furnace, showed that:—

"The heat transferred to the water in the side wall at 200 per cent. rating was 43,000 B.T.U. per sq. ft. per hour, the water temperature averaging about 125 deg. Fahr."

Radiant Superheater.—The use of back screens and side wall tubes round the combustion chamber brought forward the idea of placing the superheater in the wall as is done with the Foster radiant heat type. This consists of steel tubes set in solid blocks of cast iron placed together to present a solid wall, and laid at an angle of 15 degrees to the horizontal.

The cast iron blocks not only offer a rugged construction but help to maintain a steady superheat, because of the flywheel action of the mass of metal, also the wiping action of the gases of combustion on the flat cast iron surfaces, increases the heat absorption per unit length of element.

In convection type superheaters, the temperature rises with the load up to a certain point and then tends to remain constant, whereas this tendency is reversed in the radiant heat type, because the temperature falls off as the load increases.

In steam turbines it is important not to exceed a certain definite figure, which is usually below 700° F., and if for any reason a greater percentage of air is admitted to the furnace, the tendency is for the steam temperature at the convection superheater to rise. On the other hand, admission of this air to the furnace lowers the furnace temperature, and this decreases the radiant heat available.

Therefore, while the work done by the convection superheater increases, the radiant heat superheater decreases, with the result that when the two types are installed in series, any tendency of a dangerous rise of temperature is eliminated.

Boiler Design.—The drift in boiler design is towards placing boiler tubes around the pulverised fuel flame, and in doing this, combustion engineers are really following on the footsteps of Bettington.

That distinguished South African pioneer, who came to an untimely end as an aviator, was well in advance of his time, and if a scholarship is ever established for Fuel technology or Combustion engineering it might well perpetuate his name.

Anybody looking at the high boiler plants which are standard practice in power stations, will recognise how hopeless it would be to put them into even the largest vessels afloat.

But if it is recognised that the boilers need re-designing to suit pulverised fuel firing, then there opens up a greater vista of usefulness, which may include steamships.

The marine side of engineering has in the past done much to advance engineering for land work, for example, it was on steamships that triple and quadruple expansion engines were first used, and some will remember that the steam turbine was given its first sphere of usefulness for the lighting of ships.

When the turbo-generator was just plodding along for power station work, Mr. Richardson suggested to Sir Charles Parsons that he should get into the ship propulsion business, and as a result, the famous *Turbinia* was built, and now almost every ship uses turbines.

We may therefore have new designs of boilers, which will enable pulverised fuel firing to be a principal way of raising steam for propelling ships.

Beater Pulverisers.—The grinding mills mentioned above grind by actual contact, and they are heavy machines to give large outputs per hour. The machines mentioned below are quite different in that they depend upon hammers or beaters or pegs to do the pulverising, and they are lighter in construction and run at much higher speeds.

They are used for what is called the unit system of firing boilers, that is to say they deliver the pulverised fuel to the boiler directly it is ground fine enough.

The Bettington pulveriser has a number of manganese steel beaters mounted on a single disc which rotates inside a chamber lined with saw-toothed steel bars and the fan action of the rotating part draws a current of air through the machine, which air carries off the fine particles.

The turbo-pulveriser, made by Clarke, Chapman and Co., Ltd., has a number of discs, each carrying beaters in separate compartments, and there are openings between the compartments to allow the pulverised coal to pass from one to the other in a current of air which is drawn through by a fan fixed on the delivery end of the shaft. Machines like these are made by several firms in U.S.A. and on the continent and some hundreds are doing good work.

The Attritor machine, made by Alf. Herbert, Ltd., breaks up the coal by attrition as it passes between a series of moving and stationary pegs, and the moving pegs are fixed on each side of a rotating disc. Air induced by a fan on the same shaft carries coal particles through the series of pegs at widely varying velocities according to the positions of the pegs, and there is a special rejector to return coarser particles.

About 50 of these machines are at work or on order, including three at the Amsterdam Electricity Works, where Dr. Lulofs has evolved a system of working pulverised fuel and mechanical stokers together, which is very interesting.

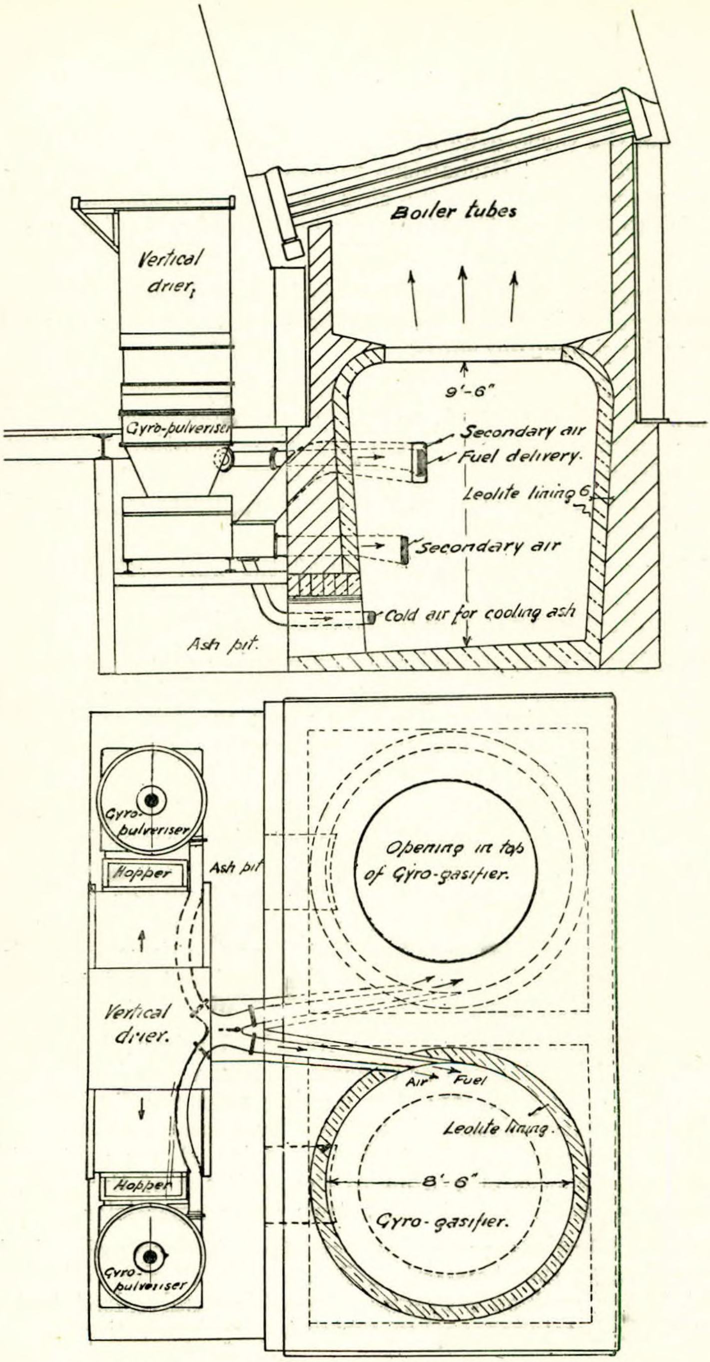


Fig. 9.—Showing two Gyro Gasifires for Boiler at Dover Power Station with tangential Jets of Fuel and Air.

The gyro pulveriser of Mr. Lindley Duffield has several sets of beaters on a vertical shaft and a fan at the top to draw off the fines, as made whilst the pieces that are too large fall back by gravity to be further pounded.

There are several other beater type pulverisers but there is not room to give further particulars in this paper.

Peterborough Power Station.—Two pulverisers of Messrs. Simon Carves' manufacture, serve two boilers, each of 25,000 lbs. per hour and they are placed on platforms over the combustion chambers, and are each driven by belts from 40 h.p. motors.

The degree of fineness of pulversation can be largely controlled by flow of air through a sliding door which also gives

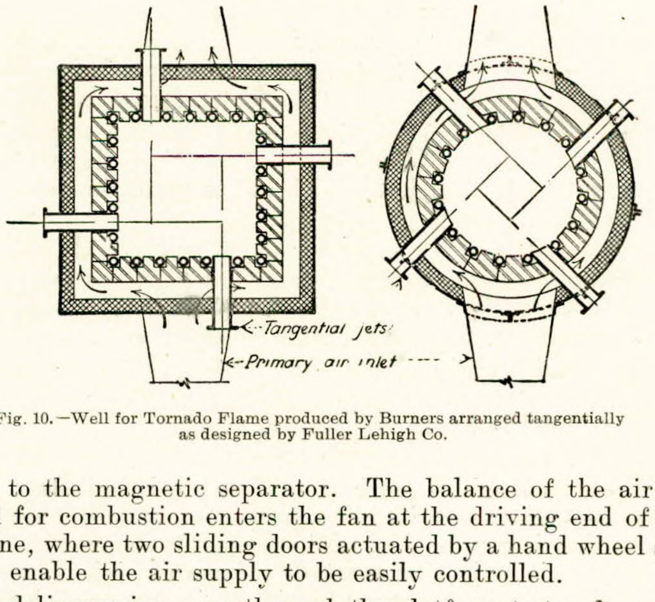


Fig. 10.—Well for Tornado Flame produced by Burners arranged tangentially as designed by Fuller Lehigh Co.

access to the magnetic separator. The balance of the air required for combustion enters the fan at the driving end of the machine, where two sliding doors actuated by a hand wheel and screw, enable the air supply to be easily controlled.

The delivery pipes pass through the platform to two burners, and either one or both may be employed according to the load.

Dover Power Station.—Fig. 9 shows two circular chambers, which Mr. Duffield calls gyro gasifires, as applied to a Vickers' spearing boiler, and it will be noted that the fuel and air supplies enter tangentially, and give two swirling flames in opposite directions.

Secondary air is admitted tangentially in the same direction as the powdered coal and it is divided into two portions, one being admitted near the centre and the other lower down. The respective proportions of secondary air affects the position of the hottest zone of the flame.

Tornado Flame.—It is a well-known fact that the wall of an atmospheric tornado is sharply defined from the surrounding air. Fig. 10 shows the Fuller Lehigh way of obtaining such a tornado flame by four pulverised fuel jets, placed tangentially.

Calling any one particular jet No. 1, its flame is deflected before it reaches the refractory wall by reason of impinging against the flame of jet No. 2, and that in turn impinges against No. 3 and so on, thus causing a swirl of flame.

It will be easily seen that the swirl has the effect of preventing what is known as a " dead film " forming on the tubes round the well, and this is a good feature, because it is the " dead films " on boiler tubes that restrict steam raising.

Higher Refractories.—A direction in which one looks for reduction in size of furnace is in the production of refractories, to withstand much higher temperatures than those which are at present on the market, which at the same time do not cost much more.

It is possible, of course, to make very highly refractory materials by calcining and sintering at high gas temperatures and especially by treatment in electric furnaces, but refractories so made are too expensive for boiler furnaces.

Refractories which give considerable promise are those containing Sillimanite; this being the name of a natural aluminium silicate found in India and elsewhere. By being neutral it is practically unaffected by either acid or basic slags.

In the journal of Society of Chemical Industry, A. F. Greaves-Walker describes the properties of Sillimanite, and claims that it can be used up to temperatures near its melting point, that it maintains constant volume at high temperatures and spalling is hardly present owing to its low coefficient of expansion.

Swan, Ratcliffe and Co., make bricks containing about 30% of Sillimanite, which are said to be able to withstand temperatures up to 1,800°C.

The principal argument in favour of spending money on highly refractory bricks, able to withstand very high temperatures, is that the relatively small chamber which results can be quickly built, and when bricks are burnt out they can be quickly renewed.

The problem as regards refractories can be briefly stated in the following way—whether is it better to (*a*) build a small chamber with say 4,000 highly refractory bricks costing £50 a thousand in one week? or (*b*) build a larger chamber with say 40,000 firebricks costing say £10 a thousand, that may take several weeks to build?

There is no doubt that as the prices of the better refractories come down, more of them will be used for pulverised fuel furnaces, and as a result the sizes of all furnaces can be reduced. It must be remembered, however, that there is a minimum, because length of flame is important, and the greater the mass of incandescent particles in a furnace the greater the radiation effect.

The above points are specially mentioned because the size of combustion chamber is an important factor when considering the possibilities of applying pulverised fuel to marine work.

Buell Burner.—Attempts have been made to design special burners for pulverised fuel, so as to give long or short flames at will, and also to deflect the flame when used for smelting furnaces.

The Buell burner (Fig. 11) is such a one, and is so constructed, that air currents cause the dust to impinge against the annular faces of an outer cone situated at the mouth of the burner, to give intimate mixing. It is claimed that combustion can be carried out completely within 6ft. of the burner.

If a long flame, travelling more or less in parallel lines, is desired, as for rotary cement kilns, or furnaces which are long and narrow, a non-dispersive flame is used, and this is obtained by screwing forward a sleeve on the fuel pipe. When a short stubby flame is required, the adjustment is made backward, and it is thus possible to increase the area of the fuel cloud about six-fold.

Sufficient air is admitted into the heart of the fuel cloud, as it leaves the first conical mouth to provide each particle of dust with its requisite amount of oxygen, but in case further oxygen is necessary, passages in the outerhousing of the burner are provided.

At the Maize Products Co., Ltd., Victoria, a Babcock and Wilcox boiler of 320 h.p. has had Buell burners in operation since October, 1923, and in a test with undried Newcastle slack coal 9·6 lbs. of water were evaporated per pound of pulverised fuel, which result showed a saving of 30% in fuel over hand firing.

An American development, the Peabody composite burner, for using gas, oil or pulverised coal, either separately or mixed, is claimed to be particularly suitable for marine work.

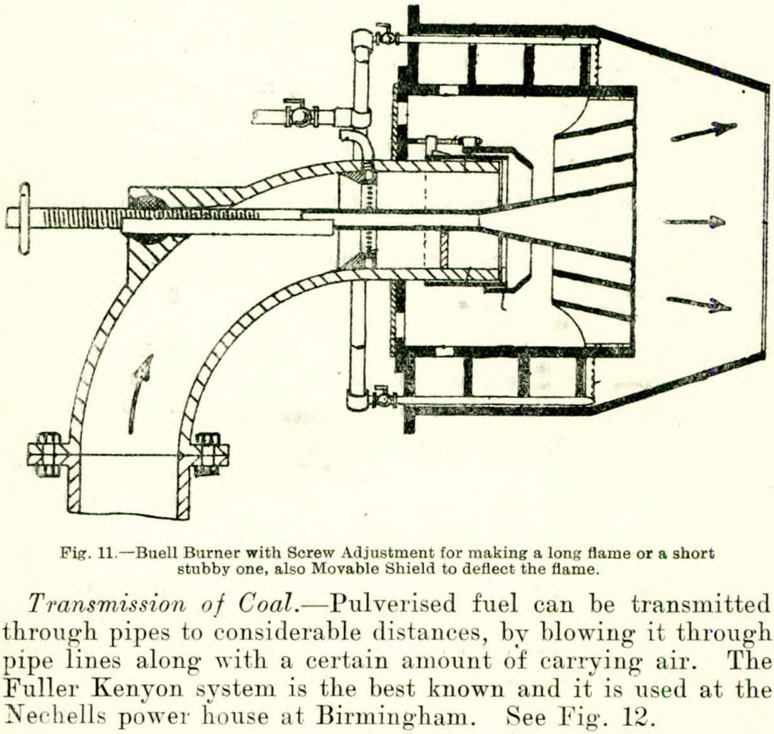


Fig. 11.—Buell Burner with Screw Adjustment for making a long flame or a short stubby one, also Movable Shield to deflect the flame.

Transmission of Coal.—Pulverised fuel can be transmitted through pipes to considerable distances, by blowing it through pipe lines along with a certain amount of carrying air. The Fuller Kenyon system is the best known and it is used at the Nechells power house at Birmingham. See Fig. 12.

The pump consists of a rapidly rotating screw which sets the pulverised fuel in motion, and a small amount of air is injected into it to fluidise or lubricate the coal, the amount being less than one per cent. of that required for combustion.

At the works of the Fuller Lehigh Co., pulverised fuel is being successfully conveyed in one stage for a distance of 5,340 feet; just over a mile.

At the Ougree Marihage Steel Works, Belgium, the Quigley system is used for transmitting pulverised coal over a total distance of 2,300 feet, and in this case the steel piping, four inches diameter, follows the contour of the ground. One case change of elevation is as much as 33ft.

The fineness of pulverisation is such that 97% will pass through 100 mesh and 84% through 200, and part of the coal is used for firing steel furnaces, and part for firing boilers of relatively small size.

Coal preparation and transport requires 20 kw. hour per ton and the quantity of coal for drying, ranges from 26 to 44 lbs. per ton of coal pulverised. The pressure for transporting the pulverised coal is about 70 lbs. per square inch.

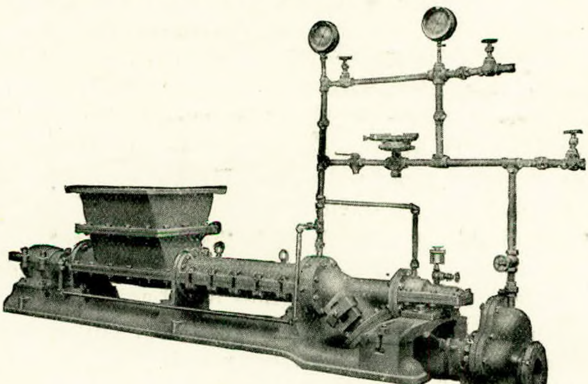


Fig. 12.—Fuller-Kenyon Screw Pump for transmitting pulverised Coal to a distance.

Fine Ash.—Many people ask questions about the ash from chimneys of plants which are fired with pulverised fuel. Ash from pulverised fuel plant does not consist of grits and cinders containing soot or tarry matter as from stoker furnaces, but the particles are extremely fine and consist mainly of silica with traces of iron, lime, magnesia.

Individual particles are so small that they are practically invisible to the naked eye, and this can be readily understood from the fact that each particle of ash has come from a particle of pulverised fuel so small that it passed through a hole in a wire mesh having 10,000 holes to the square inch.

Some firms wash out the dust by passing the flue gases through a screen of water drops. Another method, due to Dr. Cottrell of America, is to deposit dust by electro-static action at extra high tension, and this is employed for the pulverised fuel plant at the Trenton Power Station, Detroit.

Messrs. Davidson of Belfast, employ an induced draught fan to draw the products of combustion from the main flue and discharge them tangentially into the volute casing. The particles hug the periphery more and more as the radius of the volute decreases, until the dust outlet is reached. The cleaned gases then pass to the chimney.

Developments on Continent.—Pulverised fuel firing is making great headway on the Continent, particularly in France, Belgium and Germany, and therefore a few brief particulars will be of interest.

At the Vitry Power Station near Paris, there are four Ladd-Belleville boilers, each capable of evaporating about 160,000 lbs. of water per hour, fired with pulverised fuel on the Lopulco system. They have been working several months.

At the Gennevilliers Power Station there are four similar boilers but of larger size fired on the same system, and the first two have recently been started up.

In Belgium several installations have been put down at coal mines, to utilise fuel that has hitherto been considered to be only refuse. One is at the Mines des Lens.

In Germany contracts have been placed for boilers for a new super-power station at Rummellsburg near Berlin, and twelve of them are to be fired with pulverised coal on the Lopulco system. Contracts for power station at Dresden are also being placed, and the plant there will be similar to that for the Rummellsburg.

The engineering profession in Germany is now favourable to pulverised fuel, and it is a result of the experimenting that has been going on to make better use of their brown coal.

Derby and St. Pancras.—Figs. 13 and 14, which are made from the lay-out drawings of the boilers at the new power station near Derby and the power station of the Borough of St. Pancras.

In the Derby installation the boiler has two-passes, and the economiser is behind the boiler, and the flue gases enter the chimney at the bottom.

In the St. Pancras plant the boiler has three passes, and the economiser is directly above the boiler, and the gases enter the chimney at a still higher point.

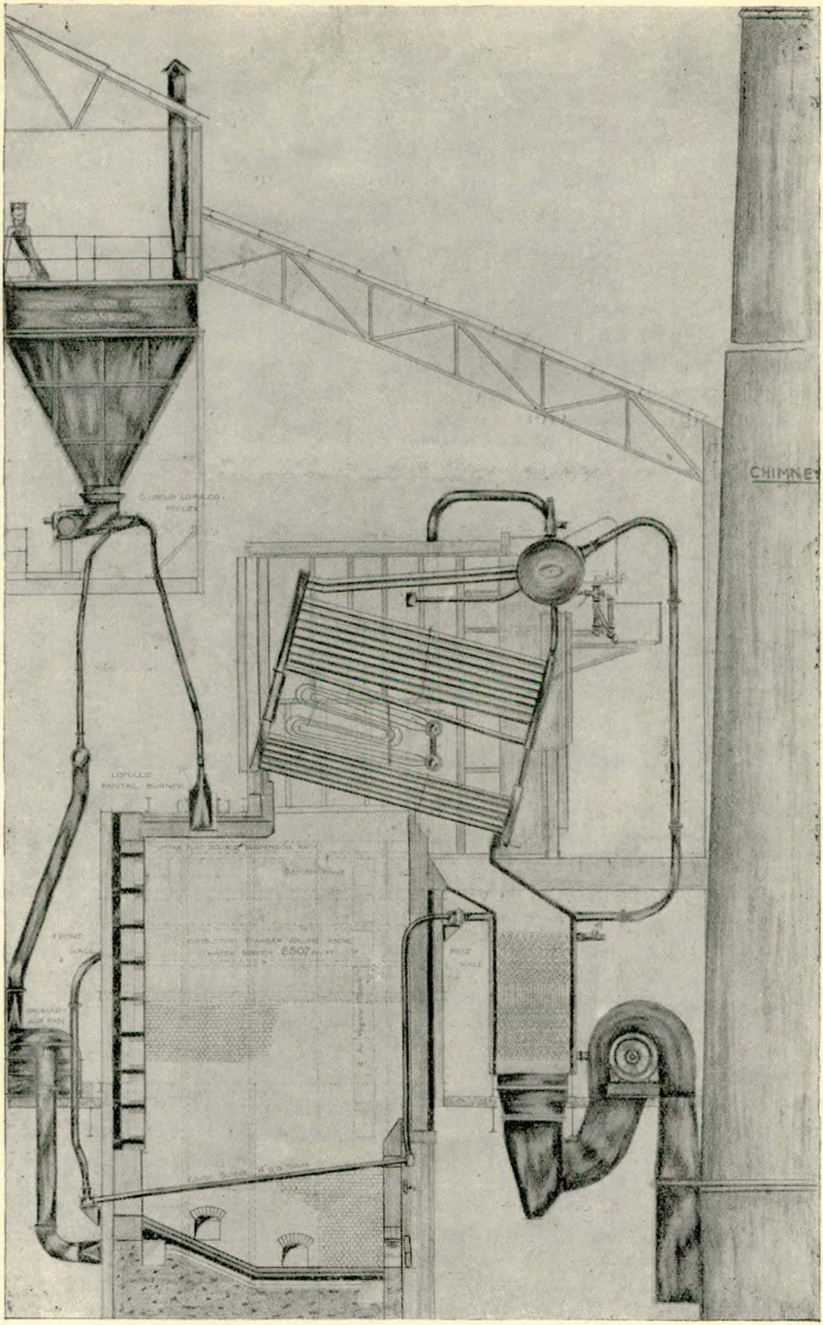


Fig. 13.—Lay-out of Boiler House of County of Derby Power Station.

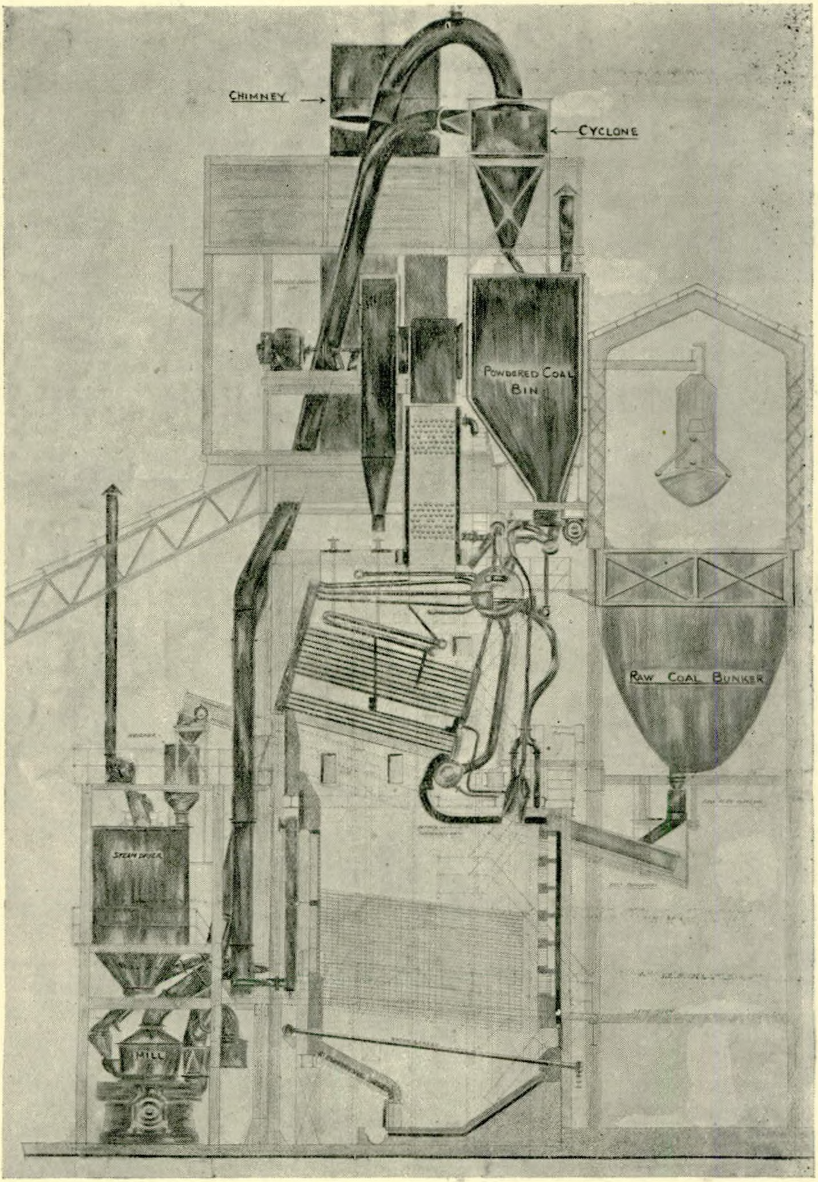


Fig. 14.—Lay-out of Boiler House at St. Pancras Station.

It will be noted that the combustion chamber has side wall tubes, and these are of the Foster cast iron block type, which fit close together.

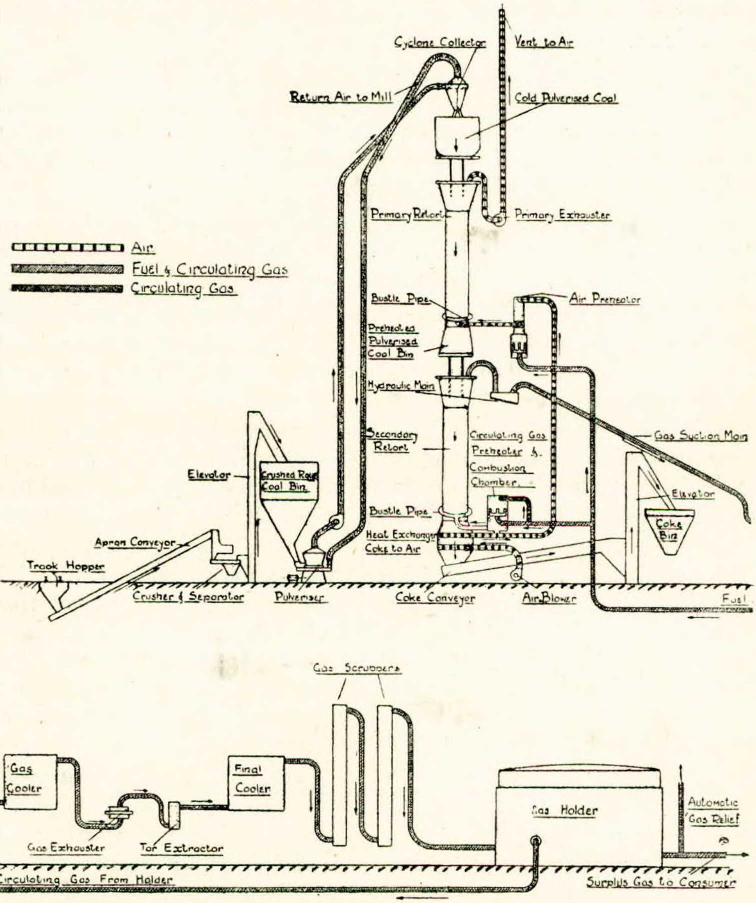


Fig. 15.—Arrangement of plant for McEwen-Runge Low Temperature Carbonisation Process. Bottom part of Figure continues that of the top.

Low Temperature Carbonisation.—There are possibilities in the direction of utilising the products of low temperature carbonisation for marine work because semi-coke made by some of these processes can be stored indefinitely.

Certain methods have had moderate success because of the coal being treated in lump form in retorts having moving parts, and requiring considerable hand operation. There is, however a method, known as the McEwen-Runge, which differs from the others in that the coal is first pulverised to a fineness such that about 80 per cent. will pass through a 100 mesh sieve, see Fig. 15.

The pulverised fuel falls down a steel tower about 30ft high and 6ft. diameter, lined with refractory bricks, the time occupied being about 40 seconds. It meets gases which enter at about 700° F., and this heat is sufficient to drive off all the moisture, the CO_2 and inert gases.

It then passes down another similar tower and meets gases that enter at about 1500° F., which is sufficient to drive off the required amount of volatiles, and they pass away at the top.

The semi-coke in powered form is withdrawn at the bottom and can be straightway burnt in a boiler furnace or stored for delivery, or pumped to a distance along with a small amount of carrying air.

It is important to note that the powdered semi-coke differs from coal in that it can be stored indefinitely without caking or danger of spontaneous combustion, and as the particles are porous they present much surface and thus burn with high combustion efficiency.

In conclusion, I have just heard that marine boiler tests with pulverised coal, under the auspices of the Fuel Conservation Committee of the Shipping Board and experts of the U.S. Navy Department and Bureau of Mines, are to take place at the League Island Navy Yard early in January. They may have a very important bearing on the selection of types of propulsive machinery for new ships now under consideration.

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Discussion on Mr. Spanner's Paper on "Construction of Ships," read on Tuesday, November 10th, 1925.

Chairman: Mr. R. S. Kennedy (Vice-Chairman of Council).

Mr. B. P. Fielden: The author mentions Casualty Returns, and I think it would add to the value of the paper if these were appended.

He draws our attention to many regulations which have to be complied with on shore, but when he mentions shipping regulations there is little information given, but as a matter of fact shipping is swamped with them. I think he would do better by proving to shipowners that there is a saving and less risk by fitting soft-nosed stems, and if he can get the underwriters to reduce their premiums and thus give the shipowners an incentive to fit this type of stem, I think he will gain better results than by advocating more regulations.

Regarding bulkheads and sub-division, I do not think that torpedoes were responsible for the new regulations, but that the unfortunate loss of the *Titanic* was the cause, and in my opinion this accident was of a totally different character to collisions as ordinarily understood and referred to in Mr. Spanner's paper, where he states that two ships must be involved in a collision.

I would like to know whether the resistance is increased and, if so, how much by fitting a soft-nosed stem, and I suggest that comparative models should be tested in the National Physical Laboratory Tank.

The sketches show that the stem has a rake, and this appears to me to be a good thing to have as there is less likelihood of under-water damage to the ship which is hit by the one having a raked stem.

The Merchant Shipping Act settles which deck the length of the ship shall be measured on, and in the case of a vessel having two decks the upper one is measured to obtain the length so that the tonnage with a raked stem is greater than it would be if a perpendicular one were fitted, and it appears to me that the ship fitted with a raked stem is therefore penalised, and I think that the author might draw the attention of the Board of Trade to this, because it does not seem right to penalise a construction which is designed to reduce risks.

I agree with the author that the vertical bow plating would be cheaper to renew than horizontal plating, and in my opinion, the general principle of his proposal is good.

Mr. W. McLaren: I think the latter part of the paper is debatable, in which the author recommends the soft-nosed type of bow for the reason that it would reduce the cost of repairs following a collision. The diagrams show the ramming vessel striking the other at right angles. Has the author considered the effects of a glancing blow? From my own experience of three collisions, the conditions may vary very considerably. Another point to be considered is that, supposing the point where the rammed vessel is struck happens to be a part which offers maximum resistance, for example, one of the longitudinals, the ramming ship, fitted with this soft, bull-nosed stem, would probably suffer severe damage herself. This would be emphasised in the case of a stem with a rake, such as the old clipper stems. These had advantages, but a disadvantage was the difficulty of manœuvring in close waters. It appears that in the event of a collision, the raked, soft-nosed stem would destroy the upper works of the other vessel, which would then heel over, resulting in the lower plates being holed, unless the ship was deeply laden. It is difficult to theorise about such conditions, and I think it is a matter for actual experiment before we can safely adopt the proposed system of construction.

Mr. F. O. Beckett: As one whose knowledge of ships is confined to the experience of being in them, and does not include knowledge of their construction, I should like to ask the author a question regarding the Isherwood type of ship, in which I understand that the whole stringers are made as in designing a bridge, *i.e.*, they are locked from stem to stern. The author states that if two vessels collide one with another, if the ramming ship is fitted with the soft-nosed stem, it will not penetrate the other vessel, but is there not a possibility that the mass of cable in the chain locker of the ramming ship would cause great damage to that ship? The impact would be very severe, and in my opinion the forward collision bulkhead would not be strong enough. Following every impact retardation occurs, the reaction being proportional to the force of the original blow, and it seems to me that, apart from the consideration of preventing another ship being rammed severely, there is a risk of the soft-nosed ship herself being heavily damaged. If you consider twice 98 fathoms of chain, that is a big quantity of iron to be resisted by the bulkhead. With the fore and aft strakes as girders there must be a housing for them, and if the soft-nosed stem is desired, I think provision should be made for the stringers on the outside so that the safe load may be carried correctly.

Has the author considered the effect of a round-nosed stem on the steering of a ship? Mr. Fielden spoke of the rake on the bow, and I endorse his views. I was once in a vessel which had a long fiddle bow. A collision occurred which drove in the boom, and the bow broke up, although with the engines going astern we managed to save the lower frames. I understand that the docking people have a great objection to the fiddle bow. They like the straight stem where possible, as it takes less room in docks.

I commend the author's ideas, and I think there is much to be said for them from the design point of view, but I would like to have further information regarding the possibility of error in the steering.

Mr. A. Jobling: This paper appeals to me as one interested in repair work, for on reviewing a large number of repair jobs which we have had, I find that they have mostly been due to stem-on collisions. For instance, the *Glenogle*, on her second voyage was collided with by a very much smaller vessel, which ripped up thirty or forty frames, stripping all the plates right down to the bilge keel. In another instance the motor ship *Domala* was struck by a very small vessel under the stern, breaking the bracket and upsetting the whole shafting. I imagine that the soft-nosed bow would have avoided much of this damage. It is a question who would welcome the alteration more—the shipowner or the underwriter. Personally, I am interested in knowing whether the alteration will give more work to the ship repairers!

Mr. John Menzies: This afternoon I happened to have had a visit from a well known official of one of the Italian shipping companies. I explained to him roughly the subject of this paper, and much to my surprise he informed me that they already have this system in Italy, and that they launched a ship so fitted for his company a few days ago. I do not know whether the author is aware of this. One point which my friend emphasised was that the ship has no stem bar. My friend was unfortunately unable to come to the meeting and explain his views, as he leaves for Italy to-morrow. I should be interested to know whether the author's idea has been anticipated. I think this is a very valuable and interesting paper, which should give rise to a considerable amount of thought, and which I hope will lead to improvements in the design of ships. I would like to ask the author whether there are any ships under construction with this type of bow.

Mr. Spanner: Not at present.

Mr. Menzies: I have no doubt that when it has had time to be duly considered, we shall hear of more ships being built to this design.

The Chairman: Mr. Fielden mentioned the question of the rake of the stem. There is another advantage of the rake which has not been referred to, which particularly applies to smaller vessels, *i.e.*, that it ensures better seagoing qualities. I have had experience of small ships of some 2,000 tons cross-ing the Bay of Biscay; those with the cutwater bows would go through practically any weather, when those with the straight stems had to lie to. That may be another inducement to the shipowner to adopt the author's design. Regarding the blunt bow I do not know much about the steering qualities, but when I had to do with trial trips of new vessels I understood that it was the run or after lines of the ship which were important and that the bow did not matter so much. We see a number of Dutch "hookers" lying out in the Thames and although they are almost flat at the bow, they steer satisfactorily.

Mr. Fielden referred to tests at the National Physical Laboratory Tank, which of course would be most admirable, but it would be necessary to experiment on a full size vessel eventually. Perhaps some of the vessels which are being condemned under the Peace Pact might be used to try the system. I think that $\frac{1}{2}mv^2$ will come into it very much, and I suppose we may eliminate some of the factors in tank experiments and then go ahead on a big scale.

Mr. A. Jobling: Does the author propose to spend any extra money on stiffening up the bulkhead in the manner he has described?

Mr. J. Menzies: Referring to the last speaker's remarks about stiffening the collision bulkhead, I have an acquaintance named Scott who tells me that he invented a patent bulkhead of corrugated form which was fitted in a ship named the *Charity*. The ship is still afloat and I understand she has changed hands at a fair price. I have not heard of any other ship being built on that principle. The inventor told me that he thought it would very largely eliminate the risk of vital damage due to collision.

Mr. Spanner: I have been very gratified to hear the comments which have been passed on the paper, because they mostly show that the ideas I have expressed with a view to increasing the safety of life at sea appeal to everyone. Certain speakers have referred to the question of the effect of the round end on the speed of a ship. That is a point which is very easily answered. Apart from destroyers, there is not a ship in His Majesty's Navy which has a sharp stem. In the Service everything possible is done to increase the speed obtained from the horse-power put into the ship. The question of the fineness of the stem ending is one which was fought out many years ago. Years ago, ships used to have tremendous rams, and the sectional endings of the ram could as easily have been made quite sharp, but extensive tank tests showed that the effect of a 9in. to 12in. radius on the ship's stem was very small. In fact, the Admiralty found that the slightly blunt end was better than a very sharp end. For a similar reason one finds that shaft brackets are never fined off to a knife edge, although it would be quite easy to make them thus.

With regard to the question of the use of a dished plate. I do not make any claim for the use of a dished plate; that has been in use many years. Cruisers and battleships generally had the upper part of the stem casting terminating on a dished plate. In Russia and Sweden, and no doubt in the Italian ships which Mr. Menzies mentioned, the dished plate is used, but that is not enough, nor is it enough to give the stem an increased rake. The Holt Line vessels have an increased rake and dished plates above the water-line. The ship I have shown is 6ft. to 7ft. from the foremost point of the stem back to the point where the line of the stem cuts the water line. No ship moving at any speed could be brought up in 7ft. There must be some means of absorbing the energy of collision, to supplement the advantage of the rake. The rake gives one a certain advantage because one starts by doing the most damage above the water line, but one must be able to go back a considerable distance. The amount of material distorted in the first seven feet would be quite small. No matter whether it was an Isherwood framed ship or a soft-nosed ship, it is necessary to be able to crush back a considerable distance if one is to avoid vital damage to the rammed vessel.

Mr. Fielden raised a point regarding insurance premiums. That was one of the first points I thought of, and I went to the London and Liverpool Associations of Underwriters and they were frankly quite interested in the proposal, but they were not volunteering any reductions, of course! Their remarks were sufficiently favourable to show that the idea was one which appealed to them. If there was a gain in the adoption of the idea they were quite sure to reap benefit from it. Ordinary competition for business would result in a reduction in premiums, for the idea has been advanced principally with a view to getting rid of total losses.

Mr. Jobling appears to think that the ship repairer would have no less work to do on a ship with the soft-nosed stem than on one of ordinary form. I agree, but I think he would waste less stem material, and he would get the job done far more quickly. If a collision occurred to a soft-ended ship, and the ship repairer was informed in advance that the damage extended back to say, No. 4, 5 or 6 frame, he could get the whole of that material ready so that when the ship came into dry dock he would have only the one intermediate strake of plate to actually fit at the ship. Nothing like that is remotely possible at present. The representatives of Lloyd's have to be called in to determine what plates can be cut, and what arrangement of butts can be agreed. One cannot do much until the ship is actually in dock. One may take the trouble of ordering a new stem bar before knowing the full extent of the requirements, but generally one waits until the survey and then one has to wait for delivery of the stem. Of course, where the ship repairer is bound to gain is that he will always get the rammed ship home, instead of it being sunk at sea.

Regarding the question as to why owners do not more often fit the raked stem as Mr. Fielden suggests. Perhaps it is that although the raked stem is advantageous from the collision point of view, on the other hand the extra length of bow is of no practical use; one cannot earn anything with it. In the case of the soft end, a 6in. radius is not very considerable, and that radius does allow one to dispose of what is a source of danger to other vessels. Further, it cuts off about 2ft. from the length of the ship for tonnage purposes. If for the ordinary stem one substituted this proposed type of stem, one would at once reduce the measurement for tonnage apart from the saving of weight. The question as to how one determines the radius of the bow plate is almost entirely a constructional one. One would require to utilise material one can easily get from the mills, say plates 5ft. wide. Working back from existing experience with Admiralty ships in which a 6in to 12in. radius is not uncommon, one arrives at the proportions shown in my diagram. There is no method of calculating it out. If one adopts 6in. radius, one can reckon that there will be 6in. to 8in. straight surface before the lap will interfere with the shell lugs. In a large ship one would probably go to 1ft. radius because it would not be at all ugly in appearance.

Many owners and owners' superintendents when discussing the idea, ask why they should fit their ship with a soft nose in order that she may be damaged and not the other ship. I think that is a question which had to be raised, although no speaker has mentioned it. The answer is of course the same as the answer to the question, "Why do we fit brakes on a motor car?" or "Why do we take precautionary measures of any kind?" Any such measure to be effective must be co-operative: everyone must follow suit. One may have the misfortune to run into another ship, or another ship may run into you. If all the ships concerned have soft-nosed stems, the rammed ships will be better off. Mr. McLaren contends that fitting the soft end will not make the ship safe under all conditions. There are, of course, cases where an anchor has damaged a ship's side as he mentioned. What I have insisted upon is that by dispensing with the stem bar and substituting a radiused stem plate, it would be impossible to inflict very great damage. The increasing of the area of impact will prevent puncture. In the case quoted by Mr. McLaren, the fluke of the anchor was a very small point which finished up by doing a great deal of damage. It did this because it got the chance to start an initial rupture.

Mr. Beckett mentioned the Isherwood system, which brings me to the most important question of all, namely, the collision bulkhead. I think one can arrive at the solution of that difficulty simply and solely by arranging the strakes of shell, deck and divisional bulkhead plating. Especial attention is required in the widths of the strakes of plate. In ordinary types of ships, I could quote several cases in my experience in which the collision bulkhead was damaged, so as to require a lot of repair, when the actual damage to the shell plating of the ship did not extend back more than 4ft. or 5ft. from the bow. The continuous longitudinal members had carried the weight back and punctured the bulkhead. That must be a not uncommon experience. I have arranged my design so that the lines of weakness of decks and longitudinals are carried back, to fail in exactly the same way as the shell plates fail, *i.e.*, along the lines of rivets. One does not want to carry the damage right back to the collision bulkhead. If you refer to the last diagram in the paper you will see that on the fore side of the collision bulkhead there are transverse plates going right across. As I have remarked, this diagram hardly gives a complete illustration, but the intention is that the strakes of deck plating and the laps of the longitudinals shall slide back past one another as the riveting fails.

Mr. F. O. Beckett : I do not agree with the author as regards the large amount of chain not being forced back on to the collision bulkhead.

Mr. Spanner : The chain might be arranged behind the collision bulkhead if preferred : it is purely a question of design.

Mr. Beckett : It is a question of the chain taking the whole force of the collision.

Mr. SPANNER: In a proper design the collapsed plating would be brought up so that the pressure on it was taken on the bulkhead stiffening and not, through a mass of chain, on the bulkhead plating.

Mr. McLAREN: When a ship is struck, she heels over and then slews round.

Mr. SPANNER: In the case of a soft-ended ship, assuming that the soft end would not penetrate the other ship, there would be more tendency to rub past. The reason large holes have been torn by stem bars in some cases is that the stem bar has penetrated slightly and held while the two ships swing together a small initial hole being thus converted into a huge rent. This could not happen with a soft ended ship.

Anyone adopting this system will still have a ship as strong and sound, which will pass all the usual requirements, which is less heavy, easier to build, and in the case of minor damage, easier to repair than an ordinary ship. The owners lose nothing by the proposal, they would be promoting improvement in the design of ships by doing away with the stem bar. The reason the stem bar survives at the bow is simply because no one has had the courage to say that it should be done away with. The keel bar has been done away with for many years. There would be no difficulty with the rounded bottom plate to the stem. This could be made in halves with a butt joint at the stem line.

Mr. BECKETT: The author stated that there would be less material and the same amount of space for the shipowner. If the collision bulkhead had to be stiffened to enable the ship to close up after a collision, in closing up, if you did not provide knee plates and ample stiffening plates you would risk rupturing the bulkhead.

Mr. SPANNER: I agree that it is essential to prevent the collision bulkhead from being damaged. I propose to fit heavy stiffening plates right across on the fore side of the bulkhead, on which the other ship would pull up.

Mr. BECKETT: It is a question of the bulkhead plate itself; supposing your ship is 25ft. draft, and you receive a big impact of many thousand tons, the plate has to be very strong to withstand that, if it is not to break.

Mr. SPANNER: There will be, in effect, several girders right across, formed by the decks and angle bars. From a constructional point of view there is nothing to prevent it being arranged so as to prevent damage to the collision bulkhead.

Of course, after any ship has rammed another it would not be able to go along at the same speed; it might be necessary to ride on the collision bulkhead: that is quite a common thing. My idea is to have the stiffening on the forward side, not the after side of the collision bulkhead. With regard to the casualty returns asked for by Mr. Fielden, I can certainly supply some of these.

I quite agree with Mr. Fielden that most of the points discussed by the Bulkhead Committee arose from the loss of the *Titanic*. Following that disaster, a system of ice patrols was started, and this patrol system enables ships to keep clear of this danger. Grounding is the risk which causes the greatest number of casualties. The ships' officers in this case are at fault and the casualty affects the one ship only. Collision is, of course, a risk which may affect even the most careful ship's master. There has been a great deal of discussion regarding the insistence of the Board of Trade on the application of the Life Saving Regulations. I think everyone must agree that the circumstances necessitating the provision of boats only arises when the ship is in collision. In the case of the *Egypt*, the passengers were thrown into great peril in the course of a few minutes. That is the reason why ships were for a while loaded up with a great number of boats which could never have been got out. If one could mitigate the risk of a ship being badly holed, it would be a great advance. Boats must be provided whether the ship has a soft end or not, but I think the soft end is probably going to give a better life-saving return than will the provision of a large number of boats which cannot always be got out in time of crisis.

Mr. Fielden: I might gave an independent view of Mr. Beckett's difficulties. I think Mr. Spanner proposes stiffening up the bulkhead and that the parts forward of it should be allowed to collapse.

I have much pleasure in proposing a hearty vote of thanks to Mr. Spanner for this paper.

CONTRIBUTED BY CORRESPONDENCE.

Mr. E. W. Blocksidge: Any proposal which has for its object the reduction in the number of casualties to ships at sea should demand the attention and awaken the interest of every member of the Institute.

Mr. Spanner gives particulars in his paper of a special form of stem which he claims will minimise the risk of total loss to ships after collision. The proposals give simplicity of construction, and the design lends itself to easy replacement of repair after damage, and its economic value will appeal to shipowners.

In introducing the subject for discussion, Mr. Spanner calls attention to the great loss in ships due to collision, and it is of interest to investigate from his point of view as to the percentage of loss of ships from collision in comparison with the total number of casualties recorded.

It is helpful to know that the number of collision cases are gradually being reduced. Over a period of 20 years, the percentage of British sea-going ships lost as a result of collision to the total number of ships lost was 15·9, the number of total losses being reduced from 52 to 23.

The published records since the War do not assist one to obtain details in regard to the casualties to small ships under 1600 tons gross, but the following information for one particular year will be of interest. Reference is made in the Table to British ships only.

NUMBER OF COLLISIONS TO BRITISH VESSELS IN RELATION TO TOTAL NUMBER OF CASUALTIES IN A YEAR.

AT SEA.

Type of Vessel.	Total loss from Collision	Total loss from all Casualties	Percentage of Loss	Total number of Collisions	Total number of all Casualties	Percentage of Number
Sea-going, Sail and Steamships registered in Great Britain ...	23	169	13·61	614	2650	23·16
Fishing Vessels ...	20	105	19·05	434	964	45·0
All types of Vessels...	49	305	16·07	1,115	3,817	29·21

AT SEA, IN RIVERS, AND IN HARBOURS.

Type of Vessel.	Total loss from Collision	Total loss from all Casualties	Percentage of Loss	Total number of Collisions	Total number of all Casualties	Percentage of Number
Sea-going, Sail and Steamships registered in Great Britain ...	27	176	15·34	1,484	4,079	36·38
Fishing Vessels ...	21	108	19·45	827	1,392	59·4
All types of Vessels ...	63	332	18·98	2,764	6,124	45·14

From the information given in this Table, it will be seen that the largest percentage of casualties as a result of collision is in fishing vessels.

I feel inclined to place more importance on the advancement of science as a means of reducing the risk of collision than the author would appear to admit. One cannot foresee the great influence of "Wireless" in this direction, but the rapid advance which has already been made during the past five years suggests that in the near future the safeguard for ships at sea and on entering harbour will develop along these lines.

Some two months ago I was present at a test in Newhaven Harbour of Fellows' system of duplex fog signals worked in conjunction with wireless telegraphy, whereby a ship will be enabled to enter or leave a harbour during foggy weather through a safe passage. This is an example of the development of navigational science towards reducing the risks to which ships are subjected under the present conditions.

I have pleasure in acknowledging the value of Mr. Spanner's proposals for the soft-nosed stem as a means of reducing the extent of damage when ships are in collision, and have taken the liberty to contribute to the discussion by giving particulars relating to collisions of British vessels in support of the author's opening remarks relating to the serious nature of the casualties which occur to ships at sea and in harbours.

Mr. Mordaunt M. Parker : Mr. Spanner has rendered public service in calling attention to the possibilities of this "soft-ended" ship.

The suggestion of a round plate stem in place of the ordinary stem bar is good, and has, as no doubt Mr. Spanner is aware, been tried on one line of steamers trading into London.

The plating of the bows in vertical instead of horizontal strakes should reduce the amount of material which would have to be removed in the event of bow damage repairs. This method of plating bows was resorted to frequently in repair work during the War.

The idea of giving the stem such a decided rake, partly defeats the object of the round stem, which, as Mr. Spanner states, is to distribute the force of impact over as large an area as possible; it has, however, the advantage of keeping the initial blow well above the water-line.

It must also be remembered that, whereas a decrease of damage to the vessel struck might fairly be expected, the striking vessel would probably suffer much greater damage and temporary repairs might well be almost out of the question, thus necessitating immediate dry-docking of the vessel.

*On proof page 3, Mr. Spanner claims five advantages for vertical bow plating. Nos. 1 and 2 seem indisputable. With regard to No. 3 it might be observed that the same, or even more corrugation of plating would occur in ice navigation with vertical as with horizontal strakes. No. 4 claim is open to question. It would undoubtedly be possible to construct the whole bow on the ground, but it would be a large weight when completed and could not be raised into position by the ordinary shipyard appliances. Then again, it is useful in erecting the bow structure to have the stem bar in position for the purpose of running out ribbands and fairing the frames. To build the bow separately would involve the making and breaking of considerable staging and the use of special ribbands or other arrangements for fairing and securing the frames. After transferring the bow to the blocks, it is probable that further staging would have to be erected for connecting the bow to the rest of the ship.

In point No. 5 I think Mr. Spanner overstates the case. It is doubtful if work could be prepared before the vessel was in dry-dock, for templates would have to be made as in the ordinary case. Further, in the majority of cases it is necessary to hold a survey in dry dock in order that all parties concerned may assess the damage and possibly call for tenders before the first blow is struck. The obtaining of a new stem forging rarely delays the work, as repairs can proceed with a false wood stem in position for templating and erecting new plating.

That the cost of building would be reduced is very doubtful, for although weight would be saved, the cost of making the round stem-plate, especially the fore-foot plate, would be high. The riveting might be a little simpler with the soft-end ship, but it is difficult to see any advantage for the caulker.

I emphatically agree with Mr. Spanner that total loss due to collision would be greatly reduced by the soft-end, but it must be borne in mind that total loss occurs from other causes also, and thus no very great reduction of insurance premiums could be expected from the introduction of the soft-end ship.

Our thanks are due to Mr. Spanner for the able way in which he has brought the subject before us.

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* See p. 480 December issue.—J.A.

Dr. Ing. Carl Commentz (Hamburg): In due course of a correspondence on the matter of collision prevention I have been asked by Mr. Spanner to send a written contribution to his paper. I absolutely agree with Mr. Spanner on the main point of his endeavour, viz., that the normal vertical stem with stem bar construction is the cause of much more losses than is usually anticipated. For other purposes I made up a year ago some statistics, from which it is obvious that in the time from 1891—1923 (war years excluded) about 31½ per cent. of the accidents caused to seagoing vessels were due to collision. Further, of the vessels that encountered a collision 3¼ per cent. were a total loss. As there are always two vessels concerned in one collision and as the ramming vessel is only seldom lost, the risk for a rammed vessel to be sunk by collision is practically about 16½ per cent. Indeed of all total losses in those years about 13½ per cent. were due to collision.

In his paper Mr. Spanner puts the matter of soft construction in the foreground. From the figures accompanying it, it may however be seen, that the "raked" stem is included in his idea. I do not only think this natural, for anyone, who ever has been occupied with the question of minimising the risk of collision danger, but should like to put it in the first row. Any vertical stem will cut from its highest to its lowest vertical point into the skin of the ship it hits. The matter endangering that ship is the intrusion of water. As a matter of fact, the lower parts of any collision wound are much more dangerous than the upper parts, because water intrudes in correspondence with its pressure, which is dependent upon the draught. Collision wounds above or even in the water line are of no material danger, if not too large. Only by a raked stem it can be provided that the main part of collision wound is above floating line. Apart from this, which is a well known fact, there are some other advantages in the raked stem that are usually not duly considered in naval architects' circles, as they run more in the nautical lines. With a raked stem the lower part of the vessel may be cut finer, so that resistance is decreased even in smooth water. Chiefly, however, resistance is materially smaller in a seaway coming ahead, as the vessel is better lifted by the waves and going across them; less water comes on the deck and the vessel may not be submerged, so that the danger of breaking hatches is smaller, to say nothing of a more agreeable sojourn on a dry vessel. Further, a vessel with a raked stem lends itself more easily to give the curve between the stem and the keel a greater radius; if this is done the centre of gravity of the lateral area of the vessel is situated more abaft and this results in less yawing and in better steering qualities of the ship. The reintroduction of the raked stem is to my opinion the most important thing in order to decrease the dangers of collisions. It has been abolished mainly by the fact that Lloyds numerals were measured on the upper deck and that the length of tonnage measurement is still. An efficient means to favour the reintroduction of the raked stem would be, if Lloyds length should be measured in future not in the loaded water line as is done now, but at half loaded draught. Indeed, the insurance companies, which have the most considerable interest in this matter, should use their influence to get such measurement. Also tonnage length measurement should be effected at a lower point than is done now.

A raked stem, if of solid stem construction is, to a certain degree, even more dangerous than a vertical stem. It puts its whole energy of movement upon a single point of the skin of the rammed vessel and must pierce it; from this point it cuts like a knife downward, ripping the body of the assailed vessel. For collisions only, the proposals of Mr. Spanner would therefore be an ideal solution of the problem. There are, however, two objections to it. The bow as proposed by Mr. Spanner will not be able to cut duly through heavy ice, and I am afraid that it may collapse rather much even at a moderate collision. It is true, the interior of the ramming vessel begins practically only at its collision bulkhead and that of the rammed vessel at its very skin, but it must be provided, that also the colliding vessel is not too much damaged in any case. I am of the opinion, that it will be sufficient to provide a soft construction up to say, where the load water line has a width of about one yard; vertically above this point the deck will, with a raked stem, have a very considerable width. The triangular or rather irregular pyramidical soft nose thus defined will take up a very good collision shock, and when it is crushed, a broad area and not only a single point or line of the skin of the rammed vessel will have to take up the rest; frames and decks, that support the skin will take their part and there will be only seldom fatal wounds effected by the collision.

Apart from this, anyone, who has had an occasion of seeing vessels work in really hard ice will admit, that only a strong and really sharp edge will be able to cut through it. In the region of ice, a rounded plate stem, even of considerable strength, will be not of much use. Even vessels, that do not as a rule frequent icy waters, would be inferior in commercial value, if they have not a strong and sharp stem, for it would be difficult to sell them to other owners. In the ice region, reaching from 2 feet below the light line to 2 feet above the loadline, there must be a strong stem construction, which may be ideally formed by a moulded piece of cast steel. A cast steel piece may, as a matter of fact, be so formed at its ends, that it can be easily connected to the plates forming the lower and upper part of the stem.

Mr. Spanner's further reply: I am grateful for the remarks which have been forwarded by Mr. Blocksidge, and for the very useful table which he encloses, which describes the conditions I have put forward as regards the importance of the collision risk.

It is of course clear that the type of construction I advocate is as suitable for fishing vessels as for any other type of ship.

I agree with Mr. Blocksidge's remarks regarding the advancement of navigational science up to a point, but when one knows of serious collisions which have occurred on many occasions in daylight, it is clear that developments of wireless and so on will not entirely eliminate the risk.

It is encouraging to know that interest in the 'soft-ended' ship proposals has been awakened in Continental countries, and further to note that a very large measure of support is given by Dr. Commentz to the ideas I have put forward.

There is no doubt about the value of rake, so far as preventing damage to the rammed ship is concerned, when the bow of the ramming ship is of ordinary construction. The rake, however, is not of such importance when the bow is of the "soft-end" type, for the collapse of the bow plating in preference to the piercing of the side of the rammed ship is ensured by the disposition of the plating.

As regards ice—I am confident that the addition of slight extra thickness to the stem plate in the vicinity of the water line would ensure that, except in heavy ice such as would require the assistance of an ice breaker, the ship would steadily make progress without damage to the stem plate.

The problem of ice can with advantage be considered from the point of view of ice attacking the ship instead of the ship attacking the ice. When considered along these lines it is clear that unless the ice is very thick and in great volume, *i.e.*, approximating to an iceberg in mass, the impact of the ice on a heavy plate rounded to a radius of six to nine inches will result in the failure of the ice at the immediate point of impact, but possible damage to the ship abaft the first foot or so where the bulk of the ice begins to get a sufficient area of bearing on the plating to result in a crushing action.

The junction of the plating of an ordinary ship to the stem bar is a point of weakness, and yet there is rarely damage due to the plating being torn back from the stem bar in the vicinity of the water line. The crushing and corrugating of the plating occurs several feet back from the stem edge.

I have given a good deal of thought to this question of ice damage and from my own experience of surveys on ships which have been in ice, I am satisfied that in certain circumstances it is impossible to prevent bow plating from becoming damaged. At the same time this damage will not be most marked at the stem or within two or three feet of the stem. It will be several feet farther from the leading edge.

Where a vessel is required to work in very thick ice which has to be rammed at speed in order to make headway at all, the suggestion put forward by Dr. Commentz would perhaps be of advantage. But few ordinary stems could stand this type of treatment.

With regard to Mr. Parker's remarks, I have covered many of the points raised in the replies made during the discussion. The particular arrangement of the bow which I have proposed differs appreciably from any which has so far been put forward principally on account of the fact that the idea has been developed with one paramount purpose in mind.

Mr. Parker suggests that the rake on the stem, which incidentally is not an essential feature of my proposals, defeats one of the objects I have aimed at, namely, the increasing of the area of impact. That is certainly the case, but the rake has been added in order that there should be greater certainty that the rammed ship should not be holed.

With regard to Mr. Parker's remarks as to the possibility of effecting temporary repairs to the stem, the conclusions at which I have aimed are: 1st, that if the blow is slight, temporary repairs would be quite easy to arrange for; and 2nd, that if the collision has been so serious as to render it impossible to effect temporary bow repairs, it would have been sufficiently serious to have rendered it an odds on chance that the rammed vessel would have sunk or been very badly holed had the ramming vessel been of normal construction.

The suggestion regarding the building of the bow on the ground, was volunteered by representatives of shipbuilding firms. I have since confirmed that there are a number of firms who could carry out the work as suggested.

I do not for a moment admit that I have overstated the case as to the facility for repairs. I have had too much experience of repair work to do this. Delays for stem bars are frequent. False wood stems are a proof of the fact that such delays are serious, for a false wooden stem itself is not made in five minutes, and is an expedient both costly and unsatisfactory. Templating for plates from a ship in dock is very wasteful and costly as compared with preparing a new stem section leaving only one vertical strake of plating to determine in dock. The stem plate can be made in a plate bending rolls with ease. The rounded part at the foot can be made in two halves and at little cost.

I am grateful to Mr. Parker for bringing forward these various criticisms, as the subject is to my mind a most important one, and a full discussion is essential before one can expect to induce builders and owners to depart from older ideas.

We all deplore collisions, and I should be more than pleased if the putting forward of these proposals results in the modification of present practice either along the lines I have suggested or along others calculated to be likely to be more efficient.

The following sheets show the casualty returns, which it was suggested might be added with advantage.

CASUALTY RETURNS. JUNE, 1924.

The Liverpool Underwriters' Association has issued the following classified Return of Casualties to Vessels of 500 tons gross register and upwards, which have been posted in the Loss Book during the month ended June 30, 1924.

CLASSIFICATION.

Nature of Casualty.	British.				Foreign.				Results.		
	Sail.		Steam.		Sail.		Steam.				
	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Losses.	Partial Losses.	Total.
Weather damage ...	—	—	—	6	—	2	—	8	—	16	16
Founderings & abandonments	—	—	—	—	—	—	—	—	—	—	—
Strandings	—	1	2	44	1	1	3	66	6	112	118
Collisions...	—	—	—	37	—	10	2	54	2	101	103
Fires and Explosions ...	—	—	—	16	1	—	—	5	1	21	22
Missing	—	—	—	—	—	—	—	—	—	—	—
Damage to machinery, shafts and propellers	—	—	—	33	—	—	—	44	—	77	77
Other casualities ...	—	—	—	37	—	—	—	43	—	80	80
Totals... June 1924	—	1	2	173	2	13	5	220	9	407	416
June, 1923	1	—	5	173	—	15	5	243	11	431	442
June, 1922	—	1	2	141	6	17	4	219	12	378	390
June, 1921	—	5	2	92	7	9	9	213	18	319	337

NUMBER AND TOTAL GROSS TONNAGE OF VESSELS LOST posted in the Loss Book during the month of June in the under-mentioned years.

Nationalty.	1924.		1922.		1923.	
	No.	Gr. Tns.	No.	Gr. Tns.	No.	Gr. Tns.
BRITISH.						
Sail	—	—	1	1,165	—	—
Steam	2	7 382	5	23,599	2	13,136
FOREIGN.						
American—						
Sail	1	1,983	—	—	6	6,898
Steam	—	—	2	5,179	1	1,321
Japanese—						
Sail	—	—	—	—	—	—
Steam	2	4,025	2	4,961	1	2.656
Rest of World—						
Sail	1	2,183	--	—	—	—
Steam	3	2,628	1	510	2	4,560
Totals...	9	18,201	11	35,414	12	28,57

Of the above-mentioned the following are the more important:—

Vessel and Flag.	Gross Tons	Year built	Material	Owners and Port of Registry.	Voyage.	Cargo.	Particulars of Casualty.
STEAM.							
Clan Macmillan (Br)	6608	1918	Steel	Cayzer, Irvine & Co., Glasgow ...	Clyde, Liverpool and Calcutta—Nukualofa and Haapai	General	Wrecked, Preparis Shoal, Bay of Bengal.
Algama (ex Eastford, &c.) (Br)	774	1904	Steel	P. Edward Fry, Cardiff...	Cardiff--La Rochelle	Coal	Stranded, Les Balienes, Dec., 1923; refloated; now constructive total loss.
Yahiko Maru (ex Glenelg) (Ja)	2653	1888	Steel	Kobe Kisen Shintaku KK., Amagasaki	Haiphong—Hongkong	Limestone ...	Stranded, 10 miles S.E. Hainan Head; sunk.
Shogiku Maru No. 2 (ex Alma) (Ja)	1372	1894	Steel	Hongo Ikichiro, Amino...	—	—	Wrecked, Saghalien.
Potrerillos (ex Elizabeth Weems, &c.) (Ch)	1186	1906	Steel	Andes Mining Co., Valparaiso ...	For Corral via Talcahuano	—	Wrecked, North of Quiriquin Island, near Talcahuano.
Haakon Jarl (No) ...	899	1879	Steel	Nordenfjeldske Damps., Trondhjem	—	—	Sunk by collision with *Kong Harald* near Landegode, Vestforden.
Strymon (steam barge) (Gr)	543	1890	Steel	G. A. Nicolaides, Piræus	—	—	Sunk by collision with *Ithaki* (Gr) in Atalanta Channel.
Saarbrucken (Ge) ...	9429	1923	Steel	Norddeutcher Lloyd, Bremen... ...	Bremerhaven—Yokohama, &c.	General	Stranded, near Tapagadja (near Sabang); refloated; damage to vessel.
Aladdin (No)	3013	1892	Steel	T. J. Farsjö & Co.. Christiania ...	Gothenburk — Kotka	Ballast	Stranded, Jussaroe Lighthouse; refloated; damage to vessel.
Sisak (Ge)	4630	1907	Steel	Deutsche Dampfs Ges. "Kosmos," Hamburg	Hamburg & Antwerp—Corral	General	Stranded, Bahia de Caraquez, May, 1924; refloated; damage to vessel.
Colombia (Am)	5644	1915	Steel	Pacific Mail S.S. Co., Inc., San Francisco	San Francisco, &c.—New York	General	Stranded, Cani Island, Costa Rica; refloated; damaged.
Metagama (Br)	12420	1915	Steel	Canadian Pacific Railway Co., London	Clyde & Belfast—Montreal	General	Collision. *Clara Camus*, 7 miles E.S.E. Cape Race; arrived St. John's (NF.); serious damage.
Yeddo (Sw)	3980	1908	Steel	Dan Broström, Gotherburg	Gothenburg & Antwerp—Calcutta	General	Beached, after collision, *Barenfels*, River Scheldt, May, 1924; refloated.
Chalister (Br)	5344	1923	Steel	Adam Bros.. Ltd., Greenock	Calcutta, &c.—New York, &c.	General, gunnies, cotton	Fire, No. 4 hold, bridge deck, at Suez; serious damage, vessel and cargo.
Lancashire (Br) ...	9445	1917	Steel	Bibby Bros. & Co., Liverpool	Rangoon—London & Liverpool	Rice, meal, &c. ...	Fire, at Port Said; damage to vessel; about 70 tons, rice meal. jettisoned.
Egremont Castle (Br)	5294	1911	Steel	J. Chambers & Co., Liverpool... ...	Loading New York for Japan	General, gasolene, &c.	Explosion; serious damage, vessel and cargo.
Hobsons Bay (Br) ...	13837	1922	Steel	Australian Commonwealth Line of Steamers, Melbourne	Brisbane and Freemantle—London & Hull	General, wool ...	Fire, at Port Said; damage to cargo.
SAIL.							
Lemkenhafen (ex Herbert, &c.) (Ge)	2183	1892	Steel	Schröder, Hölken & Fischer, Hamburg	At Cerro Azul ...	—	Dragged anchors; capsized; drove ashore North of Cerro Azul; total loss.
Robin Hood (ex Vailly) (Am)	1983	1918	Wood	Hunter Navigation Corp., New York	—	—	Abandoned, on fire, between Key West and Tortugas.

MISCELLANEOUS.

Tornado in Ohio. Tornado struck Lake Erie, June 28. The cyclone caused very little damage to shipping, but caused serious damage to town property, with serious loss of life at Lorain, Sandusky.

CASUALTY RETURNS, OCTOBER, 1924.

The Liverpool Underwriters' Association has issued the following classified Return of Casualties to Vessels of 500 tons gross register and upwards, which have been posted in the Loss Book during the month ended October 31st, 1924 :—

Classification.

Nature of Casualty.	British.				Foreign.				Results.		
	Sail.		Steam.		Sail.		Steam.				
	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Losses.	Partial Losses.	Total.
Weather damage ...	—	—	—	7	1	3	—	9	1	19	20
Founderings and abandonments	—	—	—	—	1	—	5	—	6	—	6
Strandings	—	1	—	61	2	4	5	118	7	184	191
Collisions	—	—	2	53	—	2	1	113	3	168	171
Fires and Explosions ...	—	—	—	15	1	1	3	20	4	36	40
Missing	—	—	—	—	—	—	—	—	—	—	—
Damage to machinery, shafts and propellers	—	—	—	40	—	—	—	50	—	90	90
Other casusltics... ...	—	—	—	46	—	7	—	54	—	107	107
Totals.. October, 1924	—	1	2	222	5	17	14	364	21	604	625
October, 1923	2	4	8	226	6	18	14	406	30	654	684
October, 1922	—	4	4	214	2	23	12	341	18	602	620
October, 1921	2	3	4	154	2	18	12	306	20	481	501

Number and Total Gross Tonnage of Vessels Lost posted in the Loss Book during the Month of October in the undermentioned years.

Nationality.	1924.		1923.		1922.	
	No.	Gr. Tns.	No.	Gr. Tns.	No.	Gr. Tns.
BRITISH.						
Sail...	—	—	2	1,680	—	—
Steam	2	4,952	8	20,741	4	12,364
FOREIGN.						
American—						
Sail	3	3,479	4	5,631	1	1,184
Steam	4	10,931	2	6,215	4	17,770
Japanese—						
Sail	—	—	—	—	—	—
Steam	1	2,741	4	11,381	3	2,724
Rest of World—						
Sail	2	1,854	2	2,666	1	741
Steam	9	19,411	8	8,304	5	13,777
Totals	21	43,368	30	56,618	18	48,550

Of the above-mentioned, the following are the more important:—

Vessel and Flag.	Gross Tons.	Year built.	Material.	Owners and Port of Registry.	Voyage.	Cargo.	Particulars of Casualty.
STEAM.							
Clifton (ex Samuel Mather (Am)... ...	1713	1892	Steel	Progress S.S. Co., Fairport (O.) ...	Sturgeon Bay—Detroit	Stone	Foundered, Lake Huron.
James Timpson (motor) (Am)	2016	1917	Wood	Resolved Corporation, New York ...	Belize—New York ...	Mahogany ...	Abandoned, 16 N., 86 W., Oct. 18.
Ringborg (ex Bengalen, &c.) (No)	2641	1903	Steel	H. M. Wrangell & Co., Haugesund ...	Santa Lucia (Cuba)—New York	Sugar	Sunk, about 34 N., 75 W., prev. Oct. 2.
Orion (Sw)	633	1896	Steel	A. Nilsson, Helsingborg...	Odense for Burghead	Barley	Capsized, sunk, 10 miles S.W., Lindesnes.
Ciudad de Cadiz (Sp) ...	3202	1878	Iron	Cia. Trasatlantica, Barcelona... ...	Barcelona — Fernado Po (discharged cargo at Santo Isabel and San Carlos)	Cocoa (part homeward)	Foundered after striking rock off Fernando Po.
Taisho Maru (ex Pondo) (Ja)	2741	1892	Steel	Uchida K. K. Kaisha, Kobe	China—Yokohama ...	Ore	Struck Kanabuse East Harbour entrance; broken in two, sunk.
Don Arturo (ex Piquero, &c.) (Ch)	981	1880	Iron	Cia. Minera e Industrial de Chili, Valparaiso	—	—	Wrecked, 12 miles N. Constitucion, W.C., S. America.
Marienborg (aux.) (ex H. C. Hansen) (Da)...	1660	1917	Steel	——— Copenhagen ...	Helsingfors—Gamla Karleby	Ballast	Wrecked outside Tankar.
Rhin (Fr)	2922	1921	Steel	Cie. Delmas Freres & Vieljeux, La Rochelle	Bona—Bordeaux ...	Phosphates, &c....	Wrecked, La Coubre.
Fylgia (Sw)	1526	1919	Steel	H. Metcalfe, Gothenburg	Hernosand—Seville ...	Wood, woodpulp	Wrecked off Oregrund.
Harlech (Br)	1081	1914	Steel	Harrisons (London) Colliers, Ltd., London	Hull—Brixham ...	Coal	Wrecked, Outer Binks (River Humber), after collision *Elf King*.
Glenorchy (ex A. E. Stewart) (Br)	3871	1902	Steel	Great Lakes Transp. Co., Ltd., Midland (Ont.)	Trading on Great Lakes (for Port Colborne)	Grain	Sunk, collision, *Leonard B. Miller*, Lake Huron.
Arion (ex Orion) (It) ...	535	1921	Steel	Soc. Ligure di Armamento, Genoa ...	—	—	Sunk, collision, *Borneo*. (Du.), between Genoa and Spezia.
Kansas (ex City of Charlevoix) (Am) ...	835	1870	Wood	Michigan Trans. Co., Duluth (Minn.)	—	—	Destroyed by fire, Lake Michigan.
Alden Anderson (ex Bradford, &c. (Am)	6367	1908	Steel	Associated Oil Co., San Francisco ...	Trading between Los Angeles and San Francisco	—	Fire at Avon (Cal.), total loss.
Valdarno (ex War Persian) (It)	5311	1919	Steel	Lloyd Mediterraneo, Genoa	At Panama City (Fla.)	Part loaded lumber, resin	Fire, alongside dock, total loss.

Vessel and Flag.	Gross Tons.	Year built.	Material.	Owners and Port of Registry.	Voyage.	Cargo.	Particulars of Casualty.
Port Nicholson (Br) ...	8402	1919	Steel	Commonwealth & Dominion Line, Ltd., London	London, &c.—Sydney	General	Struck rock off Isleta, Las Palmas, refloated, considerable damage.
Flackwell (Br)	7563	1898	Steel	D. L. Flack & Son, Ltd., London ...	Mormugao—Mediterranean U.K. or Cont.	Ore	Stranded, 15 miles S. of Karach, refloated after discharging part cargo.
Rosefield (Dg)	3379	1896	Steel	Baltische & Weissmeer Handels & Schiffahrts A G., Danzig	Lulea—Stettin ...	—	Stranded, Bjuro Klubb, 64 N., 21 E., refloated considerable damage.
Ettrick (Br)	993	1894	Steel	W. Sloan & Co., Glasgow	Bristol—Glasgow ...	General	Stranded below Horseshoe Bend, River Avon, refloated, serious damage.
Lake Flattery (Am) ...	2609	1919	Steel	Panama Railroad Co., New York ...	From New York at Manta	General	Fire, No 2 hold, cargo damaged fire and water.
President Polk (ex Granite State) (Am)	10513	1921	Steel	Robert Dollar Co., Inc., San Francisco	At New York from Japan	General	Fire, cargo considerably damaged, extensive damage vessel.
Spezia (Ge)	1825	1924	Steel	Rob. M. Sloman, Junr., Hamburg ...	Genoa, &c.—Hamburg	Timber, general...	Fire, No. 3 hold, at Catania, 2 and 3 holds, flooded, plates damaged, damage cargo.
West Norranus (Am) ...	5652	1920	Steel	United States Shipping Board, Los Angeles	At Galveston for Bremen	Cotton	50 bales cotton No. 4 hatch destroyed, several hundred damaged by fire, water.
Laura (It)	6181	1923	Steel	Cosulich Soc. Triestina di Navigazione, Trieste	From New York at Trieste	General	Fire, No. 5 hatch; damage to cargo.
Takliwa (Br)	7936	1924	Steel	British India S. N. Co., Ltd., London	At Calcutta	—	Fire. No. 1 hold, hold flooded; damage cargo fire, water.
Onda	2888	1907	Steel	Nav. Libera Triestina, Trieste ...	Galatz—Buenos Ayres	Timber	Fire, No. 3 hold, at Algiers, damage to cargo.
SAIL.							
Alcaeus Hooper (Am) ...	1305	1920	Wood	Crowell & Thurlow, Boston	Hampton Roads—Calais (Me.)	Coal	Abandoned, 37 N., 70 W., sunk.
Dolly Madison (Am) ...	1540	1920	Wood	J. A. Elliott, New York...	Baltimore—Caibarien	Coal	Wrecked, 21 N., 75 W.
Glance (No)	923	1869	Iron	Hans Hansen, Brevik	London—Haparanda	Ballast	Wrecked near Grossegrund.
Susanne (ex Bellas, &c.) (Da)	931	1875	Iron	Chr. Asberg (R. K. Bager), Marstal ...	Brunswick (Ga.)—Queenstown	Lumber	Put into Savannah wlth weather damage, condemned.
Van Lear Black (Am) ...	634	1889	Wood	G. Ferlita, Tampa	Nuevitas—U.S. Gulf port	Ballast	Destroyed by fire, leaving Nuevitas

MISCELLANEOUS.

Fire at Daroolbagie (N.S.W.), Oct. 18, Forbes Works, tallow, skins and fertiliser destroyed. Estimated loss between £20,000 and £30,000, less salvage.

Fire near San Francisco, Oct. 29, 600 ft. dock of Associated Oil Co. at Avon (Cal.) destroyed.

Fire at Gokak Falls, Oct. 15. In No. 36 godown of the Gokak Mills, Ltd., in which were stored 1342 bales cotton, 152 bales badly damaged fire; some 393 bales damaged water before fire subdued.

CASUALTY RETURNS, JULY, 1925.

The Liverpool Underwriters' Association has issued the following classified Return of Casualties to Vessels of 500 tons gross register and upwards, which have been posted in the Loss Book during the month ended July 31, 1925:—

CLASSIFICATION.

NATURE OF CASUALTY	BRITISH.				FOREIGN.				RESULTS.		
	Sail.		Steam.		Sail.		Steam.		Total Losses.	Partial Losses.	Total.
	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.	Total Loss.	Partial Loss.			
Weather damage	—	—	—	2	—	—	—	10	—	12	12
Founderings and abandonments..	—	—	1	—	—	—	—	—	1	—	1
Strandings	—	—	1	41	1	3	3	76	5	120	125
Collisions	—	—	—	32	—	3	—	68	—	103	103
Fires and Explosions	—	—	1	21	1	—	—	22	2	43	45
Missing	—	—	—	—	—	—	3	—	3	—	3
Damage to machinery, shafts, and propellers	—	—	—	30	—	—	—	51	—	81	81
Other casualties	—	—	—	19	—	5	—	45	—	69	69
Totals... July, 1925	—	—	3	145	2	11	6	272	11	428	439
July, 1924	—	1	1	147	2	8	10	278	13	434	447
July, 1923	—	2	3	175	1	10	12	231	16	418	434
July, 1922	1	4	1	166	4	10	8	235	14	415	429

NUMBER AND TOTAL GROSS TONNAGE OF VESSELS LOST posted in the Loss Book during the Month of July in the undermentioned years.

NATIONALITY.	1925.		1924.		1923.	
	No.	Gr. Tns.	No.	Gr. Tns.	No.	Gr. Tns.
BRITISH.						
Sail	—	—	—	—	—	—
Steam	3	7,978	1	590	3	4,034
FOREIGN.						
American—						
Sail	2	2,245	1	1,491	1	623
Steam	—	—	2	1,787	1	2,458
Japanese—						
Sail	—	—	—	—	—	—
Steam	3	4,029	4	8,450	1	3,108
Scandinavian—						
Sail	—	—	—	—	—	—
Steam	1	981	—	—	5	13,307
Rest of World—						
Sail	—	—	1	2,234	—	—
Steam	2	2,033	4	10,419	5	6,632
Totals	11	17,266	13	24,971	16	30,162

MISCELLANEOUS.

Fire at St. John's (NF.), July 4. Hickman's premises gutted by fire. Cargo remaining ex steamer *Hillbrook* expected total loss.

Fire at Victoria Dock, London, July 16. Jetty and three warehouses severely damaged, containing timber, wool, tobacco, butter.

Fire at Gothenburg, July 18. At Stroemman et Larson's woodyard side of harbour here, totally destroying the whole, including about 6000 standards and neighbouring shipyard at Hisingsstaden; slight damage neighbouring property of Goetaverken Shipyard. Number of small river craft, trawlers and canal steamers totally destroyed.

Fire at Algiers, July 11, in a large building containing bales of cork, bales of wool, quantity of hides. Building and contents belonged to Messrs. Borgeaud & Co. Contents were, for the greater part, burnt.

Fire at St. Katharine Dock, July 22. Eastern end of "D" warehouse, belonging to the Port of London Authority. Building severely damaged; large quantity wool destroyed, sugar and hops damaged by heat, smoke and water.

Fire at Havana, July 27. Warehouse(s) and wharves, hired Cuba cane, with contents, consisting of mill supplies, totally destroyed; also 5300 bags sugar, property United Railway Regie Warehouse.

Fire at Michigan, July 22. De Foe Boat Works, Bay City, Michigan, destroyed. Approximate estimate of loss £60,000.

Fire at Leith, July 31, grain elevator, east end Edinburgh Dock. Part of wood lining destroyed, considerable damage done to stock by water.

Fire at Odense, June 24. In New Harbour following warehouses burned down: Odense New Silo Warehouse, containing about 3000 tons maize; some warehouses belonging to Korn & Foderstof Kompagniet, containing grain, oilcake, flour, &c.; warehouses belonging Mr. I. I. Larsen, also containing grain, &c.; a new warehouse belonging to Fyens Andels Foderstofforretning, mainly containing oilcake. Langelandskorn's new warehouse also slightly damaged. The damage to all warehouses and contents is roughly calculated at five to six million kroner.

Fire at Manila, June 27. The copra warehouses of the Philippine Refining Corporation destroyed; damage estimated about a million pesos.

Vessel and Flag.	Gross Tons.	Year built.	Material	Owners and Port of Registry.	Voyage.	Cargo.	Particulars of Casualty.
STEAM.							
Bayeskimo (Br)	1391	1922	Steel	Hudson's Bay Co., London	Montreal—Hudson's Bay	—	Foundered, Ungava Bay, from damage by ice.
Egremont Castle (Br)	5294	1911	Steel	J. Chambers & Co., Liverpool	Hongkong & Manila—New York	Sugar, &c.	Stranded, Tub Bataha Reef (8 56 N., 120 03 E.), and sank.
Fushiki Maru (Ja)	1803	1885	Iron	Okuda Yeikichi, Amagasaki	—	—	Wrecked, Shiritoko Saki, Hokkaido.
Noto Maru (ex Tai-Lee) (Ja)	1275	1889	Steel	Toyo Kaiun K. Kaisha, Fushiki	—	—	Wrecked, Teuri Shima, Hokkaido.
Kyodo Maru No. 22 (ex Manye Maru No. 5) (Ja)	951	1917	Steel	Awanokuni Kyodo K.K. Kaisha, Amagasaki	—	—	Wrecked, Barren Island, Yantsze.
Fred Mercur (Br)	1293	1882	Wood	W. E. Lawlor, Montreal	—	—	Burnt to water's edge, St. Lawrence River, above Cornwall; hulk sank.
Zeus (No)	981	1872	Iron	Orum & Halvorsen, Oslo	Blyth Jan. 26, 1925—Reykjavik	Coal	Untraced.
Haiphong (Fr)	1493	1885	Steel	————	Saigon Nov. 26, 1924, & Quinhon Dec. 3—Tourane & Haiphong	General, gasolene	Untraced.
Elbnymphe (aux) (Ge)	540	1924	Steel	C. Krabbenhöft & Bock, Hamburg	Sandnaes Feb. 24, 1925—Langesund	—	Untraced.
Loongwo (Br)	3923	1906	Steel	Indo-China Steam Nav. Co., Ltd., Hongkong	—	—	Struck rocks 250 miles below Hankow, beached; refloated, damaged.
City of Tokio (Br)	6993	1921	Steel	Ellerman Lines, Ltd. (Hall Line, Ltd.), Liverpool	Kobe—Hankow & Hamburg	General	Stranded, Quelpart; got off, considerable damage.
Singapore Maru (Ja)	5859	1919	Steel	Kokusai K.K. Kaisha, Kobe	Sydney (N.S.W.)—U.K. & Cont.	Wheat	Stranded, 12 33 N., 44 E., near Ras el Ara, refloated by steamer Meyun; jettisoned approx. 220 tons.
Goshu Maru (ex Sàngola) (Ja)	5505	1901	Steel	Fukuhara Kisen K. Kaisha, Dairen	—	—	Stranded, about 260 miles off Vladivostock, June 23; refloated July 27, damaged.
Esquilino (It)	8500	1925	Steel	Lloyd Triestino, Trieste	Trieste—Shanghai	General	Stranded, Shumma Reef, south of Massowah; refloated after discharging part cargo.
Thomas P. Beal (Am)	5818	1921	Steel	Mystic S.S. Co., Boston	Portland (Ore.)—New York	Lumber	Struck rocks, East River, New York; refloated, damage to vessel.
Luisa (ex Albaro, &c.) (Ch)	2850	1890	Steel	F. J. Castillo, Valparaiso	—	Coal	Stranded, San Vicente (near Valparaiso); got off badly damaged; beached prevent sinking; refloated.
Gezina (ex Lake Erie) (No)	1828	1917	Steel	Th. Brövig, Farsund	Archangel—Manchester	Timber	Stranded, Dennis Head, North Ronaldshay; refloated, damaged; some deck cargo jettisoned.
Columbia (It)	5465	1908	Steel	Cosulich Soc. Triestina di Nav., Trieste	Naples—New York	General	Fire, No. 4 hold, put back Naples; damage to cargo.
Andalusia (ex Australplain, &c.) (It)	4607	1907	Steel	D. Tripcovich & Ci., Trieste	Genoa—Buenos Ayres	General	Fire, Nos. 1, 2 & 3 holds, at Buenos Ayres; cargo considerably damaged as holds flooded.
Greta (ex Frieda Fahrenheim, &c.) (Sw)	2144	1906	Steel	P. G. Thulin, Storangen	From New York—At London	General	Fire, damage to vessel and cargo.
Scythian (Br)	4865	1913	Steel	F. Leyland & Co., Ltd., Liverpool	Antwerp—Boston	General	Fire, forehold 'tween deck at sea; arrived Queenstown July 22 and proceeded July 25.
St. Vincent (Fr)	5195	1913	Steel	Soc. Navale de l'Ouest, Havre	Hamburg & Antwerp—W. Africa	General	Fire, at Boulogne; cargo damaged by fire and water.
SAIL.							
Isabel C. Harriss (Am)	1078	1918	Wood	F. Verzone, Mobile	—	—	Wrecked ½ mile south end of Barbados.
Amazon (Am)	1167	1902	Wood	J. M. Scott Shipping Co., Inc., Mobile	Gulfport—San Juan	—	Abandoned, on fire; (later) beached approx. 13 miles west of Cape Fear River entrance.

The Shipping, Engineering and Machinery Exhibition.

The Shipping, Engineering and Machinery Exhibition was opened at Olympia by the Right Hon. W. C. Bridgeman, M.P., First Lord of the Admiralty, on Monday, November 23rd, and remained open till December 5th.

There were many exhibits well worthy of the occasion and the available space was fully occupied, affording good opportunity to all interested to study various improvements and become acquainted with new features introduced in connection with different types of machinery and working elements.

Our thanks have been accorded to Messrs. Bridges, the organisers, for the generous invitations extended to our membership to visit the exhibition, when tea was provided, and the cinema hall placed at our disposal for meetings, on November 27th, when Sir Fred W. Young, K.B.E., gave an illustrated lecture on "Salvage Operations," and on December 1st, when Mr. A. C. Hardy, B.Sc., Assoc. Member, read a paper on "Motorship Progress in 1925." An invitation was extended to the President and Council; also to members from overseas to luncheon within the exhibition building on November 27th, when it was a pleasure to meet Sir Jas. Mills on his return from New Zealand. Several of the overseas members unable to attend at the luncheon were invited to dinner on December 1st and accepted. Sir Chas. Parsons presided on these occasions.

The exhibits have been freely described and illustrated in the Technical Journals; there is also a catalogue of the exhibition available for reference in the Reading Room.

Notes.

Contribution from Mr. N. G. Rutherford, Associate Member. In reading Mr. Nicholson's paper I notice that he makes reference to the Gill propeller and also the Star contra propeller in the following words: " It is probable that both of these types of propellers will have a restricted range of application, as in the larger sizes one doubts if they would stand up to rough weather conditions."

It occurs to me, in reading this criticism, that perhaps Mr. Nicholson is not fully informed as to the ability of the Star Contra propeller to stand rough weather. So far as dimensions are concerned, the largest " Stars," which have been fitted, are on the big German freighters *Thuringia* and *Westphalia*. Both these vessels have twin turbines, developing a total of 5,000 S.H.P. geared to a single shaft driving a 19ft. 8in. propeller. The " Stars," which are of the six-bladed type, weigh over seven tons, having diameters of 13ft. 9in. and the surface of the diagonal blades in each case is something like 80 sq. ft. These vessels have now been running for nearly two years across the Atlantic without mishap to these blades, which would appear to show that fears as to the ability of the " Star " to stand up to rough weather conditions, are groundless.

There are at least a dozen vessels which have been fitted and sailing for a considerable period with " Stars " having diameters between ten and fourteen feet, of which only one, the *Cornish Point*, has suffered from broken blades. In this case, it is not known under what conditions the blades were broken off and, indeed, it is said that no change in speed was observed which might serve to fix the time and state of the weather when the break occurred, but as they have not yet been re-placed it would be interesting to learn just to what extent their loss has affected the running of the vessel.

Broken blades were not unknown in the early days of this device, principally on account of the large diameter and the difficulty in obtaining sufficient root thickness to give the blades the requisite strength. Since the adoption of the four-blade type, however, the diameters have been reduced. The roots of the blades have been thickened up considerably and may be taken to compare very favourably indeed with the section of the main propeller at the same radius. Indeed, it is fairly obvious that if the blades of a revolving propeller can be made to stand up to the stresses which occur in a heavy sea, fixed blades can more easily be made to stand similiar stresses, since when a vessel is pitching, the fixed blade meets the water with the velocity of the fall of the ship only, while the revolving propeller has in addition a downward velocity due to its rotation. Broken propeller blades are not every day occurrences, why then should broken " Star " blades be any more frequent.

Experience has shown that a ship fitted with a Star Contra propeller is much steadier in a sea-way than one without. This, in itself, greatly reduces the frequency with which both the " Star " and the main propeller blades are subjected to their maximum stresses. I feel sure that in making his criticism Mr. Nicholson has not given the full consideration to these points that he has given to those which he has so skilfully brought out in the course of his very interesting paper.

In the discussion which followed the reading of the paper, I notice that Mr. A. Jobling raises the query as to whether the Star Contra propeller may be adapted to a present-day vessel. The " Star " is fitted to several present-day vessels and, seldom does the normal stern frame and the existing main propeller present difficulties which cannot be overcome. The chief requirement is that the distance between the trailing edge of the main propeller blade and the fore-side of the rudder post shall be approximately 15% of the diameter of the main propeller.

The vertical blades take the form of steel castings and are readily welded to the rudder post. The side blades, which are of cast iron, are bolted to the vertical blades and also to the rudder post by fitted bolts, but if sufficient clearance is available, these blades may be bolted together abaft the rudder-post, thus obviating the necessity for drilling the post. In either case, the bolting together of these blades and the welding of the vertical blades gives considerable additional strength to the rudder post.

The principle of, and the results obtained from fitting, the Star Contra propeller to a number of vessels have been fully explained by Mr. Walter Pollock in his paper on the subject read before the Institution of Naval Architects at their last spring meetings. Briefly, the duty of the " Star " is to eliminate the rotation in the slip stream by suitably diverting the flow of the water leaving the main propeller. In this way, a considerable amount of power which is normally lost due to the rotation of the slip stream is recovered and usefully applied to the propulsion of the vessel.

I shall be very pleased to give Mr. Jobling further information on this very interesting subject, but it would be rather difficult to do so without encroaching on the space available in the Transactions. However, I may be able to give him all the information he requires, if he so desires.

QUEENSLAND.—Quotations from report of the Chief Inspector of Machinery—Mr. Jas. Henderson, Member, I.Mar.E.—for year ending June, 1925:—

Weights and Measures.—The Weights and Measures Act is in its infancy yet, but will soon be able to stand alone. All its operations tend towards one end, that is, to see that all persons transacting business whether buying or selling shall be honest to one another. The administration of this Act reveals many weaknesses in human nature, which necessitate the regulations being made hard and fast, so that punishment may be meted out to the wrong-doer.

Boilers.—The statistics in regard to the work of this very necessary and important branch of the Service again show that this State is in the proud position of having had no fatalities with boilers under working conditions during the period under review. Credit is due to the certified engineers and engine drivers, who have co-operated with the officers of this department for the very fine record which, I trust, may long continue.

Machinery.—Unfortunately there are recorded six fatalities in connection with power-driven machinery.

Scaffolding.—This year's return shows that the cost of buildings erected in this State during the year's operations is again approximately £2,250,000, and during the whole of these operations, with thousands of men employed, there were only five mishaps. Two of these proved fatal and in both of these cases it was the carelessness of the person unfortunately killed that caused the mishap.

Certificates of Inspection.—12,111 Certificates of Inspection were issued during the year, as a result of inspections made by departmental officers all over the State.

Board of Examiners.—There were 26 meetings held during the year, at which the principal business dealt with was the consideration of examination papers of candidates for engineers' and engine drivers' certificates.

In "The Machinery Market," November 6th, the following paper is reprinted:—

FUEL ECONOMY. No. 69, "Boiler Furnaces for Pulverised Coal," by A. G. Christie (Prof. Mechanical Engineering, John Hopkins University), contributed to the American Society of Mechanical Engineers, whose Transactions we have in the Reading Room. The conclusions cited are as follows:—

This analysis of boiler furnaces for pulverised fuel indicates that for highest efficiency and maximum capacity:—

(*a*) The coal should be thoroughly dry, and be finely ground and pre-heated before admission to the furnace.

(*b*) The air entering the furnace should be highly pre-heated and this can be done best by flue gases, although there are possibilities in the use of bled steam.

(*c*) Turbulence should be maintained in the furnace to ensure rapid combustion and high efficiency.

(*d*) The furnace walls should be water-cooled, preferably with all-metal walls. The construction ensures low boiler outage, low maintenance, and heat efficiency of heat transfer. Water-cooled walls with brick facing may be desirable with certain fuels.

(*e*) Improved methods should be developed to handle ash from any coals, the discharge of dust and smoke from the tops of all chimneys should be reduced.

(*f*) To secure increased furnace capacity and at the same time secure higher boiler efficiency, more B.T.U.'s per cub. ft. of furnace volume must be developed. This is possible by employing the factors noted above.

"The Power Engineer" of July contains a leading article on the sources of Power Alcohol, referring to the Fuel Research Board Reports, in which the raw materials grown in Great Britain are quoted as potatoes, mangolds and Jerusalem artichokes. A subsequent review is also referred to from the Royal Botanical Gardens at Kew. The problem of production costs were reviewed and the possible growths suitable for the purpose in the various oversea dominions was considered. The prickly pear of Queensland and New South Wales was mentioned as being of prolific growth and the yield stated to be 10 tons at least to the acre, capable of yielding 110 gallons of spirit. Coffee pulp, acorns, and the sweet potato of South Africa are also commented upon as well as molasses and distillation from wood. Western larch yielding 33 gallons per ton of dry wood; the highest percentage from any dry wood.

Reference was made during the discussion of "Fuel Injection" on December 22nd, to the Blackstone Oil Engine. The trials of this class of engine were reported in "The Power Engineer" of July and the following comment is made:—The main innovation comprises the spring injection device, which consists of (*a*) a low pressure fuel measuring pump, which delivers a measured quantity of oil to (*b*) a high pressure fuel injection pump, which in turn works in conjunction with (*c*) a spring-loaded fuel injection valve; the fuel is always injected at the same point of the stroke and under the same pressure irrespective of the speed of the engine, while the spray velocity is also constant, the period of the spray being proportionate to the load.

In the same journal there is an article on failures of high-pressure turbines, with a survey of casualties and lessons to be learnt from them.

The following letter appeared in "The Times" of 31st December, 1925:—

ALL-ELECTRIC SHIPS.

Status of Mercantile Engineers.

Sir,—The coming year will see the completion of large motor passenger liners, the first of which, the R.M.S.P. *Asturias*, will run trials early in the New Year, in which the whole of the auxiliary machinery in the engine-room, on deck, and in the passenger quarters is driven by electricity. The next 18 months or so will witness the placing on service of large passenger liners designed for New York-San Francisco service, in which the whole of the main propelling machinery is electrically driven.

These necessary, rapid, and far-reaching advances in the field of marine propulsion, fraught as they are with mechanical problems, are not without corresponding problems of *personnel*, which conveniently may be divided under two heads. Under the first comes the question of the recognition of the importance of marine engineers on a modern power-driven ship, and especially a passenger liner; and under the second is the appreciation of the increasing importance of the electrician on shipboard. With the arrangement of accommodation on a present-day passenger liner the engineering staff is responsible directly for the operation of everything on the ship except the actual navigation and manœuvring, although even this latter depends largely upon the skill of the man at the controls below. This leads the more revolutionary among us to think, with all deference, that the navigating officer may in time become a navigating engineer or *vice versa*.

On the other hand, the electrician on an all-electric ship is in danger of usurping the position of the marine engineer. Take, for example, the case of a turbo-electric ship. The main propelling machinery, coupled to the propeller, is in charge of electricians; the boilers and turbine plant driving the generators operated by the marine engineers are virtually subservient to the electrician. The Board of Trade, however, considers that the electrician is not actually necessary to the safety of the ship, and will not permit him to rise above the rank of third engineer; neither will it grant him a "ticket." It seems very patent that these problems, outlined in embryo above, will require very careful consideration in the near future.

Yours faithfully,

A. C. HARDY, B.Sc., A.M.I.Mar.E.

The following is from "The Iron and Coal Trades Review":—

Research.—The world is now passing through a phase of organised research. The industries have their research associations, each with its group of problems calling for solution. There is a disposition to call for a speeding-up of results, to be impatient of that preliminary spadework which is so necessary to clear the ground of misconception and stereotyped fallacy. Push and go, however, though essential in business, is not always the best qualifications for scientific investigation. Spirits from the vasty deep of human ignorance do not always come to the mere calling, says the "Colliery Guardian." If they come at all, it is by patient wooing and methodical invitation. In the meantime, there appears to be a dearth of workers in scientific research, if we may judge by the demand for their services in the technological branches of industry. Research has not yet risen to the status of a profession in this country.

Plenty of post-graduate research work is being done, but it is largely in the nature of a stop-gap during the search for permanent employment in the more lucrative branches of a scientific career. Conditions will not right themselves until our industrial leaders learn to view research in proper perspective. Science is often blamed because it has failed to satisfy the extravagant claims made on its behalf, but without the authority of its leaders.

The following article is from "The Times Trade and Engineering Supplement":—

Low-Temperature Distillation.

Oil, Gas, and Liquor.

By Dr. G. S. Haslam.

When the need for scientific utilization of coal is so imperative it is natural that considerable attention should be devoted to the commercial applications of oil from low-temperature processes.

At the present time our knowledge of the chemical constitution of this oil is limited, and elucidation of the problem is complicated by the fact that the composition of the oil is appreciably influenced by the type of oven or retort in which the coal is distilled. Progress is further retarded by the very small production of low-temperature oil, which prevents the carrying out of any but small scale tests. The available information is, however, sufficient to indicate the probable trend of development.

Oil.—In the first place, these oils always contain from 20 to 50 per cent. of acidic bodies called phenols, which, unlike the phenols in coke oven and gas works tar, are complex substances of somewhat uncertain constitution. Recent experiments on the phenols of low-temperature oil show that it is possible to convert them into hydrocarbons, which makes them immediately valuable.

After the acidic substances have been removed, the residue of the oil resembles crude petroleum in chemical characteristics. Here, then, is a source of home-produced oil from which supplies of motor spirit, fuel, and lubricating oils can be prepared by the usual methods of refining. For Diesel engines, and similar type of heavy oil engines, the crude oil (containing phenols) has been successfully employed.

The quantity of low-temperature oil obtained from one ton of coal is approximately twice as much as is obtained from high-temperature processes. In addition the oil contains a remarkably small proportion of pitch, sometimes as low as 12 per cent., and certain coals, such as brown coal and cannel, yield oil containing an appreciable quantity of paraffin wax.

These remarks apply essentially to true low-temperature oil, which has been produced at temperatures not exceeding 650-700 deg. C. There are processes, however, in which temperatures of 750 deg. C. are reached, and in which cracking of the primary products of distillation occurs. Oil from such processes contains variable amounts of high-temperature products, which must detract from their value. To produce a true low-temperature oil, it is advisable that the products of distillation should not be subjected to a temperature higher than that at which they are evolved from the coal.

Gas.—The gas from low-temperature distillation processes averages 2,000 to 4,000 cu. ft. per ton and has a calorific value of 600 to 700 B.Th.U. per cu. ft., after the light spirit has been scrubbed out.

The uses to which such a gas can be put are governed mainly by local conditions, but for enriching gas from other sources it seems to hold a unique position. In a steel works, for example, where large gas-producer units are installed for the heating of furnaces, a slight increase in the calorific value of the gas can be responsible for considerable saving in the fuel bill. Since the advent of the therm system for the sale of gas the question of calorific value has become of the utmost importance. It is necessary for the companies supplying gas to townspeople to maintain a minimum calorific value. In many cases, gas companies find it necessary to resort to oil-carburetting to enrich the gas, a process which, for economic reasons, should be avoided. The substitution of low-temperature gas for enriching purposes should therefore become a proposition worthy of the consideration of gas undertakings.

The light spirit which can be removed from low-temperature gas by the so-called "activated charcoal," or the more general system of scrubbing, is a petrol rather than a benzol. In quantity it may amount to two gallons per ton of coal carbonized, which, when added to the light spirit condensed in the oil, makes the yield of crude motor spirit an important by-product.

Liquor.—In coke ovens and gas works the recovery of ammonia from the liquor is a profitable undertaking. This is not true of the liquor produced in low-temperature distillation practice. In a true low-temperature process the liquor is weakly acid, on account of the phenolic substances, which are sparingly soluble in water, more than neutralizing the small quantity of ammonia. It is a recognised fact that ammonia is not formed in any quantity unless the coal is heated to temperatures over 750 deg. C., so that yields of ammonia from low-temperature plants are of negligible importance.

These remarks will suffice to show that the liquid and gaseous products of low-temperature processes are likely to become more important as research and experience bring to light their latent properties. High-temperature tar was at one time practically a waste product, but as chemists unravelled its mystery the real value of it gradually became appreciated. So, too, with low-temperature oil. There is every indication that it is as great a mine of chemical products as the more familiar tar of the gas works.

Previous articles by Dr. Haslam appeared in the "Trade and Engineering Supplement" of April 18th, May 9th, and July 25th.—Ed.

In November, 1900, the paper by the late D. B. Morison was read and discussed—see Vol. XII.—at our meetings in 58, Romford Road, and in April, 1906 a Paper was read by Fleet-Engineer W. J. Harding, R.N., and discussed, for the convenience of many visitors, in the Cannon Street Hotel.—See Vol. XVIII.

The whole question has been again raised on the subject of the status of the R.N. Engineers, and the proposal has been considered in several quarters of arranging for a deputation to meet the Admiralty with a view to definitely settle what is the best course to follow to uphold the status of the engineer, and maintain discipline.

"The Marine Engineer and Motorship Builder" for January has an Editorial commenting on the Admiralty Fleet Order of November, which threatens to overthrow the whole of the advantages which were gained under the Act of 1915, on the accomplishment of which the following letter was sent to Lord Fisher:—

"It was with great gratification that the Council of the Institute of Marine Engineers learned of the decision of the

Lords Commissioners of the Admiralty to bestow executive rank upon the Engineer Officers of the Royal Navy, thus recognising the vital importance of their duties in the attainment of efficiency in H.M. Fleet.

The Council are aware that this step has been initiated by you and they also appreciate the great services which you have rendered to the Empire by encouraging experimental work and by boldly adopting the great improvements in machinery, which constitute so important a factor in our navy.

In these circumstances, at their meeting on the 2nd inst., they unanimously elected you as an Honorary Member of the Institute, and we beg that you will do the Institute the great honour of accepting this mark of their appreciation."

The letter was signed by the following:—Sir Arch. Denny (President), Geo. W. Manuel, Sir Thos. Sutherland, Sir John A. Durston, Sir J. Fortescue Flannery, John Inglis, Lord Inchcape, John Denny, Sir John Gunn, Sir Chas. A. Parsons, Sir Marcus Samuel, Lord Pirrie, Sir Jas. Knott, Jas. Denny, Marquis of Graham, Summers Hunter, Sir Thos. L. Devitt Past Presidents; Geo. Adams, Chairman of Council; and Jas. Adamson, Hon. Secretary; on behalf of the Council.

March, 1915.

The papers and discussions, followed by a memorandum, submitted by a Deputation of Representatives from the N.E. Coast Institution of Shipbuilders and Engineers, and the Institute of Marine Engineers, were reported in Vol. XXVI. of our Transactions, Session 1914/5, where also block representations of the letter to Lord Fisher, and his reply can be seen.

The views expressed in 1900, when the Paper was read by D. B. Morison, are as vital in 1926 for the consideration of all.

Boiler Explosions Acts, 1882 and 1890. Report No. 2714.—The ss. *Pendennis*, formerly named *Straat Svenda* when Dutch owned, was built in Holland in January, 1922, and bought by her present owners in December, 1923. The engines are triple expansion with single screw. The boilers are two of the usual type, with 180lbs. steam pressure. The stop valves of four inch diam. each with flanges of $9\frac{3}{8}$in. diam. by one inch thick, to which steel pipes were bolted to carry the steam to the main engine stop valve chest on which are two drain cocks, but none on the boiler chests.

On January 8th, 1925, when the cargo was loaded at Barry, the vessel was moved from the jetty to the buoys by the main engines, to await the rising tide. The stop valves were closed for the time being at 9.25. About four hours later, order was given to prepare for sea and the third engineer opened the engine stop valve very slightly, then opened the port boiler stop valve just off the face and crossed to ease the starboard valve; whilst doing so, a loud report was heard from the port valve chest, with an escape of steam. It was thought that the leakage was due to the joint, and arrangements were made to open the valves full, return to port and there renew it, but further investigation on reaching Barry again, showed the port valve chest to be cracked, thus necessitating renewal in port before proceeding on the voyage. On close examination it was found that the quality of the cast iron of which the chest was constructed was not of the best, being of a porous nature, 13/16ths of an inch thick; the crack was partly round the top flange at the cover. The examination was conducted and the report made by Mr. A. W. Powell, who attributed the explosion to water hammer action, as the drain valves on the engine stop valves were closed from 9.25-1.25, when any slight leakage of steam would condense in the pipes and lead to an accumulation of water, with the consequent result when steam was admitted.

The observations of Mr. Carlton were to the effect that for the avoidance of water hammer action in steam pipes it is necessary that the pipes should be thoroughly drained before steam is admitted to them, and if this precaution had been taken in this case, the water hammer action, which resulted in the failure of the stop valve chest, would not have occurred. Having regard to the action taken by the ship's engineers after the leakage from the stop valve chest was noticed, it is fortunate that a serious accident did not ensue.

BOILER EXPLOSIONS ACTS, 1882 AND 1890. REPORT NO. 2719. —This report refers to a lower stay tube which gave way in the boiler of the steam trawler *Gaul*. The tube in question failed near the back tube plate, a hole $\frac{3}{4}$in. circumferentially × $\frac{1}{4}$in. on the underside, developed and the fires had to be drawn and the trawler towed to Fleetwood, after an effort had been made to insert a tube stopper. The defective tube was removed by burning it at each end, this process prevented a full investigation of the tube failure. Appearances suggested that scaling operations were a possible cause, but close examination of the boiler and the tubes when cleaned showed good conditions all round and the conclusion arrived at was that the failure of the tube was due to an initial defect.

No. 2724.—The steam trawler, *Robert Murray*, was proceeding from Fleetwood to the fishing grounds on March 30th, when about seven miles from Fleetwood an explosion occurred, due to the studs of the salinometer cock giving way, the plug was blown out and the water followed from the boiler, necessitating drawing the fires and the trawler being towed back to Fleetwood by another trawler. The investigation was made by Mr. J. Fairley, B.T. Surveyor, Liverpool, who reported that during the overhaul prior to the departure from Fleetwood, the salinometer gland was repacked and the man who saw to this stated he did not notice anything wrong with the studs. The broken studs were not found, but when the renewal of the studs in gunmetal 7/16th inch diam. was in hand, it was observed that none of the original studs was wasted where it had given way, but the other seemed in order. The original studs were evidently on the small side. Mr. Carlton's comment was that the original studs were somewhat small for boiler fittings. There was a temptation to unduly stress gland studs in the endeavour to stop leakage. In this case the cock had been repacked and the gland tightened down, probably with undue force, thus overstressing the studs or partly breaking one or both so that they could not withstand the boiler pressure.

Report No. 2741.—The cast iron pipe connecting the water gauge glass to the boiler of the *Forestdene*, on February 28th, developed a leak through a hole on the underside and after an attempt had been made to repair it by binding it with a brass clip, it was found necessary to signal for help, and the vessel was towed into Ter Neusen, where repairs were effected and she then left for Newcastle, arriving in due course.

The *Forestdene's* boiler was built at Sliedrecht in 1919 for 180 lbs. pressure; it is single-ended with two furnaces 45in. diam., and fitted with two gauge glasses, one on each side of the smoke box, connected to the boiler shell by cast iron pipes. The engines are triple expansion. It was found on investigation that the cast iron pipe had corroded and that the metal was porous and inferior in quality. The pipe in question was one inch diam. and 12in. long, $\frac{3}{8}$in. thick; the flanges connecting the boiler shell and the gauge glass standard were $4\frac{7}{8}$in. diam., secured by four $\frac{5}{8}$in. studs and bolts respectively.

The gauge glass fittings were disconnected and overhauled at Newcastle, the cast iron pipes being renewed. The investigation was conducted by Mr. J. F. Blenkinson, Surveyor, Liverpool. The observations of Mr. Carlton were to the effect that the boiler was built abroad in 1919, and the explosion was apparently due to wastage of the poor quality cast iron material used for the stand pipes of the water gauge. Fortunately, the explosion was not of a violent nature, and no one was injured.

TITANIC ENGINEERING STAFF MEMORIAL.—Thanks are accorded to the givers for the following noted donations:—A. Taylor, Associate, £1; M. Yuill, Member, £1 1s.; P. J. Adie, V.P. Buenos Ayres, £5.

ESSAYS.—The Awards Committee acknowledge receipt of an Essay by "A. Rev." on "Oil Fuel Burning on Steamers."

Books added to the Library.

MARINE DIESEL OIL ENGINES, by J. W. M. Sothern. London, Crosby, Lockwood and Son. 42/- net.—This volume has been compiled on the method which the author has made familar to marine engineers and, as in former works, it is very profusely illustrated. The first portion of the book is devoted to descriptions of the more prominent types of internal combustion engines and in this section the ground is fairly well covered, but as there are some 32 makers of these engines in Great Britain and some 45 makers abroad it is more than one book could do to contain descriptions of every type and make.

From page 265 the second portion of the book deals with electrical notes. Some of this matter is already familiar, but it is very usefully included in the present volume. The next section deals with various details of oil engine installations, practical operations of oil engines and auxiliaries, overhauling and maintenance, defects and their causes and remedies.

Section 6 deals with indicator diagrams, this is very full and informative, and Section 7 is devoted to fuel and lubricating oils, analyses, tests and specifications.

Section 8 deals with auxiliary machinery, of all types of internal combustion motors, and Section 9 contains a series of "questions and answers" of the kind long familiar to young students; these are further supplemented by a few specimen papers of examination questions and the appropriate replies, and a final section giving useful calculations, logarithmic and metric tables and formulæ. The book represents a large amount of work on the part of its compiler, and we have no doubt that it will meet the needs of the sea-going engineer and prove a useful work of reference for him.

By the courtesy of the Council of the Institution of Engineers and Shipbuilders in Scotland.—A bound volume of the Transactions of this Institution for 1924-5 is acknowledged with thanks.

By the courtesy of Fourth International Congress of Refrigeration.—We are pleased to acknowledge with thanks the receipt of Vols. I. and II. of the proceedings of this Congress, at which the Institute was represented.

Election of Members.

List of those elected at Council Meeting of 11th January, 1926:—

Members.

Arthur Edward Aburrow, 64, Fairlawn Grove, Chiswick Park, W.4.

George William Brown, 3, Park Street, North Shore, Blackpool.

James Walter Chew, Exton House, Queen Street, Brisbane.

Henry Mowbray Defty, 9, Azalea Terrace South, Sunderland.

Samuel Ferguson Grundy, 148, Eccles Old Road, Pendleton, near Manchester.

Harold William Hooper, 20, Bromley Road, New Brighton, Cheshire.

Frederick Fortune Key, 52, High Street, Maryport, Cumberland.

William McArthur, 11, Craiglea Place, Morningside, Edinburgh.

Hugh Neill, "The Laurels," Elmfield Grove, Gosforth, Newcastle-on-Tyne.

Thomas Henry Platt, 66, Gladeville Road, Aigburth, Liverpool.

Richard Shortridge, 7, Brunswick Place, Southampton.
George Lewis Spencer, 99, Cowley Road, Ilford, Essex.
William Henry Steer, Dockmaster's House, Millwall Dock, Pier Head, London, E.14.
John Carter Malone Sutcliffe, 115, Manchester Road, Bury, Lancs.
William Whaley Tennent, Bulls Metal and Melloid Co., Ltd., Yoker, Glasgow.
James Whittle, Apia, Western Samoa.
Walter Trevelyan Wright, 4, Maberley Road, Upper Norwood, S.E.19.

Companion.

William Stevenson, Cunard Building, Liverpool.

Associate-Members.

Thomas William Bone, Jackson Street, Seaton, near Workington, Sunderland.
Norman Lyall, 39, Low Shore, Macduff, Scotland.
Jack Llewellyn Pedrick, "Manciple House," Week St. Mary, near Holsworthy, Devon.

Associates.

Frederick Mark Burgis, Oceanic House, 1a, Cockspur Street, S.W.1.
Harry Russell Smith, R.F.A. "Brambleleaf," *c/o* G.P.O., London.

Transferred from Associates to Associate-Members.

A. W. Green, 6, Ferndale Road, Gravesend, Kent.
H. B. Scott, SS. *Mundra*, Messrs. Mackinnon, Mackenzie & Co., Ltd., Calcutta.
E. O. Stephens, Wheatley Lodge, West Street, Erith.