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Electric Propulsion as applied to Passenger Liners.

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READ

Tuesday, October 8, 1929 *at* 6.30 *p.m.*

CHAIRMAN: MR. JOHN NICOL (Chairman of Council).

The CHAIRMAN: It is somewhat disappointing to the Institute that we have not with us Mr. Eskil Berg, who is the author of the paper we are to hear read to-night. He is, I understand, attending the trials of the third passenger vessel of the latest type which has been built and completely equipped in the U.S.A. for electric propulsion. We are fortunate in that we have with us, in the author's absence, Mr. W. J. Belsey, of the British Thomson-Houston Company, of Rugby. He has kindly consented to take the place of Mr. Eskil Berg, and I now have much pleasure in asking Mr. Belsey to read the paper.

Recently electric propulsion has been applied to two large liners—in fact, the largest passenger ships built in the United States of America. Both of these ships were built by the Newport News Shipbuilding Company and the complete electrical equipment was designed and built by the General Electric Company of Schenectady, N.Y. These boats operate between New York and San Francisco. The first ship was the S.S. *California,* which made her maiden trip from New York, January 28th, 1928, and has been in continuous and most successful operation ever since. The second ship, the S.S. *Virginia,* for the same line, had her maiden trip from New York, December 8th, 1928. The data of her performance during the second trip will be used in this paper, as during this run accurate readings were taken of all the power used—that is, readings were taken every 15 minutes of volts, amperes, power factor and kilowatts. The power readings were also checked by integrating wattmeters, so that it is safe to say that the power of the ship was measured correctly within one-fourth of one per cent.

PARTICULARS OF S.S. *Virginia.*

Length overall—613 ft. $1\frac{1}{4}$ ins.
Length on waterline—607 ft.
Length B.P.—586 ft. 4 ins.
Beam, moulded—80 ft. 3 ins.
Depth to Shelter Deck—52 ft.
Load Draft to Bottom of Bar Keel—33ft. $9\frac{7}{8}$ ins.
Gross Tonnage—20,773.
Displacement Tons—32,800.
Deadweight Capacity, Tons—18,100.
Capacity of Fuel Oil, Tons—5,436.
Rated Shaft Horsepower Continuous—17,000
Speed—18 Knots.
Cruising Radius at 18 Knots—16,000 Knots.
Passenger Capacity, First Class—400.
Passenger Capacity, Tourist Class—400.
Freight Capacity, Tons—8,500.
Refrigerating Cargo Capacity—100,000 Cu. Ft.

Propelling Machinery.—For the main propulsion there are installed two (2) steam turbine driven generators, having a rating of 6,600 k.w. at 2,880 r.p.m. At full power the voltage is 4,000 volts, and three-phase current is used.

Propelling Motors.—There are two (2) propelling motors, each direct connected to a propeller shaft. The motors are of the synchronous induction type, this type being lighter and more efficient than the induction motor type. The motors have a normal rating of 8,500 h.p. at 120 r.p.m. Each motor has six circuits in multiple. In other words, while the motors appear to be just one, there are in reality six independent motors. If damage should be done to one coil, all that would be necessary to do is to cut this coil open by a hack saw, separate and tape the ends and only one-sixth of the power of that one motor is lost. Under full power operation each motor is connected to one turbine generator, making two complete units entirely separated from one another. At reduced speed, however, only one turbine generator can be used driving both motors and under this condition a speed of 15½ knots can be maintained. (During trials 16 knots were run.)

Control Apparatus.—This consists of necessary contactors for closing the electrical circuit between the generators and the motors. There are two main operating levers for each motor, and two small wheels on the operating board that regulate the speed (R.P.M.) of the motors. One operating lever has three positions—"Ahead," "Stop" and "Astern." The other controls the excitation of the motor and the generator and has four definite positions—"Off," "1," "2" and "Run." On "1" position double excitation is applied to the generator alone. In this position with the reverse lever on either "Ahead" or "Astern," the propelling motor is started ahead or reversed as a pure squirrel cage induction motor. In "2" position normal excitation is applied to the motor field, leaving double excitation on the generator. In this position the motor phases in and becomes a synchronous motor. Position "Run" reduces the excitation of the generator to normal.

Speed Regulation of the propellers is made by varying the speed of the turbine. This is done by a small wheel on the control board which changes the governor setting of the turbine. All the switching is done with dead circuits as an interlock is provided by which the operating lever cannot be moved before the excitation lever is on the "Off" position. The switches are, however, designed to operate under full power condition, in case anything should happen to the interlock.

Boilers.—The boilers on the S.S. *Virginia* are of the regular Babcock and Wilcox marine type, thirty sections wide with tubes 10ft. 6in. long. The heating surface per boiler is 5,461 sq. ft. or a total for eight boilers of 43,688 sq. ft. Each boiler is fitted with a Babcock and Wilcox interdeck superheater having 601 sq. ft. of superheating surface, or a total for the eight superheaters of 4,808 sq. ft. Babcock and Wilcox feed water regulators are fitted on the drums of all boilers. The front plate of each boiler is equipped with six (6) Babcock and Wilcox mechanical atomizer oil burners of

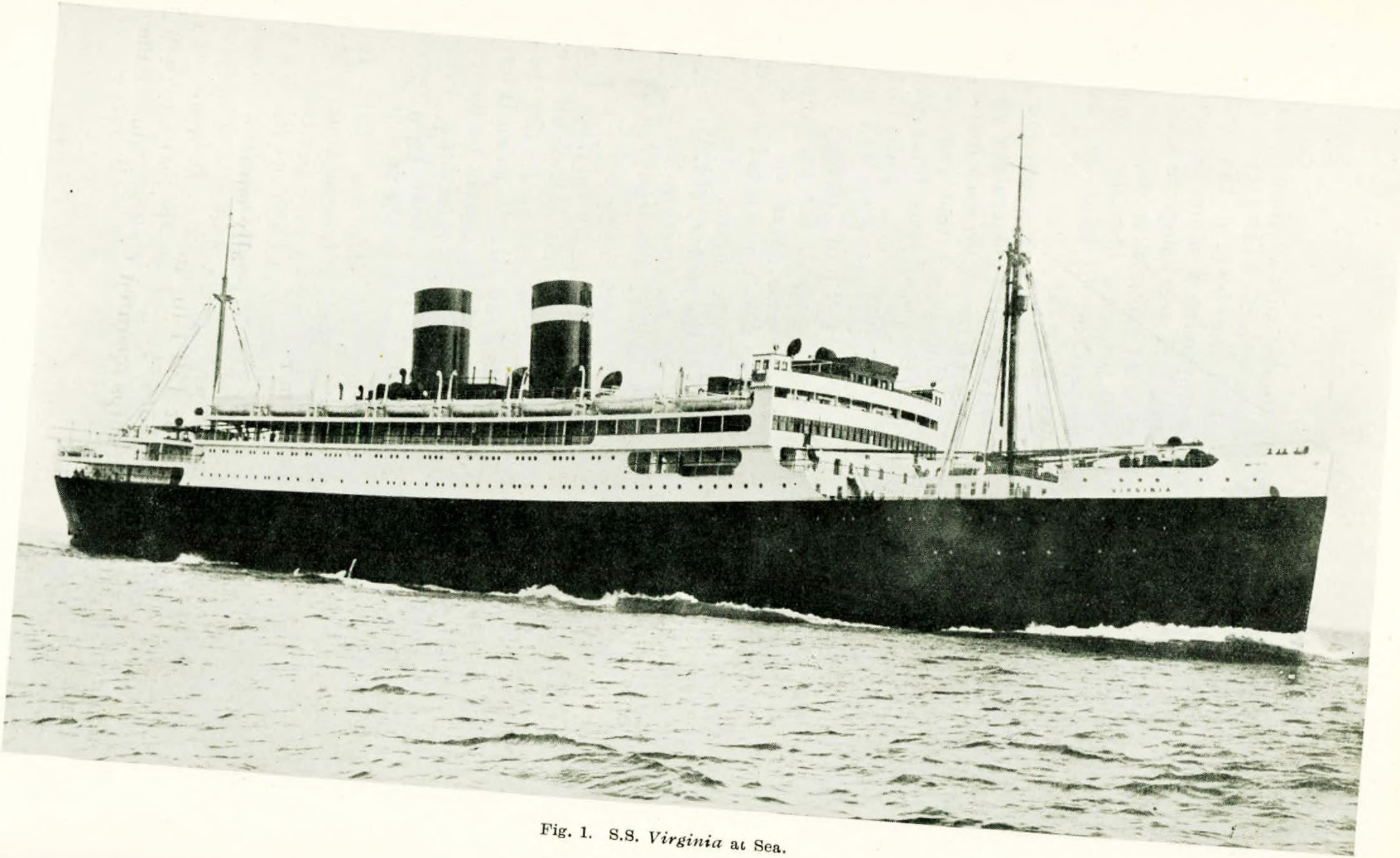


Fig. 1. S.S. *Virginia* at Sea.

the Cuyama type. On the full power run from Balboa to San Diego (2,829 knots) the *Virginia* averaged 18·4 knots, and only six of the eight boilers were in use, showing that her boilers could easily be cut down in size.

Condensers.—These are bolted directly under the turbine to the turbine casing, no expansion joint being used. A spring beam under the condenser takes care of any expansion due to temperature changes. Each condenser has 11,000 sq. ft. of cooling surface consisting of ¾in. tubes. Each condenser has two (2) Warren 18in. centrifugal pumps, having a capacity of 8,000 gal. per minute against 30ft. head. They are each driven by a 100 h.p. direct current motor, 325 to 600 r.p.m. per minute. The condensate pump is also electrically driven. Its rating is 210 gal. per min. against 60ft. head, driven by a 7½ h.p. motor at 1,200 r.p.m. Air ejectors are used of the Wheeler 2-stage Radojet type.

Auxiliary Electric Power Plant.—As all the refrigeration, cooking, baking, and heating of the staterooms are done by electricity the power plant is rather large, consisting of four (4) 500 k.w., 240-120 volt, 3 wire system, direct current geared turbine generator sets. There is one condenser for each two sets with valves, so that either set can be operated alone on the condenser, or both at the same time. Each condenser has 2,800 sq. ft. of cooling surface, using ¾in. tubes. One motor driven circulating pump, having a capacity of 3,600 gal. per min., is provided for each condenser, the motor having a rating of 30 h.p. at 675-900 r.p.m. The condensate pump is also motor driven and Wheeler 2-stage air ejectors are used.

Refrigerating Plant.—The *Virginia* has 60,000 cu. ft. of cool air space for carrying fruit and also 40,000 cu. ft. of frozen cargo space. There are four (4) Brunswick-Kroeschell CO_2 3-cylinder compressors, each driven by a 100 h.p., 250 to 325 r.p.m., direct current motor. The air is circulated through the cold air system by four (4) blowers, each of 25,000 cu. ft. capacity. The whole refrigerating system with all its pumps, etc., is motor driven and, when running at maximum capacity, consumes about 800 h.p.

Galley.—The whole galley is electrically equipped. There are, among other things, 12 large ranges and 2 bake ovens, the latter having a capacity of 180 1-lb. loaves of bread. The electric galley has proven itself most economical and will be adopted on all the new ships operated by the Panama-Pacific Line.

Steam Consumption.—When operating at 275 lb. pressure at the throttle and 200° superheat, and with a vacuum of 28·5in., the steam consumption per shaft horsepower hour with 17,000 h.p. delivered to the propeller shaft, including all the losses in the generator, motors, cables and control, is 8·1 lb.

Fuel Consumption.—On the second voyage west the ship ran full power from New York to Havana and the fuel consumption was ·715 lb. of oil per s.h.p. hour. The same results were obtained from Balboa to San Diego—a distance of 2,829 knots—and also from San Pedro to San Francisco. This figure of ·715 includes everything on the ship and, when it is considered that all the cooking and baking are done electrically, and that a very large refrigerating plant is in operation most of the time, due to the fact that the ship carries bananas and other fruit, and has a refrigerating cargo space of 100,000 cu. ft., this figure of ·715 is indeed a very fine result. This figure has been maintained and even slightly improved on subsequent trip of the *Virginia*.

Engine Room.—Figures 2 and 3 give sectional views and plan views of the engine room. The length of the engine room is 48ft. and the width is 74ft.

Electrical Losses.—At 17,000 h.p. and 120 r.p.m. of the propellers, the generators have an efficiency of 97·5%, excluding excitation, which amounts to 32 kw. per generator or less than $\frac{1}{2}$%. The motors have an efficiency of $98\frac{1}{4}$%, excluding excitation, which amounts to ·68%. The loss in cables, control, etc., amounts to ·04%. The total transmission loss is, therefore, excluding excitation, about $4\frac{1}{2}$%, and with excitation about $5\frac{1}{4}$%. At reduced speed of the vessel the efficiency of the generators and motors remains practically constant as the voltage is then reduced in about the proportion of the square root of the horsepower, so that at three-quarter speed the voltage is reduced from 4,000 volts to 2,600 volts. The transmission loss has only increased from $5\frac{1}{4}$% to $5\frac{3}{4}$%, although the power has been reduced from 17,000 h.p. to only 7,000 h.p.

ADVANTAGES OF ELECTRIC DRIVE FOR LARGE LINERS.

1. Electric transmission gives a simple and practical means of speed reduction between the high speed turbine and the slow speed propeller in almost any ratio. This means that the best turbine speed (r.p.m.) can be adopted for the design of the most efficient turbine, also that the r.p.m. of the propeller can be made such as to give the best propeller efficiency.

2. Reversal: It affords means of reversal by simple change of electrical connections, without changing the direction of rotation of the turbine, and thus eliminates the space occupied by reversing turbines and their loss while the ship operates in forward direction.

3. Reversing Torque: Any desired reversing torque up to the full power of the turbine can be obtained without in any way affecting the efficiency of the equipment in the forward direction.

4. Electric drive allows the turbine as a rule to be built in one casing, making an ideal condition for efficient design of turbine, eliminating all losses due to crossover connections and reducing the number of turbine packings and steam seals.

5. Reversal of the propellers is obtained with a minimum amount of steam drawn from the boilers as the full inertia of the turbo-generators is first used in the act of reversal and, in fact, in most cases actual reversal is obtained without drawing any steam from the boilers, and steam is only used from the boilers to accelerate the speed in the reverse rotation. This fact releases all strains on the condenser tubes and prevents leakage of the same. In fact, condenser troubles are practically eliminated on electric ships.

6. Power Measurements: Electric drive makes it possible to obtain accurate data, either by instantaneous readings or by recording instruments, of the load on the propeller shaft under all conditions of sea and wind. It eliminates the use of torsion meters. The total horsepower hours can be recorded during any given time of journey. It makes it possible to have a real check between fuel consumption and horsepower hours developed.

7. Economic Cruising Speed: With electric ships it is possible to obtain very fine economy at three-quarter speed as during that time only one-half of the generating unit with its auxiliaries will be used. Under this condition the fuel consumption per shaft horsepower will be practically the same as at full power. This is a very important consideration for the very high-speed, high-power liners now being contemplated, as these ships can be run during off season at slower speed and still maintain maximum efficiency.

8. Location of Apparatus: Electric drive allows the power generating unit, or units, to be put in any convenient place near the boilers, thus greatly simplifying the steam piping.

They can also be put on any convenient height, and the condensers can be mounted directly under the turbine. On the S.S. *Virginia* they are hung directly on the turbine casing, thus eliminating expansion joints, and making for an ideal condition toward an air-tight system.

9. It has been found that the make-up water on the electric ships is less than one-quarter that on any other type of similar steamer.

10. The propelling motors can also in most instances be put near the propellers, eliminating long, expensive shafting with its many bearing losses.

11. High Steam Pressure and Superheat: With electric drive the adoption of the above is ideal. As the turbine is never reversed it cannot have extreme temperature changes. Stage extraction for heating the feed water becomes a very simple matter and has proven itself most attractive and simple on the electric ships.

12. Electric ships can be made practically noiseless and the absolute absence of all vibrations and noise on the S.S. *Virginia* is striking and always most talked about among the passengers.

TABLE I.

S.S. "VIRGINIA." SHIP'S PERFORMANCE. VOYAGE 2, WEST.

NEW YORK TO SAN FRANCISCO.

NEW YORK TO HAVANA.

Date	Revolutions P.	Revolutions S.	Knots Eng.	Knots Obs.	Av'ge. K.W P.	Av'ge. K.W S.	Speed	Slip	Tons Oil	Length of Day
20 Jan.	118·0	117·4	473·6	403	6600	6600	17·7	14·9	127	22 Hr. 47 Min.
21 ,,	117·9	118·2	500·4	426	6600	6600	17·8	14·9	133	24 ,, 00 ,,
22 ,,	117·9	118·2	415·2	336	6600	6600	16·9	19·1	110	19 ,, 55 ,,

Average Speed: 17·5 Knots. Average Slip: 16·1. Oil, all purposes, per Shaft-Horsepower Hr.: ·715 lb.

HAVANA TO BALBOA (COLON).

Date	Revolutions P.	Revolutions S.	Knots Eng.	Knots Obs.	Av'ge. K.W P.	Av'ge. K.W S.	Speed	Slip	Tons Oil	Length of Day
23 Jan.	117·2	117·7	373·1	323	6420	6460	18·0	13·4	98	17 Hr. 59 Min.
24 ,,	113·8	113·9	482·7	393	6013	6036	16·4	18·6	125	24 ,, 00 ,,
25 ,,	110·2	110·2	335·8	283	5404	5398	16·4	15·7	84	17 ,, 15 ,,

Average Speed: 16·9 Knots. Average Slip: 16·1. Oil per Shaft-Horsepower Hr.: ·742 lb.

BALBOA TO SAN DIEGO.

Date	Revolutions P.	Revolutions S.	Knots Eng.	Knots Obs.	Av'ge. K.W P.	Av'ge. K.W S.	Speed	Slip	Tons Oil	Length of Day
26 Jan.	116·8	117·3	187·1	167	6366	6416	18·5	10·7	51	9 Hr. 03 Min.
27 ,,	118·5	118·8	513·5	449	6600	6600	18·3	12·6	138	24 ,, 30 ,,
28 ,,	118·5	118·5	516·2	480	6600	6600	19·4	7·0	138	24 ,, 40 ,,
29 ,,	118·5	118·6	516·4	447	6600	6600	18·1	13·4	138	24 ,, 40 ,,
30 ,,	118·5	118·7	516·7	443	6600	6600	17·9	14·3	137	24 ,, 40 ,,
31 ,,	118·9	119·1	514·8	446	6600	6600	18·2	13·4	136	24 ,, 30 ,,
1 Feb.	115·7	116·1	450·2	397	6080	6100	18·0	11·8	104	22 ,, 00 ,,

Average Speed: 18·4 Knots. Average Slip: 12·0. Oil per Shaft-Horsepower Hr.: ·715 lb.

SAN DIEGO TO SAN PEDRO.

2 Feb.	95·1	94·8	89·8	83	3500	3300	15·5	7·6	18	5 Hr. 21 Min.

Average Speed : 15·5 Knots. Average Slip : 7·6. Oil per Shaft-Horsepower Hr. : ·843 lb.

SAN PEDRO TO SAN FRANCISCO.

4 Feb.	117·6	117·6	396·3	353	6600	6600	18·5	10·9	106	19 Hr. 05 Min.

Average Speed : 18·5 Knots. Average Slip : 10·9. Oil per Shaft-Horsepower Hr. : ·715 lb.

NEW YORK TO SAN FRANCISCO.

Distance of Sea Passage : 5,429 Knots.
Time of Sea Passage : 12 Days, 16 Hours, 25 Minutes.
Total Oil consumed Sea Passage : 1,643 Tons. Total consumption (including New York)—1,843 Tons.
Average Speed : 17·8 Knots. Average Slip : 13·6%.
Oil per Shaft-Horsepower between pilot stations : ·7396 lb./hr.
Oil per 24 Hours : 129·6 Tons. Oil per 100 Knots : 30·3 Tons.

TABLE II.

S.S. "VIRGINIA." SHIP'S PERFORMANCE. VOYAGE 2, EAST.

SAN FRANCISCO TO NEW YORK.

SAN FRANCISCO TO SAN PEDRO.

Date	Revolutions P.	S.	Knots Eng.	Obs.	Av'ge K.W. P.	S.	Speed	Slip	Tons Oil	Length of Day
10 Feb.	117·4	117·3	401·8	353	6600	6600	18·2	12·1	109	19 Hr. 23 Min.

Displacement leaving San Francisco—29,225 Tons.
Average Speed : 18·2 Knots. Average Slip : 12·1. Oil per Shaft-Horsepower Hr. : ·724 lb.

SAN PEDRO TO BALBOA.

11 Feb.	116·2	116·0	108·7	94	6600	6600	17·7	13·5	30	5 Hr. 18 Min.
12 ,,	117·5	117·1	490·3	425	6600	6600	18·0	13·3	132	23 ,, 40 ,,
13 ,,	116·8	116·6	487·8	435	6600	6600	18·4	10·8	132	23 ,, 40 ,,
14 ,,	115·3	115·1	481·4	424	6343	6370	17·9	11·9	130	23 ,, 40 ,,
15 ,,	113·1	112·7	468·7	404	5950	5966	17·2	13·8	124	23 ,, 30 ,,
16 ,,	113·3	113·2	469·9	424	5950	5966	18·0	9·8	123	23 ,, 30 ,,
17 ,,	109·3	109·2	453·5	376	5350	5375	16·0	17·1	115	23 ,, 30 ,,
18 ,,	95·8	95·7	375·5	329	3616	3591	14·8	12·4	79	22 ,, 12 ,,

Displacement at San Pedro—28,957 Tons. Displacement at Balboa—28,422 Tons.
Average Speed : 17·2 Knots. Average Slip : 12·7. Oil per Shaft-Horsepower Hr. : ·742 lb.

COLON TO HAVANA.

20 Feb.	110·1	109·9	361·4	310	5710	5710	16·7	14·2	92	18 Hr. 36 Min.
21 ,,	110·6	110·5	468·7	423	5591	5583	17·6	9·8	112	24 ,, 0 ,,
22 ,,	95·8	95·9	287·8	274	3420	3440	16·1	5·0	58	17 ,, 0 ,,

Displacement at Havana—28,422 Tons.
Average Speed : 16·9 Knots. Average Slip : 10·0. Oil per Shaft-Horsepower Hr. : ·76 lb.

HAVANA TO NEW YORK.

23 Feb.	116·0	116·0	425·0	400	6600	6600	19·3	5·9	116	20 Hr. 45 Min.
24 ,,	116·4	116·1	492·0	449	6600	6600	18·7	8·9	135	24 ,, 00 ,,
25 ,,	116·7	116·7	365·5	321	6600	6600	18·1	12·2	97	17 ,, 44 ,,

Displacement at New York—28,155 Tons.
Average Speed : 18·7 Knots. Average Slip : 8·8. Oil per Shaft-Horsepower Hr. : ·717 lb.
Distance of Sea Passage : 5441 Knots.
Time Sea Passage : 12 Days, 22 Hrs., 28 Min.
Total Oil consumed Sea Passage : 1,584 Tons.
Total Oil consumed (including San Francisco) – 1,756 Tons.
Average Speed : 17·5 Knots. Average Slip : 11·4%
Oil per Shaft-horsepower between pilot stations : ·739 lb./hr.
Oil per 24 hours between pilot stations : 122·4 Tons.
Oil per 100 Knots between pilot stations : 29·1 Tons.

Performance.—Tables I and II give complete log data of the second voyage of the S.S. *Virginia*, and Fig. 4 gives performance curve of the ship during this run. On her trip from New York to San Francisco, a distance of 5,429 knots, the time of the sea passage was 12 days, 16 hours, 25 minutes.

Total oil consumed sea passage ... ... 1,643 tons
Average speed ... ... 17·8 knots
Average slip ... ... 13·6%
Oil per shaft horsepower between pilot stations—·7396 lb. per S.H.P. hour
Oil per 24 hours ... ... 129·6 tons
Oil per 100 knots ... ... 30·3 tons

On her return trip from San Francisco to New York the following results were obtained:

Distance ... ... 5,441 knots
Time of sea passage... ... ... 12 days, 22 hours, 28 min.
Total oil consumed sea passage ... ... 1,584 tons
Average speed ... ... 17·5 knots
Average slip ... ... 11·4%
Oil per shaft horsepower between pilot stations—·739 lb. per S.H.P. hour
Oil per 24 hours ... ... 122·4 tons
Oil per 100 knots ... ... 29·10 tons

In looking over and studying the performance curve of the *Virginia*, what particularly must impress the Marine Engineer is the low horsepower curve of this ship. The reason for this is simple, namely: that with the electric ship we obtain absolutely accurate reading of the power consumed, and this accuracy can never be obtained with other types. In this connection it is interesting to compare the Admiralty coefficient of the ships given in Mr. J. Johnson's paper "The Propulsion of Ships by Modern Steam Machinery," read before

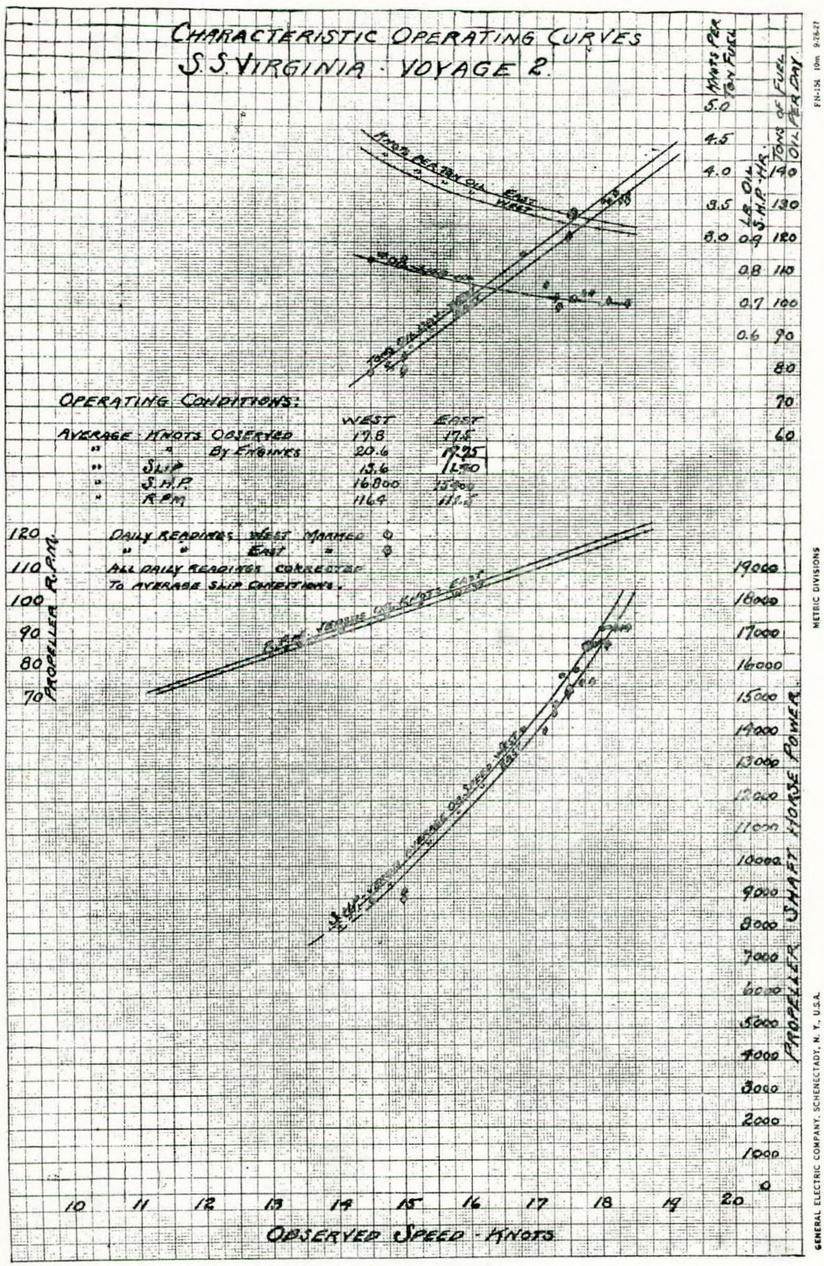

CHARACTERISTIC OPERATING CURVES
S.S. VIRGINIA · VOYAGE 2.
OPERATING CONDITIONS:
WEST
EAST
AVERAGE KNOTS OBSERVED 17.8 17.5
" " BY ENGINES 20.6 19.95
" SLIP 13.6
" S.H.P. 16800
" RPM 116.4
DAILY READINGS WEST MARKED
" " EAST "
ALL DAILY READINGS CORRECTED
TO AVERAGE SLIP CONDITIONS.
PROPELLER R.P.M.
120
110
100
90
80
70
KNOTS PER TON FUEL
5.0
4.5
4.0
3.5
3.0
LB. OIL S.H.P.-HR.
0.9
0.8
0.7
0.6
TONS OF FUEL OIL PER DAY
140
130
120
110
100
90
80
70
60
PROPELLER SHAFT HORSE POWER
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
11
12
13
14
15
16
17
18
19
20
OBSERVED SPEED - KNOTS
METRIC DIVISIONS
GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., U.S.A.
FN-154 10m 9-28-27

Fig. 4.

the Institution of Naval Architects, March 21st, 1929. He gives the following table in regard to this coefficient:—

	S.H.P. on Service.	$\frac{D^{2/3} \times V^3}{S.H.P.}$
Empress of Canada	20,000	307
Montclare	12,500	284
Minnedosa	11,500	290
Empress of Australia	20,346	294
Duchess of Bedford	16,000	293
Duchess of Athol	16,100	284

Comparing this coefficient for the three (3) electric ships we have:—

	S.H.P. on Service.	$\frac{D^{2/3} \times V^3}{S.H.P.}$
California	17,000	345
Virginia	17,000	350
Viceroy of India	17,000	355

In olden days the power was obtained by indicator cards of the engines. As the power varies greatly with the waves, the engineers were in the habit of taking the largest cards. The same thing also takes place with the torsion meters, and in the writer's experience of some thirty men taking torsion meter readings on electric ships is that these readings were from 5% to 10% higher than the electrical readings. In other words they all read more power out of the motor than was put into it. With Diesel engines, the shape of the indicator card is such that to obtain anywhere near accurate results in a seaway is practically impossible. Just recently a large new twin screw liner, equipped with Burmeister and Wain double-acting, 8-cylinder, 4-cycle engines, had her performance published in the Marine Journal (New York), Feb. 1st, 1929 issue. The particulars of this ship as compared with the *Virginia* are as follows:—

	Diesel Ship.	*Virginia.*
Length	608′ 9″	613′ 1¼″
Width	78′	80′ 3″
Displacement	26,700 tons	32,800 tons
Draft	29′	33′ 9⅞″
Speed	18 knots	18 knots
Horsepower	26,000 Indicated	17,000 S.H.P.

At 16·18 knots the starboard engine indicated 9,045 horsepower and the port engine 9,035 horsepower, or a total i.h.p.

of 18,080. Fuel oil consumption, excluding lubricating oil, 77 tons for all purposes. Mean draft of ship 25ft. 8ins. The S.S. *Virginia* under this condition takes but 11,500 h.p. to drive and her total fuel consumption is but 96 tons. As Diesel oil at this writing costs in New York just twice the price of fuel oil, the 77 tons of Diesel oil become the equivalent of 154 tons of fuel oil, and compares with 96 tons of the *Virginia*, which is a much larger ship. The weight of all the machinery on the *Virginia* is less than that of the Diesel ship and the space is also less, as well as the cost. It appears, therefore, as if Diesel engine drive for large passenger liners may not be correct from an engineering point of view, and we know that a great many of the passengers do not admire them from the point of comfort due to their vibration. The wonderful success, economy and popularity of the *California* and *Virginia*, have drawn the attention of the whole marine world. The Ward Line and the Grace Line have recently adopted this type of drive. The Peninsular and Oriental Steam Navigation Co. has completed the big liner *Viceroy of India* with electric drive furnished by the British Thomson-Houston Company, of Rugby, England, an associate company of the General Electric Company in the United States of America. Her performance will be even better than that of the *Virginia* on account of higher steam pressure and superheat. At 18·5 knots, "Engineering" (London) reports so little sign of movement or vibration that it is hard for a passenger below decks to believe the boat is not stationary. The popularity of the all electric liners is going to be so great that the travelling public is going to demand it, and with the adoption of high steam pressure and superheat, and stage extraction for heating the feed water, the economy will be so good that Diesel ships, even if the fuel price were about the same, could not compete due to the lighter weight, less space, upkeep and first cost of the electric drive.

(For description and performance of the S.S. *California*, see paper entitled "Description and Trials of S.S. *California*," read by Capt. Roger Williams of the International Mercantile Marine Company before the Society of Naval Architects and Marine Engineers, November 15th-16th, 1927, an abstract of which appears in the September, 1929, Transactions of your Institute.)

A great deal of attention has lately been given to the wonderful performance of the S.S. *Bremen*, and the published data given, credits her with a fuel consumption of ·685 per S.H.P. for all purposes. This compares with ·715 on the S.S. *Virginia*.

		Bremen	*Virginia*
Boiler Pressure ...	...	330	300
Temperature Steam	...	700 deg.	621 deg.
Vacuum... ...	...	28·5"	28"
Boiler efficiency ...	...	85%	80%
S.H.P.	...	110,000	17,000

The higher boiler efficiency of the *Bremen* is because her boilers are equipped with economizers and air preheater. Making proper allowance for the higher steam pressure, superheat, vacuum and boiler efficiency, and the fact that more efficient turbines can be designed for 110,000 S.H.P. than for 17,000 S.H.P., the ·715 for the *Virginia* would be reduced to ·61 as compared with the *Bremen's* ·685.

The *Virginia* has about 800 H.P. of refrigerating machinery and the figure ·715 includes this as well. For the very large and fast liners which are at present being considered, the General Electric Company and also the British Thomson-Houston Company of Rugby, England, have made up rather complete and tentative designs, but unfortunately the same cannot be published at this time. The overall economy is, however, so good that no one should seriously consider any other type of drive. The installation of the machinery in the engine room is simple, and all steam piping is reduced to only a fraction of that required for a geared turbine job similar to that of the *Bremen*. It is hoped that at the reading of this paper an announcement can be made that a contract for at least one or more of the large superliners has been closed with turbo-electric drive. There is no doubt but that such an installation will prove itself successful from the start, and will open up a new era in marine propulsion for these high-powered, high-speed liners.

TURBINE ELECTRICALLY PROPELLED VESSELS BUILT BY GENERAL ELECTRIC CO.

	Name.	Type of Ship.	Year in Service.	Speed.	S.H.P.	Propeller. No.	Propeller. R.P.M.	Turbine. Stages.	Turbine. R.P.M.	Generators. No.	Generators. Voltage.	Pressures. Gauge.	Pressures. Vac.	Superheat. Deg. F.
SS	Joseph Medill ...	Fire Boat	1908	11·7 miles	500	2	179	2	1800	2	275	160	27	0
SS	Graeme Stewart ...	Fire Boat	1908	11·7 miles	500	2	179	2	1800	2	275	160	27	0
USS	Langley (ex-Jupiter)	Airplane Carrier ...	1913	14·5 knots	5400	2	110	9	1900-2100	1	2300-2420	175	27·5	0
USS	New Mexico ...	Battleship ...	1918	21 knots	28000	4	161	10	2130	2	3000-4242	250	28·5	50
USS	California	Battleship ...	1921	21 knots	28000	4	170	10	2065	2	3000-4242	250	28·5	0
USS	Maryland	Battleship ...	1921	21 knots	28000	4	170	10	2065	2	3000-4242	250	28·5	0
USS	West Virginia ...	Battleship ...	1921	21 knots	28000	4	170	10	2065	2	3000-4242	250	28·5	0
SS	Eclipse	Cargo	1920	11 knots	3000	1	100	8	3000	1	2300	200	28·5	200
SS	Invincible	Cargo	1921	11 knots	3000	1	100	8	3000	1	2300	200	28·5	200
SS	Archer	Cargo	1921	11 knots	3000	1	100	8	3000	1	2300	200	28·5	200
SS	Independence ...	Cargo	1921	11 knots	3000	1	100	8	3000	1	2300	200	28·5	200
SS	Victorious	Cargo	1921	11 knots	3000	1	100	8	3000	1	2300	200	28·5	200
SS	Cuba	Pass.-Cargo ...	1920	17 knots	3000	1	100	8	3000	1	1150	175	27·5	150-250
SS	Tampa	Coast Guard Cutter	1921	16 knots	2600	1	130	8	3000	1	2300	200	28	75
SS	Haida	Coast Guard Cutter	1921	16 knots	2600	1	130	8	3000	1	2300	200	28	75
SS	Mojave	Coast Guard Cutter	1921	16 knots	2600	1	130	8	3000	1	2300	200	28	75
SS	Modoc	Coast Guard Cutter	1921	16 knots	2600	1	130	8	3000	1	2300	200	28	75
SS*	San Benito* ...	Pass.-Cargo ...	1921	12·5 knots	3000	1	100	9	3000	1	1100	190	27·5	200
HIJMS	Kamoi	Fuel Ship... ...	1922	15 knots	8000	2	120	10	2400	1	2300	250	28·5	150
SS	Hayward	Ferryboat	1923	17 miles	1200	2	100-125	3	3600	1	500	210	28·5	50
SS	San Leandro ...	Ferryboat	1923	17 miles	1200	2	100-125	3	3600	1	500	210	28·5	50
SS	W. R. Hearst	Ferryboat	1923	16 miles	2200	2	123-176	8	3240	1	2300	250	28·5	200
SS	Rodman Wanamaker	Ferryboat	1923	16 miles	2200	2	123-176	8	3240	1	2300	250	28·5	200
SS	Geo. W. Loft ...	Ferryboat	1924	16 miles	2200	2	123-176	8	3240	1	2300	250	28·5	200
USS	Lexington	Airplane Carrier ...	1927	33 knots**	180000	4	317	13	1800	4	5000	265	28·5	50
USS	Saratoga	Airplane Carrier ...	1927	33 knots**	180000	4	317	13	1800	4	5000	265	28·5	50
SS	T. W. Robinson ...	Bulk Freighter ...	1925	13·8 miles	3000	1	100	8	3450	1	1150	300	28·5	200
SS	California	Pass.-Cargo ...	1928	18 knots	17000	2	120	16	2888	2	4000	250	28·5	100
SS	Carl D. Bradley ...	Bulk Freighter ...	1927	15 miles	4800	1	105	8	3600	1	2300	300	28·5	281
SS	Virginia	Pass.-Cargo ...	1928	18 knots	17000	2	120	16	2880	2	4000	275	28·5	200
SS*	Viceroy of India* ...	Pass.-Cargo ...	1929	19 knots	17000	2	109	17	2690	2	3000	350	28·5	258
SS	Viking	Yacht	1929	16 knots	2600	2	168	10	3600	2	1150	240	28	150
SS	Pennsylvania ...	Passenger-Cargo ...	Bldg.	18 knots	17000	2	120	16	2880	2	4000	275	28·25	200
SS	Ward Line 1 ...	Passenger-Cargo ...	Bldg.	20 knots	16000	2	144	13	3168	2	3150	275	28·25	200
SS	Ward Line 2 ...	Passenger-Cargo ...	Bldg.	20 knots	16000	2	144	13	3168	2	3150	275	28·5	200
SS	Grace Line	Passenger-Cargo ...	Bldg.	18 knots	12600	2	120	13	3000	2	3000	275	28·5	200
SS	Pere Marquette 1	Car Ferry ...	Bldg.	18 miles	7200	2	120	14	3600	2	2300	300	28·5	200
SS	Pere Marquette 2	Car Ferry ...	Bldg.	18 miles	7200	2	120	14	3600	2	2300	300	28·5	200
SS	——	Yacht	Bldg.	18 knots	6000	2	257	10	3600	2	2300	285	28·5	190

*Equipped by British Thomson-Houston Co., Ltd., of Rugby, England, associate company of the General Electric Company, U.S.A.
**Designed speed.

DISCUSSION.

The CHAIRMAN: We are much indebted to the author for the time and trouble he has taken in the preparation of this paper, which is now open to discussion. I think it will be very appropriate if the discussion is opened by the reading of a contribution from one of our Vice-Presidents, Mr. B. P. Fielden, who was in very close touch with the author during the building of the *California* and *Virginia*, both of which vessels are fitted with this type of machinery and the records of the latter are embodied in the paper we have heard.

Mr. B. P. FIELDEN (By correspondence): We regret that Mr. Eskil Berg has been unable to personally deliver his lecture and visit our Institute. The trials of the sister vessel of the S.S. *Virginia* were held last week, and these, with probably other important work, have prevented him from honouring us with his presence. We should have been glad to welcome him because of the work he has done for the advancement of engineering.

The title of the lecture appears to me to show the class of vessel for which this type of propulsion machinery is suitable, and it is doubtful whether it would be economical to use turbo-electric machinery in other than special types of vessels.

Mr. Berg states that the data of the second trip of the *Virginia* is used, as during this run accurate readings were taken. Someone might assume that the readings on the first trip were not accurate, and I am sure that " more detailed " instead of " accurate " would express what the author intends to convey to us.

Number 5 claim of the advantages of electric drive for large liners includes a statement about leakage of condenser tubes being eliminated in this type of machinery. I hope this is correct, but I have serious doubts of its accuracy as my experience is that small pit holes on the water side of the tubes are the principal defects from which condenser tubes suffer, and I fail to see that strain causes them. These pit holes do not appear in one particular spot, but may be six inches from the end of the tube, or they may be four feet from the end, and neither are they confined to the top rows of the tubes or in any other position.

Another advantage of electric drive which Mr. Eskil Berg has not claimed is that owing to the higher revolutions of the turbine, as compared with a geared turbine, the size of the turbine is much smaller and consequently it is very much easier to open up for examination or renewal of blades, and if it is necessary that the rotor must be removed to works on shore the job is comparatively a simple one. It will be noticed on the plans showing the general arrangement of the machinery of the S.S. *Virginia* that the main propulsion turbines and generators are on a flat which is practically under the skylight. The parts which are liable to require renewal or repairs are therefore conveniently situated, and as all the turbines run in a similar direction, spare gear can be kept which will suit any engine of either ship of the class.

Being able to place the generator at any desired level, the length of the engine room can be less than is necessary for a geared turbine, and a good arrangement of pumps and other auxiliary machinery can be made to provide proper access to these and the piping.

I do not think number 10 of the claims of advantages to be of much importance in a passenger liner. The motor has to be kept under observation, and if it is put at the aft end of the ship at least one tunnel would be required, and the ventilating of the motor would make a complication. The operation by the staff would also be more difficult and for overall reasons I think the best place for the motor is where it is situated on the S.S. *Virginia*.

Owing to the fact that the turbines and generators are kept running whether the propellers are working or not, also the large percentage of astern power, the steamers *California* and *Virginia* are easily navigated, and on the particular trade in which the vessels are employed, going in and out of various ports and through the Panama Canal, this handling efficiency is a big advantage.

The author gives a comparison of Admiralty coefficients of different vessels. Theoretically horse-power has a definite value, but practically what with assumptions used with torsion meters and estimated losses in turbo-electric machinery the actual horse-power can only be approximate and I think that the better coefficient to use in making such comparisons is to substitute for S.H.P. the oil consumption per day, or better still, the heat units. The displacement and speed and what the shipowner has to pay for are all definite.

It was my privilege to be associated with Captain Roger Williams, Manager Operating Department, and Mr. G. H. Gaskin, Superintendent Engineer of the International Mercantile Marine Company at New York during the building of the steamers *California* and *Virginia,* and when the time arrived to appoint the staff of engineers and electricians, these officers were transferred from other ships of their fleet. Previously these men had had no experience of turbo-electric machinery, but they very quickly learned what, to them, was a new method of propulsion, and were soon favourably impressed with it. Marine engineers soon adapt themselves to progress, and within the last few years there has been a great advance of the introduction of motors to replace steam engines, especially for auxiliary purposes.

Mr. A. C. HARDY, B.Sc.: Mr. Berg's paper would appear to be particularly valuable to those of us who are interested in obtaining accurate operating data upon turbo-electric ships, but from a point of view of the matter one would expect to find contained in the paper as a result of the title, it is somewhat disappointing.

It would appear from what he has said, that Mr. Berg is particularly favourable towards turbo-electric propulsion, and indeed the trend of his remarks would appear to be rather in the nature of a justification for this form than an unbiased discussion as to the relative methods of generating the current which afterwards goes to the propellers.

The *California* and her sister ships appear to be in every way noteworthy vessels, and I have always felt that such ships, when developed along the right lines, as they appear to be developing at present, will be very strong competitors of the direct driven Diesel ship.

One has always felt that apart from certain advantages of manœuvreability and a necessarily complete absence of vibration, electric propulsion can be justified only on the counts of cheapness with which current can be delivered at the shafts, and the ease with which it can be tapped off for auxiliary purposes. It is difficult otherwise to justify, with the necessarily high initial cost that an electric ship must have, such a fuel consumption, as for example the *California* of 96 tons per 24 hours, even with the relative prices of coal and of oil as they are. Even so, too, it must be remembered that the electric ship has to carry the extra weight of fuel about with her, and this should be taken into account when assessing the relative weights of turbo-electric and Diesel-electric plants. Mr. Berg in his paper states very generally that the weight of the *Virginia's* machinery is less than that of the Diesel engined ship (obviously the *Kungsholm*) he uses as the butt of his motorship criticism. But General de Vito in his recent I.N.A. paper has shown that the total machinery weight, including fuel, of a 26 knot 100,000 S.H.P. turbo-electric liner is 16,880 tons, while for a similar Diesel-electric ship it is only 14,315 tons. A direct Diesel layout driving through Vulcan gears weighs 15,915 tons—a sort of mean between the two. The direct turbine layout weighs 18,130 tons. Putting it another way, the turbo-electric plant weighs 378 lbs. per S.H.P., the Diesel electric plant weighs only 320 lbs. per S.H.P. The root difference which accounts for this very important lighter weight is the fact that the turbo-electric ship must carry 11,880 tons of fuel oil, whereas the Diesel-electric ship needs only to carry 8,515 tons. In other words, 3,365 tons—the carrying capacity of a small coaster—is saved in the motor-electric ship, which assuming the same dimension can be that much smaller, or alternatively this space can be used for cargo or for passengers. The Diesel-electric plant is to use 0·5 lb. per S.H.P. per hour, whereas the turbo-electric plant uses 0·7 lb. per S.H.P. per hour. The *Virginia*, according to the data published by Mr. Berg, uses over 0·7 lb. per S.H.P. per hour, which figure includes some 800 H.P. required for refrigerating machinery. The Diesel-electric machinery *per se* is 800 tons heavier than the turbo electric plant, but these figures alone are not a criterion.

General de Vito's figures are all for large mammoth type passenger liners, and in this class the difference in fuel requirements becomes all the more marked, and unquestionably will have to be taken into account when new designs for electric mammoths are considered. Mr. Berg dismisses Diesel-electric propulsion from his paper without even a reference, and thus perhaps unconsciously echoes the attitude of some electrical firms towards electric propulsion. A turbo-electric ship represents for them a complete contract, turbines and electrical gear. That is why electric propulsion has gone ahead so much in America. A Diesel-electric plant necessarily means co-operation with an outside engineering firm, in such a way that two heads are not always better than one. Some electric firms have attempted to develop a Diesel engine specially for their own purpose, but not generally with complete success.

Mr. Berg certainly has a strong case in his plea for turbo-electric propulsion for the transatlantic type of passenger liner of moderate or average size, although he does not make the best case on account of his apparent very definite bias in favour of turbo-electricity. The turbo-electric ship constitutes a very dangerous rival to the motorship—not on the grounds of tons of fuel per horse-power per hour, but on considerations of cost per unit of power delivered at the propeller. This in the *Viceroy of India* costs about 0·346 pence. Taking a long shot it would seem safe to predict that electricity as applied to the general type of transatlantic liner will be in nearly every case turbo-electricity whereas for the largest of transatlantic ships there may be some successful examples of Diesel-electric propulsion—on grounds of smaller fuel bulk and weight and the ease with which the very heavy auxiliary loads can be handled. The ease with which the total load can be apportioned by cutting in and out various generator sets will also unquestionably recommend itself. In this connection, however, the possibility of dangerous vibrations with certain sets running and certain other sets cut out will have to be taken into consideration. Mr. Berg, too, would no doubt suggest here that an almost equal flexibility can be obtained by the use of one or two generator sets and the cutting out of certain boilers in conjunction with the number of generators used. In either case there seems to be an advantage over direct steam propulsion in a great many cases, but the economics of the whole business are very involved. The best that can be done at present is to put the hors d'œuvres on the table and let the shipowner use his judgment in selecting the olive.

Finally, Mr. Berg suggests as an advantage of electrical propulsion generally, that the propelling motors could in most instances be put near the propellers, thus eliminating long excessive shafting with its many bearing losses; but recent practice surely has shown that the tendency to put motors near propellers has been abandoned in favour of having them in the same compartment as generator sets, because this makes for ease of communication between the two. Earlier ships were fitted with motors in separate compartments, but in nearly every case in modern practice, the two have been arranged together.

Mr. P. JACKSON (Visitor) : It has long been admitted that the electric drive has many advantages compared with the direct drive. These advantages are very well outlined in Mr. Eskil Berg's paper, in particular on page 692. The advantages with regard to space occupied, the position in which the prime mover can be placed, the weight of the machinery, and the position of the controls are all important features of the electric drive.

These advantages do not apply solely to the turbo-electric drive; they also apply to the Diesel-electric drive, so that where the author refers to the turbine in his list of advantages the term " prime mover " could be substituted, to cover either type.

The advantages of electric drive depend upon the size of the vessel; the higher the power of the vessel the greater the advantages of electric drive. With powers of 50,000 b.h.p. and over, it is practically the only type of drive available. With regard to moderate powers, such as required for the great majority of cargo vessels, the choice of drive is mainly a question of cost. The advantages of electric drive claimed by the author hold for moderate powers, but the choice depends upon cost. With turbine motive power the introduction of an electric drive does not cheapen the steam plant much. No great increase of turbine speed is possible, and I cannot see that the extra cost can be justified. With regard to the Diesel-electric vessel, however, a high speed engine can be used, which should mean a lower cost as compared with the slow speed direct drive engine, but in this country at any rate it is difficult to establish the Diesel-electric drive. There have been many enquiries from shipowners during the past few years to the large electrical firms in this country on the subject of Diesel-electric drives. I remember one about 18 months ago for a vessel of 15,000 h.p., practically a cross-channel vessel. The electrical firm tendering put forward in the first instance a scheme comprising six 2,500 h.p. Diesel sets running at 300 r.p.m. and costing £10 per h.p. inclusive of generating units, propelling motors, and cables. You gentlemen who are more concerned with direct drives will be able to compare that cost with your own figures. I think it is quite competitive. The owners' representatives objected to the speed of the engines, saying it was too high, and that there was no such speed in operation at sea. When pressed for a definite reason for their objection they mentioned vibration. They had many examples showing that 300 r.p.m. or 300 oscillations per minute seemed to be particularly favourable for the hull of a ship to take up. The higher the speed of the machinery the more likely it is that there will be vibration, but I cannot see why 300 r.p.m. in particular should be any worse than 300-400, and I should expect still more vibration at 500. I should like to ask whether Mr. Berg has any experience in America of ill effects at about 300 r.p.m.

In the particular instance I have quoted the naval architect concerned said that the engines must not run at more than 250 r.p.m., and consequently the proposal was amended to provide for eight instead of six engines, and the cost was increased to £13 per h.p. The vessel was a fast one and this enabled one Continental maker to offer direct drive engines running at 180 r.p.m. Obviously such a direct propulsion was much simpler and cheaper. I repeat that the present position in this country with regard to electric propulsion is—many enquiries, but little business.

The electric drive as a whole, not only the Diesel but also the turbo-electric drive, has disadvantages, for instance complication of machinery in the form of electric transmission units. I am surprised to see that according to the author the difference in fuel consumption due to transmission losses is only 5%. It is usually assumed to be more in the region of 12%-15%. The additional weight of the generating motors is also a disadvantage of the turbo-electric drive.

For obtaining larger powers of 50,000 h.p. and over, with Diesel engines, we are compelled to adopt either a geared drive or an electric drive. The geared drive has been developed somewhat on the Continent, but has not found favour in this country. The electric drive will undoubtedly find favour for powers of that order. Probably the ultimate solution will be engines somewhat on the lines of those which have recently been designed for the new German cruiser *Ersatz Preussen*, i.e., double-acting engines of 300 r.p.m. We are told that the weight of these engines will be something like 20 lb. per s.h.p. It seems unbelievable, but if such can be done there is much to be hoped for from Diesel-electric drive. With such high speed double-acting engines one can get 1,000 h.p. per cylinder, so that 10-cylinder engines would be sufficient for a ship of the largest size built to-day, viz., 100,000 s.h.p. With ten engines there would always be one out of action, but there would be an ample factor of safety.

Referring to the author's comparison on page 698 between the *Virginia* and a ship fitted with Burmeister and Wain 4-cycle engines, he claims many advantages for the *Virginia*. Are these due to the turbine or to the electric drive? The inference seems to be that they are due to the latter, but the electric drive could be equally well adapted to the Diesel ship. If on the other hand the economy is solely because the oil-fired boilers of the *Virginia* can use a poorer class of oil than the Diesel engines mentioned, that reason is likely to fail in general cases because there are many Diesel engine makers who will guarantee their engines to run on any oil which can be burnt under a boiler. Moreover many of the advantages quoted by the Author apply to the two ships only under the particular conditions taken, and cannot be applied generally to every case.

MR. E. G. WARNE: There are several figures quoted in the paper which I am not sure that members of this Institute will accept without question.

The fuel capacity of the *Virginia* is 5,436 tons, i.e., enough for the round voyage from New York to San Francisco. Therefore the *Virginia* will always bunker at the latter port, where fuel is much cheaper. At San Francisco the price of Diesel oil is 17% higher than that of fuel oil. On Mr. Berg's own showing the fuel consumption over the whole run is practically 0·74 lb. per s.h.p. hr. It is also known that an outside figure for the consumption of a corresponding Diesel-engined vessel is 0·45 lb. per b.h.p. hr. The net result is that the *Virginia* is burning 65% more oil than a motor vessel, which bunkers the best quality fuel at a cost only 17% higher than that of the steamer. I venture to suggest that Mr. Berg's comparison of prices at New York does not represent the true position.

With regard to the economic cruising speed, the " very fine economy " at 3/4ths full speed, using only one half the generating unit, is not borne out in practice with the turbo-electric drive. The fuel consumption is not, as stated in the paper, " practically the same as at full power." The table on page 695 shows during a voyage from San Diego to San Pedro, at a speed of 15·5 knots, a fuel consumption of 0·843 lb. per s.h.p. hr., which is 18% higher than the best recorded at 18·4 knots, namely, 0·715 lb. per s.h.p. hr. In a Diesel-electric vessel under the same conditions the fuel consumption would scarcely rise more than 2% or 3%.

In making a note of electrical losses I am rather touching upon the same points as the last speaker's, but accepting Mr. Berg's figure of $4\frac{1}{2}$% (or $5\frac{1}{4}$% inclusive of excitation losses), this represents a remarkable increase of efficiency, even allowing for alternating current instead of the direct current system employed in previous vessels. It has been admitted that a transmission loss of 13% is a customary figure for these losses in direct current practice; are we to assume that the increase of efficiency in the case of the *Virginia* is due to unexplained causes?

Lastly, with regard to indicators, the accuracy of which has been questioned in the paper, I submit that the accuracy of these instruments of up-to-date design, intended for Diesel engines, is not usually doubted. Cards of exact trial trip results are not usually taken wholly in such a seaway that the engineers have to despair of their value. However, allowing for some inaccuracy, if the author insists, we have to face the fact that it will cut both ways, and the average results must work out in such manner as to cancel out any possible error; the figures are not calculated from a few isolated diagrams.

Mr. W. J. BELSEY (for the Author): On the question of efficiency mentioned by Mr. Warne, there is a very big difference in efficiency between large size alternating and small size direct current machines. The commutator losses alone are quite considerable on d.c. machines. The figures given by Mr. Berg are absolutely correct for a turbo-electric drive of the capacity under discussion; with machines of less capacity the efficiency would be lower and with machines of greater capacity the efficiency would be higher.

Mr. D. GEMMELL: I am sure that Mr. Berg's excellent paper on Electric Propulsion will promote increased interest amongst those connected with shipping. In the year 1921 I had the good fortune to survey for classification purposes the electric propelling machinery installed in the S.S. *San Benito*, and my impression during the trials of that vessel were that the electric drive would be especially suitable for passenger vessels where reliability and comfort are the chief assets. I was particularly struck by the complete absence of vibration and noise, and the remarkable manœuvring capabilities. These impressions are now supported by the excellent performances of the S.S. *Viceroy of India* and other vessels which Mr. Berg has mentioned in his paper.

I have no criticism to offer on the main part of Mr. Berg's paper, which deals with the propelling machinery, but I would like to draw his attention to the paragraph on page 691 under the heading "Refrigerating Plant." He says that the S.S. *Virginia* has 100,000 cubic feet of refrigerated space, and that to cool this there are four CO_2 refrigerating machines, each driven by an electric motor of 100 h.p., making a total of 400 h.p. for these machines alone, without taking their attendant auxiliaries into account. He then says that the whole refrigerating plant when working at maximum output consumes 800 h.p., so that 400 h.p. must be used for auxiliaries alone. Now, taking a liberal allowance of 1·7 h.p. per ton of refrigeration, 400 h.p. would be sufficient for 235 tons of refrigeration. This appears to be out of all proportion to usual practice, and I would like to know if the refrigerating machinery has other duties which demand such a heavy consumption of power, besides cooling the cold storage spaces. With ordinary practice, allowing one ton of refrigeration to 1500 cubic feet of storage space, which is a liberal allowance, the approximate capacity of the machines required for 100,000 cubic feet would be 66 tons. The 400 h.p. used for auxiliaries in the refrigerating plant appears to be extremely high, and it would be interesting to have an explanation from the author.

Mr. G. R. HUTCHINSON: Mr. Berg's paper is an interesting, if controversial one, but I would like to have seen more information concerning the control mechanism. I think that if we had been given a wiring diagram for the *Virginia* most of us would have found it helpful, while it is not inconceivable that its publication would have given the ordinary geared turbine quite a good " leg up "! There is no doubt that to most British marine engineers, the installation looks very complex, and while I am full of admiration for the fool-proof arrangements which are provided and the proved reliability of the control systems used on modern electrically-driven ships, its complexity strikes one very forcibly when one looks at the diagrams. In fairness to electric propulsion, however, it should be pointed out that the Atlantic Refining Company carry no electricians in their Diesel-electric ships, which is a good testimony to the electric drive.

Mr. Berg mentions a fuel consumption of ·715 lb. for all purposes. If we consider the *Duchess of Bedford* and her sister ships, they are fairly comparable with the *Virginia* as regards speed and power. I think that in their case, speaking from memory, they show a fuel consumption of about ·63 lb. for all purposes, which is quite an appreciable reduction on the figure given above. The Canadian Pacific " Duchess " liners are equipped with single-reduction geared turbines working with rather better conditions for economy as regards steam temperature and pressure. I would like the author to comment on this comparison. My own opinion is that the electric ship is only slightly inferior in economy to the British ship, thus confirming Mr. Berg's figure of $5\frac{1}{4}\%$ for electrical losses.

I think the most interesting part of the paper is Mr. Berg's list of the advantages which he claims for the electric drive.

As regards item 1, I do not think the electric drive shows any advantage at all. Exactly the same can be done with a geared turbine; it is all a matter of design. If people were not so afraid of double-reduction gearing to-day the geared installation would show even more wonderful economy than has, for instance, the "Statendam," and I think the turbo-electric drive would then be hard-pressed to equal geared vessel performances.

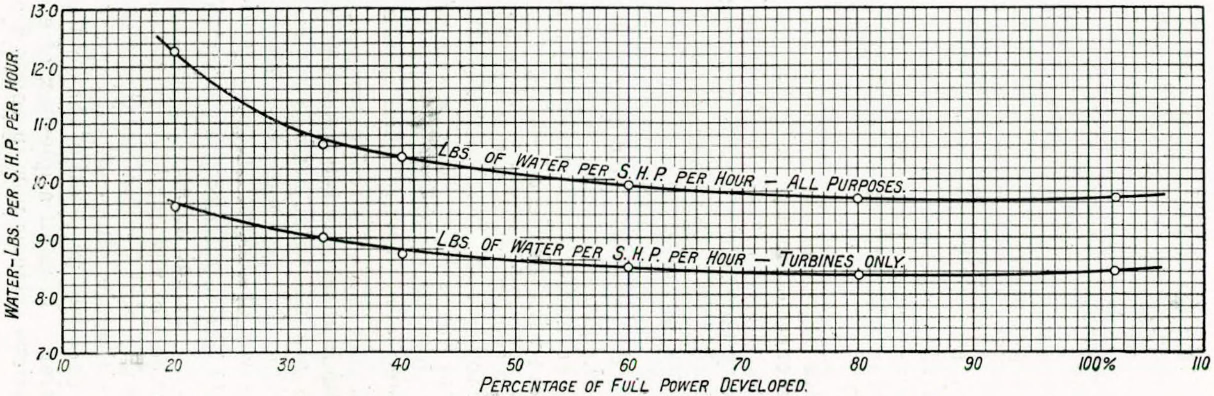
Advantages 2 and 3 are of course very important. As regards item 5, the statement referring to condenser tube trouble is very debatable, and I cannot follow the Author's reasoning. If one uses good cupro-nickel of 30-40% nickel, with bell-mouthed ferrules on the inlet ends of tubes, metallic packing and well designed water boxes, I do not think the condenser bogey matters very much to-day.

Advantage 6 is a good point for the electric drive, although it might be added, in parenthesis, fairly reliable torsion-meters are to be had at the present time.

As regards economic cruising speed, this feature seems to be one of the principal arguments in favour of the electric drive. On the other hand with suitable staging and nozzle arrangements, one can obtain good economy at 3/4ths down to 1/2 power in a geared installation as the trials of H.M.S. *Nelson* to quote an instance, showed. A curve is given herewith by permission of the Editor of "Shipbuilding and Shipping Record," which I am sure will interest both Mr. Berg and Mr. Belsey. It shows that the rate of fuel consumption of the *Nelson* at 1/2 power is very little below that at full power, the overall results being as good as could be obtained over the same range of powers with the electric drive on a lower weight and cost of machinery.

Regarding the hanging of the condensers underneath the L.P. turbines, the same has been done for years in geared installations.

I can fully appreciate that the quantity of make-up feed water in an electric ship will be less than in any other type of steamer, but I cannot understand how it can be less than one quarter, as the author claims, and I would like more information. As regards the claim that the propelling motors can be placed aft, near the propellers, this claim has already been referred to by a previous speaker. Usually one sees the motors placed amidships in the engine room, which has certain practical advantages. Another point in this connection is the fact



H.M.S. *Nelson*. Results of comparative steam consumption trials.

that for a fairly big ship of high speed the diameter of the motors will be probably such that it will be difficult to arrange them aft because of the breadth of the vessel at this point. This is probably the principal reason for placing them amidships in such a vessel as the *Virginia*, and Mr. Berg's comments on this point would be of interest. The shafting losses are not sufficiently great to worry about.

With regard to vibration, I again disagree with the author because there is no reason why there should be less vibration in an electrically-driven ship than in a geared turbine vessel of the same dimensions, form, r.p.m. and propellers; it is a matter of mechanics, not of whether turbo-electric or geared drive is used.

The performance figures of the *Virginia* are certainly very good. With reference to the Admiralty constant figures given on page 698, are we to assume that there is some intrinsic merit in the horse-power produced electrically as compared with that of the geared installation? Does that account for the better Admiralty constants, or are we to suppose that the builders of passenger ships on Clydeside are inferior to American firms? I think, seriously, that it looks like a case of inaccurate power measurements in the geared turbine ships quoted, a fact which lends weight to the author's claim for absolute accuracy of power measurement with the electric drive.

Referring to the comparison of the Diesel ship and the electric ship, I prefer to leave Mr. Berg to Mr. Warne. The motorship figures are not the best that could have been obtained and I have no doubt that the author's figures will not cause the owners of the *Kungsholm* to regret their choice of machinery.

The author is wrong in his figure for the s.h.p. of the *Bremen*. Instead of 110,000 it should be 130,000 s.h.p., and as far as I know the boilers are not fitted with economisers. Furthermore, I do not think that this fine vessel has yet shown what she can do in the way of specific fuel consumption.

Finally, I would like to refer to the author's delightful concluding remarks. I do not agree with him, but then we all hope that the pioneers of new methods and systems will "get there"! On the face of it I cannot see that electric propulsion is going to oust either the all-steam ship or the direct Diesel, particularly that excellent proposition the double-acting Diesel engine with gearing. It is all a question of economics and I think that the various systems now in vogue are likely to continue to find favour for economic as well as technical reasons.

The CHAIRMAN: The thanks of the Institute are entirely due to Mr. J. M. Dewar, who has been largely instrumental in obtaining this paper for the Institute, and I understand that it is partly due to him that we have been favoured by Mr. Belsey's presence to-night. I think it would be fitting that we should pass a vote of thanks to Mr. Dewar for the assistance he has rendered in this connection. (Applause. Carried with enthusiasm.)

Mr. J. M. DEWAR: I thank you for your kind remarks. It was only in July last that at one of our Council Meetings the Papers Committee reported that they had been unable to secure a paper on electric propulsion. They approached me, and knowing that Mr. Eskil Berg was an authority on these matters, having dealt with numerous ships of this type, I cabled him and gave two dates, in October and next March. When I tell you that he consented and has compiled this paper since the end of July, I am sure you will agree with me when I propose that we accord Mr. Berg a hearty vote of thanks, and also to his colleague, Mr. Belsey, for coming to-night to read the paper. (Applause. Carried with enthusiasm.)

Mr. W. J. BELSEY (for the Author): It has been a great pleasure to come and give this paper for my old friend Mr. Eskil Berg. I think he will be pleased to reply to the discussion. Perhaps I might remove a little misapprehension as regards the relative merits of the electric drive. Personally I hold this belief, that for every type of vessel there is a particular form of propulsion which is best suited to that type, and the old, efficient, reciprocating engine will never disappear. The geared turbine will find its place, and the Diesel, the electric Diesel, and turbo-electric systems will find their places. To say that any particular form of propulsion is applicable for all ships is a mistake. I hope to discuss this subject more fully in a paper which I am to read next Spring before another Institution.

The CHAIRMAN: Possibly there are several members present to-night who have not had an opportunity to read the paper prior to this meeting and who would like to contribute to the discussion. They are invited to forward such contributions to the Honorary Secretary in writing.

A vote of thanks to the Chairman was proposed by Mr. A. Jobling, seconded by Mr. R. S. Kennedy, and carried unanimously.

Mr. W. E. FARENDEN (By correspondence): The steam consumption of the *Virginia*, namely, 0·715 lb. of oil per s.h.p. hour at 18·5 knots is very good, including as it does refrigeration, electric cooking and all power in the ship. This figure shows a saving of over 30% on quadruple reciprocating engines, and better than single reduction turbines with Scotch boilers by 15%.

No separate turbine has to be installed for going astern, which is important. The full power of the main turbines can be used when required for going astern.

The ship can be run at reduced speed very economically as only one turbine generating unit need be used for driving both motors and shafts and still maintain high efficiency, although in the ship's performance given in table 1, the consumption increased to 0·843 lb. per s.h.p. hour at 15·5 knots.

I think that it is too soon to state that condenser troubles are practically eliminated on electric ships; we hope that this is the case, but it requires verification.

With regard to the 800 h.p. mentioned for the refrigerating machinery installation, this appears to be very excessive for dealing with a total cargo space of only 100,000 cubic feet. If each of the four machines takes 100 h.p., it leaves 400 h.p. for the brine, water, and other pumps, a very high figure for dealing with this work.

Nothing is mentioned in the paper as to the cost of upkeep and running repairs; this should be considerably less than with either reciprocating, or Diesel machinery.

Reference is made in the paper to the *Viceroy of India*, the first large passenger electrically driven steamer to be built in this country; her performance should be better than the *Virginia* on account of higher steam pressure and superheat. This vessel is giving excellent results, the machinery working quietly and well, with entire absence of vibration, a very important matter on a passenger ship.

Mr. S. A. SMITH, M.Sc. (By correspondence): Mr. Eskil Berg's paper which Mr. Belsey so ably read bears out to a large extent the excellent results which have been obtained on the *Viceroy of India*. This vessel in service has a speed range under voyage conditions of 14½ knots to 18½ knots. To meet these varying conditions of service with economy the electric drive lends itself admirably and in the *Viceroy of India* each alternator has been made of sufficient power (11,600) to give the vessel a maintained sea speed of 16½ knots.

With one alternator running a steam consumption of 7·92 lb. per s.h.p. is obtained for turbines only, whilst at full power of 17,000 s.h.p. the steam consumption is 7·83 lb. per s.h.p. on 28 inches vacuum. This means that for a reduction in power of 32% the steam consumption per s.h.p. is only increased by 1·15%. There is also to my mind the considerable advantage of practically eliminating the trouble of a leaky condenser, an item of note where water-tube boilers are concerned, not to mention the reduction in cost of upkeep, as for a large portion of the voyage only one alternator is in use. On a recent cruise the whole voyage was accomplished at an average speed of 15·8 knots on one alternator.

The *Viceroy of India*, like the *Virginia*, has all auxiliaries electrically driven and has a large "hotel" load, to meet which she is installed with four turbo-generators, each of 500 k.w. output. The steam pressure for the main turbines and the auxiliary turbo-generators is 350 lbs. gauge at 700° Fah. total temperature, generated in six Yarrow water-tube boilers having a boiler efficiency on service of 85%. The auxiliary load on the *Viceroy of India* consumes about 30,000 pounds of steam per hour including galleys, laundry and calorifiers, and this taken as a percentage increases as the shaft horsepower is reduced. With these services in operation the fuel consumption works out at ·69 lb. per s.h.p. when two turbines are delivering 14,500 s.h.p. and auxiliary generators 870 k.w.

A voyage comparison of the *Viceroy of India* and the *Rawalpindi* on similar voyages at similar times of the year is as follows:—

	Date.	Time under weigh, hours.	Distance.	Speed.	Displacement.	Gross Fuel.	Gross Fuel per 1,000 knots.
Viceroy of India ...	May	806	13,146	16·31	20,195	3,521	264·5
Rawalpindi	May	818	12,996	15·88	19,187	4,477	339·5

The *Rawalpindi* is fitted with quadruple expansion twin screw machinery and Scotch boilers of 215 lbs. working pressure.

There is no mention in the paper regarding feed heating and feed system or of the method of supplying the make up feed water. In the *Viceroy of India* we have three stage heating, and incorporated in the feed system is a low pressure evaporator and Weir's closed feed system is installed. The condensate is drawn from the bottom of the condenser by the W.E. pump and passes through the air ejector and drain cooler, increasing the temperature by about 10° Fah. to the L.P. heater in which the temperature is raised by about 65° Fah., giving a final temperature to the suction of the turbo feed pump of about 174° Fah. when the regenerative condensers are working at 28 inches vacuum and turbine at 11,600 s.h.p. The discharge pressure of the W.E. pump is 25 lb. gauge (267° Fah.) so that there is no possibility of vaporisation in the suction pipe of the turbo feed pump. From the feed pump the feed water is pumped through the I.P. heater, the temperature being raised to 230° Fah., thence through the H.P. heater, from which it passes to the boilers at 300° Fah. The heaters are supplied with bled steam from the 15th, 13th and 9th stages of the turbine respectively. The make up feed from the evaporator is passed as distilled fresh water vapour to the L.P. heater, the steam consumption of the evaporator being 1·28 lbs. of bled steam (bled from stage 13) per lb. of water made, which is equivalent to ·595 lb. of live steam per lb. of water made, a saving in evaporator steam consumption of 53%.

Mr. Berg on page 698 queries the method of recording the i.h.p. of Diesel engines. I have before me the actual log of a large motor vessel and it is remarkable to note that this installation running at 80% of full power shows a consumption per i.h.p. of 0·286 lb. and per s.h.p. of ·44 lb. The ratio between these two gives a mechanical efficiency of 65%. Now it is doubtful if the Diesel engine maker is prepared to admit that his mechanical efficiency is only 65% at 80% power. This efficiency is dependent on the power registered by the indicators, and I am inclined to the opinion that in this respect the author is correct in his finding. Again with regard to the geared turbine, here we have to obtain the s.h.p. by means of torsion meters. Recently there was read a paper on Geared Turbines in which the fuel consumption per s.h.p. for all purposes was given as 0·625 lb. Working out a heat balance for this consumption one finds that the turbines have an exceptional efficiency. Here again we are forced to the conclusion that all is not well with the power measuring instrument. With turbo-electric machinery we measure the power delivered to the motors with the same accuracy as in power station work, which I think all will agree is the most accurate method obtainable.

On page 691 the author gives the power of the refrigerating plant as 800 b.h.p. for a refrigerated space of 100,000 cubic feet. This appears excessive, as it allows an auxiliary power of 400 b.h.p. and machines 400 b.h.p. In a recent installation having 180,000 cubic feet of space three machines, each of 95 b.h.p., were proposed, i.e., 285 b.h.p. for the machines, the auxiliary brine pumps and circulating pumps being 60 b.h.p. combined.

On page 692 the author gives the advantages of electric drive. My views on these are as follows:—

No. 1. The advantage claimed here can be equally well met with geared turbines.

Nos. 2 and 3. The reversal of the propellers is more efficiently and expeditiously done with electric drive, with the added advantage of full power in the astern direction. On the *Viceroy of India* the propellers are reversed from 109 revs. per minute ahead to revolving astern in 30 seconds. In service all pilots have spoken of the ease and quickness with which the vessel can be manœuvred.

No. 4. There is the advantage pointed out by the author and also the simplicity of overhauling the turbines, with consequent reduction in costs.

No. 5. I should like the author to give a fuller explanation with regard to "strains on the condenser tubes." I am of the opinion that if the installation requires both condensers to be in operation over long periods of the voyage one is no better off as regards leaky condensers than with geared machinery. In the *Viceroy of India* we have met the advantage more completely than in the *Virginia* by making each turbine capable of driving the vessel at 16½ knots on load displacement, thereby making it possible for one set of machinery with its auxiliaries to be closed down over considerable periods of the voyage. In this case we have a standby condenser, and since wear and tear are reduced the upkeep bill is also reduced.

No. 6. Power Measurement. As mentioned above the horse-power is obtained with power station accuracy every watch, and is logged six times a day, thus giving a continuous record of the power. I also think that the thrust meters which are also continuously read enable one to obtain valuable data regarding the propellers and the effect of hull foulness.

No. 7. On the *Viceroy of India* under service conditions with one turbine developing 10,400 s.h.p. the fuel consumption for main engine, propelling auxiliaries, 800 k.w. auxiliary turbo-generators, galleys, laundry and calorifiers is ·77 lb. per s.h.p. hour. When it is remembered that the auxiliary load is practically constant and is therefore a much greater percentage at reduced powers, the result, I think, is in keeping with the author's statement.

No. 8. There is certainly an advantage in being able to place the main turbo-alternator in any convenient position. This cannot be done with geared machinery, as the location of the gearing and shafting determines the location of the turbines.

With regard to the underhung condenser this is standard with either geared or turbo-electric drive.

No. 9. The make up feed will be less than with geared turbines, but I think the author's figure rather optimistic. On the *Viceroy of India* it does not exceed two tons per 1,000 s.h.p.

No. 10. If the vessel's after lines will allow the motors to be placed aft, there is a decided gain, not only in the reduction of shafting and bearings but in increased cargo carrying capacity by the elimination of the tunnels and reduced length of engine room.

No. 11. There is a decided advantage in overcoming extreme temperature changes, and the electric drive lends itself admirably to high pressures and superheat.

No. 12. The absence of vibration on electrically driven vessels is remarked upon by passengers and on the *Viceroy of India* at all speeds above and below 92 revs. per minute there is an absolute absence of vibration throughout the ship. For all ships there is generally at least one revolution which synchronises with a natural hull vibration. In the vessel mentioned one revolution either side of 92 eliminates the vibration, which even at the synchronous revolution is not more than generally persists on ships installed with reciprocating machinery.

The author's reply to the foregoing discussion will be published in a later issue. See index.

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THOMAS NEWCOMEN: FATHER OF THE STEAM ENGINE. — By W. T. Tucker (Member).

In the September issue of the Institute's Transactions there is an article on "Newcomen," which was taken from the "Engineer," and was written by Mr. H. W. Dickinson. This article is very interesting and no doubt it would be more so if a fuller history of the Newcomen engine was known. By way of adding to this history, I thought it would interest you to know that a few Newcomen or Cornish engines were at work for many years in the Furness district near Dalton and

Barrow. As a boy I often went to see those old engines at work near Barrow, and I feel sure that if you were to apply to the Barrow Steel Company, who controlled the old iron ore mines near Barrow, you would get some particulars of those engines; also a letter to the editor of the "Barrow News" might get some old local miners to give some interesting experiences with those old Cornish engines.

As far as I can recollect or estimate, those old Cornish engines were erected some sixty years or more ago, and I believe they were second-hand engines then, and they worked away until about 30 years ago when the mines were closed down, as foreign ore could be got cheaper than what it cost at Barrow to raise. There is still good ore to be got in Furness! Unfortunately those old engines I refer to were broken up and sold as scrap. If my memory is correct I would say the boiler pressure was about ten pounds.

I well remember how as a lad of about twelve I touched a lever of the largest engine at Stank near Barrow, and the resulting crash as the beams came down on the supports frightened the driver and everybody else out of their wits, but I am glad to say there was nothing wrong after all. Those engines were beautifully polished, and the engine room floor was scrubbed snow white. The drivers took great delight in their jobs, and there was great keenness to get appointed as drivers. Drivers had to graduate from stoking in those days. They had no certificates or much education, but they had to be strictly sober, sound men, and they worked eight hours per shift per day every day in the year.

In conversation with one old driver some 40 years ago I was interested to hear from him of, to him, his great "adventure" in going with other Cornish drivers to Holland in his younger days to drive Cornish beam engines installed there to pump out reclaimed land in connection with the drainage system. This would indicate that Cornish pumping engines had a world-wide reputation, say 60 to 75 years ago, and it would be interesting to find out what became of those Cornish engines used in Holland and worked by my old friend in his younger days.

It is a great pity that one of those old Cornish engines near Barrow was not preserved, but possibly there may yet be in the country some other good old examples that could be procured and kept intact. They really were wonderful engines.

I also have a recollection of hearing from a Cornish engineer that some 60 or 80 years ago some Cornish engines were sent to the United States for pumping mines there, and that it was from these old engines that American marine engineers got their ideas for building the machinery of their famous lake steamers, which, as you know, have or had huge beam engines for driving the paddle wheels. The beams could be seen from the shores working above the ship—quite a pretty sight.

AN EARLY " INTERNAL COMBUSTION " ENGINE.

Contributed by H. COKE POWEL (Member).

In 1882 I resigned the position of Manager of the Antofagasta Railway to take an interest in, and management of, the well-known engineering works of Thomas Powel, at Rouen in France, which had been established there about 100 years. Soon after joining the firm, I went to examine a gas engine which we were asked to manufacture. I found it to be a far simpler engine than any then on the market, and I advised that it should be taken up. It was of the type then known as the Otto four-cycle type, and knowing that Messrs. Crossley Bros., the makers of the Otto engines in England, were successfully defending legally the Otto patent, I advised our not accepting any responsibility in defending any law suit for infringement of the Otto or any other Patent.

French patent specifications were not then published, and one had to get copies made at the French Patent Office; this we did of the Otto patent, and the Delamare-Deboutville and Malandin patents of the Gas Engine to which I refer. We submitted these copies to a French legal expert on such matters and some time afterwards he gave the opinion that there was no infringement of the Otto patent. This new engine was known as the " Simplex," and we thereupon commenced its manufacture. The simplicity of the engine was in its electric ignition which was really 'fool-proof.' Messrs. Crossley Bros., the celebrated gas engine makers, at that time used a flame ignition, followed later by the tube ignition—a great improvement.

The " Simplex " had at the back of the cylinder a slide valve face, in which there was a small port opening into the cylinder, with similar ports through the slide and its cover; the port in the cover opened into a closed chamber, containing the original ignition, or sparking plug, which was but little different in design from the millions of sparking plugs now used. We tried to replace the electric spark by spongy platinum, but it was not practicable. The magneto was then little more than a scientific toy. For the continuous spark required we used a liquid battery which gave no trouble, and we guaranteed it for 100 working hours. With the slide valve the point of ignition could be easily fixed. After several experiments we fixed the ignition point at 15° past the dead centre, our compression being higher than then generally adopted.

The following is a description of some of the details which may be of interest.

The general arrangement of the horizontal engines was that now adopted for such engines. We made but one vertical engine to order for, we understood, a boat at Bordeaux. The vibrations in a horizontal engine are not so objectionable as in a vertical engine, hence the multiple vertical engines now installed in motor vehicles. The piston design was the same as that used to-day. The piston rings, except the first one, were the French light hammered metal ones as now generally used; this type made of cast iron had been used by the French for many years for their steam engines, and when properly fitted lasted the life time of the engine; they were adopted later for locomotives in this country and were known as Ramsbottom rings. When selecting the first ring we tested the several English patented ones and adopted one of these.

Working to 0·01 in. was then hardly known, and had anyone suggested working to 0·001 in. we should probably have turned the man out of the building as being of doubtful mental balance. One or two of our original engines, when on the test bed, suddenly stopped after a few revolutions; we simply returned the piston to the turning shop to have it eased. The cylinders were never scored by the sudden stoppage; what happened was that the piston, a wee bit too tight a fit, got heated by the explosions to the point at which the last one expanded the piston, suddenly fixing it with its large surface in the cylinder. This could also occur through want of lubrication and explains some sudden stoppages in other internal combustion engines for which the engineer was dismissed for allowing his connecting bolts to get loose. Generally these bolts act as safety devices, and give way. I have come across two such cases.

Two or three of the first engines that we made for experimental purposes had the inlet and outlet valves placed horizontally, the valves having knife-edges closing on flat surfaces, a German design which we used in a German ice making machine which we manufactured. The knife edge quickly flattened to the necessary surface to resist the pressure of working. Although we saw nothing against this type of valve, we had to adopt the coned-faced valve to satisfy the Consulting Engineer.

The exhaust valves we placed low down, surrounded by a large volume of water. In the small engines the valves were worked by a lever with cam action; in the larger engines this valve was worked by an arrangement of lever which, from a dead slow upward movement rapidly increased its speed and valve opening. This we considered had practical advantages over the cam movement. The lever also had the advantage of giving a powerful leverage to start the valve off its face. From dead slow to rapid rise of valves is seen in the Corliss and Perkin's steam valve arrangements. We had no trouble with our exhaust valves; if we had, we should have heard of it, for, except in the larger engines, the valves could not be got at except by removing the pistons.

In our first engines we made the crank-shafts of cast steel, for, by their stiffness the shock of the explosion was taken up entirely by the crank-shaft bearings. We purposely broke two or three for examination after they had been working some time, and although they were not quite free from blow holes, gas engine shafts were made large to resist the effect of the explosions rather than the small B.H.P. developed. This we had also to do away with to please the Consulting Engineers who at that time in France, at least, were too theoretical. The governor was the 'hit and miss' type, and we found no reason to abandon it; for the larger engines it was designed to vary the amount of the mixture entering the cylinder to meet the varying resistance. For driving dynamos we first used the long belt; but its wobbling, at high belt speeds, did not please. We considered it must, at high speeds of the belt, take up uselessly some of the engine power; and experiments later on gave the loss of the total H.P. as about 5%. We then arranged to drive the dynamo by the pulley on the flywheel, attached to it by leather friction; it started off all right, but proved not to be 'fool-proof.' We then placed the dynamo on a balanced lever to give the friction necessary for the belt to work and we placed the dynamo so near the flywheel pulley that the belt of the dynamo pulley embraced just enough to drive the dynamo and, at each explosion, to allow a slight slip. This acted perfectly and was adopted for all such drives.

We had two large engines (70 B.H.P.) working most successfully in factories, with Dowson's gas generators. We only made such engines as an advertisement, they being larger than any then made by other makers. On our smaller engines we made over 50% profit, and only from 10 to 15% on the larger ones.

Most of the engines at that date used town gas as fuel, but we had a most successful carburetter for petrol. The carburetter consisted of a cylinder surrounded by a jacket of the hot water from the engine cylinder. The petrol supply tank was fixed on top of the carburetter and fitted with a small cock to feed the spiral brush in the carburetter. The engine drew its supply of petrol mixture from the bottom of the carburetter. One day when testing an engine with petrol, we were surprised at the engine stopping, and on examination we found the brush full of snow. Mallindin added a second cock to give a small quantity of hot water with the petrol. The result was surprising for it allowed the whole of the petrol to be used up, and not the lighter portion as before (the petrol of those days was not of the highly refined quality now supplied); it also reduced the consumption of petrol per H.P. and carbonisation of the piston heads was unknown.

One of the first engines made was a two-cylinder 20 H.P. set for the Paris journal "Le Petit Parisien." About a week after it was started, the Otto Company commenced an action against us for infringing their patent, and the engine was removed. A few days afterwards we received an anonymous postcard suggesting our getting a copy of Beau de Rochas' patent specification, which we did, and found the Otto patent practically a copy of it, so we continued to manufacture the 'Simplex.' We won the law-suit and got 55,000 francs damages and the publication of the verdict in ten journals. The only copy of the Beau de Rochas specification in England was in the British Museum. The English judges would not accept it as having been published, so Messrs. Crossley got an injunction against any firm using the Otto cycle without their permission.

Starting our engine was a simple affair; we filled the cylinder with the explosive mixture when the piston was at half-stroke during the explosion portion of the cycle, and then fired it by means of the electric spark. The indicator cock told us when the cylinder was full. Dr. Lanchester, designer of the only wholly English car and petrol engine, came to see us at Rouen to suggest our adopting his very simple starting system, but we showed that we practically did the same thing. The Lanchester system had one advantage over ours—that he could fill the half cylinder at any part of the cycle. Dr. Lanchester's system was such that when the gas came through the indicator cock he fired it and quickly closed the cock, so firing the gas in the cylinder. Our drivers managed the stopping of the engine at any part of the cycle by manœuvring with the indicator cock, and seldom missed; if they did miss it meant only turning the engine with no compression to overcome. I have been much surprised at Dr. Lanchester's system not being generally adopted.

We exhibited at the Paris Exhibition a large gas engine which was intended to be worked by a gas generator, designed by the greatest authority on furnaces in France. It did not work and we applied for assistance to Mr. Dowson, who immediately sent us two of his small generators, by means of which the engine worked during all the time of the Exhibition. We had also exhibited a Worthington high duty pump for supplying the exhibition with water, and also a four-cylinder triple expansion engine and an American Armington and Simms high speed engine. I had given me personally the highest award, the Diplome d'Honneur, and our Paris agent the medal and green ribbon, an educational decoration. I was told that if I applied through our Ambassador, the award of the Legion d'Honneur would be considered, but foolishly I did not apply. I had previously been awarded the Gold Medal at the Havre Exposition.

In 1889 my firm was turned into a company, the managing director being a young Frenchman who had the College degree of Engineer and so had only to teach, and nothing more to learn.

In 1892 the managing director was persuaded to take an order for an engine with a cylinder of 1 metre (39·37 in.) diameter. I refused to have anything to do with it, for we had had no experience of cooling such a volume of flame as the explosion of such a volume of gas in the cylinder would generate, also as I had complained of the deterioration of the good workmanship which the firm was well known to turn out, this led to my resigning, with a prophecy that the firm would be bankrupt in seven years as orders were taken for other large engines. This 1-metre engine had the cylinder end and the shaft replaced before it reached the scrap heap, and seven years later the ground on which the shops once stood was occupied by maisonnettes.

Both Edward Delamare and Malandin died soon after the failure of the works. M. Malandin, a retired naval engineer, was the real inventor and a charming and clever man.

I hope that the Members will find this history interesting in connection with the up-to-date history of the oil engine already published.

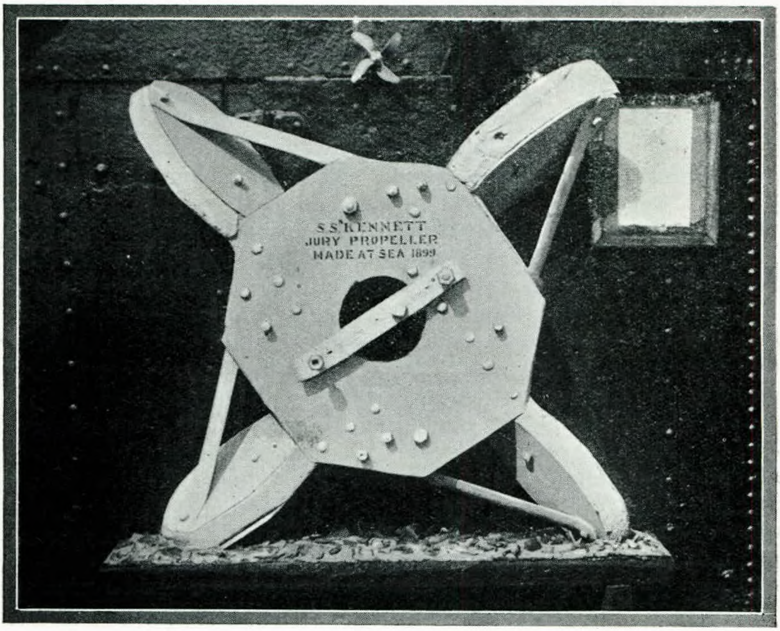
THE "MAURETANIA" AND THE BLUE RIBAND.

Great prominence has very rightly been given in the daily papers and technical press to the fine achievement of the new Norddeutscher Lloyd express liner *Bremen* in wresting from the veteran Cunarder *Mauretania* the Blue Riband of the North Atlantic, which she held unchallenged for upwards of two decades. It is equally fitting that attention should be drawn to the subsequent remarkable performances of the *Mauretania* in her attempt to regain the laurels, thereby demonstrating her continued high efficiency after so long a period of service. As a monument to British skill in shipbuilding, naval architecture and marine engineering, the recent performances of the famous Cunarder will serve for all time; and while the skill of her designers, constructors and "rejuvenators" is deserving of high commendation, it is only fitting that a word should be said in praise of her admirable engineering personnel. Her chief engineer, Mr. Cockburn, has shown himself to be obviously possessed of all the skill of his craft in maintaining the vessel's machinery at that pitch of perfection which is essential when the last ounce of power and efficiency are demanded, not momentarily but for an Atlantic crossing of several days duration. Furthermore, the enthusiastic co-operation of his subordinates, down to the humblest member of "the black squad," is imperative under such arduous conditions. The maintenance of condenser vacuum and steam pressure at the highest possible level implies conscientious application not only during the stress of a record-seeking crossing but also in port. Members of this Institute know full well what the performance of the *Mauretania* exacts from her engineering staff, and it is to be hoped that some day a facile pen will place on record the part they have played, not only recently but during her splendid twenty-five years of existence in making her fine performance possible. It is fitting, however, that the admiration of members of the Institute of Marine Engineers should be placed on record in this connection.

G.R.H.

AN ENGINEER'S FEAT AT SEA. "Syren and Shipping," 7th August, 1929. Block for illustration kindly lent by the Editor.

Opposite the main gate of the Mercantile Dry Dock Company, Jarrow-on-Tyne, there is exhibited the strange object shown in our illustration. It bears, as will be seen, an uncouth resemblance to a ship's screw, and it is, in fact, a propeller which was improvised hundreds of miles from land. In 1899 the S.S.



A Makeshift Propeller.

Kennett lost her propeller when well out at sea. An accident of this kind, though decidedly unwelcome, is by no means novel, and it appeared at first that with a little delay the spare propeller would be mounted in place. However, an examination showed that the specially-prepared end of the engine shaft had broken away with the lost propeller. The chief engineer was thus faced with the unpleasant fact that his "spare" was useless. But being a resourceful man, he resolved to provide a substitute. He cast about for materials which could be persuaded into the shape of a propeller and be adapted to the broken tail shaft. After 16 days of toil a clumsy but effective replacement was made and fitted. Iron plates from bunker doors, odd bolts and such homely materials as cement and wood were pressed into service. It will be observed that the boss is unusually large in proportion, being $3\frac{1}{2}$ ft. across—the whole is $6\frac{1}{2}$ ft. in diameter. The boss itself is formed by a block of concrete clamped between two plates. It holds four blades—very solid ones made of 3-in. blocks of wood strengthened by iron plates and further secured by iron stays. So much for the propeller proper. How was the much more formidable job of fitting it achieved? The broken end of the shaft had originally terminated in a threaded portion on which a retaining nut was screwed against the propeller. This was missing, but there remained the keyways for the flat keys of steel that prevented the propeller from rotating on its shaft. Slots were therefore provided in the central hole of the improvised boss, so that it could be keyed on. As this alone would not retain the propeller, a flat bar having two holes was mounted across the hole. Now came the critical and dangerous work of fitting the propeller. A slot intended for the flat bar was cut across the end of the broken shaft; in this slot holes were bored and threaded, and screwed studs inserted. The propeller was keyed on the shaft; the flat bar dropped into its special slot, and nuts were run on the studs, which now projected through it. The engineer had made a thoroughly sturdy makeshift, and when the engine was again working and the ship under way he prudently remained satisfied with the low speed of four knots. His ingenuity and caution were rewarded—for the ship safely sailed 1,200 miles to Barbados, where the jury propeller went into retirement. Thirty years have gone by since the feat, and the identity of the engineer who brought it into being is lost, but no doubt it is inscribed somewhere in the annals of the sea.

HEAT TREATMENT OF STEEL. "Syren and Shipping," 7th August, 1929.

In view of the attention being given to low-temperature carbonisation, it is interesting to note that one of the most important fields is in the iron and steel industries; that is, treating bituminous coal dust and smalls to obtain smokeless solid fuel in large pieces along with low-temperature tar and light oil, and using all the clean rich gas direct for the heat treatment of steel. At the present time the general method adopted is hot uncleaned producer gas, but there is also employed, to a lesser degree, coal or other solid fuel in the lump form, pulverised coal, oil, natural gas and coke oven gas. In this connection a paper, " Fuel Used in Heat Treatment of Steel," has been read in Philadelphia by Mr. Martin J. Conway, fuel engineer to the Lukens Steel Company, Coatesville, Pa., which firm are taking all the gas from a " K.S.G." low-temperature carbonisation plant. Mr. Conway sums up the advantages of low-temperature carbonisation gas for steel works furnaces as against hot uncleaned producer gas as follows: (1) Cleaner operating conditions without soot and deposits in the gas mains, and entire absence of ash and clinker; (2) Constant calorific value of the gas, which does not obtain with producers, especially because of the necessity of clinkering; (3) Ease of control, due to constant pressures and calorific values, thus allowing of highly efficient automatic gas supply with constant heat; (4) Flexibility in the sense that low-temperature carbonisation gas of this character can be piped with the greatest ease to any part of the plant, whereas hot, dirty producer gas cannot be sent for long distances, and the supply pipes, lined inside with firebrick, are costly to install and to keep in operation; and (5) Great accuracy in the actual heat treatment of the steel in that the flame can be altered instantly so as to give a slightly reducing or slightly oxidising atmosphere at will, with continuous maintenance of these conditions in a manner impossible with producer gas or oil firing. The " K.S.G." plant now being erected by International Combustion Engineering Corporation adjoining the Lukens Steel Works, consists of six standard rotary cylindrical steel retorts, each with a throughput of 80 tons of coal per 24 hours (480 tons for the complete plant). The retorts are slightly-inclined steel cylinders 85 ft. long and 5 ft. 6 in. diameter, carrying an outer cylinder 72 ft. 9 in. long and 10 ft. diameter, running at a slow speed of one revolution in 90 seconds, driven by suitable gearing, and giving 2½ hours' carbonisation with a maximum temperature of 925 deg. to 1,025 deg. Fahr. by means of external heating, along with steaming of the charge, and blending, if necessary, with a small amount of the smokeless fuel smalls.

THE LOAD LINE. " Shipbuilding and Shipping Record," 5th September, 1929.

The Board of Trade are charged by Parliament with the administration of many restrictions imposed by merchant shipping legislation, but of all these restrictions no one of them is so important in the operation of the shipping industry as the restriction on loading by the compulsory marking of the load-line disc on the sides of ships. It was first instituted for safety of life at sea and is still regarded as primarily for that important purpose. Its usefulness as a factor in safety is beyond all dispute, although it must never be forgotton that in the last resort safety oftentimes depends more upon the human element—the skill, the judgment and the resourcefulness of the experienced navigator—than upon anything else. It is, however, obvious that to restrict the loading of ships must gravely affect the economics of the shipping industry, and thus the position at which the load line is fixed is of paramount importance also to those who operate ships. It is, therefore, essential to the well-being of a nation dependent upon sea-borne commerce that the position should be regulated so as to ensure safety without hampering unduly freedom to trade.

The old " Plimsoll Line " simply indicated for each voyage the position beyond which the shipowner did not propose to load his ship; but since 1890 the load-line disc has indicated the position beyond which the Board of Trade will not permit a ship to be loaded. The Board of Trade have never arbitrarily fixed the position of the Government load line on their own opinion; they have always enlisted the best advice obtainable, notably those possessing experience in dealing with the design and strength of ships, in order to formulate rules under which the position should be fixed. The rules adopted by the Board in 1890 were those contained in the report of the Load Line Committee appointed in 1883, which was issued in 1885. These rules were largely based upon rules put forward earlier by Lloyd's Register of Shipping, and since 1890 they have been subject to modifications but only as the result of investigations by Load Line Committees appointed as necessity arose. The latest Committee was appointed in 1927, and their report, just issued, is before us as we write. It is, perhaps, the most important and the most comprehensive of all the reports on the subject, and will probably be the most far-reaching in its influence. It is bound to affect the thought and action of all those concerned with the fixing of load lines the world over.

The report is really a combination of four separate reports on allied subjects, so well-balanced in principle that they dovetail one into the other and form a clear and interesting study of modern load-line problems. The four subjects dealt with are: (1) The sufficiency of the present load-line rules (which have operated since 1906) to provide adequately for existing conditions; (2) the regulation of the carriage of timber deck cargoes and the assignment of special load lines for use when ships carry such cargoes; (3) the grant of preferential treatment to oil tankers in the assignment of load lines; and (4) the definition of the geographical areas within which the seasonal load lines shall operate. In each case the Committee make definite recommendations upon conclusions which it is evident from the report were arrived at after patient and thorough inquiries. Emphasis is very properly laid upon the wealth of evidence taken from shipmasters and officers as to the actual conditions met with at sea and the behaviour of ships of all types under those conditions. We would add that it was equally important for the Committee that shipowners, shipbuilders and ship-repairers were also represented so fully among the witnesses. It is important to the shipping industry, and will reassure the general public, that the Committee found that by an examination of the facts of shipping casualties; of the experience of the Board of Trade, Lloyd's Register, British Corporation and Bureau Veritas, who assign load lines and deal with the structural efficiency and equipment of ships and of the experience of shipmasters, shipowners and others, it was "proved that the freeboards given by the Rules of 1906, both to cargo ships of the older type and to those of more modern design and construction, were sufficient for the average conditions met with on the trade routes of the world." It has, however, been recognised for many years by technicians, both at home and abroad, that in applying the Rules of 1906, inequalities between ship and ship occurred, and the Committee did not overlook this fact. Further, there has been a lack of simplicity in procedure. Therefore, once satisfied on the essential point of the sufficiency of the rules for existing conditions, they undertook the difficult task of formulating new rules to deal with these facts. The Committee state that "in framing the new Rules for Determining Load Lines our main endeavour has been to simplify the structure and arrangement of the Rules so as to facilitate their application, to provide equitable treatment for different types of ships, and to avoid the anomalies and inequalities which exist in the present rules." A first examination of the new rules shows that the Committee have accomplished their task and have, moreover, approximated closely to the present minimum freeboards. No doubt there will be technical criticism of the new rules, but one authority has informed us that they are the best which have ever been devised to deal with the intricate problem of load-line assignment.

It is refreshing to find that the Committee have exposed so relentlessly the anomalous position created by the operation of the present regulations for the carriage of timber deck cargoes. They point out that these regulations "have undoubtedly limited, especially since the beginning of the present century, the employment of British shipping in the timber trade to this country, and have discouraged the building of steamers specially suitable for the trade," and further, that in some respects they are "liable to increase the risk to life and property rather than to diminish it." It is no wonder that the Committee recommend the repeal of the law containing the regulations and that power be given to the Board of Trade to make new regulations for the future, applying everywhere instead of only to voyages to this country, as at present, and to modify them from time to time in consultation with the interests concerned. They also provide in their new rules for the assignment of special timber load lines which will permit, under specified conditions, steamers carrying deck cargoes of timber to load deeper than the ordinary load line allows. The provision in this respect was only made after exhaustive examination of the practice, extending over 20 years, of the Scandinavian countries, an examination which included a personal visit of inspection of the actual loading at Swedish ports and the actual condition of the loaded ships on arrival at Continental ports. The handicap to which British shipping has been subjected is thus fully recognised and remedied.

In dealing with the load lines of oil tankers, the Committee points out that the tanker is a modern development, built to meet a modern need, so much so that there was no necessity for the Rules of 1906 to provide for this type of steamer. They therefore propose that preferential treatment over the ordinary cargo steamer should be given to tankers in the assignment of load lines. The Committee state that "While fully appreciating the special construction of tankers, their comparative immunity from sea-damage, and the value of the fore and aft gangway in providing a satisfactory height of working platform, one main ground for accepting the principle (of preferential treatment) is the efficient protection provided for openings in weather decks by means of watertight covers." Scarcely any informed authority will quarrel with this conclusion. The Americans have consistently acted upon the principle, but on this side of the Atlantic it has not been done. The Committee do not agree with the amount of extra draught to which the United States shipowners have loaded their tankers, and they do not state the amount of deeper loading which they think would be permissible. They leave the decision on this point to an International Conference, but they do specifically lay down the conditions to be complied with before any deeper loading is permitted. Apparently they consider that the amount of deeper loading is debatable; the qualifying conditions are matters of fact.

In view of the desirability of an international load line, it is significant that in dealing with the application of the seasonal load lines, the Committee have come to an arrangement on the subject of geographical areas with the United States Load Line Committee, which is now engaged in the preparation of rules to apply to American ships when the compulsory marking of loadlines becomes operative in September, 1930, under the new Merchant Shipping Act, passed a few months ago. The map which accompanies the British Committee's report is an interesting solution of a much-discussed problem.

We print in another column the conclusions and recommendations of the Committee, but the whole report is worthy of close study. It is cautious against committing this country to additional administrative action without international agreement, especially on regulations for the uniform application of international load-line rules once they are agreed. We congratulate Sir Charles Sanders and his colleagues on a memorable contribution to the complicated subject of the assignment of load lines to merchant ships.

THE WEST INDIA DOCKS. "The Engineer," 13th September, 1929.

On the afternoon of Thursday of last week, September 5th, the Union-Castle mail steamer *Llandovery Castle*, of 10,609 gross tons, entered the South-West India Dock by the new lock entrance, thereby inaugurating one part of the new scheme of improvements recently undertaken by the Port of London Authority. By constructing a new entrance lock, 35ft. deep, with a width of 80ft. and a length of 590ft., compared with the 54ft. 6in. and 480ft. of the earlier lock, and providing a system of inter-connecting channels, with a uniform depth of 28ft., it is now possible for larger ships to use the West India Dock system, and to pass conveniently to any desired berth. The actual water area of the new dock system is 127 acres, and the warehouse and railway facilities have been greatly improved, at a total cost of over $1\frac{1}{2}$ million pounds. A noteworthy feature of the new entrance lock is the fact that large ships can use it from an hour and a half before high water until four hours after high water, whereas with the old arrangement the margin was a comparatively narrow one, and most of the entering vessels had to be berthed at high tide. It is hoped that many of the ships which previously would have hesitated to use the West India Docks, $4\frac{1}{2}$ miles above the King George V. Dock, will now freely use them, and that that traffic will be brought farther up the river than previously.

THE SCHNEIDER TROPHY CONTEST. "The Engineer." 13th Sept., 1929.

On Saturday, September 7th, the tenth—or eleventh, counting the annulled meeting at Bournemouth in 1919—contest for the Schneider Seaplane Trophy was held over the Solent. Six machines, three British and three Italian, were engaged in the race. All three British machines completed the course, the winner being Flying Officer Waghorn on a Supermarine Rolls-Royce "S 6" machine, with an average speed for the seven laps of 328·63 miles an hour. Flying Officer Atcherley, on a similar machine, achieved an average speed of 325·54 miles an hour, but was disqualified for failing to round one of the marks correctly. On two of his laps he established the record speed for a closed circuit of 332 miles an hour. Flight-Lieut. Greig on a Supermarine Napier "S 5" machine produced for the previous contest in 1927, was awarded third place with an average speed of 282·11 miles an hour. Of the Italian machines, only one, a Macchi Fiat, produced in 1927 and flown by Warrant Officer Dal Molin, completed the course. This pilot's average speed was 284·2 miles an hour, and he was awarded second place. The two new Italian machines, both Macchi Isotta Fraschini aircraft and piloted by Lieuts. Cadringher and Monti, were forced by minor defects to descend on their second laps. Their speeds on the first lap were respectively 284 and 301 miles an hour. Great Britain has now won the contest four times, Italy three times, the United States twice, and France once. The trophy becomes the permanent property of any country which wins it three times in five successive contests. This country will therefore secure it for good if we win any one of the next three contests. If Italy is to rob us of final possession, she will have to win the next two contests. America to do likewise would have to win three out of the next five contests. The final destination of the trophy is, however, by no means as clearly indicated as these figures would imply. At one time Italy and at another time America were in precisely the same favourable position as we are to-day. It appears, too, that the great expense of competing in the contest may possibly prevent its being perpetuated. Last Saturday's race, it is said, cost the Italian Government from first to last about £1,000,000, and the British Government about £250,000.

FRACTURE OF A CAST-IRON TEE-PIECE IN S.S. "MACHARDA." "Engineering," 13th September, 1929.

*The S.S. *Macharda* is a vessel of 6,209 tons register, belonging to Messrs. T. and J. Brocklebank, Limited. She has four cylindrical boilers, working at 220 lb. per square inch. The auxiliary steam pipes are of steel throughout, the general lay out was well designed to allow for expansion and shock, and the pipes were supported by clips to the side bunkers. Over one boiler, however, were two isolating valves, a right-angled vertical bend, and a cast-iron tee-piece connecting the system to the boiler stop valve. When the ship was on voyage from Gibraltar to Boston, U.S.A., on December 9th, 1928, this cast-iron tee-piece fractured, and two Lascar stokehold hands unfortunately lost their lives through scalding. Examination made immediately after the accident showed that the material was sound, but that the break was open about $\frac{5}{8}$ inch. At the time of the accident, the ship was experiencing bad weather, and it was thought that the shock of a heavy sea striking the ship was transmitted to the tee-piece which failed. In his observations on the report, the Engineer Surveyor-in-Chief said that it was evident the constructors fully appreciated the need for providing ample flexibility, " and it must be assumed that it was by oversight so short and rigid a connection was made between the tee-piece which fractured, and the straightest part of the steam pipe range." After the accident, a gun-metal tee-piece was fitted.

HEAT TRANSMISSION IN BOILERS. "Shipbuilding and Shipping Record." 19th Sept., 1929.

The amount of heat transmitted through the plates and tubes of a boiler depends, not only upon the thickness and the

* For full Report see p. 678 October Issue.

material of which these are made, but also upon the difference of temperature which is maintained between the two sides of the metal. It has been shown, by numerous experimenters, that, in order to keep this difference of temperature at as large a figure as possible, adequate circulation must be maintained, both on the water side and on the flue gas side of the metal. An interesting development in the method of circulating the flue gases over the heating surfaces of boilers, as a result of which a considerable increase in the heat transmission is obtained, consists in using baffles so arranged that the flue gases flow transversely, instead of in a longitudinal direction, across the heating surface. In the case of the marine type boiler with corrugated flues, the desired result is produced by inserting a smaller corrugated tube in the flue, so as to leave an annular passage for the gases with corrugated walls on each side, while for water-tube boilers, corrugated baffle plates are inserted between the rows of tubes. It is further suggested that a corrugated strip may be inserted in the smoke tubes. In a series of tests on an experimental boiler fitted with various baffles in this manner, it was found that the heat transfer coefficient could be increased from two to two and three-quarter times the value attained without the baffles, although it is to be noted that the draught required was multiplied $4\frac{1}{2}$ to 9 fold. This increase of draught is not thought to be prohibitive, and no trouble is anticipated from fouling of the heating surfaces, as the increased velocity of the flue gases tends to keep the heating surfaces clean.

THERMAL ECONOMY OF STEAMSHIPS. "Shipbuilding and Shipping Record." 19th Sept., 1929.

In any investigation as to the most suitable type of machinery to employ for the propulsion of a ship, it is not sufficient to consider merely the efficiency of the main engines, the effect of the auxiliary machinery both in the engine room as well as on deck, together with the problems of lighting, heating and ventilation, must also be taken into account, since these latter are often profoundly affected by the type of propelling machinery which is employed. In former times, when nearly all the auxiliary machinery was driven from the main engine, the question was relatively unimportant, but to-day, particularly in large passenger steamers where the auxiliary power for all purposes may represent 20% or even more of the power of the main engines, it is essential that the thermal economy of the vessel as a whole should be considered if the best operating results are to be achieved. A very good example of the consideration of the thermal economy of a vessel as a whole is to be found in the design of the Holland-American liner *Statendam,* which claims to be the most economical steamship in the world. The relative interdependence of the main and the auxiliary equipment on this vessel, together with the very efficient results obtained, were described in a paper which was recently read before the Koninklyk Instituut van Ingenieurs, at the Hague, by Dr. Ir. W. M. Meyer, the superintendent-engineer of the Holland-America Line. In his introduction, Dr. Meyer points out the various purposes for which heat is necessary, either directly or indirectly, as energy on a large passenger liner, these being, in addition to operating the main and the auxiliary machinery, navigation, lighting, ventilation, food preparation, cooling cargo and provisions, and loading or unloading cargo.

The main engines take by far the largest part of this heat, and it is only natural that the chief endeavours should be directed towards increasing to the utmost extent the heat economy of the propelling machinery, and with this end in view, high-pressure, high-temperature steam is employed, the initial pressure being 28 kg. per sq. cm. (398 lb. per sq. in.) and the initial temperature 350° C. (662° F.). Moreover, the condensing system is such that a vacuum of 95% is maintained, which is equivalent to 28·5in. with a 30in. barometer. Since, however, the bulk of the heat which is lost in any steam-engine installation is due to the latent heat of evaporation which is lost when the steam is subsequently condensed, for all additional purposes, the attempt is made, as far as possible, to utilise the steam in such a way that where condensation occurs this latent heat remains in the system. Thus, as might be expected, the feed heating is performed by means of steam, two stages of surface heating being employed utilising steam bled from the intermediate and the high-pressure turbines, the drains from the intermediate-pressure heater passing to the condenser and that from the high-pressure heater direct to the condensate. Thus, all this steam apart from small radiation losses, operates at full 100% efficiency. As, however, the steam must be clean if it is to be made to yield usefully its latent heat of evaporation, it follows that, as far as possible, steam should not be employed for driving the auxiliary machinery, and this led to all the auxiliaries, with the exception of the feed pumps, being electrically driven, four 400 kw. Diesel-driven generators being installed. The feed pumps are steam-driven by means of reciprocating pumps, since it is considered inefficient to use electrically driven rotary pumps for this purpose, the exhaust from these pumps being utilised for various heating purposes. Among the other purposes for which steam heating is employed, mention may be made of heating the ventilation air, water heating for domestic purposes, food preparation in the galleys, and heating the hot plates and cupboards in the pantries. In all of these, attempts are made to condense the steam, the condensate being passed through steam traps back to the system.

As indicating the overall efficiency which has resulted from the adoption of these measures, a few figures may be given which justify the assertion that the *Statendam* is the most efficient steamship in the world. Dr. Meyer states that on the trial and during the first voyage the daily consumption was 143·6 metric tons of fuel oil and 7 tons of Diesel oil for a power of 22,140 s.h.p. Expressing this in terms of the equivalent consumption for all purposes with a calorific value of 10,555 calories per kg. (19,000 B.Th.U. per lb.), the figure is 149·2 metric tons per day, which is equivalent to 280·7 gm. (0·619 lb.) per s.h.p. per hour for all purposes, which represents an overall efficiency of 21·6%. Considering merely the turbine after making allowance for the heat utilised for various heating purposes and assuming a boiler efficiency of 87%, Dr. Meyer estimates that the efficiency of the turbine is 25·3%. But while these figures certainly indicate that the performance of the *Statendam* taken as a whole is highly economical, the paper is of great value as suggesting means whereby the equipment of a vessel may be considered as a whole rather than as a number of separate and independent parts, and it certainly merits the careful study of all Marine Engineers who are desirous of seeing the overall economy of the steamship improved.

A NEW AIR SPEED RECORD. "The Engineer." 20th Sept., 1929.

On Thursday, September 12th, Squadron Leader Orlebar, flying the Supermarine Rolls-Royce "S 6" machine, which won the Schneider Trophy, succeeded in slightly surpassing the three-kilometre straight course speed record. From 355·8 miles an hour, he took the average speed for four consecutive laps of the course to 357·7 miles an hour.

His successive lap speeds were 354·6, 358·7 352·5 and 365·1 m.p.h. It is of interest to note that on the previous Tuesday, when the weather conditions were deemed to be partially unfavourable, his successive lap speeds were 368·8, 345·3, 365·5, and 343·7 m.p.h. It will therefore be seen that the highest speed on the Thursday was less than that achieved on two of the laps on the Tuesday. The figures provide a commentary on the effect of wind velocity on the speed of aircraft. They show, for example, that an aeroplane of given speed will perform a given journey, out and back, in the least time when there is no wind. It is a simple arithmetical fact and does not involve any aerodynamical considerations that the benefit of an assisting wind in one direction must always be more than lost by the hampering effect in the other direction. The fact that aircraft can now attain a speed equal to half the velocity of sound must have raised in the minds of many people questions as to whether, and, if so, how much, further progress in aircraft speed is possible.

PROGRESS OF SYDNEY HARBOUR BRIDGE. "Engineering," 27th September, 1929.

According to a statement made recently by Mr. F. R. Litchfield, supervising engineer of the Public Works Department, the total weight of the steelwork of the Sydney Harbour Bridge, erected up till the beginning of August last, was 19,200 tons. The work so far completed includes the five approach spans on the northern side and the five approach spans on the southern side, the deck steelwork through both pylons, and the first three panels of the arch span on the southern side. The building of the arch span on the northern side was commenced recently. The total weight of the steel to be used in the five northern and five southern approach spans and in the main arch span amounts to 50,200 tons.

COAL AND OIL FIRING ON SHIPS. "The Engineer," 27th Sept., 1929.

An official memorandum has been issued to surveyors by the Mercantile Marine Department of the Board of Trade regarding the simultaneous use of coal and oil as fuel on board ship. The practice of using coal and oil either simultaneously or alternatively on a passenger ship, although not definitely prohibited, is strongly deprecated. The memorandum instances two recent fires on ships which were using coal and oil simultaneously, the *Carmarthenshire*, which took fire in the Thames, and the *Trojanstar*, which met with mishap off the Pacific Coast of North America. The case of the *Trojanstar* is probably more illuminating than that of the *Carmarthenshire*. The vessel left port as a coal burner, and was being converted to oil burning at sea when a pipe joint failed, and caused a spray of oil to be directed on to the front of a coal-fired boiler, a furnace door of which happened to be open at the time. A fierce fire was started, which resulted in the loss of one life, and which, but for the gallant action of a fireman, would almost certainly have led to the abandonment of the ship. The Board has now instructed its surveyors not to grant passenger certificates to steamers in which it is intended to burn coal and oil in a common stokehold unless adequate provision is made for isolating the oil fuel boiler space from the coal fuel boiler space, and the full fire appliance equipment required for an oil-burning vessel is also provided. If pulverised coal and oil are burned simultaneously, the risk of fire, it is admitted, is less than with ordinary coal and oil, but it is held to be greater than if oil only is used. Modified requirements are laid down to meet this case. Cargo vessels are also dealt with in the memorandum. The dual system of firing, and especially the practice of conversion at sea, are to be held as rendering a vessel unseaworthy, unless precautions are taken, to render the risk of fire remote, to limit its extent by division of the boiler-room, and to extinguish it by the provision of adequate fire appliances.

SAVE FUEL ON SHIPPING BOARD VESSELS. "Marine Review." Sept., 1929.

The Fuel Conservation Committee of the United States Shipping Board, Merchant Fleet Corp. has given out its semi-annual honour roll and honourable mention list of chief engineers and masters, covering the six months period July 1st, 1928 to December 31st, 1928. The fuel conservation section of the Fleet Corporation, which is responsible for carrying out the Committee's policies, is headed by C. J. Jefferson. As a means of stimulating interest among the personnel of the fleet, the Committee decided several years ago to issue these honour rolls and honourable mention lists of the vessels making the best showings. As a further inducement, the Board authorised the payment of a $50 bonus to each chief engineer and master on the honour roll.

The honour roll consists of fifty ships, representing the best performers of the fleet, and is accompanied by an honourable mention list of fifty vessels, whose performance, while falling short of the standard required for the honour roll, was so good as to deserve mention. These vessels were selected from the reports of 254 active vessels inspected during this period. The total mileage covered by the vessels in the six months was 5,820,541, the hours at sea being 563,179·5 and in port 475,890·5. To entitle an honour roll listing, a vessel must have travelled at least 20,000 miles during the period and must have attained a combined sea and port efficiency equal to or better than 95% of that obtained by the leader of her class and equal to or better than 95% efficiency.

In spite of the large progressive fuel savings made in the several years past and the increasing age of the vessels, it is interesting to note that the fuel economy has still further continued during this six months period. This saving in fuel consumed taken in conjunction with the low prices of fuel oil now prevailing, represents a sizeable saving in the fuel bill. Comparing the last half of 1928 with the first half of 1928, there has been an actual fuel saving of $221,905·67. This figure is conservative.

NEW BOILER STEEL TO BE MADE IN OHIO. "Marine Review." Sept., 1929.

A remarkable new alloy steel, used in the boilers of the North German Lloyd *Bremen* is to be manufactured in America under Krupp patents exclusively by the Central Alloy Steel Corp. of Massillon, O. Announcement that the metal soon will be introduced in this country is made by F. J. Griffiths, chairman of the company.

The alloy will be produced under the name of "Izett," coined from the German letters I. Z., which stand for Immer Zahe—always tough. Leading metallurgical authorities of the world regard Izett as one of the five greatest developments in the art of steelmaking in the last 15 years. Its largest demand will be for construction of boilers and steam-generating equipment.

A point of interest to American technical men in the trip of the *Bremen* was its demonstration of an economical boiler material which is able to meet the growing modern requirements for more power and higher boiler pressures. These requirements have reached the limit of the capabilities of exist-

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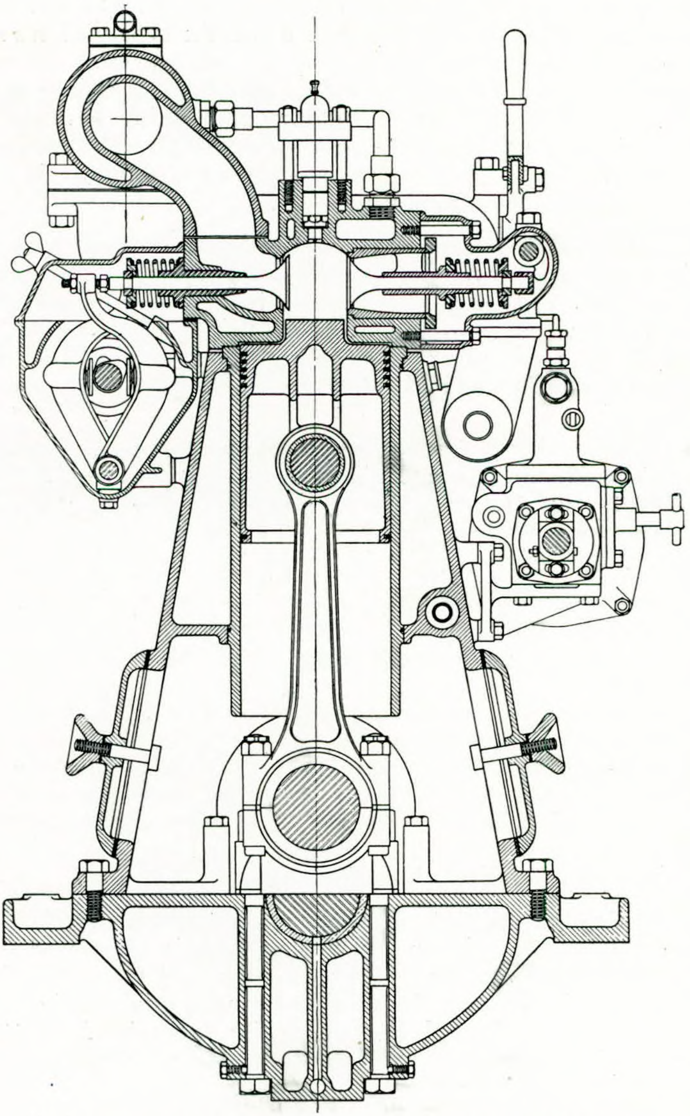
power, will be available for driving the vessel ahead. The fifth, fitted with a negative pitch propeller, will be used when the motion has to be reversed. This arrangement is more or less temporary. Light alloy propellers are now being developed which may enable the original plan of fitting all the propellers with reversible blades to be carried out. The Airship Guarantee Company's vessel " R 100," which has been constructed at Howden and which is of radically different design, is expected to complete her shed trials within the next fortnight.

GLENIFFER HIGH-SPEED DIESEL ENGINE. "The Marine Engineer and Motorship Builder." Oct., 1929.

Gleniffer Motors Ltd., Anniesland, Glasgow, have produced a new high-speed light-weight Diesel engine of original design. Three, four, and six-cylinder engines are being made, and all have a cylinder diameter of 6in. and a stroke of 7in. The power per cylinder is 15 b.h.p. at 700 r.p.m., while 20 b.h.p. is developed at 900 r.p.m. As the sectional drawing of the Gleniffer engine which is reproduced with this article shows, it has horizontal valves with a compact form of combustion chamber wherein high turbulence is promoted by the projection on the piston crown entering the combustion chamber as shown. The fuel valve is centrally placed between the valves. Each cylinder has a separate fuel pump, the fuel pump unit and automatic fuel valves being of Bosch manufacture.

The timing gear is mounted at the fly-wheel end of the engine, the camshaft being driven by a duplex roller chain from a sprocket on the crankshaft. This chain, after passing round an automatic tensioning jockey support, is led over a pump-driving sprocket to the camshaft sprocket and thence back to the crankshaft sprocket. The camshaft operates directly on to the exhaust valves and, through pull rods, on to the inlet valves.

The bottom half of the crankcase forms the main bedplate, while the top portion constitutes the main frame and carries the cylinder liners, which are of centrifugally cast iron. Each cylinder head is a separate casting secured against the upper flange of the cylinder liner by six studs. Lubrication is on the dry sump system, the delivery and scavenging forced lubrication pumps being of the oscillating plunger type. An Auto-Klean strainer is incorporated in the system, which is notable in having an absence of internal oil distribution pipes. Oil distribution passages, with cast-in pipes, are used in the crank-



Section through Cylinder of New Gleniffer High-Speed Diesel Engine.

case, while the crankshaft is drilled in connection with the forced lubrication system.

The engine is started by means of a small four-cylinder compressed air motor driving through a Bendix type pinion on to a gear ring on the flywheel. The air receiver for the compressed air motor is charged from a leak-off valve on one of the engine cylinders. When the engine is running and the receiver has to be charged, the fuel valve of this cylinder is cut out and the leak-off valve opened, whereupon pure air is compressed into the starting air receiver.

For propulsion purposes the new engine is fitted with the makers' patented reversing gear, while 2 to 1 reduction gearing can also be fitted if desired. On test the engine has given a specific fuel consumption of about 0·43/0·44 lb. per b.h.p. per hour between full load and three-quarters load, the fuel having a specific gravity of about 0·89.

THE LATEST DEVELOPMENT OF THE MARINE DIESEL ENGINE.* "The Marine Engineer and Motorship Builder." Oct., 1929. By H. H. Blache, Dr.-Tech.H.C., Managing Director of Burmeister & Wain, Copenhagen.

The characteristic feature of the different types of two-stroke cycle engines as being built to-day by the leading firms is the scavenging method. The earlier types of two-stroke cycle engines, having the scavenging valves arranged in the covers and exhausting through ports in the cylinder liner, directed by the piston, have been completely abandoned. The scavenging is now, as a rule, carried out by means of scavenging and exhaust ports, opened by the piston close to its bottom position, and the utilisation of the various scavenging devices according to this system is the location and shape of the ports allowing the scavenging air to be forced up into the cylinder, clearing it of the exhaust gases.

According to the tests carried out by Burmeister & Wain with special devices in an experimental engine, none of these scavenging methods have proved fully satisfactory, which particularly is the case for double-acting engines, where the piston rod passes through the combustion space in the bottom. This relation is of great importance as the scavenging of the

* Abstract of paper read at the General Meeting of Civil and Marine Engineers and Naval Architects from the Northern Countries, August 28-31, 1929, in commemoration of the Centenary of the Royal Technical University, Copenhagen.

cylinder determines whether smokeless combustion shall follow, and thus affects the horse-power and working reliability of the engine.

The best known double-acting two-stroke cycle type is the M.A.N., of which the Hamburg-Amerika Line have 13 ships in service. These engines are working exceedingly well according to the reports of the voyages, but with a very low mean pressure on account of the scavenging method. The largest number of ships in service fitted with two-stroke cycle engines is, according to the available figures, of the Sulzer type. The difficulty with respect to the scavenging is evaded by fitting a special set of ports for filling the cylinders with fresh air, after the exhaust ports have been closed by the piston; the engine therefore works with a combustion at a higher pressure and with a mixture of combustion gases and air.

The only really effective way to scavenge a cylinder is to blow fresh air in at the one end of the cylinder, thereby forcing the gases out of the other. This principle is adopted for the Doxford engines, which are of the so-called opposed piston type. The latest two-stroke cycle type is the Burmeister & Wain engine, which is being built double-acting as well as single-acting.

B. & W. Double-Acting Two-Stroke Engine.

The design of all the main parts of the double-acting engine, shown in Fig. 3, is based on the experience gained by Burmeister & Wain's double-acting four-stroke cycle type. The parts of the engine which are subjected to the high combustion temperature and pressure, viz., the piston and piston rings working on the cylinder liners, are cast of Perlit iron, particularly resistible to wear and heat stresses. The piston rod is thus provided with a loose liner of Perlit iron, and the stuffing box is fitted with piston rings working on the piston rod liner. This design, which is proved from Burmeister & Wain's four-stroke cycle double-acting engine, has been further developed in the new two-stroke cycle type, the stuffing box being portable and provided with external piston rings, working in the central aperture of the bottom cover. The portable stuffing box directs the exhaust by means of ports, and a cylindrical piston is arranged in a similar way in the top cover. The two pistons are rigidly connected to each other, and operated by means of a system of rods from a chain-driven auxiliary crankshaft, fitted in the forced lubricated crank casing. The scav-

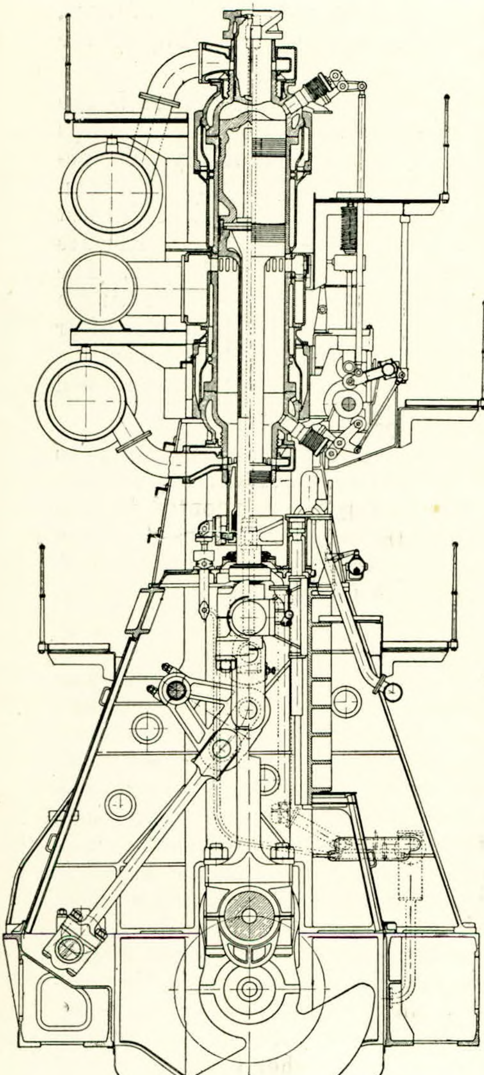


Fig. 3.—B. & W. Two-Stroke Cycle Double-Acting Marine Diesel Engine.

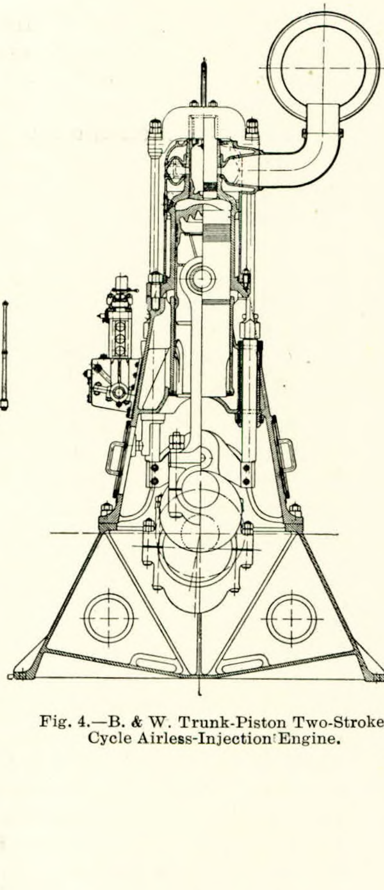


Fig. 4.—B. & W. Trunk-Piston Two-Stroke Cycle Airless-Injection Engine.

enging air is admitted through ports arranged in the centre around the whole of the circumference of the cylinder liner, and directed by means of the piston.

The advantage of this design is that the main piston does not pass over the exhaust ports, subjecting the piston surface to strong heat from the rebounding of the exhaust gases from the remainder of the cylinders, as is the case with the other types of two-stroke cycle engines. The cylinder itself is devoid of exhaust ports; thus the difficulties encountered with the otherwise strongly heated bars between the exhaust ports are eliminated, and the whole of the cylinder circumference may accordingly be utilised for the admittance of the scavenging air. This is admitted at a low pressure, 0·2 atm., through ports of ample area, evenly distributed around the whole of the circumference to obtain good scavenging. On the other hand, the exhaust ports do not require a large area, owing to the small specific gravity of the hot gases. These ports may therefore be distributed on a cylinder diameter which is about one-half of the main cylinder, and the guiding piston valve has only a stroke which is about 1/5th of the main piston. The exhaust piston valve does not require so much lubricating oil owing to the low piston speed, as the main piston for engines having the exhaust ports in the centre of the cylinders, which is of importance, as most of the lubricating oil covering piston rings and the piston passing exhaust ports is lost through these. There is also a certain similarity with this engine and a steam engine fitted with piston valves, but while a certain amount of work is expended by the piston valve motion of the steam engine to overcome the friction due to the piston valves, the condition in this case is quite the reverse. These exhaust piston valves develop a certain amount of useful work, and on account of their lead in relation to the crankshaft, the indicator card will even be very full. It is therefore necessary that the engineers take cards of the main cylinders as well as of the piston valves, and the work developed by the latter is about 10% of the whole of the work in the cylinder. On account of the good scavenging conditions, the engines have proved to work smokeless with a mean pressure which is 5% higher than the maximum for a four-stroke cycle engine without pressure on the inlet air.

The first set of engines to be constructed by Burmeister & Wain of this type is a six-cylinder main engine for a ship building to the order of The East Asiatic Company. The cylinders are 620 mm. diameter by 1,400 mm. stroke, and low revolutions, 100 per minute, are chosen with regard to the propeller efficiency for single-screw. The engine is capable of developing 7,000 b.h.p. and the weight is 380 tons, corresponding to 5·15 tons per 100 b.h.p. Single-acting engines of the trunk-piston type are being built according to the same system as auxiliary and stationary engines, as well as for Diesel electric locomotives and fishing craft. Fig. 4 shows a section through a single-acting trunk piston engine. The main characteristic difference between this and the crosshead type is that the single exhaust piston valve in the top is operated by eccentrics from the crankshaft itself by means of a system of rigid rods.

DIRECT-CURRENT ELECTRIC MOTORS. SYSTEMATIC MAINTENANCE THAT WILL REDUCE THEIR LIABILITY TO BREAKDOWN. By W. E. Warner. "Ice and Cold Storage," Oct., 1929.

Electric motors are used to a large extent in the cold storage industry for driving compressors, a direct-coupled electric motor forming an efficient driving unit.

Electric motors have a high efficiency, and are reliable in service. Various defects, however, appear from time to time, being brought about either by wear or defective operation.

Frequent cleaning and systematic maintenance will greatly reduce the liability to breakdown. The commutator and brushgear are the parts that give the most frequent trouble; they are continually wearing and therefore require constant attention.

Sparking at the brushes is a frequent trouble; it also brings on other troubles such as blackening and roughening of the commutator, roughening and burning of the brushes and overheating of both. Sparking may be due to either electrical causes or to dirt, etc.; the former can be detected by being bluish and vicious, while sparking due to the latter is reddish-brown.

Sparking due to electrical causes may be due to some fault in the armature such as an open circuit, short circuit, or earths; these faults should be detected and remedied. It may also be due to the brushes being in the wrong position round the commutator. If the motor has an interpole winding this winding may be either too strong or too weak, or quite possibly reversed in direction; the latter being particularly likely after a machine has just been connected up.

Sparking Due to Dirt.

Sparking due to dirt is much more frequent and liable to occur in the case of machines the commutator and brushgear of which are very dirty, sparks may jump between adjacent brushholders; this is known as ring fire.

The commutator and brushgear of motors should be cleaned weekly of all collected dust. The commutator and brushes are continually wearing, and the dust formed by this wear, which is highly conductive, collects on the brushgear, etc., and if left will lead to electrical leaks as well as sparking. A commutator in good condition should develop a smooth, chocolate-coloured glaze which should be maintained in service by the abrasive action of the brushes. If, however, it tends to blacken and roughen it should be given a cleaning with some fine sand-paper whilst running, this being held against its surface as it rotates.

Mica Troubles.

A cause of much sparking is micas. The copper segments wearing more rapidly than the mica between them, the mica projects above the segments and causes the brushes to chatter as the commutator revolves. In some machines these mica segments are cut down below the surface of the copper, known as undercutting; in other machines, known as flush mica machines, the surfaces of both the copper and the mica are flush with one another and have both to wear equally if the commutator surface is to keep true.

With undercut micas, the mica cannot project, but dust and dirt soon collect in the narrow slots between the segments, tending to cause shorts between them.

With high-speed motors this dust and dirt will be prevented from settling by the centrifugal force when revolving; with these motors undercutting is often adopted. With low-speed motors there is insufficient centrifugal force to throw the dust out of the slots which therefore tends to collect and cause shorting between the segments; these machines are usually used as flush mica machines. The slots can, however, easily be kept clean with an old tooth brush; the usual way to undercut mica being to hold a steel rule along the edge of the mica and cutting with a piece of hacksaw blade, the rule acting as a guide in keeping the hacksaw from cutting the copper. With flush mica commutators it is usual to use slightly more abrasive brushes than otherwise, the abrasive action of these wearing down the mica and keeping the commutator surface true.

The use of a lubricant such as vaseline on a commutator is inadvisable. If the brushes squeak the application of a stick of paraffin wax horizontally across the commutator will give sufficient lubrication, and is all that should be necessary. Some grades of brushes have lubricant impregnated into them during manufacture; these give continuous automatic lubrication but are liable to smear the commutator.

Brushes Sticking.

Another cause of sparking is brushes getting stuck in their holders. When a brush sticks it sparks badly and overheats. Brushes should move easily up and down in their holders, and should be a good but not tight fit in them. When the brushes are an easy fit the usual cause of their sticking is dirt accumulating round the sides. Frequent cleaning and inspection are necessary.

Another possible cause is the brush becoming heated and the expansion causing it to stick; metal graphite brushes expand more with a temperature rise than carbon brushes, and sticking is more likely.

Sometimes one set of brushes only will spark continuously. The cause of this, in the absence of any fault at the brushes, is a faulty field coil above the armature coils undergoing commutation at that set of brushes. The magnetic flux coming from each of the poles round the armature must be roughly equal; if any of the turns in a coil get short-circuited or the air gap between the pole shoes and the armature is increased due to wear at the bearings, the magnetic flux coming from that pole will be reduced and sparking will take place at the set of brushes connected to the armature coils acted on by that coil. A faulty field coil can often be found by feeling the coils; if one of them is found to be cooler than the rest there is probably a fault in this coil, its coolness being explained by the fact that some of its turns are short-circuited or it is receiving less current than the rest, causing there to be less heating due to the current.

The air gap between the field pole shoes and the armature should be kept as near equal as possible. The air gap may be tested with a long pair of feelers, these being inserted into the gap, and when the maximum air gap exceeds the minimum air gap by more than 50% the armature bearings should be taken up. The greatest wear usually takes place on the bottom halves of the bearings, causing the air gap to increase under the top pole shoes.

Wear of Brushes.

The grade of brushes used greatly affects the amount of sparking and wear at the commutator. There are many grades in use, including carbon, carbon graphite, graphitic and metal graphite brushes. The principal properties of brushes are hardness, abrasiveness, resistance and mechanical strength.

Hardness means the resistance of a brush to mechanical wear; these brushes do not wear rapidly themselves, but are apt to cause wear on the commutator. However, they make little dust, due to the lesser wear, which is an advantage in some cases.

Abrasiveness in a brush is the effect which causes wear; a proper amount of abrasiveness in a brush will scour the commutator and keep it clean, and on flush mica commutators will keep the mica level with the copper.

Brushes that are too abrasive cause excessive wear on the commutator. As a rule brushes should have sufficient abrasiveness only to keep the commutator clean, although on flush mica machines very abrasive brushes may be necessary to wear the mica down.

The specific resistance of a brush means the ohmic resistance it offers to the current; a high resistance increases the voltage drop through the brush, and for a given current density increases the heating.

The resistance of a brush should be kept as low as possible except in the case of non-interpole machines, where high-resistance brushes help to prevent sparking. Brushes also need mechanical strength in order to stand up to the operating conditions without breaking. Carbon brushes usually have the greatest strength and graphite brushes the lowest, but are sufficiently high to stand up to the ordinary service conditions.

The current-carrying capacity of brushes vary. Forty amperes per square inch is the limit for ordinary carbon brushes, but some types of graphite brushes have a capacity of seventy-five amperes per square inch, making it possible to use smaller and lighter brushes. Graphitic brushes have much to recommend them, but the dust they make as they wear is highly conductive, adhesive and greasy, and may cause trouble through its settlement on conducting parts. A trouble that may occur is through this dust being carried through the commutator risers to the back of the commutator and inside the armature by the ventilating air. This dust will collect on any surface and in crevices, and causes much operating trouble through earths and short-circuits. Owing to its greasy nature it may not be removed by blowing out, and it tends to collect in inaccessible positions.

The best remedy is to varnish the surfaces behind the commutator with a smooth insulating varnish, and use brushes that produce a minimum amount of dust.

In some cases the spaces between the commutator risers have been closed by a wrapping of muslin or duckcloth, which prevents the passage of dust behind the commutator, but also interferes with the ventilation and is liable to lead to overheating.

Another defect that may lead to sparking and overheating at the brushes is through their not bedding over their entire area. Brushes are bedded and ground to the commutator surface by sand-papering. The best way of doing this is to adjust the brushes to a moderate tension, obtain a strip of sand-paper and place this under the brushes, rough side toward the brushes, and pull the strip backwards and forwards, thus grinding the face of the brushes to the curvature of the commutator. When the brushes have been well bedded down, replace the sand-paper used with a strip of very fine sand-paper and employ this as before, but pull in the direction of rotation, only taking off the tension on the brush for the backward stroke. This treatment gives a smooth and true surface. After the brushes have been bedded they should be rubbed with a soft cloth to remove any grit that may have become embedded in the carbon, the whole of the commutator and brush gear should also be blown out to remove any trace of abrasive dust.

Systematic maintenance is necessary to get the best results from electrical machinery. A great number of the faults that develop with electric motors are avoidable and come about principally through neglect.

LARGE WATER-TUBE BOILERS. "The Shipbuilder." Oct., 1929.

The present trend of marine steam-engine development, which is leading so definitely towards higher steam pressures and temperatures, is gradually but surely overcoming the natural antipathy which the majority of Marine Engineers have hitherto shown against the water-tube boiler. It is generally recognised that the safe upper limit of pressure for the large-diameter Scotch cylindrical boiler cannot, with present-day design and materials, exceed 300 lb. per sq. in.; and as the full benefits to be derived from high-pressure steam cannot be realised except at pressures substantially above that figure, it follows that the Scotch boiler must, of necessity, make way for the water-tube boiler. If this consideration of pressure alone were the only factor, the water-tube boiler must sooner or later displace the Scotch boiler in the modern high-powered steamship; but there is another and equally important advantage enjoyed by the water-tube boiler in regard to the power which may be developed or generated in individual boiler units.

A fair average figure for the power generated in the ordinary double-ended Scotch boiler of the largest standard dimensions as usually built will be found to be about the equivalent of 2,000 h.p. Thus, for, say, a 12,000 h.p. installation an arrangement might be six double-ended Scotch boilers, or, what is more general, four double-ended and four single-ended Scotch boilers. As the total power required increases, it is apparent that in such a vessel as the *Aquitania*, for example,, a large number of boiler units is required, as well as very great lengths of steam piping. Such an arrangement with large radiating surfaces, all of which require careful insulation, inevitably results in material heat losses. Taking for comparison such representative modern ships with water-tube boilers as the Canadian Pacific Steamships' *Duchess* class, or the practically similar P. & O. Line's *Viceroy of India*, each of these vessels is fitted with six large water-tube boilers for propulsion. As the total power developed is about 18,000 to 20,000 s.h.p. per ship, each boiler generates the equivalent of more than 3,000 h.p. The corresponding arrangement with Scotch boilers might be 10 double-ended boilers, or, alternatively, eight double-ended and four single-ended boilers. It is apparent that the water-tube boiler arrangement requires less space, has a much smaller exposed surface from which radiation losses may arise, and requires a greatly simplified piping arrangement. If the two new Norddeutscher Lloyd liners *Bremen* and *Europa* are considered, the advantage secured by the adoption of water-tube boilers is even more striking. In each of these vessels there are 20 large water-tube boilers; and as the maximum power developed by the *Bremen* on trial exceeded 130,000 s.h.p., the individual boiler output was roughly equivalent to 6,500 h.p. With Scotch boilers, this very high power would have required between 60 and 70 double-ended boilers, which it might or might not have been possible to accommodate in the available space.

Large as the boilers of the two Norddeutscher Lloyd liners appear to be in comparison with the capacity of the Scotch boilers, they are eclipsed by the water-tube boilers at present under construction for the converted machinery of the four vessels of the *Albert Ballin* class owned by the Hamburg-Amerika Line. As has already been recorded in our columns, these four 20,000 ton transatlantic liners—which are at present fitted, as originally built, with machinery of about 12,500 s.h.p. taking steam from four double-ended and four single-ended Scotch boilers—are about to be given new propelling machinery of much higher power in order to raise the service speed from 15½ to 19 knots. The designed output of the new propelling machinery is 28,000 s.h.p., and the eight Scotch boilers are being removed and replaced by four large water-tube boilers arranged in pairs, two abreast. In other words, each of these boilers will generate the equivalent of 7,000 s.h.p., which must be a record output for any mercantile marine boiler. The length of the drums in boilers of this capacity is naturally considerable; and the new boilers for these ships will be unique in being *double-ended*, *i.e.*, they will, as the term implies, be fired from both ends. The double-ended water-tube boiler—never previously utilised in any merchant ship so far as we are aware—has certain obvious advantages. For a given power one large double-ended water-tube boiler costs substantially less than two smaller boilers, and, *ceteris paribus*, takes up less space. With two smaller boilers, the back of the furnace represents a dead wall from which heat radiates; whereas, with the double-ended boiler, the equivalent is two single-ended boilers back to back, but with the two backs or dead walls eliminated. That the large boiler units save space is apparent from the fact that, in the conversion of the Hapag ships, the space from which the eight Scotch boilers are being removed is more than sufficient to accommodate the four water-tube boilers, which are moreover of almost $2\frac{1}{4}$ times the power.

In central power-station practice ashore, water-tube boilers of very large dimensions are the rule and many of these boilers are rated at the equivalent of more than 10,000 h.p. per unit. There would appear to be no practical obstacle to the adoption of the 10,000 h.p. double-ended water-tube boiler is mercantile tonnage. On the contrary, the advantages of such high-pressure boilers appear to be so pronounced as to render their adoption for the largest liners a logical and almost certain development of the near future.

THE DESIGN OF MOTOR-SHIP MACHINERY. "The Motor Ship." Oct., 1929.

A short time ago a statement was widely published that a new oil engine had been developed which was likely to revolutionise internal combustion motor manufacture. As a well-known Diesel engine builder remarked last month in the course of a dissertation on marine Diesel engines which we *publish elsewhere, there is no likelihood of any such revolutionary change. There is, however, as much and as important progress along sound and moderate lines now being made in the design and construction of the machinery of motor ships as has ever been the case; but it cannot be termed revolutionary.

In summarising the position which has now been reached and in estimating future possibilities there are certain lines of progress which stand out in a marked degree, although they have proceeded so gradually that their importance has, perhaps, not been fully estimated. It is but a year or two since the maximum economic output for four-stroke single-acting machinery was placed by nearly all engineers at about 3,000 b.h.p., but trials were run at the end of last month of a ship with such engines capable of developing 4,500 b.h.p., and vessels are on order to be propelled by four-stroke single-acting motors of 5,000 s.h.p.

Many useful improvements have lately been made in steam machinery, but in most cases they have not effected a reduction in fuel consumption greater than 10 per cent. This is approximately equivalent to the advantage which the adoption of airless injection confers on Diesel engines, and the extent of the advance of this system will come as a surprise to many when it is mentioned that 46 vessels are now in course of construction to be fitted with one type of airless-injection Diesel motor alone. There would almost appear to be something of a flight from the air-injection engine, and this applies to four-stroke machinery, both of the trunk-piston and crosshead design; also to two-stroke double-acting and single-acting engines.

A steady evolution with a view to the attainment of higher efficiency in the widest sense is to be observed with the auxiliary plant installed in motor ships. An economy which may reach 3% to 5% of the total fuel is now obtainable by the use of an exhaust gas boiler which is becoming a common feature on motor ships. New and improved types of centrifugal purifiers have just been produced, and whilst auxiliary Diesel engines in most instances now operate at higher speed than was common in the past, and airless injection is gaining ground with them also, it is not unlikely that still faster running and lighter motors will make their appearance shortly. A new system of centralised control for the engine room electrical machinery is described elsewhere in this issue* and should represent, if not an improvement in efficiency, an advantage from the operating standpoint, which, in the end, is much the same thing. Even in the construction of propelling Diesel machinery new types are still making their appearance as exemplified by two new double-acting two-stroke engines, which are described later in these pages.*

The conclusion to be reached after reviewing the present position of the design of motor-ship machinery is that the limit of progress has not by any means been reached, whether progress be viewed from the aspect of higher efficiency, reducing the weight or rendering the conditions of operation more advantageous. No vast and unexpected improvement is likely, and no engine of any particular class, four-stroke or two-stroke, double-acting or single-acting, trunk-piston or crosshead, is likely to attain universal adoption at the expense of all other types. That appears to be the lesson which has been learned from the experience of 17 years of Diesel engine service at sea, during the course of which it has many times been predicted that one class of machinery would ultimately replace all others. But of this there is no sign.

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* See "The Motor Ship," Oct., 1929.

MACHINERY WEIGHT FOR FAST PASSENGER LINERS. "The Motor Ship." Oct., 1929.

In the paper of exceptional interest which Gen. E. de Vito, Director of Naval Construction of the Ansaldo Yard, presented last month before the Institution of Naval Architects, he gave some figures relating to machinery and fuel weights, calculated for a 26-knot transatlantic liner equipped with machinery of 100,000 s.h.p.

Although the estimated fuel consumption for a motor ship of this type appeared to be somewhat high (0·5 lb. per s.h.p.-hour) the noteworthy fact was brought out that, when comparing Diesel-electric propulsion with turbo-electric propulsion, there is a saving in total weight of 2,565 tons in favour of the motor ship for propelling machinery and fuel oil for a double trip. Comparing Diesel machinery with geared turbine plant, the saving in favour of the motor vessel is 2,215 tons. The respective weights in lb. per s.h.p. are:—

Geared turbines	405 lb.
Turbo-electric machinery	378 lb.
Diesel-electric machinery	320 lb.
Diesel motors with Vulcan gears	356 lb.

General de Vito comes to the conclusion that high speed can be obtained without running into increased displacement. In order to effect this he would avoid double bunkering and would reduce the fuel oil reserve from 20% to 10%. This is an interesting point, for if it be done, one of the main advantages of single bunkering, namely, the possibility of obtaining cheap fuel in America for the round journey, is abandoned. As the difference in price between boiler and Diesel oil is greater in America than in Europe, the fact has some bearing on the question of the employment of steam and Diesel machinery for transatlantic liners.

*PINION DESIGN OF THE "BREMEN." The "Marine Engineer," October, 1929.

5, Slagimor Gardens,
Bloomfield, Belfast.
Sept. 3rd.

To the Editor of "The Marine Engineer."

It is with great interest that I followed your article on the *Bremen* in your issue for September, particularly the illustra-

* See p. 670, October, 1929 Transactions.

tions and description of the pinion. Here you refer to the interesting nature of the divided pinion, and point out that "the torque of the turbine is transmitted directly to the flange in the centre of the pinion and from there equally to the two-tooth faces—an arrangement which minimises the torsional deformation of the pinion and equalises it as between the two halves, although it entails the adoption of a sleeve shaft or quill drive."

With the remarks quoted I am in complete agreement, and sincerely congratulate our German friends on their choice of design. I should like, however, to have some more information about this pinion and its wheel, the form of teeth being my especial interest. But the design is not new, for it will be found fully discussed, as regards loading, etc., in "The Marine Gear Problem," of the A.E.S.D. series of technical pamphlets, and also in my second paper, "A Basis for the Explanation of Marine Gearing Troubles," read before the Institute of Marine Engineers on December 18th, 1923 (Transactions, February, 1924)—see paragraph 41 and Figs. 32, 48 and 49.

I wish to draw your attention particularly to Case 9 in appendix "C," and in Table, Fig. 50 of the paper. in which the "hollow pinion, mid point drive, graded dedendum teeth" is shown to be the ideal form of pinion.

In my concluding remarks after the discussion (see Transactions, April, 1924) my three years' private work on the subject was dedicated to the engineering public for them to use as they think fit; and there the matter rests.

WILLIAM SELLAR.

INSTITUTE NOTES.

Mr. H. F. Carmichael, Member 1674, has been appointed Mayor of the Borough of Worthing, according to a Press notice which we read with pleasure and appreciation.

Sir Dugald Clerk, K.B.E., J.P., D.Sc., F.R.S., has been elected an Hon. Vice-President of the Institute by the Council.

ELECTION OF MEMBERS.

List of those elected at Council Meeting of October 14th, 1929:—

Members.

Percy Jarvis Boaler, M.S. *Kistna*, B.I.S.N. Co., Ltd., *c/o* Boustead & Co., Singapore.

Alfred Bradshaw, 5, Parkfield Road, Waterloo, Liverpool.

David Croll, B.Sc., *c/o* Drydock Company, Tandjong Priok, Westerstraat ii, Rotterdam, Holland.

Richard Embleton, M.B.E., M.C., Premier Buildings, Orchard Street, Newcastle-on-Tyne.

John Archibald Forrest, Central Technical College, Birmingham.

Stanley Harding, 88, Ormonde Street, Sunderland.

William Francis Hunt, Gleneagles, Stoke Road, Slough, Bucks.

Alexander Hendry, 43, Balfour Street, Leith.

Edward John Jordan, 77, Preston Avenue, Newport, Mon.

James Sheridan Lockhart, 43, Strathfield Gardens, Faircross, Barking, Essex.

Hugh Macniven, 1172, Argyle Street, Glasgow, C.3.

Alan Hanwell Miller, 78, Church Street, Newcastle, N.S.W.

John Pratt Moralee, 25, Water Lane, Seven Kings, Essex.

Alexander Robert Murrison, 26, Cliff Road, Dovercourt Bay, Essex.

Archibald John Campbell Ross, (Sir), K.B.E., St. Peter's Works, Newcastle-on-Tyne.

Edmund Tom Ryland, Anglo-Saxon Petroleum Co., Ltd., St. Helens Court, E.C.3.

Ernest Edward Tuck, 49, Aldersey Gardens, New Barking, Essex.

Hector Henry Reginald Walker, 117, Vicarage Road, Sunbury Common, Middlesex.

John White, 23, Park Crescent, Strathaven, Lanarkshire.

Companion.

Francis Bartram Snell, Room 64, 110, Fenchurch Street, E.C.3.

Associate-Members.

James Percy Anderson, *c/o* G. & J. Weir, Ltd., 78, Gracechurch Street, E.C.3.

Donald Gordon McDougall, M.V. *Port Huon*, *c/o* Commonwealth and Dominion Line, Ltd., 9 and 11, Fenchurch Avenue, E.C.3.
Edward Harry Patterson, 184, Battlefield Road, Glasgow, S.2.

Associates.

Laurence Andrew Jamieson Anderson, *c/o* Mrs. Davies, 1, The Drive, Ilford, Essex.
George Henry Hayward, School House, Ricardo Street, E.14.
Ernest John Woolgar, R.A.F. Station, Felixstowe, Suffolk.

Graduates.

Peter Aldbury Beresford, Waterside, Kings Langley, Herts.
Charles Paterson, 3, Malcolm Street, Dundee.

Transferred from Associate to Member.

Andrew Cecil Kennedy, 10, Waterloo Road, Hakin, Milford Haven.

Transferred from Associate to Associate Member.

John Hodson Trickey, 8, Claremont Road, Highgate, N.6.

Transferred from Graduate to Associate-Member.

Alfred Harold Jobling, Red Star Line, Rhine Quay, Antwerp, Belgium.
Walter Nicholson, Ivyholme, 2, Aldersgate Terrace, Park Road, West Hartlepool.

List of those elected at Council Meeting of November 4th, 1929:—

Members.

Joseph Edwin Chamberlain, 21, Bennett Park, Blackheath, S.E.3.
Andrew Grieve, 2, Brunton Avenue, Warwick Road, Carlisle.
Charles Edward Hall, 111, Dominion Street, Barrow-in-Furness.
David Farquhar Mackie, *c/o* Messrs. J. King & Co., 90, Garden Reach Road, Kidderpore, Calcutta.
George Alexander Mussett, 218, Brockley Grove, S.E.4.

Robert James Raine, Eng.-Lieut., R.I.M., K.P.T., Manora, Sind, India.

Anders Risoe, Messrs. Mansfield & Co., Ltd., Penang, S.S.

John Brown Sanderson, *c/o* McLachlan, 108, Pollok Street, Glasgow, C.5.

John Robert Storey, 48, Highbury Grove, London, N.5.

Arthur Edward Tyrer, Yennadon, Lodge Lane, Salfords, Surrey.

Herbert William Wallis, 273, Coventry Road, Ilford, Essex.

Edward Stanley Wood, The Firs, Belmont Road, Southampton.

Reginald Leworthy Bennee, 16, Glenshiel Road, Eltham Park, S.E.9.

Associate-Members.

William George Higgs Beauchamp, The Quest, Liberton, Edinburgh.

George Brownless, *c/o* Messrs. Mackinnon, Mackenzie & Co., Strand Road, Calcutta.

John Frost, 21, Moorland Road, Woodsmoor, Stockport.

William Mitchell, Cheviot Mills, Budge Budge, Bengal, India.

William Alan Vose, 35, Parkway, Seven Kings, Essex.

Graduate.

Ellis Robert Chamberlain, 17, Chalk Road, Plaistow, E.13.

Transferred from Companion to Member.

Geoffry Anderson, *c/o* Fyvie & Stewart, Box 1210HH, G.P.O., Sydney, Australia.

BOOKS ADDED TO THE LIBRARY.

PURCHASED.—

British Engineering Standard Specifications:—

No. 44—1909. Cast Iron Pipes for Hydraulic Power. 2/2 post free.

No. 164—1924. Limits and Fits for Engineering. 2/2 post free.

No. 190—1924. British Standard Whitworth (B.S.W.), Bright Hexagon Bolts, Nuts, Set-Screws, Split-Pins, Washers and Studs, Dimensions. 2/2 post free.

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No. 327—1928. Derrick Cranes. 2/2 post free.

"Naval Electrical Manual, 1928." Published by H.M. Stationery Office (by Authority of the Lords Commissioners of the Admiralty). Price 12/6.

"Report of the Fuel Research Board for the Year ended 31st March, 1929." Published under the Authority of His Majesty's Stationery Office by the Department of Scientific and Industrial Research. Price 2/-.

"Lloyd's Calendar, 1930." Published at Lloyd's, London, E.C.3. Price 3/6.

PRESENTED BY THE PUBLISHERS:

Electric Arc Welding Operator's Handbook, published by Alloy Welding Processes, Ltd., Ferry Lane, Walthamstow, London, E.17. Pp. 38. Illustrated.

The A.W.P., Ltd., in publishing this Operator's Handbook supply most useful information to those interested in repairs of all kinds. The treatise relates principally to the various electrodes necessary for different kinds of metals, ferrous and non-ferrous.—A.J.

British Engine, Boiler and Electrical Insurance Co., Ltd.—Technical Report for 1928. Pp. 150; numerous illustrations. Published by the Company at 24, Fennel Street, Manchester. Price 7/6.

Of late years welding practice has advanced to such an extent that it not only competes with the older methods of assembly, but completely supplants them in certain directions, and is now a recognised factor in the engineering world; consequently the Technical Report of the British Engine, Boiler and Electrical Insurance Co., is of particular interest, as it is almost exclusively devoted to a detailed description of an exhaustive series of tests and investigations by the Company's staff into the use of fusion welding, mostly for non-fired pressure vessels.

The Report contains definite recommendations and provisional rules have been prepared for the guidance of manufacturers making fusion-welded vessels.

It is pointed out in the preface that the use of welding for pressure vessels is extending, and it is of the utmost importance that this should be controlled and confined to legitimate channels. It would no doubt have been preferable had some authoritative body taken steps in the matter, but since none in this country has done so, the company, as being to some extent in a tutelary position in regard to the public, has decided to conduct its own investigations and to publish the results, and the inferences drawn therefrom. If as a result official regulations are issued, the position which exists—some claiming that welding is suitable for all purposes, and others damning it for any—will be simplified.

The tests carried out have necessarily been of an extensive nature, including electric arc welding, carbon arc welding, and acetylene welding. These tests are tabulated, together with micro-prints, sulphur prints, and photographs, also the form in which some of the test pieces were especially designed for the enquiry.

Regulations are required if the legitimate development of welding is not to be retarded, and until such regulations are framed and enforced it is inevitable that trouble and disappointment will be the lot of makers and purchasers alike.

A. J.

BOILER EXPLOSION REPORTS.

REPORT No. 2968. STEAM TRAWLER *Harvest Moon*. O.N. 120335.

Investigated and reported upon by Mr. F. Rae, B.o.T. Surveyor, London.

The boiler was of the usual marine type. It was 8 feet long, 8 feet 6 inches in internal diameter, and fitted with two plain furnaces 2 feet 8 inches outside diameter. The combustion chambers were separate and the back plates were originally 17/32nds inch, the side wrapper plates 15/32nds inch and the bottom wrapper plates 9/16ths inch in thickness. The backs of the combustion chambers were stayed by screwed stays $1\frac{1}{4}$ inches in diameter, pitched $8\frac{1}{4}$ inches horizontally and $7\frac{1}{2}$ inches vertically. The combustion chamber side stays were $1\frac{1}{8}$ inches in diameter, pitched 8 inches vertically and 6 inches horizontally, and the tops of the chambers were supported in the usual manner by girders and stays.

The necessary mountings were provided, including two spring loaded safety valves which, it is stated, operated at a working pressure of 110 pounds per square inch. The boiler was constructed for a working pressure of 130 pounds and was stamped as having been tested in 1904 to 260 pounds per square inch.

The boiler was made by Messrs. Riley Brothers, Stockton-on-Tees, in 1904, and was, therefore, about 24 years old.

No repairs had been carried out since the present owner acquired the boiler in September, 1926. There is no available record of repairs prior to that date, but welding had been carried out on the landing edges and flanging of the starboard combustion chamber back plate, also some building up on the bottom wrapper plate.

No adequate and regular examination of the boiler had been carried out.

The boiler was not insured.

The explosion was of a minor character. A hole about 5/16ths inch in diameter was formed in the lower wrapper plate of the starboard combustion chamber, through which the contents of the boiler escaped.

The wrapper plate, having been thinned by severe corrosion on the water side, was unable to withstand the ordinary working pressure of the boiler.

This vessel was built in 1904 by Messrs. Crabtree and Company, Limited, Great Yarmouth. She was formerly named *Joe Mudd* and *Progress*. The firm that previously owned the vessel is defunct, and no information regarding the ship, before the present ownership, has been obtained. She was purchased from Kent Trawlers, Limited, on the 27th September, 1926, by Mr. Stanley Rowden. Since that date the vessel has been employed fishing from Ramsgate.

The boiler was originally constructed for a working pressure of 130 pounds per square inch and it has not been ascertained when the working pressure was reduced to 110 pounds. It is stated to have worked without trouble since the vessel was acquired by the present owner.

The vessel had been fishing prior to the explosion and returned to Ramsgate on Friday, the 16th November, with her catch. The boiler was working on Saturday morning supplying steam to the winch and when the cargo was discharged fires were banked until 11 p.m. that evening. At that time everything appeared to be in order and steam was raised, the vessel proceeding to sea at 1.15 a.m. on Sunday, the 18th November.

About half an hour after leaving Ramsgate there was a slight explosion and water was observed issuing from the starboard furnace, the fire being soon extinguished. The engineman stopped the engines and tried to maintain the water level by means of the donkey pump, but without success. He then re-started the engines and worked the steam off the boiler. The skipper was informed of the position and, as the vessel was near her home port, it was decided to request towing assistance from the *Kestrel* which was in the vicinity. The latter took the *Harvest Moon* in tow and Ramsgate was reached at 4 a.m. without mishap.

When the boiler was examined it was found that a hole about 5/16ths inch in diameter had formed in the bottom wrapper plate of the starboard combustion chamber, the plate having been thinned by corrosion on the water side. An attempt was made by the local repair firm to build up the wasted part by welding, but the plate buckled and this method was abandoned. They then decided to renew the bottom of the combustion chamber, that is the lower wrapper plate and a portion of the back plate.

These parts had been cut out when I inspected the boiler and the repairs that were in hand were found satisfactory and sufficient to restore the soundness of the boiler. The new plates fitted were $\frac{5}{8}$ inch in thickness and new water space stays were fitted as required in the plates. The work was inspected on completion and the boiler was examined generally and found in a satisfactory condition.

The advantages of having the boiler properly and regularly examined was impressed upon the owner, who has taken the necessary steps to have it insured with a reputable company.

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

The danger arising from the use of steam boilers that are not regularly inspected by some competent person is emphasised by this explosion. If an inspection had been made the condition of the boiler would have been ascertained and the explosion avoided.

After the explosion had taken place an attempt was made to repair the wasted plate by welding, but this method had to be abandoned because the plate buckled, which appears to indicate that the wastage was widespread. Repairs of this nature should not be undertaken without full consideration and inspection of the defective parts.

The wasted plate has been renewed and the owner has very wisely taken steps to have the boiler insured, which should entail regular inspection.

REPORT No. 2984. S.S. *Kildrummy*. O.N. 144825.

The circumstances were investigated and Report made by Mr. G. Brown, B.o.T. Surveyor, Aberdeen.

The boiler was a donkey boiler of the Blake type, 6 feet internal diameter and 12 feet 6 inches total height. The shell was a vertical cylinder with a hemispherical top. The upper half of the firebox was cylindrical, the lower half being in the form of an oblique truncated cone. The bottom plate of the firebox was 19/32nds inch thick and was attached to the lowest ring of the shell by a double riveted seam. The shell plate at this part was 15/32nds inch thick. Smoke tubes were arranged horizontally between the upper part of the firebox and the shell. The usual mountings were provided, including a pair of spring-loaded safety valves adjusted to lift at a pressure of 100 lbs. per square inch.

The boiler was made by the Blake Boiler, Wagon and Engineering Company, Limited, Alliance Works, Darlington, in November, 1924. It was therefore not quite four years old at the time of the explosion.

About March, 1925, all the rivets were recaulked in the seam by which the case of the firebox was attached to the shell. The wasted portion around a small hole which appeared in the shell plate close to the blow-down cock was built up by means of electric welding in June, 1928. These appear to have been the only repairs made.

The boiler was surveyed during construction by Surveyors to Lloyd's Register of Shipping, who witnessed a hydraulic test to 200 lbs. per square inch on completion. At the time of the explosion the boiler had not become due for the next Lloyd's survey. In the meantime, the boiler had been under the superintendence of Messrs. Pirie and Smith, Consulting Engineers, Aberdeen, and had been inspected by the chief engineer of the vessel.

The explosion made a loud report, a hole about $\frac{3}{4}$ inch by $\frac{3}{8}$ inch being formed in the shell close to the bottom of the boiler and near the back. Through this the water and steam escaped from the boiler.

Sufficient allowance had not been made for the upward expansion of the firebox when at its working temperature. Undue mechanical stresses were thereby imposed locally on the lower shell plate, which became corroded and reduced in thickness until it could not withstand the pressure to which it was subjected.

The S.S. *Kildrummy* was built in December, 1924, and the donkey boiler was installed at the same time. On the 8th June, 1928, a small hole was discovered in the shell just below the blow-down cock. This was repaired by electric welding. On the 23rd October, 1928, at 12.30 p.m., while the chief engineer, Mr. W. L. Sang, was on deck, he heard a report like a rifle shot. Owing to dense volumes of steam he was unable to enter the fidley door, so he proceeded to the stokehold via the engine room. When the stokehold was accessible he had the donkey boiler fire drawn and when the steam had cleared away an examination revealed a hole $\frac{3}{4}$ inch by $\frac{3}{8}$ inch in the shell at about the same height as, but about 4 feet 2 inches nearer the back of the boiler than, the first hole. When the defective plate was removed from the boiler careful measurement showed that it had become considerably reduced in thickness over an area of from one to four inches vertically and extending for more than half the circumference of the boiler in the form of a band a few inches above the seam whereby the firebox was connected to the shell. As the boiler, which was situated in a recess in the centre of the stokehold bulkhead, was accessible all round, the lower part of the boiler was not likely to become damp, and, as the shell plate below the furnace attachment seam had not corroded, the bottom of the boiler must have been dry. According to the evidence of the chief engineer, who thoroughly examined the boiler on the 19th August, 1928, there were no signs of leakage from this or any of the other boiler seams, either by bulging of the lagging which covered the seams or by dampness below the lagging. Both of these defects it will be noted occurred before the boiler was four years old and several reasons were put forward to explain such unusual occurrences. These included the following:—

(1) Inferior plate material.
(2) Injurious boiler cleaning fluid.
(3) Composition of lagging.
(4) Leakage from seams covered by lagging.

No good case, however, could be made for any of these and it would appear that the real cause was faulty design causing undue mechanical stresses to be imposed on the plates forming the lower part of the shell and firebox.

In boilers of types similar to this it is frequently the practice to carry the downward load, caused by the steam pressure on top of the firebox, etc., by means of a specially thick base ring, by which the firebox is connected to the shell. In the present case, however, it appears to have been the intention of the designer to carry most of this load on two plate stays suspended from the crown of the shell. These were of substantial construction, each being 11½ inches by 15/16ths inch connected to the shell and fire-box crowns by double angles 3½ inches by 3½ inches by ½ inch. Under a cold hydraulic test everything would appear to be in order, but with the boiler under working conditions and the temperature of the firebox plates much greater than that of the outer shell, things would be different. The firebox having become longer and being unable to expand upwards on account of the rigidity of the staying system of the furnace crown would exert a downward thrust, which would pass along the cone-shaped plates of the furnace side and tend to push outward the bottom of the shell plate, at the same time throwing considerable stress on the base of the firebox. That this was the action that had been taking place appears to be proved by the following:—

(1) The bottom of the shell plate was in a wasted condition for nearly the entire circumference and for from one inch to four inches vertically.

(2) Where the shell plate had been stiffened locally, by means of a mudhole compensation ring, etc., the plate reduction was more severe but extended for a shorter distance vertically. It was at such a place at this, just below the riveted pad for the blow-down cock, that the first hole appeared in June, 1928.

(3) Where the thrust was in a practically vertical downward direction, as at the back of the firebox, the base of the firebox plate suffered; also where the shell plate was stiffened by means of the plate overlap at the double riveted vertical seam.

(4) At the front of the boiler, where the mouth piece of the firing hole diffused the thrust, the plates did not suffer greatly.

(5) Slight grooving of the firebox crown, close to the heel of the back stay, shows that there has been an upward thrust there.

The boiler has since been repaired under the supervision of Surveyors to Lloyd's Register. Most of the lower ring of the shell, which was originally 15/32nds inch thick, has been replaced by a plate $\frac{5}{8}$ inch thick, and the base of the firebox has been reinforced as required by electric welding. The boiler will in future be carefully watched to see that further trouble does not arise.

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

This boiler had apparently been in use less than four years, and the unusual wasting of the lower part of the shell is attributed to faulty design. Apparently it became necessary a few months after the boiler was built to recaulk all the rivets securing the base of the furnace to the shell, and, later, to repair the lower part of the shell where a small hole had developed. It would have been prudent when the latter repair was effected to have ascertained definitely the extent of the wastage of the shell plate, which must then have been very serious.

REPORT NO. 2987. S.S. *Constance*. O.N. 115934.

Report No. 2987 deals with an explosion in the boiler of the S.S. *Constance*, investigated by Mr. D. G. Guthrie, B.o.T. Surveyor, Leith.

The *Constance* is a vessel of 166 tons gross, registered at Leith and engaged in the coasting trade. She was built in 1902, and was purchased by the present owners in 1914.

On 25th March, 1929, about 4 p.m., the vessel left Aberdour for Grimsby, and proceeded down the Firth of Forth without any incident of note until 8.15 p.m., when the explosion occurred without warning, the steam pressure being at the time 110 pounds per square inch.

The boiler and engine are in the same compartment, the engine platform being about one foot higher than the firing platform in front of the boiler. The engineman had just attended to the engine, and was about to step down to the firing platform when the explosion occurred. He and his assistant, considering that it might be impossible to maintain the water level in the boiler, drew the starboard fire, and being unable to approach the port fire from the engineroom, they extinguished it by means of a hose manipulated from the deck.

At 9.55 p.m. the vessel was taken in tow by the S.S. *Rattray Head* (a vessel belonging to the same owners) and arrived in Leith at 2.30 a.m. on 26th March. The defective part was electrically welded so as to fill the hole and reinforce the adjacent plating, and I inspected it after this had been done. A satisfactory repair has been made.

There is no evidence that the boiler had required any repairs prior to 1914. Of recent years, defects have developed in the combustion chambers and were dealt with as previously mentioned. Mr. Alexander Reid, the owners' superintendent, has been in sole charge of the boiler as regards inspection and maintenance since 1915. He has had considerable experience in the inspection of boilers and is the holder of a Board of Trade certificate of competency as first class engineer. He states that the collision chock was removed about two years ago and he did not consider such wastage as the plate had then sustained to be alarming. The plate after removal of the chock was thoroughly chipped and painted and the chock replaced. The space between the collision chock and the boiler would retain wet ashes, the moisture content of which would be maintained by the frequent damping of ashes against the boiler and plate. The conditions, therefore, favoured active corrosion, which finally reduced the thickness of the plate until it could no longer withstand the pressure. The plate was also corroded internally about one-eighth of an inch in depth over a considerable area.

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

The part of the boiler end plate which failed was hidden by the collision chock and could only be properly examined by having the chock removed. The explosion shows how necessary it is during inspection to pay special attention to any part of a boiler which cannot in the ordinary way be seen, especially where the plates are subject to corrosion due to the wetting of hot ashes or other causes.

This is another case in which the Insurance Company covering the vessel did not require inspections of the boiler to be made.

REPORT No. 2996. S.S. *Inanda*.

O.N. 147310.

Report No. 2996 deals with an explosion from the auxiliary stop valve chest on the S.S. *Inanda*, the cause of which was examined by Mr. W. L. Watson, B.o.T. Surveyor, London.

The combined valve chest was made of cast iron from $1\frac{1}{8}$ ins. to 1 3/16th ins. in thickness in the body, and contained the header and auxiliary stop valves; the former, a screw lift valve, was directly over the outlet from the boiler and admitted steam under the auxiliary stop valve, which was of the non-return type. The auxiliary steam pipe branch had a bore of six inches, and the header branches, port and starboard, were five inches in internal diameter. In addition, there was a branch two inches in diameter from under the header valve to take the mixing steam valve, and also a branch of similar size above the auxiliary valve to which was fitted the circulating steam valve for the superheaters.

The length of the chest was $32\frac{1}{2}$ inches and its breadth $19\frac{1}{2}$ inches, both dimensions taken over the flanges. The casting was provided with a flanged support under the part forming the auxiliary stop valve chest.

Two drain cocks, each having a bore of $\frac{5}{8}$ inch, were fitted, one above and one below the auxiliary stop valve.

The valve chest and cover were fractured, the centre portion of the cover being blown out of position, and after the explosion it was found to be lying on the top of the boiler close to the chest. The explosion was caused by water-hammer action.

The *Inanda* is a steel single screw steamer of 5,985 tons, of the passenger and cargo type, and was employed in the West Indian trade. She has one auxiliary boiler and two double-ended main boilers, fitted with superheaters, which supply steam at 220 pounds pressure to quadruple expansion engines.

The vessel arrived at London from abroad on the 6th instant. The main boilers and their mountings were then shut down for cleaning, overhaul and periodic inspection. The auxiliary boiler was kept continually at duty supplying steam in connection with the deck machinery, dynamo engines and heating of crew's quarters. Steam was, however, shut off the auxiliary steam range about 5.30 p.m. on the 8th April, to enable the port and starboard auxiliary stop valves on the main boilers to be overhauled, and, during the same evening, that work being completed, steam was again turned on, and the auxiliary range remained under steam pressure until the explosion occurred.

On the 13th instant, owing to certain ballast tanks having been filled, the vessel took a list of about four degrees to port. The list was maintained until the 15th instant, when, at about

8 a.m., the filling of the starboard fresh-water tank was commenced. The list on the vessel was gradually reduced, until, at about 11.30 a.m., the vessel reached the upright position, but immediately afterwards took a slight list to starboard. At the same time a dull report was heard from the top of the boilers, followed by an escape of water and steam. The stop valve of the auxiliary boiler, which, fortunately, had only been opened slightly, was shut immediately and the emission of steam stopped. An investigation showed that the port auxiliary stop valve chest had been damaged in the manner already described, and it was also observed that the appearance of the top of the boiler indicated that a considerable quantity of water must have escaped when the explosion occurred.

After the vessel took a list to port on the 13th instant, water would collect in the port auxiliary steam pipe, and, as it was allowed to remain there, conditions favourable to water-hammer action existed when the vessel was brought to the upright position and the explosion resulted.

The chest appeared to be of ample strength for the purpose intended, and no old flaws were found in it when examined after the explosion.

Additional shut-off valves are now being fitted in the auxiliary steam pipe range at positions marked A on Plate II. This will enable certain sections of piping to be shut off when not required. The drains will then be opened and the pipes kept clear of water, and a repetition of the conditions which led to the explosion will be avoided.

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

The arrangement of the auxiliary steam pipes was such that when any one of the three boilers was used separately for supplying steam to the auxiliary range, there would be no flow of steam in one section either on the port or starboard side according to which boiler was in use. Very little fall was provided in the lead of the pipes and consequently any list to the side away from the boiler in use, would cause condensed steam to collect and conditions favourable to water-hammer action would be set up. A drain cock would not be effective in such a case unless set to drain continuously any water that might collect, or, alternatively, fitted with an efficient automatic steam trap. This is the second explosion that has taken place on board this vessel due to water-hammer action, but now that shut-off valves have been fitted to isolate sections of the pipe line not in use, and provided each section is drained before the isolating valve leading to that section is opened, a repetition of the conditions which led to the explosion is improbable.

REPORT No. 3008. Explosion from a steam stop valve on the Steam Trawler *Powis Castle*.

The investigation was undertaken by Mr. N. S. Couch, B.o.T. Surveyor, Swansea.

The valve was made of cast brass with an overall length of 7 inches between the flanges which were 5 inches diameter and $\frac{5}{8}$ inch thick. The body of the valve was $3\frac{1}{8}$ inches outside diameter with a thickness of $\frac{1}{8}$ inch at the side which failed and 3/16ths inch at the other. The diameter of the valve was $1\frac{1}{2}$ inches and that of the inlet and outlet branches $1\frac{3}{8}$ inches. The working pressure was 180 pounds per square inch.

The *Powis Castle* is a vessel of 275 tons gross and 107 tons net registered tonnage and is propelled by a set of triple expansion engines taking steam from one single-ended boiler working at a pressure of 180 pounds per square inch. The vessel was built in 1916 by Messrs. Smiths Dock Co., Ltd., Middlesbrough, and was engaged in the fishing industry. The valve which failed was fitted direct to the top of the boiler and was used for controlling the supply of steam to the whistle.

At about 4 a.m. on the 13th February, 1929, while the vessel was off the Old Head of Kinsale, Ireland, the second engineer, who was on watch, reported to the chief engineer that steam was escaping from the whistle valve. On examination it was found that a piece of metal about $\frac{3}{8}$ inch in diameter had blown out of the body of the valve below the seat. As the metal appeared to be very thin the hole was enlarged in an attempt to get a sufficient thickness of metal to tap the hole and fit a screwed plug. This, however, was not successful, so it was decided to reduce the pressure from 180 pounds to 120 pounds per square inch and run for the nearest port, which was Berehaven. On arrival the valve was taken off the boiler and the aperture blanked off. When the vessel returned to Swansea a new valve was fitted. As previously stated, this valve was fitted to the top of the boiler and, immediately above it in the boiler casing, was a hinged iron grating for purposes of access to the boiler top. In such a position it was exposed to the effects of sea water which, in these small vessels, is shipped in fair quantities in heavy weather; further, as the boiler lagging was recessed to clear the valve, this formed a pocket in which sea water would lie until it was evaporated by the heat of the boiler. Under these conditions it might be expected that, sooner or later, the material would be affected, and unless the valve was designed and made of such a uniform thickness as would allow for wastage, or the lagging kept sufficiently clear to permit of a thorough examination, such a failure as is dealt with in this report might be anticipated.

The owners are paying particular attention to similar valves on their fleet of trawlers, and several, with which they were not quite satisfied, have been renewed.

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

The body of the valve chest which failed appears to have been originally somewhat light in construction, so that when subjected for some time to wastage, it became insufficiently strong to sustain the ordinary working pressure. The access of water to the space above the boilers of such small vessels as trawlers is likely to occur unless the covers of the manholes are a good fit and kept watertight. The danger of water entering this space is obvious, and may include serious corrosion on the parts of the boiler shell surrounding the recesses in the lagging where the mountings are fitted.

REPORT No. 3024. S.S. *Rimutaka*.
O.N. 111355.

Report No. 3024 deals with an explosion from a main steam pipe on the S.S. *Rimutaka*. The cause was investigated by Mr. H. Proudfoot, B.o.T. Surveyor, London.

The pipe fractured on the forward side at the neck of the socket joint in a circumferential direction for about two inches, resulting in slight emission of steam.

The explosion appears to have been due to a condition of fatigue in the material of the pipe, caused by the expansion of the main steam range, together with structural movement incidental to the hull and machinery.

The *Rimutaka* is a twin-screw passenger and cargo vessel of 8,997 tons gross register, and was built in 1900 by Messrs.

William Denny and Brothers, Dumbarton. The propelling machinery consists of two sets of triple expansion engines, steam for which is supplied by four single-ended boilers of the cylindrical multitubular type working at 180 lbs. per square inch. The main steam pipes were originally fitted with Pope joints, but for some time past these joints have been in process of substitution as opportunity offers, the pipe which forms the subject of this inquiry being so dealt with in May, 1927.

The vessel left Monte Video for Las Palmas on 17th May last, in continuation of the homeward run from Wellington, New Zealand, to London. On the 21st May steam was observed about the lagging of the main steam pipe to the port engine, and on examination the pipe was found to be fractured as stated. A clamp covering the fracture was fitted as a temporary measure, the revolutions of the port engine were reduced and the vessel headed for Bahia for repairs. The means at this port for executing a suitable repair appear to have been somewhat limited, but after an ineffective attempt to braze over the fracture, a collar of spelter was burnt on to the pipe which successfully withstood a hydraulic test of 250 lbs. per square inch.

This repair, in conjunction with three long bolts fitted as stays between the flanges—a commendable reinforcement—proved sufficient for the remainder of the voyage. The pipe was subsequently broken through in my presence, when it was found that the fracture had extended until complete or partial separation had taken place throughout the section of the pipe. It is probable, however, that a considerable part of this extension occurred during the process of repair which, incidentally, destroyed all evidence regarding the physical condition of the material immediately prior to the explosion.

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

Trouble had been experienced on several occasions with this steam pipe, apparently from concentration of stress due to vibration and expansion, and where such is the case a modification of the arrangement is the only sure method of preventing failure. The repair of copper pipes by brazed socketed joints is not satisfactory for a permanent repair.

BOARD OF TRADE EXAMINATIONS.

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

For week ended 28th September, 1929:—

NAME.	GRADE.	PORT OF EXAMINATION.
Evans, Aaron C.	1.C.	Cardiff
Parry, John M. B.	1.C.	,,
Hewitt, Frank W. R.	2.C.	,,
Davies, Reginald	2.C.M.	,,
Beaton, Charles	1.C.	Leith
Manson, Alexander D.	1.C.	,,
Morris, Alexander S.	1.C.	,,
Reid, David R.	1.C.	,,
Scott, Robert	1.C.	,,
Blackman, Richard J.	1.C.	London
Quack, Bryan M. A.	2.C.M.	,,
Diamond, Harold G.	1.C.M.E.	Liverpool
Edwards, John A.	1.C.	,,
Godfrey, Thomas G.	1.C.	,,
Jones, Evan R.	1.C.	,,
Madrell, Horace H.	1.C.	,,
Mawdsley, Walter L.	1.C.	,,
McRoberts, John	1.C.	.
Parker, Robert S. B.	1.C.	,,
Tomlinson, Harry	1.C.	,,
Wood, John S.	1.C.	,,
Griffiths, Elias	2.C.	,,
Harms, Geoffrey	2.C.	,,
Pinnington, Alfred	2.C.	,,
Silver, Trevor	2.C.	,,
Smith, Walter	2.C.	,,
Dodsworth, George M.	2.C.M.	,,
Forder, John E. P.	1 C.	North Shields
Potts, Frederick J.	2.C.	,,
Sutherland, Gilbert	2.C.	,,
Armstrong, Frederick J. ...	1.C.M.E.	,,
Brand, John W.	1.C.M.E.	,,
Russell, Henry	1.C.M.E.	Glasgow
Simpson, Harold	1.C.M.E.	,,
Andrew, Alexander	1.C.	,,
Cairns, Owen	1.C.	,,
Mattocks, Frank E.	1.C.M.E.	Southampton
Steel, Benjamin H.	2.C.	,,
Mackay, Alexander M.	2.C.	Belfast
Reid, Harold	2.C.	,,
Vogan, Robert J.	2.C.	,,

For week ended 5th October, 1929:—

Thomson, Peter	1.C.M.E.	London
Cowell, Charles H.	1.C.	,,
Lowe, Thomas P.	1.C.	,,
Ottley, George B.	2.C.	,,
Bruce, Andrew F.	1 C.	Glasgow
Cameron, Alexander S.	2.C.M.E.	,,
Kinnear, John T.	1.C.	,,
Thomson, Alexander	1.C.	,,
Biggam, John	2.C.	,,

For we k ended 5th October, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION
Lockhead, James W.	2.C.	Glasgow
McInnes, John	2.C.	,,
McKay, Donald	2.C.	,,
Potter, David	2.C.	,,
Young, James	2.C.	,,
Bradley, Charles D.	1.C.	Liverpool
Campbell, Richard H.	1.C.	,,
Gibson, Leonard J. W.	1.C.	,,
Gray, Charles W.	1.C.	,,
Gurney, George W.	1.C.	,,
Bridge, John H.	2.C.	,,
Butler, Arthur	2.C.	,,
Hunt, Arthur A.	2.C.	,,
Whalley, Sydney B.	2.C.	,,
Clarkson, Edward	2.C.M.	,,
Taylor, Thomas W.	1.C.M.E.	,,
Paul, Sidney	1.C.M.E.	North Shields
Forster, George J.	1.C.	,,
Kane, Charles F.	1.C.	,,
Smith, Fred	1.C.	,,
Turner, Richard S.	1.C.	,,
Robson, Edmund V.	2.C.	,,
Usher, William J.	2.C.	,,
Robinson, John G.	2.C.M.	,,

For week ended 12th October, 1929:—

Gardiner, William O.	1.C.M.E.	London
Campbell, Allan	1.C.M.E.	Glasgow
Colthart, David	1.C.M.E.	,,
Gardiner, Archibald W. ...	1.C.	,,
Miller, Fergusson A.	1.C.	,,
Jarvie, James	2.C.	,,
Weir, James	2.C.	,,
Kirwan, William T.	1.C.	Dublin
Lawson, Frank	1.C.	Hull
Stevenson, Wilfred P.	1.C.	,,
Stokes, Henry J.	1.C.	,,
Tiplady, Edward P.	1.C.	,,
Leathley, David C.	2.C.	,,
Potter, Frederick E.	2.C.	,,
Gillet, Joseph	1.C.	Liverpool
Rochell, Herbert	1.C.	,,
Venables, John C.	1.C.	,,
Barry, Douglas G.	2.C.	,,
Davidson, Thomas H.	2.C.	,,
Tilston, Stanley B.	1.C.M.E.	,,
Kemball, Charles V.	2.C.M.	,,
Bamford, Thomas	1.C.	London
Davies, Henry	1.C.	,,
de Jager, Alfred E.	1.C.	,,
Gavin, James S.	1.C.	,,
Gough, Horace W.	1 C	,,
Munn, Archibald W.	1.C.	,,
Thomson, Richard	1.C.	,,
Lane, George L.	2.C.	,,
Duffy, Arthur P.	1.C.M.	,,
Burke, Anthony V.	1.C.	North Shields
Hoy, William F	1.C.	,,
Forsyth, George H.	1.C.M.	,,

For week ended 12th October, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION
Horsman, George C.	1.C.M	North Shields
Riple, Erling K.	1.C.M.	,,
Elliott, Frank J.	2.C.	,,
Baker, Leonard	1.C.	Sunderland
Kyle, George T.	1.C.	,,
Miller, Thomas S.	2.C.	,,
Peacock, Alfred	2.C.	,,
Robinson, Cyrus W.	2.C.	,,
Smith, Thomas	2.C.	,,
Swan, John W.	2.C.	,,
Brown, Donald E	2.C.M.	,,

For week ended 19th October, 1929:—

Gray, David F.	1.C.M.E.	Leith
Johnson, John M.	1.C.	,,
Robertson, George	1.C.	,,
Videon, James M.	1.C.	,,
Bedford, John D.	2.C.	,,
Robertson, Alexander	2.C.	,,
Wood, Joseph G.	2.C.	,,
Cowell, Charles H.	1.C.M.E.	London
Verano, Frederick E.	1.C.	,,
Woolley, Allan A.	1.C.	,,
Beckingham, Henry C. A. ...	·2.C.	,,
Crawley, Leonard	2.C.	,,
Hogg, Richard W.	2.C.	,,
Gordon, Charles E.	1.C.	Glasgow
Thomson, John K.	1.C.	,,
Cumming, Robert	2.C.	,,
McColl, Angus	2.C.	,,
Procter, John	2.C.	,,
Walker, George S.	2.C.	
Lashmore, Ernest G.	1.C.M.	,,
Thomson, Robert H. B.	1.C.M.	,,
Joyce, Peter H.	2.C.	Southampton
Reynolds, Jack S.	2.C.	,,
Richardson, John A.	2.C.	Cardiff
Walters, Lewis L.	2.C.	,,
Dunlop, Samuel H.	1.C.	Liverpool
Grantham, Eric	1.C.	,,
Griffith, Christopher	1.C.	,,
Wileman, Cyril	1.C.	,,
Milton, James H.	2.C.	,,
Price, Sidney A.	2.C.	,,
Thomas, Ivor	2.C.M.	,,
Mawdsley, Walter L.	1.C.M.E.	,,
McLachlan, John McI.	1.C.M.E.	,,
Woodward, Herbert M.	1.C.M.E.	,,
Nicholson, Charles R.	1.C.M.E.	North Shields
Clement, Henry	2.C.	,,
Forman, Charles E.	2.C.	,,
Frier, John W.	2.C.	,,
Gilbertson, John G. D.	2.C.	,,
Robinson, Leslie	Ex.1.C.	Sunderland
Shilston, Thomas D.	Ex.1.C.	,,
Young, Hugh	Ex.1.C.	,,
Crandell, Thomas C.	Ex.1.C.	London
James, David A.	Ex.1.C.	Liverpool

For week ended 26th October, 1929:—

NAME.	GRADE.	PORT OF EXAMINATION.
Paul, Alexander D.	1.C.	Glasgow
Urquhart, Robert	1.C.	,,
Dickie, Robert W.	2.C.	,,
Jack, Andrew H.	2.C.	,,
Conway, Hugh	2.C.M.	,,
Izat, Alexander	2.C.M.	,,
Livingston, Hugh	1.C.	,,
Cameron, Alexander S.	1.C.M.E.	,,
McArthur, Archibald	1.C.M.E.	,,
Hobart, Henry J.	1.C.M.E.	Liverpool
Wilson, John G.	1.C.M.E.	,,
Bowtell, Albert E.	1.C.	,,
Ferris, Clarence R.	1.C.	,,
Howe, Alfred	1.C.	,,
Smith, James R.	1.C.	,,
Cain, Frank C.	2.C.	,,
Christian, Edward S.	2.C.	,,
Ripley, George A.	2.C.	,,
Thompson, Wallace	2.C.	,,
Coverdale, Henry	1.C.	London
Brown, Herbert H.	2.C.	,,
Plummer, Hugh C.	1.C.M.	,,
Jones, Rhys T.	1.C.	North Shields
Leach, William S.	2.C.	,,
Wilson, Richard	2.C.	,,
Benjamin, Alfred M.	2.C.M.	,,
Russell, William F.	1.C.	Sunderland
Afifi, Amin I.	2.C.	,,
Little, Edwin W. T.	2.C.	,,
Sibson, John P.	2.C.	,,
Strong, George W.	2.C.	,,
Wilson, Robert	2.C.	,,
Worthy, Alfred	2.C.	,,
Somerville, Alfred H.	2.C.M.	,,

member of the Custance Committee which was set up to put the scheme into shape and operation. In October of the same year he became Manager of the Engineering Department of Portsmouth Dockyard. He was subsequently appointed to the Admiralty as Engineering Assistant to the Director of Dockyards, and was promoted to the rank of Engineer Captain in 1916 In this position he also received the honour of C.B. in 1918, and in May, 1919, he was transferred to the Department of the Engineer-in-Chief. He was promoted to Engineer Rear-Admiral in December, 1919, and in June, 1920, on the retirement of Rear-Admiral Edouard Gaudin, C.B., of Belleville boiler fame, he became Deputy Engineer-in-Chief. He succeeded to the highest office open to an engineer officer, that of Engineer-in-Chief of the Fleet, in June, 1922, on the retirement of Engineer Vice-Admiral Sir George Goodwin, K.C.B., LL.D.

Admiral Dixon was elected a Member of the Council of the Institution of Naval Architects in 1923, and received the honour of Knighthood (K.C.B.) in 1924. He is also a Member of the Council of the Institution of Mechanical Engineers. In 1926 Sheffield University conferred on him the honorary degree of Doctor of Engineering, and the same year he was elected President of the Junior Institution of Engineers. In April, 1927, he was elected a Vice-President of the Institution of Naval Architects. He is a Member of the Fuel Research Board, and Chairman of the Committee on the behaviour of materials at high temperatures.

He retired from the Active List of the Royal Navy on the 1st June, 1928, since when he has become prominently identified with recent developments of marine high pressure steam propulsion following his appointment as a member of the Board of Directors of Messrs. Babcock & Wilcox Ltd.

Throughout his career, Admiral Dixon has taken a keen interest in everything relating to the entry, training and status of engineer officers of the Royal Navy, and he gained the affection and confidence of those officers in a very remarkable degree. He had a very important share in adapting the regulations to meet the Selborne-Fisher scheme.

It is gratifying to know that our President is continuing in the vanguard of technical progress in marine engineering, in connection with which his outstanding abilities and wide experience are invaluable.