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Merchant Ship Service Performance Analysis.

BY E. V. TELFER, D.SC., PH.D. (Member).

READ

Tuesday, March 12, 1929, *at* 6.30 *p.m.*

CHAIRMAN : Mr. R. T. WILSON (Vice-Chairman of Council).

The CHAIRMAN : We meet to-night to hear a paper on "Merchant Ship Service Performance Analysis," by Dr. E. V. Telfer. He is the first Doctor of Philosophy in Naval Architecture in this country and is at present Assistant Naval Architect to the Monitor Shipping Corporation, and his duties call for a large amount of research into Ship Performance Analysis. I may say that the Doctor is recognised as one of the foremost authorities on ship propulsion, and has read many papers on this subject.

I am sure that I voice the sentiment of those present when I say that we are deeply indebted to him for having accepted the invitation to be with us this evening, and that we all extend to him a very hearty welcome. I have now great pleasure in introducing the lecturer, Dr. Telfer.

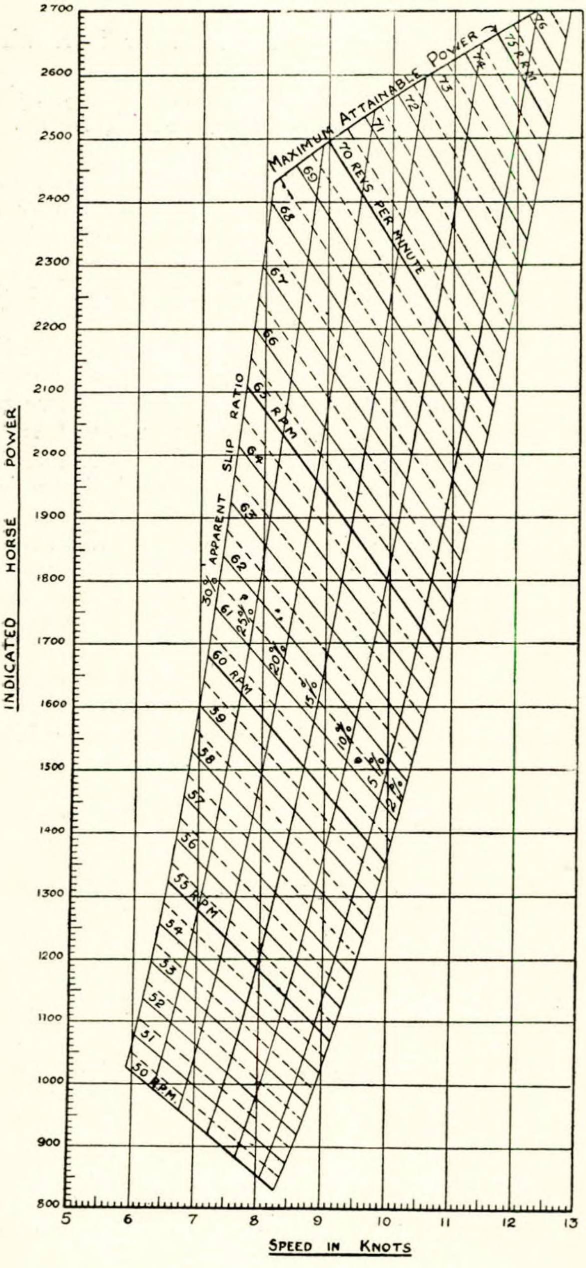
1. When I received from our Council a request to read this paper, I felt that the opportunity thus accorded of securing the views of members so intimately and practically connected with

the everyday aspects of the subject, would fully justify and condone whatever shortcomings the paper itself might possess. It is my intention therefore merely to outline a system of investigating the service performances of merchant ships which has proved of considerable value in my own professional practice; and to present this system more from the standpoint of its use to the marine engineer in his capacity as consultant to the shipowner, than to discuss the matter as a particular branch of the subject of the resistance and propulsion of ships.

2. Probably at no time have the shipowner and his technical advisers been faced with so many alternative and additive means of improving the propulsive economy of merchant ships than is the case to-day. Such alternatives naturally sub-divide themselves into two broad classes: those intended for engine improvement or the generation of power, and those devoted to hull and propeller improvement or the utilisation of power. The acid test of their efficacy applied by the shipowner is reduction of fuel consumption for given speed, or increase of speed on the same fuel consumption. Engineers, however, are inclined to submit pounds per horse-power hour as the test of engine economy, whilst the naval architect endeavours to insist that only power and speed should influence the reviewing of hull economy. Both are right, of course, but in an imperfect world the last word is with the shipowner who asks with some force and considerable truth, "of what use is low pounds per horse-power—whatever that may be—or low power, if the fuel consumption of my vessel is still far too high?" This challenge can only be met by engineer and naval architect sinking their differences — which are not hypothetical—and coming to agreement on the true average power developed by the engines and hence required by the ship. There should be no need here to emphasise that the majority of indicator cards, all generally of the peak variety, returned by sea-going engineers and received by superintendents, are, taken at their face value, utterly spurious either as a guide to engine economy or to the standard of hull performance; there should be no need to emphasise that abstract logs can serve other purposes than merely wasting an engineer's leisure or lumbering a superintendent's office; and that finally, progress is only achieved by a thorough analysis of accurately recorded experience.

To pass judgment, therefore, on any device, calculated to reduce fuel consumption, the task which devolves upon the owner's technical adviser is briefly this: he is required to detect an economy of some x per cent. consequent upon the installation in a vessel of some device, and this despite the wide fluctuations in fuel consumption inseparable from varying coal quality, coal shortage, incidental engine trouble fortuitously inherent or introduced by incidental personnel, the weather and currents experienced and the foulness or cleanness of a vessel's hull—to mention only the more insistent of the usual explanations of a vessel's poor performance. The accomplishment of such a task is obviously not mathematical: it is of necessity statistical. Sometimes the task is simple, as for example when a vessel immediately after installation of a device, easily beats all her previous best performances of consumption and speed. This simplicity is of course merely due to the fact that all the previously mentioned causes of performance deterioration are fortuitously absent from the data compared. It is merely a happy special case of the more general in which all these complications enter to confuse the issue. This issue can only be faced by the systematic collection of accurate statistics and by their accurate interpretation. The statistics requisite for this purpose must admit of the determination of true average horse-power and speed, a reasonable assessment of average weather intensity, the influence of fouling and coal quality, and finally the mean displacement of the ship. Moreover, in the compilation of these statistics one fact of supreme importance must be borne in mind, their purpose is to predict the *life* average performance of the vessel since this average is the final test by means of which a vessel's propulsive merits should be reviewed.

3. Let us now consider this statistical problem in detail, necessarily confining attention solely to the vessel's loaded life. The first requirement is true average power. Its determination was fully dealt with in a paper read by the author two years ago before the North East Coast Institution of Engineers and Shipbuilders. For the sake of completeness, an outline of the method therein proposed is given in an appendix to the present paper. Suffice here to say that a propeller is practically a perfect power absorption dynamometer and when the power it absorbs at any revolutions and slip (or ship's speed) is known, it is a very simple matter accurately to determine the power required at any other revolutions and speed. This can be done most conveniently by constructing for each vessel, from her load trial or service data, what I term a power diagram, a typical example of which is shown in Fig. 1. If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INDICATED HORSE POWER
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8
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10
11
12
13
SPEED IN KNOTS
MAXIMUM ATTAINABLE POWER
76
75 R.P.M.
74
73
72
71
70 REVS PER MINUTE
69
68
67
66
65 R.P.M.
64
63
62
61
60 R.P.M.
59
58
57
56
55 R.P.M.
54
53
52
51
50 R.P.M.
30% APPARENT SLIP RATIO
25%
20%
15%
10%
5%
2½%

Fig. 1.

on a particular voyage this vessel averaged 10 knots on 62 r.p.m., the diagram shows the average power to be 1,520 I.H.P. An engineer returning cards for this voyage would incidentally take them round about 64 r.p.m. at say $10\frac{1}{2}$ knots. His power would probably be returned as 1635·399, more attention being given to the third decimal place than to his seven to eight per cent. overstatement of the efficiency of his job. Further, if his indicator springs became soft, this is generally taken as a cause for self congratulation rather than an obvious test of his common sense in wondering where the extraordinary efficiency of his job came from—and went to.

However, leaving this human side of the subject, it is evident that in the power diagram the superintendent has the means of accurately determining true average power independently of his vessels' engineers, a very important advantage. Power diagrams can be prepared by the method given in the appendix for every type of main engines. They are particularly desirable for Diesel engines and being prepared from the builder's load trial data and hence based upon indicator cards which have much more claim to accuracy than the service Diesel indicator card, are practically a necessity once their use is appreciated. The turbine driven vessel or the turbo-electric vessel admit of simple power diagram construction in terms of shaft horse-power, but one of the most useful applications of the device is to the Bauer-Wach and other combined reciprocating engine exhaust turbine main engines. To avoid the use of a torsionmeter to determine total s.h.p. in these vessels, the power diagram can be prepared from the vessel's loaded performance with the turbine out of action. The method admits of the reliable and fundamental extrapolation of the data to higher powers than those realised; and with the turbine in action, the total equivalent i.h.p. required to turn the propeller at any revolutions at any ship speed can at once be determined from the diagram.

Continued experience with the diagram shows that it holds good as a means of accurately determining average power in all weathers and with clean hull and foul hull. It holds good whether the propeller is bronze or cast iron, provided in this latter case the propeller is undamaged. Increased blade roughness of an ordinary extent does not appear to invalidate the diagram. This is a very important advantage and would appear to be due to the fact that the power required to rotate the propeller is due to two causes, first and primarily the production of thrust, and secondly the overcoming of blade resistance. A rough blade reduces the thrust developed but increases the resistance to turning, and it appears probable that so far as s.h.p. is concerned, these effects practically neutralise each other.

With this means available of accurately assessing average power the superintendent can study the economy of engine room improvements quite distinct from those of the hull. He can now accurately calculate specific fuel consumption and relate it to the calorific value of his fuel, or more simply in the case of coal-burning ships, to the ash percentage of the fuel which in itself for the heavier and less volatile coals is a remarkably close guide to calorific value. Similarly he can separately calculate the efficiency of the hull and related devices by accurate determination of the Admiralty constant, affected however, it is true, by weather, by draught, and by fouling, but at least and at last entirely separated from the efficiency or waste of the engine room.

In what follows, therefore, attention will now be confined to the problems of the efficiency of the hull. We must now first consider the weather question. It is obviously practically impossible for anyone to look down the weather column of a log abstract, when mixed weather has been experienced, and mentally assess the speed loss caused by adverse weather on the voyage. It is equally impossible to evolve any numerical system which will give this speed loss with mathematical accuracy. Such accuracy, however desirable, is not essential. What is required is some system by means of which the major influence of weather can be accounted for.

To study the loss of efficiency due to various broad classes of weather, the author analysed the total life of a number of vessels and calculated the average Admiralty constant in fine, moderate, heavy and very heavy weather classes separately. The interesting result was found that the loss in Admiralty constant from fine weather to moderate, was substantially equal to that from moderate to heavy and from heavy to very heavy. In other words, the total losses in each class were in the ratio of $0:1:2:3$. This implies no loss in fine weather, unit loss in moderate weather, twice this loss in heavy weather and three times in very heavy weather. Thus, if on a particular voyage the respective percentages of fine, moderate, heavy and very heavy weathers are represented by $F+M+H+VH=100\%$, then the total loss in Admiralty constant will be proportional to $(0 \times F + M + 2H + 3VH)$. This factor is a percentage, and when multiplied by the unit loss in moderate weather gives the total loss in Admiralty constant for the particular voyage. Obviously, therefore, this percentage is a fundamental indication of weather severity and may be termed the Weather Intensity. When its value equals zero the weather has been all fine, 100 the weather is equivalent to moderate, 200 to heavy and with 300 the weather has been all very heavy. Thus, once this percentage is known for a particular voyage, it is a simple matter to determine the loss in efficiency due to weather severity. It may be objected, however, that the real difficulty will be to determine this percentage with any pretence of accuracy. Weather, for example, may not be so severe as heavy and yet be distinctly worse than moderate. Again, heavy weather following a ship may not be intrinsically heavy weather so far as the ship is concerned. Similarly, beam weather is generally not so severe as bow or head weather. Finally, it may be objected that the average voyage does not admit of a sufficiently extensive and definite set of weather observations to allow of valid averaging; and in any case that the task is not one for the superintendent but for the navigating officer who makes the observations.

The Weather Intensity previously defined, must thus be capable of adequately allowing for direction as well as severity of weather and must admit of initial specification by the ship's officer. These conditions, fortunately, can be very simply respected. In his official log book the officer is required by law to describe the state of weather watch by watch. He thus has at least six daily weather observations; and these require to be daily booked into their respective class. For this purpose four additional columns should be available in his abstract log headed respectively F, M, H and VH. To distinguish between head or bow, beam, quarter and following weather, take the case of say moderate weather lasting unchanged throughout one day. If this weather were ahead or on the bow, the whole six watches should be booked as moderate, if on the beam three watches should be booked moderate and three fine; and if entirely following, the whole six watches should be booked to fine. A similar gradual stepping-up can be adopted for heavy weather and for very heavy. Again, moderate weather just forward of the beam may be classed four moderate and two fine; abaft the beam, four fine and two moderate; and quarter weather five fine and one moderate. Used with discretion the officer can so split up his watches to obtain quite a sharp definition of the weather throughout the day. To illustrate this weather classification more closely, the following table gives the classes of weather usually distinguished by the navigator, and I append the corresponding watch classification.

TABLE I.—WEATHER CLASSIFICATION.

Description of Weather.	Watch Classification.			
	F.	M.	H.	V.H.
Calms, to light wind, smooth sea	6	—	—	—
Moderate following wind and sea	6	—	—	—
Moderate quarterly wind and sea	5	1	—	—
Moderate wind and sea abaft beam	4	2	—	—
Moderate beam wind and sea	3	3	—	—
Moderate wind and sea forward of beam	2	4	—	—
Moderate head or bow wind and sea	—	6	—	—
Strong following wind and heavy sea	—	6	—	—
Strong quarterly wind and heavy sea	—	5	1	—
Strong wind and heavy sea abaft beam	—	4	2	—
Strong beam wind and heavy sea	—	3	3	—
Strong wind and heavy sea forward of beam	—	2	4	—
Strong head or bow wind and heavy sea	—	—	6	—
Following gale and very heavy sea	—	—	6	—
Quarterly gale and very heavy sea	—	—	5	1
Gale and very heavy sea abaft beam	—	—	4	2
Beam gale and very heavy sea	—	—	3	3
Gale and very heavy sea forward of beam	—	—	4	2
Head or bow gale and very heavy sea	—	—	—	6
Hurricane weather of whatever direction	—	—	—	6
Total	26	36	38	20

It should be noted that each type of weather described refers to wind and sea in the same direction. Where this is not the case, the navigator must judge for himself the equivalent classification. For example, in ballast or with high deck cargoes, greater weight would be given to the wind direction than when loaded with other cargoes.

Now, imagine this table to be the daily weather description for a particular voyage, each class of weather persisting throughout the particular day. To obtain the weather intensity for the whole voyage, we first add up the total watches in each class. These totals are respectively 26 F: 36 M: 38 H: 20 VH: the complete total of all watches being 120. Next add the moderate total to twice the heavy to three times the very heavy, i.e.,

$$36 + 2(38) + 3(20) = 172.$$

Divide this by the total number of watches and express as a percentage, viz.:

$$\frac{172}{120} \times 100 = 143.$$

Thus 143 is the average intensity of the weather detailed in the above table; and it is submitted that to characterise weather in this form has obvious advantages over any mere attempt to describe average weather. Anyone who has read a captain's dismal or eulogistic description of the weather which he has experienced on a particular voyage will realise that such descriptive summaries are practically useless, since inevitably far too much weight is given to some particularly good or to some particularly bad patch in the voyage. The numerical system here outlined, however, has the outstanding advantage that every watch throughout the voyage is automatically given full weight in the determination of average weather. Whilst this system is essentially based upon descriptive observations it appears probable from a study of model experiments in waves, that the numerical value of the intensity can be simply correlated with the length and height of the waves met with. Moreover, experience with the system will show that although the navigator's daily classification be quite coarse, provided it is free from bias, it is remarkable how little the voyage average intensity can be changed by any subsequent overhaul of his observations in refinement.

It should be noted that the classification given in the foregoing table presumes the particular weather to last throughout six watches or one day. Actually it is applied by the navigator as referring to each watch regarding each watch as a day, and after totalling up the respective classes, the totals should be divided by six before entering in the daily abstract. There is, of course, no need to work to a fraction of a watch in this abstract and only the nearest whole number should be entered.

The author has had extensive experience with the routine use of this system and can confidently recommend it. One important fact emerges from this experience. The average Weather Intensity met with by a large number of vessels in world trade over a long period of time works out at practically 100 or moderate. It follows from this that a vessel engaged in world trade will, after a long period of time, average weather of 100 intensity. The recognition of this fact requires that in any presentation of ship performance statistics to shipowners and among shipowners, these statistics should all refer to weather of 100 intensity. After the first year of service a vessel may, however, have only averaged 60 weather or on the other hand 140 weather, and her statistics are thus not comparable with the standard. It is, therefore, necessary to determine from her statistics the average loss in Admiralty constant with increase in Weather Intensity. This, whilst desirable, is not strictly necessary, for it is a curious fact that merchant ships over a very wide range of size seem to lose 60 points in Admiralty constant for 100 points increase in Weather Intensity; and as ultimately, all world trading vessels will have an average intensity somewhere in the vicinity of 20 points on either side of 100, it is not essential in correcting their Admiralty constant to standard weather, that the influence of weather on Admiralty constant be any more accurately known than is got by accepting this average value of 60 per 100.

We have now arrived at the point when we can be morally certain of a vessel's true average speed, power and displacement and hence Admiralty constant; we can define and measure the average weather it has experienced and finally we can eliminate the influence of weather on Admiralty constant by standardising on the world average weather intensity of 100. There is still a further factor to be considered, and this is the influence of fouling. To determine this influence for any particular vessel, what we obviously require to do is to take each voyage Admiralty constant, correct to 100 standard weather and note the variation in the constant with mean days out of dry dock to mid point of voyage. Analysing thus a large number of ships, the author has found that a vessel loses on the average 25 points in Admiralty constant per 100 days out of dry dock. This particular rate of fouling refers to standard weather and also to the point when the vessel is 100 days out of dock. Calculating the average days out of dock for a large number of vessels, it is found that they average 100 (implying docking every 200 days). This fact can again be respected and offered as a standard to which all statistics can be reduced, since if long period average weather is 100 intensity, and average days out of dock 100, these external conditions are obviously those which influence the long period commercial earnings of the ship.

One point in connection with this fouling correction should be noted. As it stands it presumes that fouling loss increases

TABLE II.

VESSEL A.—SERVICE ANALYSIS.

No.	Ports and Dates.	Days.	Distance	Revolutions.	Bunkers.	Ash.		Mean Draught.	Displace-ment.	Displ'mnt. × Days.	Weather Classification.					Speed.	r.p.m.	Slip.	i.h.p.	Coal per day.	lb. i.h.p. hr.	Coal Coefft.	Adm. Coefft.	Days out of dry dock.	Days out of dry dock × days on passage	No. of boilers in use.	Cargo.	Current A.C.	Current Weather Intensity.	Current Days out of Dock.	Standard A.C.
						Weight.	Per cent.				F.	M.	H.	V.H.	In-tensity																
	Launched 11-6-26																														
1	Baltimore—Immingham 27-8-26 to 12-9-26	14·986	3,603	1,353,770				24'-7½"	13,470	201,860	64	25	2	—	32	10·01	62·7	10·14	1955				290	84	1,255	3	Coal	290	32	84	245
2	Baltimore—Portland ... 9-10-26 to 26-10-26	16·600	3,271	1,452,040				24'-1½"	13,170	218,620	11	12	40	37	203	8·21	60·8	23·90	1975				149	129	2,140	3	Coal	214	121	108	229
3	Baltimore—St. Nazaire 30-11-26 to 18-12-26	17·457	3,803	1,529,750				24'-1¼"	13,160	229,730	17	41	44	3	131	9·08	60·85	15·96	1880				227	181	3,150	3	Coal	215	125	133	242
	Docked, Tyne 17-1-27																														
4	Tyne—Port Pirie ... 16-2-27 to 9-4-27	50·781	12,217	4,579,700				21'-2"	11,530	585,505	180	88	32	12	60	10·02	62.6	9·98	1920				267	56	2,840	3	Coke	242	92	94	236
5	Thevenard—Rotterdam 18-5-27 to 17-7-27	56·861	12,502	5,018,880				24'-6¼"	13,410	762,505	151	83	78	21	91	9·16	61·3	15·92	1915				227	151	8,590	3	Grain	235	91	115	233
	Docked, Tyne 6-8-27																														
6	Portland O—Naples ... 25-9-27 to 3-11-27	38·821	9,264	3,495,250				24'-7"	13,440	521,755	194	35	4	–	18	9·94	62·5	10·30	1925				289	70	2,720	3	Grain	244	77	107	232
7	Vancouver—Avonmouth 14-1-28 to 25-2-28	41·119	8,647	3,578,550				24'-1¼"	13,160	541,125	107	81	53	7	84	8·76	60·4	18·30	1870				200	182	7,480	3	Grain	237	78	119	228
	Docked, Cardiff 6-3-28																														
8	Vancouver—Rotterdam 20-4-28 to 29-5-28	37·182	8,883	3,324,900				24'-7¼"	13,480	501,210	154	61	9	—	34	9·95	62·3	10·28	1915				292	65	2,420	3	Grain	244	72	112	230
	Totals and Means ...	**273·807**	**62,190**	**24,332,840**				**23'-10¼"**	**13,010**	**3,562,310**	**878**	**426**	**262**	**80**	**72**	**9·46**	**61·7**	**14·30**	**1920**				**244**	**112**	**30,595**						

TABLE III.

VESSEL B.—SERVICE ANALYSIS.

No.	Ports and Dates.	Days.	Distance.	Revolutions.	Bunkers.	Ash.		Mean Draught.	Displacement.	Displacement. × Days.	Weather Classification.					Speed.	r.p.m.	Slip.	i.h.p.	Coal per Day.	lb. i.h.p. hr.	Coal Coefft.	Adm. Coefft.	Days out of Dry Dock.	Days out of Dry Dock × days on passage.	No. of Boilers in use.	Cargo.	Current A.C.	Current weather intensity.	Currer days o of Doc
						Weight.	Per cent.				F.	M.	H.	V.H.	Intensity.															
	Docked, Tyne 15-10-25																													
1	Tyne—Port Pirie ... 27-10-25 to 16-12-25	49·459	11,984	4,445,000				21′-7″	11,700	578,670	143	83	42	30	86	10·1	62·3	7·68	1,850				287	37	1,830	3	Coke	287	86	37
2	Bluff—Dunkirk ... ... 17-2-26 to 11-4-26	52·517	12,189	4,807,010				20′-11½′	11,325	594,755	80	150	62	24	110	9·67	63·4	13·10	2,020				228	152	8,000	3	Wool & Zinc Concentrates	252	97	97
	Docked, Tyne 23-4-26																													
3	Newport News—Barrow 8-7-26 to 22-7-26	13·521	3,328	1,195,400				24′-8¾″	13,520	182,800	62	15	4	—	28	10 25	61·4	4·64	1,745				350	81	1,095	3	Coal	264	90	95
4	Philadelphia—Middlesbro 25-8-26 to 9-9-26	15·204	3,572	1,327,000				24′-8¼″	13,500	205,255	49	41	1	—	47	9·79	60·5	7·82	1,685				316	132	2,010	3	Coal	270	85	99
5	Baltimore—Chatham 10-10-26 to 27-10-26	15·916	3,400	1,380,700				24′-7½″	13,450	214,070	9	15	36	36	203	8·90	60·2	15·70	1,780				224	170	2,700	3	Coal	264	98	107
6	Baltimore—Immingham 1-12-26 to 17-12-26	15·756	3,626	1,390,500				24′-1½″	13,170	207,510	27	35	26	7	114	9·60	61·3	10·70	1,800				278	230	3,620	3	Coal	264	100	118
	Docked, Tyne 3-1-27																													
7	Tyne—Port Pirie ... 21-1-27 to 14-3-27	51·146	11,994	4,448,890				21′-2″	11,450	585,620	121	131	44	15	85	9·77	60·4	7·6	1,685				281	34	1,745	3	Coke	271	96	94
8	Geelong—Naples ... 15-4-27 to 26-5-27	39·312	9,186	3,467,690				24′-3″	13,250	520,880	133	63	38	—	59	9·74	61·3	9·5	1,780				290	123	4,840	3	Grain	273	91	102
9	Mejillones—Bordeaux ... 22-7-27 to 26-8-27	32·841	7,263	2,878,560				24′-8″	13,480	440,070	80	90	24	—	75	9·21	60·8	13·2	1,800				246	217	7,120	3	Nitrates	273	88	116
	Docked, Tyne 16-9-27																													
10	Tyne—Port Pirie ... 2-10-27 to 21-11-27	50·625	12,092	4,502,880				21′-0″	11,350	574,590	97	163	20	24	90	9·95	61·7	8·04	1,800				277	41	2,080	3	Coke	272	89	104
11	Port Pirie—Antwerp ... 24-12-27 to 14-2-28	50·985	12,418	4,625,070				24′-1″	13,160	668,260	160	105	35	7	64	10·15	63·0	8·02	1,905				306	125	6,380	3	Zinc Concentrates	275	85	107
	Docked, Tyne 28-2-28																													
12	Prince Rupert—Hull ... 14-4-28 to 24-5-28	38·329	9,329	3,473,040				24′-10″	13,570	520,125	130	74	26	—	55	10·14	62·9	7·80	1,890				313	66	2,530	3	Grain	280	83	103
	Totals and Means ...	**425·611**	**100,381**	**37,941,740**				**22′-10¾″**	**12,450**	**5,292,605**	**1,091**	**965**	**358**	**143**	**83**	**9·83**	**61·9**	**9·42**	**1,825**				**280**	**103**	**43,950**					

Standard A.C.
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uniformly with time. Actually, of course, this is not so, the fouling being less rapid the greater the time. A closer assessment of the fouling loss for D days out of dock is given by $2.5\sqrt{D}$, but since we are principally here concerned with the presentation of long averages, where the days out of dock will not differ very materially from the 100 standard it is immaterial which correction is used. When only the merits of one voyage are being considered the root correction is of course preferable.

We have now finally a means of accurately discussing a vessel's true propulsive performance in standard weather and at standard days out of dock; and it will now be of interest to consider a rather full example of the use of the methods described.

4. Tables II and III give the complete loaded service statistics for two recent 10,000 ton deadweight steamers, sister ships save that one has a hull of normal form and the other the same lines, but built as a corrugated ship. I will refer to these vessels as A and B. For both vessels a power diagram was prepared, there being a slight difference in propeller pitch, quite sufficient to produce a measurable difference in power absorption at given revolutions and ship speed, but having no possible influence on propeller efficiency.

The statistics are presented passage by passage. The first column gives the terminal ports and dates and also the dry docking dates. Column 2 gives the total steaming time pilot to pilot; column 3 gives the total steaming distance pilot to pilot; column 4 gives the total propeller revolutions pilot to pilot; column 5 gives total bunkers (here omitted as our purpose is to compare hulls, and not engine economy); column 6 gives total weight of ash discharged (also omitted); column 7 gives ash percentage (also omitted); column 8 gives passage mean draught; column 9 gives passage mean displacement; column 10 gives the product of 9 and 2, and columns 11 gives weather classification and intensity. These contain the basis statistics as collected from the abstract logs specially drawn up for the purpose. The remaining columns give the corresponding averages, speed, r.p.m., apparent slip, I.H.P., coal per day, lb./I.H.P./Hr., Admiralty constant, coal coefficient, days out of dock, ditto multiplied by days on passage, and finally nature of cargo carried. The four final columns give the vital factors of the whole statistical investigation. The first gives the current values of life average Admiralty constant including the passage in question, the second the corresponding life average weather intensity, the third the corresponding life average days out of dry dock, and the fourth the life average Admiralty constant corrected to 100 weather intensity and 100 days out of dock. A glance at this last column shows how remarkably steady this standard Admiralty constant really is, voyage after voyage. If vessel B be examined closely, however, it will be seen that there is some kind of a periodicity in the figures and this puzzled the author for a long time. It revealed itself particularly when in progressively reporting the results of the comparison of the two ships to the owners, passage by passage, the fluctuation in the economy of vessel B over vessel A was quite apparent. The cause of the fluctuation should have been obvious, but like most obvious things, required looking for by a process of elimination. The key to the fluctuation was found in the mean displacement column. Vessel B was frequently in the coke trade and consequently her mean displacement was on these occasions some 2,000 tons short of that when heavier cargoes were carried; her time in this condition represents practically half the vessel's loaded life. On the other hand, vessel A has only been in this trade on one passage representing less than one-fifth of her total life. Now, if the last column on the two sheets of data is compared with the mean displacement column, it will be seen particularly for vessel B that, starting with two low displacements, the standard constant is low and becomes lower, it rises progressively through several passages in which the displacement is high and immediately falls again at the next low displacement. It builds up again only to fall when its displacement is again low. A's statistics are initially somewhat high due to the influence of favourable currents in the particular trade, but the same peculiarity is also evident. To elucidate this point thoroughly, vessel B's statistics were subdivided into full and low displacement passages respectively, and the respective group standard Admiralty constants obtained. These were quite different, and to test if the variation with displacement was systematic, these group standards, the total life standard and the current life standards were plotted to a base of corresponding displacement as shown in figure 2.

It will be seen that the spots clearly define a curve passing through a flat maximum in the vicinity of the full load displacement and decreasing steadily towards the lower displacements. The curve must obviously pass through zero Admiralty constant for zero displacement, and this fact can be used to extrapolate to lower displacements than those investigated. It offers incidentally an interesting means of connecting ballast and loaded conditions, and a study of its nature together with that of similar curves for other vessels has already thrown valuable light on the relation of upper to lower displacement for highest economy in all conditions. The curve practically exactly follows the variation in hull-effective horse-power Admiralty constant deduced for this particular hull form from model experiment data. It is perhaps just as well that this fact was not appreciated earlier since it shows the accuracy that statistical analysis of service data can possess.

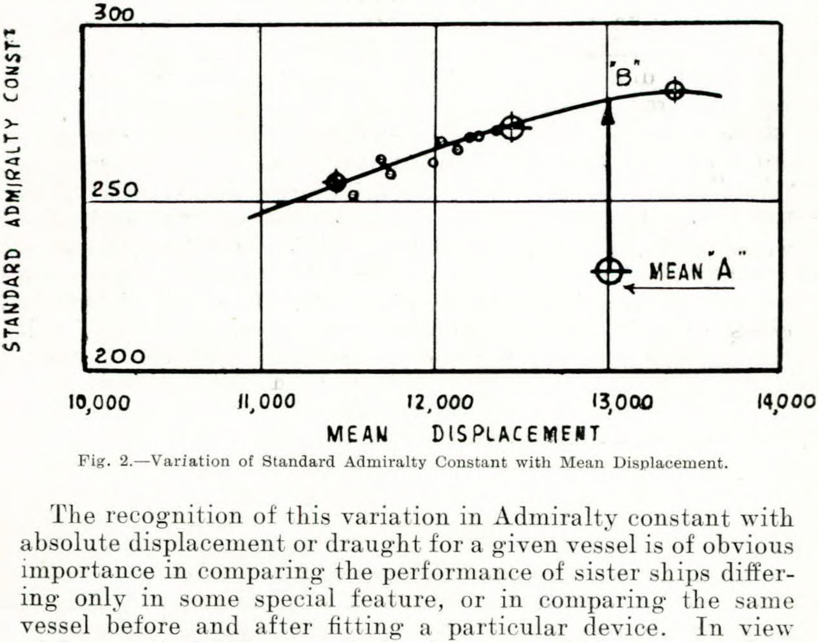

Fig. 2.—Variation of Standard Admiralty Constant with Mean Displacement.

The recognition of this variation in Admiralty constant with absolute displacement or draught for a given vessel is of obvious importance in comparing the performance of sister ships differing only in some special feature, or in comparing the same vessel before and after fitting a particular device. In view of the practical differences in displacement which can take place in service, it is thus essential that such vessels be compared at the same displacement as well as in standard weather and standard days out of dock. Thus, to revert to the comparison of vessels A and B, it follows that the standard Admiralty constant of A should be compared with that of B read off from the diagram in figure 2 at the same displacement. Vessel A has a current standard Admiralty constant of 230 at 13010 displacement. Vessel B at this displacement has a value of 278. The intrinsic economy of B over A is thus 17 per cent.

If no attention were given to weather, fouling or displacement, and merely the true, incidental life average Admiralty constants compared, A's statistics read 244 Admiralty constant on 13010 tons displacement in 72 weather and 112 days out of dock, whilst B's are 280 on 12450 tons displacement in 83 weather and 103 days out of dock. The influence of external conditions thus reduces the economy of B to 13 per cent. instead of 17 per cent. It could easily have happened that these external conditions were reversed and the apparent economy would have been 21 per cent. This shows how important it is to cut out all fluctuations in external conditions as far as possible. For example, a simple way of demonstrating the comparative merits of two vessels is to grade their passage Admiralty constants in descending order of magnitude, neglecting weather, fouling and displacement differences. Although the total average values may have a weather, fouling or low displacement bias, so long as each vessel has sampled the same range of conditions, this grading of the passage Admiralty constants will reveal the intrinsic merits of the two vessels. The better vessel should have maximum values not attained by the worse, and the latter should have minimum values less than those of the former. Table 4 shows this type of presentation for the two vessels previously discussed. It clearly shows the economy of B. In this table, three approximately simultaneous passages for the vessels are indicated, (b) and (c)

Table IV.

Vessel B.	Vessel A.
350	—
316 a.	—
313	—
306	292
290	290 a.
*287	289
*281	—
278 c.	—
*277	*267
246	—
*228	227 c.
224 b.	—
—	200
—	149 b.

NOTE.—Values thus * are at low displacement. Passages a, b and c practically simultaneous on same route. Vessel B some 48 days longer out of dock in each case.

within about eight hours leaving the same port and (a) leaving neighbouring ports within two days of each other. This is a type of comparison very rarely obtainable and is a valuable confirmation of the superiority of B as independently established by the statistical examination of service in all trades. Incidentally, it is interesting to note the substantial weather identity derived from analysis of the vessels' logs for passages (b) and (c).

This example is a case of the application of the methods of the paper to investigate the economy of some device present on one vessel but not another. Applying the method to the analysis of long period averages of absolute sister ships it is surprising how rapidly the standard Admiralty constant for all such vessels settles down to practical identity. On two to four year averages there is rarely two per cent. difference between all the standards deduced, and as such differences as appear to exist may be peculiar to the different mean displacements averaged, it is obvious that the method is one of considerable accuracy. It incidentally disposes of the doctrine that sister ships always differ. They do not; at any rate not without some very definite reason.

5. It is my purpose in preparing this paper not to make it unduly long and technical. Because of this I trust it will make a wider appeal amongst the circles for which it is intended. As one interested in a proprietary device, I would appeal to those similarly interested to co-operate in the establishing and wide recognition of some satisfactory statistical method of presenting and distinguishing the facts of ship performance. I offer the present method as one which has worked exceedingly well in practice and proved of considerable utility outside that of its main purpose, in the detection of waste and revealing the way to still better design, thus ensuring progress based on the rock foundation of analysed experience.

There are many further side lines of this subject to which I would have liked to refer, but considerations of space prevent my doing so. In conclusion, however, I might mention one incident which bears very largely on the whole subject matter of this paper. A certain corrugated ship made a long maiden passage. The owner was anxious to build further tonnage and cabled out to the captain for his opinion of this particular vessel. The captain cabled back to this effect: "Must say apparent slip extraordinarily small but coal consumption unfortunately excessive." This cable as it stood showed the captain to be a perfectly true witness. The cable was unfortunately entirely misconstrued at home. Instead of its being immediately realised that low apparent slip meant, on this run, a very efficient hull requiring low power, and that if the coal consumption were excessive the cause must be sought in the engines, the captain's cable was construed, as a natural consequence of the shipowner dogma of coal and speed, as indicative of an inefficient hull. Time showed, however, the waste to be definitely in the engine room and this was eventually eliminated. The owner of this vessel in comparing its performance with that of a plain sister vessel, in writing recently to the author's Company, stated that, "As you have had all the data . . . ., it is needless for us to point out which of these vessels has shown the best results, and on that very reliable comparison, it seems to us that you may reasonably claim to have proved your case."

I mention this incident solely to show how essential it is that the subject of merchant ship service analysis be placed on a firm and lasting basis, and so avoid the stultification of progress contributed to by our innate ignorance, indifference and prejudice. Progress, however, whilst dearly bought, is yet inevitable.

APPENDIX.

Construction of Power Diagram.

(*a*) With Load Trial Data available.

After careful scrutiny of cards for indicator errors, plot all mean referred pressures to base of revolutions squared as shown in Fig. 3. From an initial ordinate at zero r.p.m. representing constant frictional mean referred pressure (and averaging about 3·0 lb/in.^{2} for modern steam engines above 1,500 i.h.p.), draw mean line through spots. From speed and revolutions data, after elimination of current influence, determine mean of all apparent slips. This corresponds to mean line of mean pressures. Take any convenient revolutions, say 60 r.p.m., and calculate propeller torque from brake mean pressure read off from mean line. From propeller particulars, calculate torque constant $Q_c = \frac{Q}{n^2D^5}$, where Q is the torque in metre-kilograms, n the revolutions per second and D the propeller diameter in metres. Interpolate from Fig. 4 (which is based upon Schaffran's systematic model experiment data for four-bladed propellers of 37 per cent. disc-area-ratio and five per cent. thickness ratio) for the face-pitch ratio of the propeller, the real slip ratio corresponding to the basis torque constant.

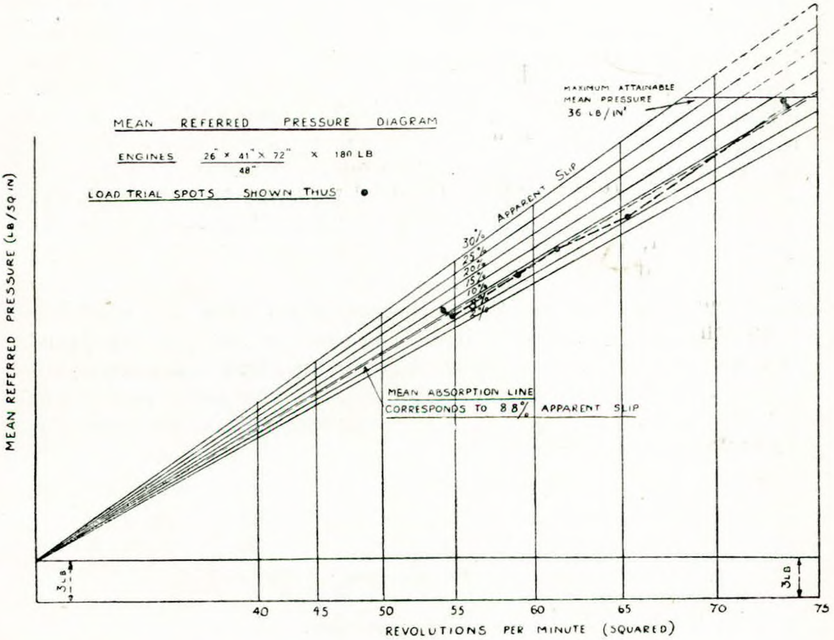

Fig. 3.

From the relation :—

$$\frac{S_r - S_a}{1 - S_a} = w,$$

determine w, the Taylor wake fraction, S_r and S_a being the real and apparent slip ratios based on face pitch. Transforming the above relation to the form

$$S_r = (1 - w) S_a + w,$$

calculate the real slip ratios corresponding to apparent slips of 5, 10, 15, 20 and 25 per cent., using the value of w previously found. Interpolate from Fig. 4 the torque constant values corresponding to these real slip ratios and express them as ratios to the basis torque constant. Plot these ratios to a base of apparent slip and fair if necessary. Next multiply basis brake mean pressure by these ratios and erect in Fig. 3 above the frictional mean pressure base. Draw rays through these spots to the initial frictional ordinate and label the spots with the apparent slip to which they correspond. Refer to actual apparent slip of each observation of mean pressure and see that it correctly locates itself within the required slip rays. If not, and a *systematic* error is evident—which rarely happens—note separately, for every brake mean pressure observation, the ratio which the torque constant ratio for the particular apparent slip of the observation, bears to that of the mean of all apparent slips. Modify the brake mean pressure in this ratio, thus referring it to the mean apparent slip. Having modified all observations in this manner, draw in, or calculate by method of least squares, the best straight line through the spots thus obtaining a corrected initial ordinate. Repeat the whole calculation with this correction, when it will be found that the systematic discrepancy will have disappeared. For Diesel engines, the frictional mean pressure found from shop trials should be used as initial ordinate for first trial analysis. More generally, with engines having an expected mechanical and/or shaft transmission efficiency η, the best trial value for the initial ordinate is $1 -$ times the maximum mean referred pressure or torque.

The finally constructed pressure diagram gives related values of revolutions, mean referred pressure and apparent slip. From the first and second the indicated horse-power can be calculated, and from the first and third the ship speed. We thus obtain related values of power, speed, revolutions and apparent slip. Calculate these systematically and plot as in Fig. 1, thus obtaining the required power diagram.

(*b*) With only service data available.

Preferably instruct the vessel's engineer to conduct load trial over widest possible range of power—particularly the lowest powers, and analyse as in (*a*). Alternatively, take all available loaded service cards. See that all are evaluated for the revolutions at which they were taken and *not* for the revolutions averaged for the day. Scrutinise for card errors by comparison of admission and gauge pressures. Note daily observed and patent log slips determined in conjunction with revs. counter. Reject all observed slips which due to manifest current are materially different from logged slips and replace by latter. Average for all accepted cards the mean referred pressures, the revolutions per minute and the observed and log slips, taking the mean of these two latter. These give one

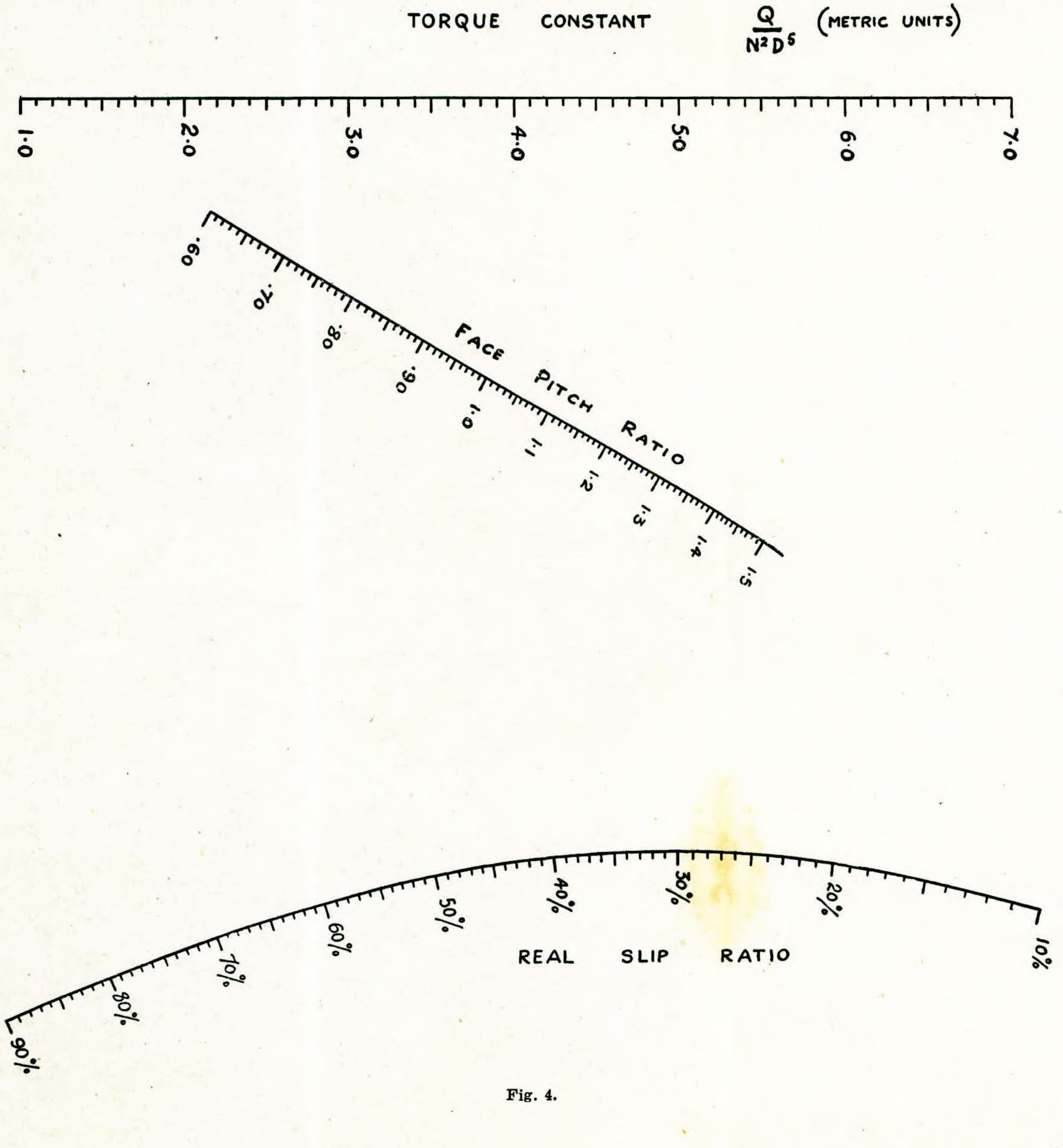
TORQUE CONSTANT $\frac{Q}{N^2D^5}$ (METRIC UNITS)
1.0
2.0
3.0
4.0
5.0
6.0
7.0
FACE PITCH RATIO
.60
.70
.80
.90
1.0
1.1
1.2
1.3
1.4
1.5
REAL SLIP RATIO
90%
80%
70%
60%
50%
40%
30%
20%
10%

Fig. 4.

basis spot on the mean pressure diagram. Estimate frictional pressure ordinate as in (*a*), and draw in basis mean pressure line. Continue exactly as in (*a*).

DISCUSSION.

The CHAIRMAN: The paper gives the impression that a great amount of time and thought has been devoted to its preparation. The author is willing to explain any points which may not be quite clear. The discussion of a paper is always valuable in bringing out further information, and I invite someone to open the discussion.

Mr. J. CALDERWOOD, M.Sc.: It is, I think, hardly an engineer's place to open the discussion on a paper that deals primarily with the ship resistance side of performance data, but I venture to offer a few remarks on points when the information given by the author might with advantage be amplified.

The method of weather intensity measurement will no doubt give excellent results if Dr. Telfer himself always makes the observations, but I doubt whether he will be able to get truly comparative data from different ships or even from the various officers on any one ship, as the personal element is so important a factor in any such observations. On one ship with which I spent a considerable amount of time at sea I noticed that regularly on the second officer's watch the weather was recorded as worse than on the chief or third officer's watch, in days when, in my own opinion, it did not vary appreciably. Such differences are going to affect your voyage result analysis to a very marked extent, and it would be interesting to know whether Dr. Telfer has standardised any sort of instructions to the ship's officers as to how they are to estimate this weather intensity.

On (proof) page (3) Dr. Telfer suggests that 100% weather intensity affects the value of the Admiralty constant by 60 points. I quite agree that on an average tramp vessel of about 10 knots this is just about correct and have checked it in several cases, but surely the author must take the type of vessel into consideration. The weather may affect a slow ship to the extent mentioned, but I do not think it would have the same effect on a 16 knot ship. The general layout of the ship above the water must also be taken into account. The type of ship referred to by the author is the average cargo ship with practically nothing above the upper deck except, of course, the bridge.

Ships with a large amount of superstructure would be greatly influenced by the wind, but waves would have no more effect than in other vessels with little superstructure.

With reference to the correction for fouling, Dr. Telfer takes a standard of 28 points loss in Admiralty constant for every 100 days out of dock, but I think the percentages of time spent in port and at sea are likely to have considerable influence on this rule, also the particular port at which the vessel is lying. I think the author said that the fouling correction became progressively less. My own experience, with figures which I have been able to collect, is that up to 100 days the effect is exactly the opposite. The first few days period out of dock has remarkably little effect, and it gets progressively greater until about the hundredth day, after which it begins to follow a rule such as Dr. Telfer suggests. He might with advantage give a little more information on this point.

I would like to thank Dr. Telfer for his very interesting paper, and hope that my comments will elicit more valuable information in his reply to the discussion.

Mr. T. R. Thomas, B.Sc.: I wish to support Mr. Calderwood in thanking Dr. Telfer for a most interesting paper which will be a valuable addition to the transactions of the Institute, the more so because of Dr. Telfer's unique knowledge of this subject. His method of comparison of results is most interesting, but it is probable that no system will ever be devised which is universally applicable, and it is better to regard this one as applicable only by an individual to the comparison of the performance of vessels with which he is familiar, which are of similar characteristics and engaged on the same service. Dr. Telfer suggests that his system might have a wider application and be used for the comparison of the relative efficiencies of vessels having, say, two different types of rudder. It is to be feared that the personal effect would have too great an influence to allow of this. As a matter of interest, perhaps, Dr. Telfer could tell us if his experience bears this out. He might also be good enough to refer to the matter already mentioned by Mr. Calderwood, who drew attention to the probable failure of the method when applied to ships of different characteristics as, for instance, high class passenger ships and tramp steamers. It would also be interesting if Dr. Telfer would give us some indication of the effect of displacement. The diagram he gives is presumably only strictly accurate when applied at the displacement at which it was made, *i.e.*, the trial displacement.

The amount of the propeller immersion seems to be the varying factor here, and information on this point would be appreciated. While we know that many ship-owning firms do pay considerable attention to this matter of analysis of results there must be many who will be glad of Dr. Telfer's explanation of his own methods.

Mr. G. R. HUTCHINSON: Dr. Telfer's principle of regarding the propeller as a power absorption dynamometer in preparing his power chart is most ingenious, but it only holds good for the fully loaded condition, or, at least, for so long as the propeller is immersed adequately. In the ballast condition the propeller will not act as an " almost perfect power absorption dynamometer," and the method breaks down. Could the author tell us if he has any approximate correction, in the form of a simple formula, for instance, whereby the power at any speed, r.p.m. and apparent slip can be derived for the ballast condition from the fully loaded power at the same ship speed. Ships, unfortunately, make a high percentage of ballast trips to-day, and a check on performance in this condition is important.

Referring to the point raised by Mr. Calderwood, *i.e.*, the classification of weather, this is rather a thorny problem and the personal element enters into it to what appears at first sight an undesirable extent. At the same time, we should not lose sight of the fact that the effect of weather is eliminated, for a tramping vessel at any rate, if voyage results over a sufficiently long period are available for analysis. One must be well versed in the application of Dr. Telfer's method before one can have confidence in it. I have had the pleasure of working for several years with Dr. Telfer, and I know that it gives astonishingly good results, in his hands at any rate. I have seen it applied to quite a number of vessels of different size and form, all 10-12 knot cargo ships, and he can make wonderfully good predictions of power at different speeds by its use. Whether it would hold so well for an intermediate liner or a large passenger ship, I do not know. It is voyaging into the unknown at this stage, and it would be interesting to have Dr. Telfer's comments on the applicability of his system to larger ships of higher speed and finer form.

I also would like to thank Dr. Telfer for what is really an excellent paper. We, as an Institute, should know more about the subject, because too many engineers are apt to judge ship performance in terms of coal consumption and speed and leave it at that. Dr. Telfer has put forward a method of power estimation and service performance analysis which meets the requirements of superintendents and consultants and it is to be hoped that the paper will receive their closest study.

Mr. A. F. C. TIMPSON: Every previous speaker seems to have attacked Dr. Telfer's method of weather analysis. I think his method at least gives us some basis to work on. This method gives data which is bound to be more accurate than mere casual observations. Degrees of weather cannot be stated mathematically, and this classification is the next best thing. As regards the paper generally, a shipowner wishes to get down, finally, to the cost per ton mile, and the method proposed by Dr. Telfer seems to be an excellent one for the purpose.

Mr. W. McLAREN: The author speaks a great deal about the engineer and the indicator. Generally the engineer has indicated his engines the day before the ship enters harbour, and very likely he takes the next cards just after leaving port again. These may be days of fine weather or otherwise. Now, if you consider a grain-laden ship, and the various methods of stowing the grain or getting it into a shapeable condition, when that ship is several days out she is quite a different ship in a sense, owing to the cargo having settled down into all the corners. Then again, take well-deck ships which may carry many tons of water on the fore part when the ship is diving into heavy seas; some account must be taken of the effect of such conditions when applying the author's method of what may be termed a " wet " ship. Again there is the bunkering question to consider; a ship loaded a little in excess at the head is quite a different ship from what she would be if she were down by the stern. On one voyage across the Western Ocean in January, we took twenty-three days to do the trip which normally took ten days. What about the revolutions then? In another extreme instance we were seven days between Liverpool and Cardiff, whereas the next time we were only thirty hours, the ship being light. What about the revolutions then? It seems necessary therefore to standardise some method of allowance for these varying conditions. We have instruments which can record pitching, rolling, and depth of water fore and aft, so that it would be worth while to co-ordinate these factors for the use of the shore staff.

I wish to add my thanks to Dr. Telfer for bringing such an analysis forward. Could he tell us what difference, if any, is found in the rolling of a plain plated ship and a corrugated ship?

Mr. T. R. Alexander: Dr. Telfer is to be congratulated on his methodical examination of the problem of merchant ship performance, which will be of valuable assistance to all classes of marine technicians.

There is one important aspect of the analysis of the engine room performance which has always seemed to me to be fundamentally wrong, namely, the inclination (to use Dr. Telfer's words) of engineers to submit pounds per horse-power hour as the test of engine economy.

The objections to this form of analysis are, briefly:—

(1) No account is taken of the calorific value of the fuel which may differ considerably on a homeward bound voyage from that on the outward bound.

(2) No account is taken of the consumption of auxiliaries supplying light, heat, ventilation and refrigeration, which vary with the time of the year and the latitudes in which the vessel trades.

(3) No discrimination is possible between boiler efficiency and engine efficiency.

(4) The indicator diagram forming the basis of the analysis is but a spot test, and as Dr. Telfer points out, is usually taken only occasionally, then under the best conditions, and gives fictitious performance figures.

If there were some means of obtaining an accurate performance of the boilers and engines, watch by watch, it would be of very great assistance to the chief engineer during the voyage, and valuable to the superintendent when analysing the results after a voyage.

Now Dr. Telfer mentioned that the revolutions of the propeller were for all practical purposes proportionate to the power consumption, within normal variations, in the revolutions per minute and the loading of the vessel. This being the case, it is a simple matter to calculate from the indicator diagrams the H.P. hours per revolution, which will be a basic standard, and when multiplied by the total revolutions per watch, will give the H.P. hours consumed in propelling the vessel during the watch.

The other important factor to determine is the steam consumption during the watch, and the inclusion of an integrating steam meter in the main steam pipe of each main engine is the keystone of accurate performance analysis.

Steam meters to-day are comparatively cheap and reliable and very accurate, and it is not a platitude to affirm that they quickly pay for themselves. With such apparatus, the chief engineer and indeed all the engineers, are able to accurately log performance watch by watch, and any exceptional consumption can be investigated as soon as it develops.

With regard to the boiler performance, a water meter on the discharge side of the feed pumps is of great value. By such means, not only can the lbs. of steam per lb. of coal be calculated, but also the steam consumption of the auxiliary plant if the steam consumption of the main engines be subtracted from the water meter.

It only remains for the chief engineer to take a reliable and average sample of the fuel during the voyage, and for the superintendent engineer to have the calorific value of it determined to enable a very perfect analysis of the performance of the individual sections of the engine department to be obtained.

Mr. J. Foster Petree (Visitor): The question of weather intensity which has exercised previous speakers occurred to me also, and in this way. Suppose that in a ship of, say, 10,000 tons displacement, there are three watch-keeping officers. Assume that the second officer has been with the ship for a couple of years and is perfectly familiar with her behaviour. The chief officer has perhaps come from a junior position in a much bigger ship; while the third officer, also new to her, has previously been in smaller ships. The weather will appear to these three men in very different lights. To the chief, used to big ships, it may seem heavy, and he will log it as such. The man from the small ship may think the same weather to be only moderate, though he would have classed it as heavy in a vessel of half the displacement; on the other hand, if he sees the chief officer recording it as heavy, the third may think it wise to do the same. The result is bound to be somewhat removed from the truth, despite the correct entries of the second officer. Against this, of course, we have Dr. Telfer's statement, confirmed by Mr. Hutchinson, that the scheme works. In any case, whatever its shortcomings, it is obviously a sincere attempt to classify what really cannot be exactly described.

Again, how do these men gauge the weather? This question was suggested by one of the new cross Channel steamers, having a long boat deck with the house and bridge placed considerably abaft its forward end. A head wind is therefore quite likely to shoot clear over the bridge, and the officer may thus be led to underrate the weather. In another ship, which I understand to have given some trouble in steering, the forward end of the upper deck is not closed in, so that the wind gets under the bridge and tends to blow the ship off her course. This might cause a newly appointed officer to put down as " severe," weather which is almost " moderate."

Such varying conditions will average out over a long period; but one cannot spend the whole life of the ship accumulating data from which to deduce a formula. To be useful, the analysis must be completed early in the ship's life. I should like to know what length of observation Dr. Telfer considers is necessary in order to estimate a fair average life performance. Presumably at least two or three years; in which time there might be a number of different officers in the same ship, which would complicate matters, unless the owners go to some trouble to keep the same men.

With regard to the question of I.H.P. and S.H.P., I may mention that difficulties of this sort can be surmounted by measuring the propeller thrust.

Dr. Telfer did not read through the appendix, but he showed the mean pressure diagram on the screen, and I notice in that, that he has allowed a constant frictional loss equal to 3 lbs. per square inch for the main engine. I am under the impression that this loss is not constant. I think Seaton is responsible for the statement that some 70% of the frictional loss varies directly with the revolutions, and the remainder at a higher rate; which is borne out by experiments made at the National Physical Laboratory by Dr. Stanton, in which he found that the friction of piston rings varied directly with the revolutions. It may well be, however, that the figure given by Dr. Telfer is not so far inaccurate as to invalidate the results.

If this paper has the effect of bringing home to owners and to the engineers themselves the importance, not merely of taking records, but of taking them constantly and so " keeping their hands in," it will have done a great service. Possibly Dr. Telfer has never attempted to estimate the percentage of cargo vessels in which indicator records are taken consistently, but I should doubt whether it would reach 30 per cent.

Mr. A. Robertson: In a paragraph, Dr. Telfer states that "a rough blade reduces the thrust developed but increases the resistance to turning, and it appears probable that so far as S.H.P. is concerned, these effects practically neutralise each other." I have always understood that with a rough-bladed propeller the S.H.P. is increased. If so, the efficiency of the installation as a whole is reduced. Has Dr. Telfer made any specific observations with regard to different standards of loading? If a ship is loaded with heavy cargo she has a higher metacentric height which causes excessive rolling, whereas with a lighter cargo she has a lower metacentric height.

Mr. W. A. Christianson: With regard to the degree of weather, is this not a question of wind velocity, and if so, could it not be measured by an anemometer, in recorder or indicator form? It would appear to require two instruments to be fitted in a vessel, one fore and aft, and another athwartships, or alternatively one only, automatically kept facing the wind, whilst the speed of the vessel would also require to be taken into account, to arrive at the wind velocity. I should like to ask Dr. Telfer's opinion as to the practicability of this suggestion.

Mr. G. Selman (Visitor): With regard to the diagram (Fig. 3) shown by Dr. Telfer, it appears very difficult indeed to obtain the reliable data necessary to prepare such a diagram. Trial data often gives evidence of quite astute salesmanship! If one is going to use that data the ship must be run in a condition comparable with the average voyage condition of the ship. In such a case the relation between the speed and the revolutions in a light ship would be quite different from that in a ship in a loaded condition. That also affects the relation between the displacement and power coefficient inasmuch as it will not follow the change of ships (c) value with draft as Dr. Telfer infers but will be modified by the fact that the propeller will be working very ineffectually when the ship is in a light condition.

Mr. F. O. Beckett: I must ask Dr. Telfer how he measures the ship's draught and who agrees to this? It seems to me that the vagaries of human nature are not sufficiently allowed for in the paper. Until we get oil and water to mix we cannot have either a weather chart or revolutions. If you consider vessels of the cargo carrying type it is invariably left till the ship reaches the Straits of Gibraltar to indicate the engines. As one speaker has remarked, the S.H.P. or the consumption of water is far preferable to I.H.P. There are many occasions where comparisons can be made between ships of the same company because their logs can be seen in the office, and no doubt comparisons are made, but when it comes to classifying weather as fair, moderate, heavy, or very heavy, I do not see why the engineer could not be relied upon to record the weather watch by watch by reference to the ventilators. I find there is a difference between men steering a vessel by the compass and those who steer by the head. I have made many passages zig-zag across the Atlantic and others straight across, due to the difference in steering. The former generally resulted in the engineer getting blamed for his heavy coal consumption per H.P., which is not surprising when you consider the effect of a steering engine working all the time at full speed with a 2in. pipe blowing into the condenser. I certainly agree with previous speakers that there are many points in this problem where the human factor may be very misleading in the tabulated results.

Mr. R. Jolly: After reading the paper one is left with the conclusion that the last word is with the shipowner. Dr. Telfer may have been fortunate in getting his data from ships running from port to port. I assume that the mean draught is the mean of the draughts at the beginning and end of the voyage, but the shipowner has to make comparisons between intermediate ports. To get a true average draught and Admiralty constant for any voyage is difficult. The real criterion is average results, and the shipowner's dogma based on power and consumption is still with us. Books are written on it, but the dogma will always remain the same . The shipowner asks, "What does it cost in fuel to carry a cargo a certain distance? I use a similar formula and I am always asking for more information on the subject which will enable me to determine the cost of carrying tonnage (*i.e.*, deadweight) at a certain speed, and had hoped the author would have gone farther on this point. I have found that the performances of sister ships do vary on the same routes and over the same distances. I therefore take an average of not less than three voyages on the same run, for comparisons I cannot approach this problem as a naval architect, but only as an engineer, but I endorse Mr. Beckett's remarks about the importance of the personal element; it is quite understood that diagrams are not taken under ideal conditions. I have taken and investigated thousands of indicator diagrams, and I know the work entailed in getting them, but they are very useful. In the absence of loaded measured mile data, the shipowner wants to know the cost, and if the indicator cards are described as " spurious," or " not worth their face value," these cards must nevertheless form the basis of the Admiralty constant, and you then give the shipowner four columns of figures on which to cast suspicion. I do not see how it can be a reliable index of the average draught of a ship. I join in thanking Dr. Telfer for his paper.

Mr. F. A. Hunter: It seems to me that the use of the torsion meter more fully would eliminate many of the difficulties due to unreliable indicator cards. The coal consumption might then show considerably fewer discrepancies. With regard to weather, I suggest that Dr. Telfer might evolve some instrument by which weather could be indicated on a clockwork recorder which would give a definite basis as to the amount of rolling and pitching of the ship, and not just left to the personal opinion of the man taking the observation. After all, it is the action of the waves on the ship which causes it to roll, and the greater the roll or pitch the greater the deviation on the recorder. With regard to taking indicator cards, the chief and junior engineers are usually fully occupied in these days; would it not pay the owners of large fleets to engage a man to go on the ship and take records from time to time. Many superintendent engineers cannot worry about it, due to being too busy. If a qualified man were employed to go on an outward and homeward voyage and obtain true and unbiased data, he could then go on other ships later on and perform similar duties with probably satisfactory results as the work would be carried out by one individual.

Mr. Petree: That system has, I believe, been applied. Before the war I was told that the North German Lloyd employed a special staff of experts, who would descend on a ship without warning at the start of a voyage and proceed down Channel with her. During this time the master himself was under their orders—subject, of course, to the safe navigation of the ship—and if they wished to run, say, at half speed for the purpose of their tests, it had to be done. My informant had himself been engaged in this work for some years.

Author's Reply: I must first thank the members present for the excellent discussion they have accorded my paper. So many good points have been brought out that it will be difficult to reply to all. I will therefore deal only very briefly with the salient points in each speaker's remarks.

I thank our chairman for the exceedingly kind way in which he introduced me to the meeting; and in reply to his more technical remarks discussing my reference to the general spurious nature of indicator cards, I might explain myself a little further. Cards are not so much spurious in themselves as in their interpretation by the engineer and all too frequently even by the superintendent. A card "under average conditions of working" is one not only very ambiguously defined but also very difficult to take, since, in fact, true average conditions are not known until the end of the voyage. The peak card is all that can be expected from the engineer, but he should be made to appreciate that its value is only pictorial and should not be used in conjunction with voyage average coal consumption to misjudge the efficiency of the engine installation.

Referring to Mr. Calderwood's comments, ships' officers have admittedly to be trained to the use of a weather classification; and the table given in my paper is supplied to every vessel whose performance I analyse. It is really surprising how well the system works, and if given a fair trial, satisfaction will automatically follow. I have frequently checked the weather identity of vessels sailing in company and I have traced the variation of weather intensity throughout the year on various trade routes, the statistics building up quite a definite relation.

The allowance of 60 points in A.C. per 100 weather intensity appears to hold good over a very wide range of size and type of ship. It can be independently endorsed by an analysis of Mr. J. L. Kent's work on the subject. Vessels do differ from this standard, of course, but so far as the prediction of life averages is concerned, any possible departure from the standard is of little consequence. For example, if one vessel has the standard rate of 60 and another one of 70—a large difference incidently—if the first averages an A.C. of 220 in 120 weather and the second 220 in 80 weather, then whilst the true A.C.'s in standard weather of 100 would be $220 - 14 = 206$, and $220 + 12 = 232$, by adopting the standard allowances these figures would be 208 and 232, and thus the difference in the assessment of average relative efficiency would be less than one per cent.

Mr. Calderwood doubts the accuracy, in principle, of my allowance for fouling. Here I am afraid that his own views are directly opposed to those of the French and American naval authorities, Messrs. Denny, and also, more recently of Dr. J. L. Taylor, which views are in remarkable agreement with my own.

Mr. Thomas refers to the case of a vessel fitted with a special type of rudder after having originally had a normal rudder. I have analysed such a case and have found no weakness in the method of analysis.

Mr. Hutchinson points out that the power diagram only holds good for the loaded condition. This is so, and the method of its extension to the ballast condition I gave in my N.E. Coast paper.

When Mr. Timpson states that my weather analysis gives at least some basis to work on, he neatly summarises my main argument. A basis is all that is necessary and it is just this which has hitherto been lacking.

Mr. McLaren raises the general question of the influence of trim and nature of cargo carried on ship performance. I have been quite unable to trace any material influence of trim; and so far as cargo is concerned, only an ore cargo appears to be definitely worse than any other. Statistics bear this out unmistakeably. Mr. McLaren further enquires as to the comparative rolling of plain and corrugated ships. I would refer him to Mr. M. P. Payne's 1924 I.N.A. paper on the subject which definitely bears out our own experience.

Mr. Alexander's remarks refer to the checking of performance internal to the engine room, and have my endorsement.

Mr. Petree discusses my weather classification, and to him, as to all members who doubt its practicability and accuracy, all I can say is, try it. It is possible with only three months' statistics of a vessel's loaded life to predict her life average, provided of course, that the vessel has sampled all kinds of weather. Even if this is not the case, the application of the standard corrections will give a very close prediction.

Mr. Petree further refers to my adoption of constant frictional losses in the preparation of the power diagram. There is no doubt that this constancy is very nearly true, but whether it is or is not, does not affect the accuracy of the power diagram to the slightest extent. This diagram is only concerned with the interpolation of known data of total I.H.P., revolutions and ship speed; and whatever my internal dissection of these variables, the original data remains unchanged.

Mr. Robertson discusses my reference to the influence of blade roughness on S.H.P. at given revolutions. As I state in the paper, the S.H.P. at given revolutions and slip appears to be independent of roughness. The thrust of the propeller, however, *is* reduced and consequently to produce the same thrust as a smooth propeller, the revolutions, S.H.P., and slip must all be increased, *but their internal arrangement as represented by the original power diagram will be unchanged.*

As I mention in my reply to Mr. McLaren, I have found that ore cargoes pull down a vessel's performance. This is probably due to the excessive rolling caused by excessive metacentric height as Mr. Robertson points out.

In reply to Mr. Christianson, the accurate measurement of wind velocity for ship work has been successfully carried out by Mr. Kent and also by the Hamburg Tank. The measurements obtained are very valuable scientifically, but I do not think that they are necessary for ordinary service analysis.

I would refer Mr. Selman to my N.E. Coast paper for a fuller consideration of the ballast performance of ships.

Mr. Beckett, I think, is inclined unduly to stress the human factor. All our experience is of necessity human, yet actuarially considered, the law and order in this experience is beyond question. A little investigation work along the lines I indicate will soon convince Mr. Beckett of the very subordinate place of the human element.

On one point, however, I can console Mr. Beckett. The power diagram will not lay the blame of bad steering on the engine personnel! Since the speed averaged on the straight line will be less than on the true zig-zag course, using the former to read off average power results in this being over-estimated and consequently in lb./I.H.P./hr. being under-estimated. The engineer thus derives a bonus from the defects of the deck. This fact alone should assure the immediate and universal adoption of the power diagram!

Mr. Jolly deals with a more difficult type of analysis when he discusses cargo liners having a large port itinerary. The greater difficulty, however, is only due to the increased work involved. Actually, because of the data being available for all conditions of loading, the analysis of such vessels is all the more valuable. If Mr. Jolly will apply the methods of this paper to his work, he will have no difficulty in solving the problems he has to face. The hull performance must be separated from that of the engine room and the coal purchasing department, but, starting from accurate data from each, "the cost in fuel to carry cargo a certain distance" is merely a question of arithmetic.

I can assure Mr. Hunter that the torsion-meter will not remove the difficulties of the indicator. I agree with him, however, that a fleet engineer would be an invaluable commercial as well as technical asset to the shipowner.

The CHAIRMAN: I should like you to accord a very hearty vote of thanks to Dr. Telfer, both for his paper and for his answers to the questions which have been put to him.

The vote of thanks was heartily accorded, and a vote of thanks to the Chairman on the proposal of Mr. W. McLaren, seconded by Engr.-Lt.-Comdr. A. J. Elderton.

The CHAIRMAN (By correspondence): The author refers to the majority of indicator diagrams taken at sea as being utterly spurious as a guide to engine economy or to the standard of hull performance.

While it is generally considered that conditions at sea do not often admit of the scientific recording of engine power and data in as comfortable a manner as during trial trips with a large staff of operators, in the absence of trial trip data at load conditions I do not see how else a power diagram can be obtained than by recording diagrams at sea. It is not always convenient to obtain diagrams over a range of power and speeds while on normal service owing to the requirements of schedule speed and revolutions being adhered to. I find that a series of indicator diagrams at normal power and speed and a record at full power on each voyage are very useful in determining consumption often asked for at varying speeds, and the actual results come close to the figures estimated from the data provided on the diagrams.

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Notes.

In view of the questions which have been discussed as to water-tube boiler drums for high pressure service, the following descriptive notes from Mr. J. H. Martin are useful:—

*THYSSEN WATER-GAS LAP-WELDED BOILER DRUMS.—As steam pressures have gradually increased, the difficulty of making riveted drums to stand up satisfactorily to the more exacting duties required have often been great.

The inherent defects of riveting, such as local compression of material with its resulting damage, hardening due to

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*British Representatives, Messrs. Perrins, Limited, Astor House Aldwych.

breathing along seams and under butt-straps, and the practical impossibility of securing even distribution of stresses in thick plates, are only too well known.

One way to eliminate these shortcomings has been to make drums in one piece, forged down from heavy ingots. This method necessitates costly machining on all surfaces as it is not desirable to forge down the pierced ingot to the final thickness.

Although this method has much to recommend it from a practical point of view, its application can only be an economical one for the super-pressures requiring wall thicknesses of 3in. or more.

For all pressures between those in which riveted drums have proved successful, and those where such forged drums become economical it was felt some other form of construction was desirable.

On the Continent during the last five years a new patent process of manufacture by Messrs. Thyssen of Mulheim to fill this *hiatus* has been perfected and widely adopted for the range referred to which is approximately between 200 and 800 lbs. pressure. This method consists of making such drums from a single plate rolled over with a longitudinal lap joint which is welded by means of internal and external water-gas burners, these have the advantage of being reducing flames, thus no slag is formed which might otherwise find its way between the edges of the adjacent plates in the weld.

A special welding machine is used in which the " human element " is eliminated, in which two feet is welded at a time, and the overlaps are hydraulically squeezed down into single thicknesses by means of a roller passing to and fro over the laps the rollers being held down by means of a saddle plate under hydraulic plunger pressure. After this longitudinal joint is welded up, the shell is then annealed and put on the rolls red hot, and kept rolling so as to retain its circularity while cooling, the pressure being taken off the rolls before it gets too much cooled so as to prevent overworking of the material. The joint is then most carefully cleaned by scaling and the surface of the weld subjected to a most minute inspection. When found to be satisfactory the shell is put in a hydraulic testing machine and subjected to 1½ times its working pressure.

After it passes this test successfully the shell is taken to a special vertical and horizontal press by which the ends are closed down hemispherically in three heats leaving a manhole at the centre of each spherical dome-shaped end. These ends constitute the best shape to resist pressures as they ensure the most favourable stress distribution in the wall, which then being closed in, increase in thickness towards the manhole and thus effectively strengthen the material where it is most required. Manholes are then machined and doors fitted after which the drum is subjected to an excess pressure test 3½ to 4 times its operating pressure by which in fact in parts the yield point of the material may be passed and the drum will tend to set itself to take up the best shape to resist this pressure.

Careful circumferential measurements are taken along its lengths during the testing. It is generally acceded that this searching test affords the best possible proof of the reliability of the weld, any weakness of which would be bound to show itself at such an extreme test, while it also proves the freedom of any other material defects.

After this very severe test the entire drum undergoes a highly scientific heat treatment for which specially large gas-heated furnaces are available fitted with pyrometers placed at various points along and inside the drum and temperatures are automatically registered on polar diagrams during this treatment.

All internal stresses and any cold stretching effects are eliminated thereby yielding a drum with high resistive power against internal pressure, perfectly free from fatigue effects and internal stresses, and thus in the ideal condition against ageing and for standing up to the service required of it.

Engineers now well appreciate that a welded drum tested above its elastic limit having its deformation carefully measured and afterwards properly annealed affords greater reliability than a cold-bent, riveted and caulked drum. Another advantage worth mentioning is that with this method the original hard mill skin is retained on these drums which is a highly desirable property, especially with high pressure boilers in which corrosive action is much more acute from water on its interior, and gases and moisture on its exterior services. Forged drums, which of a necessity have their surfaces machined down perforce have to lose this highly resistive and hard outer skin.

A weld strength is guaranteed to be at least 90% of that of the plate itself. It has been pointed out that if no tube holes are put through the weld in a boiler drum a 100% ligament is in service there as compared with one of 50% or less, in the row of tube holes.

One of the most attractive features is that the cost of welded drums is very materially below that of forged drums.

Some 800 of these welded drums are now in successful operation in about a dozen countries on boilers in pressures ranging from 200-860 lbs. per sq. in. Many have also been used as gas receivers, autoclaves, etc. A total of about 5,000 welded drums and shells have now been manufactured on this process. The illustration Fig. 1 shows such a welded drum in section, the thickening of the ends can be clearly seen from this.

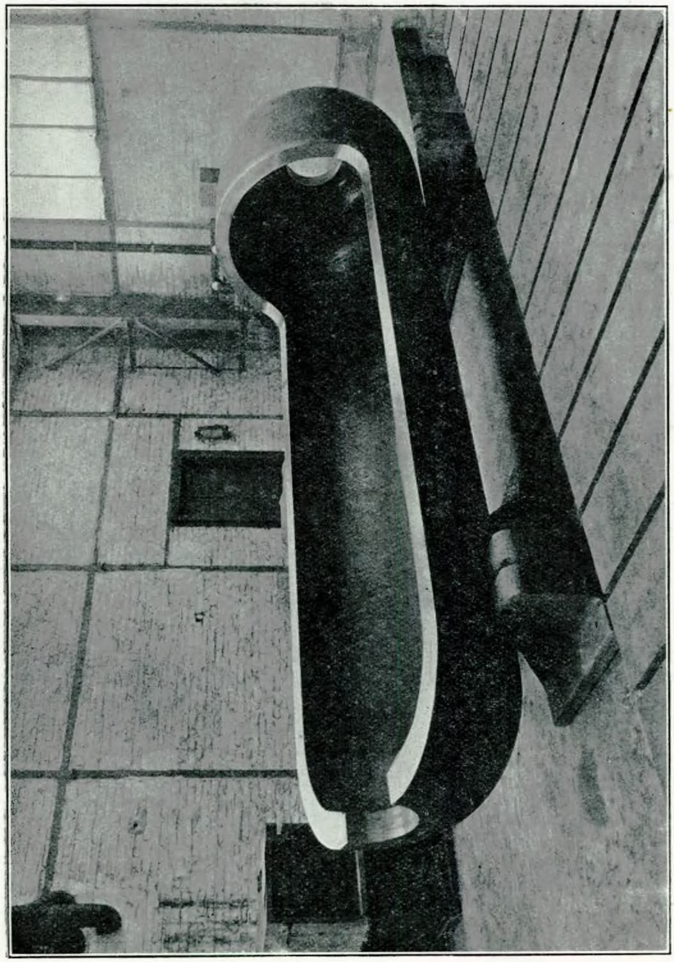

Fig. 1.—Thyssen Watergas Rollerlapwelded High Pressure Drum, in section. Wall thickness 3½″.

The other photograph (Fig. 2) shows some finished drums leaving the works, it is to be specially noted that the hard mill skin so desirable for corrosion resistive purposes, can be plainly seen on these.

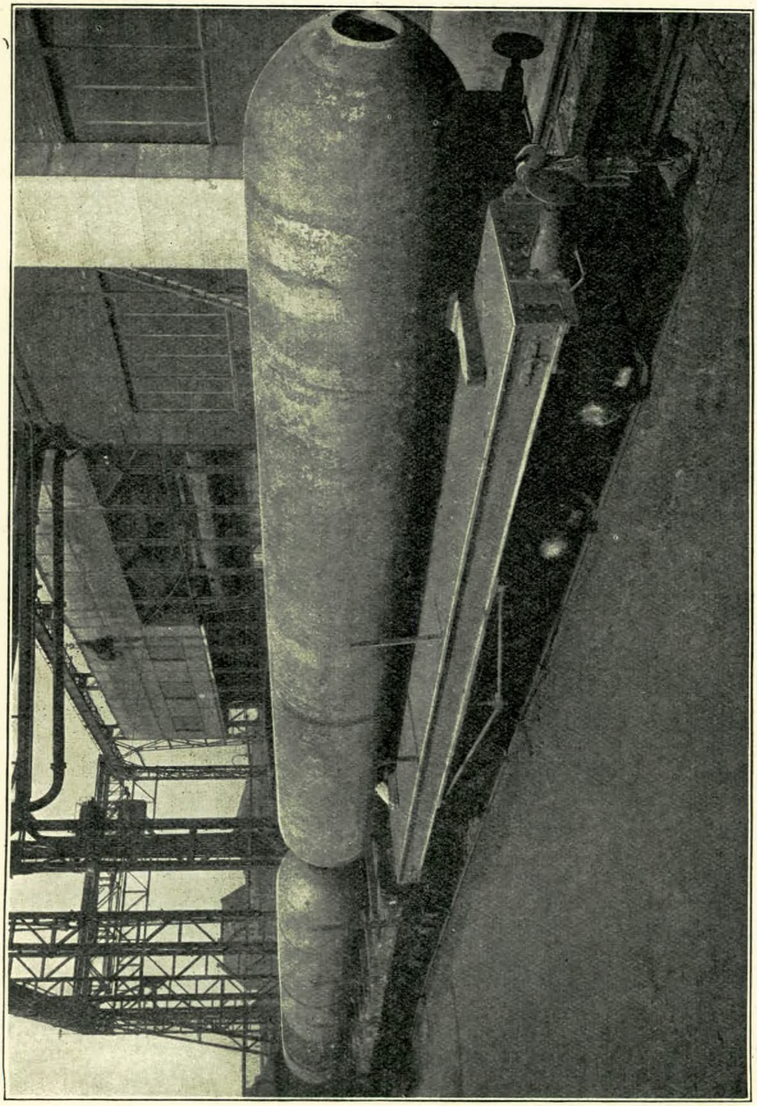

Fig. 2.—Despatch of two Thyssen High Pressure Lapwelded Boiler Drums. Diameter, 5′ 3″; Thickness, $1\frac{5}{8}$″; Length, 41′.

Great interest is being shown by Boiler Makers over here lately, not only for land boilers but also for applying these for marine work, and it is to be hoped that the Registration authorities and Insurance companies may give this method of manufacture their careful and sympathetic consideration.

In regard to this it is of interest to note that already in more than a dozen foreign countries where several hundreds of these welded drums are at work, they have been approved of by the local Registration authorities and by the Insurance societies, which should be the best possible proof of their soundness and great practical and economical value.

At the Institution of Naval Architects' meetings, during the discussion of Mr. Arthur Spyer's paper on ' Modern Developments of the Water Tube Boiler for Marine Purposes." read 22nd March, 1929, Mr. Harold Yarrow mentioned during the discussion that those welded drums were finding wide adoption on the Continent and seemed to prove successful, and where the drawbacks of riveted joints and the consequent desirability of eliminating these as much as possible for high pressure work was now generally appreciated, and those welded drums show every promise, it seemed to him that they were bound to be introduced over here before long and more information on these would be appreciated.

Mr. Hamilton Martin supplied further data on these drums which are now made out of one single plate up to a size of 4ft. 3in. diam. and 31ft. long, thus only having a solitary longitudinal welded joint and are supplied in thickness up to about 2½in. He also asked in view of the fact that such welded drums show decided practical advantages over riveted drums and were less expensive than forged drums whether the time had not arrived when an opportunity might be given for a closer inspection by our Registration authorities as to their practical and economical possibilities.

These welded drums are obviously proving a sound proposition, and nobody wishes to arrest the forward march of progress in these days, or could afford to do so, but on the contrary will try and grasp and investigate anything which may tend to offer a more, or equally sound construction for less outlay. Authorities' considered opinion on this welding method which is much less dependent on the " human element " than riveting—as it can be inspected and tested in a more definite manner might then be expressed and their future attitude made known towards the adoption of such welded drums for use in boilers or high pressure receivers.

On the Continent it is of interest to recall here a buttstrap covering a weld on boilers is not insisted upon any longer as it is considered to offer no real security, and fails to meet the purposes for which it is intended, for if the weld has been well made this security is superfluous, while if it were not perfectly made it would only be further weakened by the holes put through it for taking the buttstrap rivets.

It is preferred therefore to give welds the utmost care in manufacturing, subjecting them to the closest inspection and then hydraulically testing all drums to a limit which will never occur again in service, after which all stresses are removed by a most careful scientific heat treatment. In this way their dependability is ensured.

In regard to the British Registration Authorities' attitudes towards welding in boilers, it is interesting to note that both the B.O.T. and Lloyd's Register have lately approved of arc welded flanges on all main steam pipes on the new P. and O. turbo-electric liner, *Viceroy of India* fitted with high pressure Yarow water tube boilers. It was this fact which has prompted the foregoing suggestions.

In replying to the discussion, Mr. Spyer confirmed that several of these welded drums had been installed by their Continental works and have behaved well since then, and where this was the case and welds on boilers could be done satisfactorily and safely, the position as to their use over here must be considered.

Messrs. Rosencrants, Patchell, Dr. Munsinger and other authorities have likewise expressed themselves strongly in favour of these, and they will no doubt prove of interest to many of our members.

MENTAL PHILOSOPHY.

It is well to train the mind to think correctly, to discriminate between right and wrong modes of thought and cleave to the good and true.

The following is quoted from an old notebook of University Lectures delivered to us students many years ago and the thoughts conveyed may be of advantage for our juniors to read.

Mental Philosophy in its general sense as a science comprises two sections, Moral and Intellectual Philosophy, and it is proposed now to specially treat on the latter. It comprehends the laws by which we proceed to consider the impressions upon the mind from outward objects, the Laws of Intelligence, the process and the products of thought or intelligence which may be summed up in the definition " Reflection on our experience," which results in a knowledge of things gained either from our own experience or culled from that of another. Mental Philosophy defines the process which the mind goes through in attaining knowledge. It is essentially an inward process, although the knowledge itself comes from without; the incoming of knowledge is that inner consciousness of certain facts or qualities which belong to our inmost self, and the apportioning of these to their true value, after due consideration of their etched face value as presented by an outsider.

The centre around which all knowledge and philosophy cluster is consciousness and as the mind of man is very complex so of necessity is the study of it. As mental philosophy takes cognizance of all kinds of knowledge, it may be termed the ultimate or primary science, and in a sense the " Universal Science," inasmuch as its leading aims are: 1, To tell or investigate what knowledge is; 2, to investigate the inner consciousness; 3, to investigate the results of universal science.

Intellectual philosophy may be divided into three branches, all however closely connected with each other, i.e., they have an organic unity.

1. Phsycology, which may be termed the root of the science, as dealing with facts of the past and present, and even yet this root is not sufficiently studied, hence errors in reasoning or wrong conclusions are deduced, and if we look around to-day we can trace sample cases.

2. Logic applies to the laws of philosophy and is based upon the lines of strict accuracy.

3. Metaphysics takes cognizance of different objects.

The use of mental philosophy is obvious for a study when we consider the necessity of reflection, and note the lack of it here and there, mental philosophy analysis, aided by certain facts and we draw conclusions, or simply reflect upon the knowledge gained, mental philosophy analysis or aids by certain laws our reflections to arrive at the true and avoid the false. We are conscious of certain wants or desires in our inner selves, these we may term high or low according to the source whence they spring, although quite natural, such as the requirements of food, shelter, clothing, which we may term "physical wants," and although in the lower strata—as in the animal creation—yet out of these spring utility, whence are evolved the ideas of work and industrial art on its utilitarian side, that is the process for getting something to satisfy want, with its beneficial results and then generating something noble by helping others, whence sprang the civilization stage in man. Then came the general sense or acknowledgment of Right and Justice and Government to maintain these. In the early stage, strength or force might prevail to maintain ownership, in the more advanced stage there is a recognition of duty between man and man, and a gradual rise to a nobler standard of duty by philanthrophic effort and benevolent action under moral philosophy. Besides the sensations of hunger, cold, thirst, etc., we have a consciousness of other senses which put us in communication with the outer world, the emotional or æsthetical side, flowers of scent, beauty, musical sounds, sublime experiences. These points bring before us the question as to how far we can rely upon our emotional sensations or impressions to arrive at the real and true. (*a*) What right have we to assume that we have the right and true conception?; (*b*) What test can we apply to prove the true from the false?

In our search after truth we may arrive at contradictory results, clearly then we must examine again and discover where we have erred in our reasoning or deductions, as it is not possible for the human mind to rest satisfied in a state of doubt for any length of time, hence it is important to determine the satisfactory tests of a true proposition, that is tests which will satisfy our intelligence. Attention to duty and avoidance of neglect which may injure others.

We see that utility is the root idea of industrial art, the end is the result we aim at or for the sake of which something is done. There is also the means by which we attain this end. The idea of right and wrong is a more general one than justice. Under the former we class benevolence and philanthrophy. Let us ponder over the question for good reason. Speculative philosophy is indigenous to every soil on which civilisation has root.

The assumption may be held that truth and true principles regarding justice, goodness and beauty are to be found as the result of effort. This is natural faith. Can we vindicate it?

Have we any test or criterion by which we can rationally and to our own intelligent satisfaction distinguish truths in these enquiries from fallacies. Questions must be considered to find the right, the just and the beautiful. The conclusions arrived at may not be consistent, as thought travelling by different roads may arrive at opposite results, and the mind may come to a standstill, unable to tell the true from the false. This entails doubt or scepticism; our nature is such that we cannot continue in doubt, we therefore must have some faith, and realising that we have gone wrong in our conclusion, go back and try to find where error has arisen.

It is specially interesting when considering the lessons derived from intellectual philosophy, to read the history of past ages, the aborigines of the nations, the cave man and his advance step by step to civilisation from the "club" to the "sweet smiling morn." The desire of all nations should be to help one another in progressing towards the best, doing that which is right and well pleasing for all and avoiding the adage "Don't do as I do, but as I bid you." The Cambridge Historic Records volumes of the British Empire contain many examples illustrative of the right and the wrong views of life's duties and responsibilities.—J.A.

From the "Mechanical World and Engineering Record" of October 12th, 1928, the following are quoted:—

*PULVERISED FUEL. There is considerable evidence that pulverised-fuel firing for the purpose of steam raising is passing through what may be termed a real testing time. Indeed, there is the danger that the use of pulverised fuel for any purpose may suffer from the exaggerated claims of its sponsors. Therefore, the very long and detailed series of papers and the discussion upon them at the Fuel Conference should serve as a corrective to the dissemination of exaggerated ideas concerning the use of fuel in the pulverised form, and at the same time put the whole thing in a little better perspective, perhaps, than has been the case at any rate on certain occasions. It is interesting to note that the criticisms of pulverised fuel come less from without than within. In other words, it is perfectly true that the advocates of the use of mechanical stokers still have a large say in discussions concerning use of pulverised fuel by the aid of what are known

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* cf. Paper read by E. Kilburn Scott on December 8th, 1925.

as the bin and feeder or central system of handling the pulverised fuel, or the direct system of firing, and it is confidently claimed that powdered fuel will not attain the success which is hoped for until it is able to achieve the same order of efficiency in operation as is obtained by the mechanical stoker at the present time. At the same time, probably the most heated arguments go on between those who are pushing the use of the central or bin and feeder system on the one hand, and those whose interest lie with the direct-fired system.

One of the unsatisfactory features of the long session devoted to this matter at the Fuel Conference was the fact that so much of the discussion was contributed by the makers of apparatus, and so little—indeed, none—by the users of pulverised fuel. Whilst no fewer than five representatives of one firm alone took part in the debate, it was surprising to find the central electricity power station engineers, and others similarly situated, silent. We had in the chair Mr. Archibald Page, chief engineer to the Central Electricity Board, who, beyond making the obvious and quite general remark that pulverised-fuel problems are among the most important facing the combustion engineer at the moment, and that before any large new power station or extensions to existing power stations are decided upon, the claims of pulverised fuel are considered, adopted a very correct official attitude, and did not favour us even with any personal view of his own upon the technical aspects, of which he must of necessity have quite a lot. Thus the discussion resolved itself into something of a dog-fight between the advocates of the bin and feeder or central system and the direct system of using pulverised fuel, these advocates being makers of either one or other of the two types of apparatus. In the meantime the remarkable thing to observe is the great attention being paid to the pulverisation not only of coal as we know it in this country, but to the softer brown coals and lignites, and even of peat in almost every one of the civilised countries of the world. Russia in particular is paying close scientific attention to the pulverisation of peat, and there were papers on the subject generally from Czecho-Slovakia, Germany, Great Britain, Holland, Japan, United States, and Russia. Each of these papers dealt with the problem from a separate and distinct aspect, but the impartial observer cannot fail to express the view that neither pulverised fuel in general nor any one particular system for using it is likely for a long time to come to hold the field to the exclusion of all other methods and processes. It is readily admitted by those who are not tied by commercial interests to any one particular system that the direct-fired system of using pulverised fuel is particularly suitable for relatively small undertakings, whilst the bin and feeder system finds a readier application in the large central stations and steam-producing undertakings. Those who have gone in for manufacturing the direct-firing apparatus claim that this method has gone ahead much more rapidly in the last year or two than the bin and feeder system, and this type of competition is all to the general good of the interests of the use of powdered fuel.

There is, however, a great deal more attaching to the use of pulverised fuel, by whatever system is adopted, than the mere coal-handling apparatus. The new fuel is involving radical modifications in boiler design, and it is generally agreed that there still remain to be solved a number of problems concerning the design of combustion chambers, fineness of grinding, fusion point of coal ash, the grinding process itself, transport of fine coal, and the disposal of the flue dust. This latter, indeed, is an extremely serious matter, and although the commercial gentlemen concerned in the sale of the apparatus may sometimes indulge in what might be termed a little obvious leg-pulling by suggesting that their particular system does not permit of dust being emitted into the atmosphere, honesty does not permit of such a claim being taken too seriously. Indeed, the dust difficulty is a real and serious one, and is receiving a great deal of attention. By some it is suggested that electro-static means for extracting the flue dust is the only suitable method; but it is admittedly very expensive, and nobody yet seems to have installed it. There are other means of dealing with the dust, but it is by no means certain that they constitute a definite cure as against merely a palliative. Experimental work upon powdered anthracite is being carried out in Japan, and those who wish to follow the subject closely cannot do better than make a point of studying this series of papers and the discussion upon them when they are published in volume form, because they will be found to constitute the most complete record up to date of all the knowledge of the whole subject of powdered fuel that has yet been collected.

The Integrity of the Technical Man.—It has fallen to the Institution of Automobile Engineers to be among the first in the session with its presidental address;

but Mr. L. H. Hounsfield, the new president, was specially interesting in what he had to say from quite another point of view. It is obviously increasingly difficult for presidents of engineering institutions to find a topic for their discourses if they are to avoid writing what would be nothing more nor less than an ordinary paper on some particular subject. The difficulty there lies in the fact that presidential addresses are not usually discussed, and therefore if anything of a technical nature is to be dealt with it would have to be more or less personal, which most engineers and technical men are not too fond of doing in such circumstances. The line adopted in many cases is to give a historical review of some aspect of the branch of industry with which the particular president is concerned; but although that is interesting up to a point, it does not always reach the desired end. Mr. Hounsfield, however, adopted quite a new and novel line for a presidential address to an engineering institution, in that he dealt with the integrity of the technical man. The address, indeed, forms an admirable dissertation of philosophic character with a more than definite practical touch, cleverly applied to the automobile industry. The same address could with but few alterations be applied to all other industries, and with but a few deletions could be placed before any assembly, however remote from engineering. It is this very fact which makes this presidential address to the Institution of Automobile Engineers of outstanding notice, and it is to be commended to all to read and study as apart from what some people might regard as dry and technical. The whole address is in a lofty plane, and puts the outlook on the life work of engineers and others in an admirably frank manner.

THE FUEL RESEARCH BOARD.—There is a certain appropriateness in the issue, during the run of the World Fuel Conference, of the annual report of the Fuel Research Board, some members of the staff of which have been taking a prominent part in the proceedings at South Kensington. As usual, the report makes interesting reading, and serves once more to put matters in their right perspective. Indeed, the Fuel Research Board seems destined to have to apply a corrective to the many optimistic things hoped for from low-temperature carbonisation, and this year it is definitely pointed out that the Board does not consider low-temperature carbonisation as necessarily the most important aspect of fuel research. It is definitely stated—and if the public can only remember it they should profit by it when considering prospectuses for these processes—that low-temperature carbonisation can hardly be expected to supply oil of suitable quality in sufficient quantity to make the country independent of imported oils. Indeed, we seem to be receding farther than ever from the hopes that have been entertained from time to time in this respect. A great deal of money and brains was expended a few years ago upon the possibilities of power alcohol, and quite apart from excise difficulties, which no doubt could be overcome, it appears to be accepted that the problem of distribution is such a serious one that the existing oil-distributing organisation must be made use of, and therefore the price of power alcohol, even when the manufacturing difficulties are overcome, would necessarily be the same as that of petrol and petrol mixtures. From the report of the Fuel Research Board it rather appears that it regards the greatest possible advantage of low-temperature carbonisation to be in the provision of a suitable solid fuel for domestic purposes, although producing at the same time useful quantities of oils.

PREVENTING AVOIDABLE SCRAP.—It is not sufficiently well recognised that a good deal of scrapped work can be obviated if the foremen and charge-hands exercise due care at the beginning of the job. In these days, when so much unskilled labour is employed, it is obvious that greater responsibility rests with the foremen, for the operatives do not possess that proficiency which will enable them to detect errors, such as is the attribute of skilled mechanics, and for these operatives to produce accurate work it is necessary for someone to see that the job is accurate at the beginning. Many foremen are under the impression that because there is an inspection department they are relieved of some of their responsibilities; but actually it is the foreman who is responsible for the standard of workmanship, and the inspector who certifies that the standard is being adhered to. While the foreman has the right to assume that when a job has been passed for the first operation by the inspector it can be put in hand for the next operation without further question, he must not lose sight of the fact that there may be an error—this particularly when inspection is on a percentage basis,—and it is his duty (and that of his charge-hands) to keep a watchful eye on each job as it is put in hand, so that if there is an error it can be detected early enough to prevent further work being done until the fault has been rectified. Much scrapped work is occasioned by failure on the part of the foreman and his assistants to give sufficient attention to this aspect; and in one works the matter assumed such serious proportions that special instructions were issued to all foremen and charge-hands. These instructions were to the effect that no scrapped work would be paid for if the fault was one which should have been detected by the foreman or charge-hand prior to the operative commencing his operations. In each instance the inspector sent to the foreman concerned a slip giving brief details of the work scrapped, and this slip had to be signed or queried by the foreman, and sent to the planning department. A plain signature denoted acceptance of the ruling that the work should not be paid for, but a query signified the foreman's dissent from the inspector's findings, and an application for payment, signed by the foreman, accompanied the slip to the planning department. The scrapped metal was kept pending investigation in the inspection room, and was open for the foreman's inspection. The chief planner acted as umpire between the foreman and inspector, and his decision had to be accepted by both parties. It will readily be understood that, to avoid trouble with the operatives on the one hand, and the inspection department on the other, the foreman would be careful to watch every job before it was taken in hand. This procedure had the effect of considerably reducing the amount of scrapped work, and fully justified its use.

Safety in Industry.—It has been stated that about three times as many in-patients of hospitals are due to street-traffic accidents as are caused by accidents in industrial occupations. But while mishaps under the first category show a marked tendency to increase, those under the second reveal a slight but distinct improvement. This is no doubt due in part to the safety-first movement, as well as to the growing appreciation by the workers of the facilities available in the first-aid stations of large works. But still much time is lost due to septic cases which arise through wounds not receiving early attention. In the case of one of our large steelworks, during the first half of the year 15,093 cases were dealt with at the first-aid stations. Of these, 8,128 were for re-dressing, and 262 were treated for illness; 48 septic cases were reported, and fully one-half of these were not attended to at the time of the accident. A feature was the number of accidents due to falls on the level, many of which were due to the carelessness of other workers in littering up gangways with tools, scrap, blocks of timber, etc. In connection with industrial accidents generally the recommendation of the National Safety First Association are worthy of note. These submit that the management officials and foremen in the individual works should foster throughout the works a due appreciation of the necessity for avoiding accidents, and make it recognised in the works that safety is regarded as a consideration of the highest importance, and that all possible steps should be taken to interest the workers in the work of accident prevention. The safety organisation in a works should include, among other methods, arrangements for a works investigation of every accident occurring in the works, and the consideration of the methods to be adopted for preventing a recurrence; the systematic supervision of the works, machinery, and plant for the purpose of ensuring safety, and in particular of seeing that all safeguards and other safety appliances are maintained in proper order and position; the explanation to new, and especially young, workers of the possible dangers of the work or the machinery or plant connected with their work; the organisation of first-aid and ambulance arrangements; and the encouragement of suggestions for rendering work safer.

MARINE MECHANICAL STOKING.—Greater attention is now being concentrated upon the steamship power plant, largely because of the formidable advance of the marine Diesel engine. Some indications of this are water-tube boilers, high steam pressures and temperatures of superheat, air heating, " bleeder " turbines, pulverised-fuel firing, boiler-feed meters, and combustion recorders. It is significant also that marine mechanical stoking for water-tube boilers is now commencing to make progress. At the present time, for example, no fewer than twenty-six vessels of the Koninklyke Paketvaart Maatschappi of Amsterdam are being operated with great success by the Underfeed Type E " mechanical stokers of the Underfeed Stoker Company, Ltd. The first vessel was fitted in 1921, and the whole fleet are operating in the North Sea, the Dutch East Indies, and for trading trips in the Far East generally, largely between Java and the Chinese Coast, using, of course, all kinds of coal, and very largely with native labour.

The " Underfeed Type E " design is a coking stoker containing a number of rather unusual features, particularly in connection with the discharge of the ash and clinker at the sides, and the heat of part of the air supply, combining in a very ingenious manner the coking principle for the combustion of coal with supply of heated air and simultaneous air-cooling of the firebars to prevent undue wear and tear. In operating the stoker the coal is thrown by hand, at fairly long intervals, into a hopper in the front, subsequently falling through an opening in the bottom of this, as controlled by a slow-moving ram. From this point the coal passes into a deep central trough, the entire length of the furnace, along which it is caused to travel by means of a slowly reciprocating flat ram which carries the coal along on the forward stroke. This trough is soon filled with coal, which then flows over and down each side on to inclined grates at right angles to the trough, parallel with the boiler front, composed of inclined transverse bars of special design. The coal travels down these bars partly by gravity, but also because each alternate bar has a slowly reciprocating motion which pushes the coal downward on the forward stroke and slides back underneath it on the return. The coal is ignited in the trough and cokes, the gaseous and volatile matter being driven off and burnt, and this coking action is approximately completed as the material passes on to the inclined bars, whilst the coke is burnt as it travels down the bars. The residual ash and clinker accumulate on flat dumping plates at the bottom of the bars. These plates work on a hinge, being supported by a hinge bar, which is withdrawn as required, so that the material is dumped down on the ash floor, being withdrawn through ash doors as required. The stoker mechanism is actuated by a piston in the cylinder C, and is adjustable in speed by means of a valve, so that any amount of coal from, say, 1 cwt. to 2½ tons per hour, can be supplied.

As already indicated, the distribution of the air supply, from a mechanically driven fan, is ingenious. The air enters a trunk under the stoker, being adjusted as required by air dampers, and passes to a closed wind-box underneath the central coking trough. A portion of the air is then discharged direct into the fuel bed through openings or "tuyères" along the top of the trough at each side, the combustion at this stage being therefore operated with a forced blast of cold air. The remainder of the air then travels past the tuyères and down through the inclined transverse firebars, which are hollow and have no openings except at the bottom end. The air is therefore forced to travel down inside the bars, and is discharged in a heated condition, about 350-400° F., into separate enclosed air chambers underneath the inclined grate. From here the heated air then passes between the moving bars up into the fires above in the usual way, and completes the combustion of the coked material as it travels down the inclined bars. On these lines the passage of the cold air down the inside of the bars first keeps them cool, and prevents "burning," whilst the resulting heated air completes the combustion of the ash and clinker in the most efficient manner.

The power taken to drive the stoker is approximately 3 to 4% of the steam production of the boiler, the forced draught fan requiring, say, another ½%, assuming, of course, non-condensing sets, this being less than ordinary closed stokehold practice. As a result of the regular and progressive combustion of the coal on the coking principle, smokeless and efficient combustion is obtained with an average of 15-20% saving in the coal bill on this fleet of Dutch steamers, in addition, of course, to much better conditions in the firehold.

SOME OPERATING EXPERIENCES WITH A PULVERISED-COAL SYSTEM*.—Some difficulties have been encountered with slagging of the lower rows of boiler tubes. This slagging usually occurred after the boiler had been carrying about full rating continuously for 48 hours or longer. Little trouble was experienced when less load was carried at night than in the daytime, and it has been noticed that much slag which had accumulated when operating at high rating fell off when the rating was reduced for several hours. On one of these occasions, when a high rating had been maintained for longer than 48 hours, an attempt was made to cause the slag to drop by increasing the excess air, but this apparently had little effect. One proposal advanced to prevent this trouble was to remove every other tube in the bottom row of boiler tubes, which would mean that the spacing of this bottom row would then be approximately the same as that of the water screen, and, consequently, slagging would be greatly reduced. The boiler manufacturer has recommended against removal of these tubes, and, instead, suggests removing every other tube in the lower row and installing deformed tubes which would have a drop of 7in., thereby accomplishing the same result with no loss in heating surface.

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* Abstract of paper by A. L. Penniman, junr., and F. W. Quarles, presented at a meeting of the A.I.E.E.

The air heaters are arranged with straight vertical flue gas passages and U-shaped air passages, the air entering and leaving on the same side of the heater, thereby providing very unequal resistances to flow in the air lanes. The result of this was a wide spread in the air temperatures leaving the air heater, there being about 200° F. temperature difference between the top and bottom of the duct discharging air from the heater. A deflecting-type baffle was applied to guide the air towards the lanes having the longer paths. Another scheme which was also experimented with, consisted of adding resistance at the air inlet to the shorter paths, the increased resistance to flow of air being obtained by the application of metal strips. The two schemes materially helped the situation, and were of about equal merit, although neither attained the desired result. Both schemes are objectionable from the standpoint of power loss caused by the increased duty placed on the forced-draught fans. The air-heater manufacturer is now taking the necessary steps to improve the performance of this apparatus.

The bearings on the primary air and induced-draught fans are of the ring-oiled type, provided with an integral oil cooler built into their bases to eliminate the necessity for separate oil pumps for the circulation of the oil, and also to permit the use of harbour water for cooling. There was some trouble from the leakage of water into the oil reservoirs, which was eliminated by a slight change in the design of the coolers.

The induced-draught fans are of the plate type, because of the high duty imposed by the requirement of handling 135,000 cub. ft. per minute of 450° F. gases against a static head of 15·8 in. of water. These fans have given excellent service, except for some slight vibration due to the bearing pedestals being somewhat light. This has been corrected by the application of bracing. Two failures of an induced-draught fan motor have occurred, the reason for which cannot be ascribed to overload or faulty control.

Five failures of fin tubes constituting the back furnace wall have occurred. These tubes have all failed in the same manner and almost at the same spot—namely, the outside of the top bend of the rear wall tubes near the sides of the furnaces. In one case a large bulge was noticed before an actual rupture occurred. The water circulation is to be investigated to determine whether or not there is considerable difference in rapidity of water circulation in different parts of the back wall. The obtaining of this information will no doubt make possible a satisfactory analysis of this condition.

Because of the high rating for which these boilers are designed, it was necessary to supply two 6 in. feed water regulating valves. It was found that the thermostatic tubes of the feed-water regulators were not sufficiently powerful to operate the valves properly. New pistons were designed by the manufacturer in an effort to reduce the friction, which was apparently caused by water flow, since the friction was quite low when no water was flowing through the valves. The new pistons did not prove entirely satisfactory, and attention was directed towards the use of hydraulic power, utilising the thermostatic tube to actuate only a pilot valve. Operation was so much more satisfactory that the manufacturer equipped all the regulators similarly.

Soon after starting the plant it was determined that the moisture content of the steam leaving the boiler drums was higher than desirable. The boiler manufacturer has developed and installed a new type of baffle, which has produced excellent results. This improvement should be of much benefit in the maintaining of cleaner surface on the interior of the superheater tubes, since the moisture, of course, carried solids in solution. It also will reduce the duty on the superheater for a given temperature of steam leaving the superheater.

The plant operated for a large portion of the year 1927 with lower superheat than the design value. It was held advisable to delay the raising of the steam temperature until other apparatus which would influence the result had been tuned up. Just recently the baffling of the gas passage at the superheater has been changed to give the desired steam temperature. The remaining feature to be reckoned with is the pressure drop of the steam through the superheater, this being approximately 35% higher than expected.

As to the matter of combustion control, several difficulties were experienced in the burning out or breaking down of coils and grounding of wiring. Discharge resistances were provided to lessen the inductive kick from the coils, and wire with varnished cambric insulation was used in the control boxes to withstand the oily atmosphere. The pole-changing feature of the motors contributed some complications on account of the necessity for providing control overlap.

The combustion control is normally set to maintain a 15% CO_2 average across the section of the boiler gas outlet. This setting is interfered with to some extent by a variation in feed-water temperature. This is particularly so if the two higher pressure feed-water heaters are cut out of the circuit at 20,000 to 35,000 k.w. load on one boiler. An attachment has been designed quickly to correct the meter for this condition and is being installed. The combustion control which we have installed is not suitable for quick changes in load, this having been demonstrated several times. It is our usual practice to operate on semi-automatic control for the quick changes in load which can be anticipated, such as the noon-time drop and the morning pick-up.

There are eight 4½in. high-lift safety valves on the drum and two on the superheater outlet of each boiler, each drum valve having a relieving capacity of 52,500 lb. per hour, and each super-heater valve 35,000 lb. per hour. While these valves have not been tested for relieving capacity, two occasions have arisen when the entire plant load has been lost in which the safety valves relieved a total of 380,000 lb. per hour satisfactorily. One of these occasions was when an air drill penetrated the high-voltage leads from the main generator, causing the differential relays to trip out the oil switch and field breaker, the other when the throttle valve of the main unit became unlatched. The leakage and maintenance of these valves has been very slight, and, as a matter of fact, has not been any higher than has been experienced at the Westport plant on 200 lb. pressure service

There are three ash gates per boiler, 41in. × 56in., actuated by oil-operated cylinders, which at times have refused to move, due to friction, distortion, and failure of cast-iron plates. In certain places where two ferrous materials rub on each other, one of them has been replaced by non-ferrous material, clearances have been increased, and the cast-iron support plates have been reinforced with steel. The result has been almost complete elimination of the sticking difficulties.

From "the Marine Journal," U.S.A., of November 20th:—

TODD PULVERISED COAL BURNING SYSTEM INSPECTED AT LEAGUE ISLAND NAVY YARD.—A large group of shipping men, marine engineers and others interested in the development of pulverised coal burning apparatus for marine application were guests of William B. Todd, Tuesday, November 13th, at the League Island Navy Yard, where most of them had journeyed in special Pullman cars from New York to witness the Todd Pulverised Coal Burning System while undergoing an eighty-hour continuous test in combination with a Scotch marine boiler in the coal laboratory of the navy yard. This test is similar to the one recently given under approximate sea-going conditions to the equipment, which with some modifications, was placed on the SS. *Mercer*, the first successful seagoing installation.

While detailed results of the test of Todd apparatus will not be available for several days, many of those who witnessed the test expressed confidence that on the excellent showing already made, the new system will meet all requirements when applied to marine use. Captain C. A. McAllister, who was one of the first to see the possibilities and has been an enthusiastic champion of pulverised fuel for marine use, spoke highly of the latest addition to the ranks of pulverised coal burning equipment, and others who saw a great future for the Todd System were: J. J. Fagan, chief engineer of the SS. *Leviathian;* Chief Engineer Schneider of the North German Lloyd liner *Suttgart*, and Samuel Aitken, of the Moore and McCormack Company. Mr. Gardner, of the Todd organisation, has been closely in touch with developments, and Carl J. Jefferson and Commander Brosheck, who have long since become known as experts in the marine use of pulverised fuel, were personally in charge of the tests.

A high speed impact mill is used to obtain superfines from bituminous screenings which are quoted $4·50 a ton F.O.B. New York. From the pulveriser, the superfines pass through small, compact independent distributing units to the burners which are attached to each furnace of the boiler. The units are arranged to allow the use of fuel oil. The coal used for the tests assays 7 per cent. moisture. During the test demonstration, the coal is fed from bins by gravity conveyors, which distribute it to the pulverisers, from whence it is fed into the distributors and burners by compressed air. The system gives excellent combustion for there is practically no ash and no trace of soot in the boiler room.

It is reported that the Todd System will soon be installed on an American freight steamship and also on one of the new freighters now building for the North German Lloyd.

Mr. Todd arrived from Atlantic City to join his guests, who, following the inspection, were driven in large busses through the Navy Yard under the personal direction of Admiral Latimer, the Commandant. The entire trip was conducted with careful attention to detail, which is characteristic of the Todd organisation. A detailed description of this installation, together with results of the test, will be published in an early issue of " Marine Journal."

*NAVAL ARCHITECTS INSPECT COAST GUARD CUTTER *Chelan.*— In the course of the technical sessions an invitation was extended to the members of the Society to inspect the Westinghouse equipped Coast Guard Cutter *Chelan,* known as " The Floating Power House," which was berthed at the foot of West Ninety-sixth Street.

This remarkable vessel, which is one of ten planned and is one of the five in the first part of the building programme authorised by Congress to be equipped with turbo-electric propulsion furnished by the Westinghouse Electric and Manufacturing Company. A paper descriptive of this installation was read before the meeting and further reference will be found elsewhere in this issue as to particulars of the vessel.

When these vessels were designed, central station power plants, which supply service to industry and homes, were taken into consideration and the same principle was applied on ship board. It is possible under this arrangement to supply power for lighting, pumping, radio and other purposes throughout the vessel directly from the main engine.

On her " shake-down " cruise the *Chelan* was put to the severest test ever applied to a new vessel. Shortly after leaving Boston she received a distress call from the New York Nautical Training Schoolship *Newport,* which had lost her

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* This will be of interest to some of our members engaged in coast traffic abroad.

propeller off the Bermuda. The electrically driven cutter raced for the *Newport* and towed her 1,500 miles to New York harbour. In this, the severest tests were applied to all of the *Chelan's* machinery.

The following descriptive articles—the blocks for illustrations by which have been kindly lent to us—are from " The Mechanical World and Engineering Record " of January, 18th :—

THE METALLING OF BEARINGS. By A. L. Walker.—In general engineering, occasions arise when equipment employing plain or sleeve type bearings breaks down, due to excessive wearing of the bearing metal. Apart from specialised industries as automobile and marine, where the lining of bearings forms a considerable portion of their activities, much occasional work is performed in a perfunctory manner, it being generally considered sufficient to melt the metal, pour, and peen the bearing, with little regard to temperatures employed and degree of adherence attained.

Making or relining a bearing involves consideration of bearing metals, method of pouring, preparation of bearing shell and temperatures employed.

Bearing metals employed range from lead base alloys to those of a high copper content, and temperature necessary for casting will be dependent on the type of bearing metal used. The alloy selected for the purpose in hand must suit the conditions, both as to pressure and speed obtaining in the bearing. Lead base alloys may be considered as suitable for slow speeds and low pressures. Tin base alloys are especially suitable where large wear and tear are encountered, as in heavy engines for rolling mills, cement grinding machinery, etc. Those containing a high copper content are especially adapted for use under high speed and heavy pressure, and are not prone to become hot under normal conditions.

Typical composition of each of the above type alloys are here given—Lead base alloy: Lead, 78½% ; antimony, 16½% ; tin, 5%. Tin-base alloy: Tin, 84% ; antimony, 11% ; copper, 5%. High copper alloy: Copper, 6% ; zinc, 80% ; tin, 14%.

Melting of the metal should be carried out in a clean ladle, heating to the pouring temperature as quickly as possible.

Uniform heating is also important, and the metal should be kept well stirred. To prevent oxidation and formation of dross, a little fine dry charcoal may be sprinkled over the molten metal. Pouring temperatures involved will be contingent upon the type of bearing metal used, and will range from 310-490° C. Whenever possible a pyrometer should be used to indicate the temperature. Should one not be available, a rough guide to pouring temperature may be obtained by using a piece of white deal. For tin base alloys and those containing copper the pouring temperature is approximately reached when the wood will just ignite; for lead alloys, charing of the wood will indicate the correct heat.

Overheating is invariably injurious to the metal, causing oxidation, partial loss of the constituents, and may be shrinkage. A brittle bearing may result, or on the other hand the result may be too soft. Too low pouring temperature will result in a coarse crystalline structure. The surface appearance of the metal after casting should be bright and clean; a dirty surface frequently shows too high a temperature has been used.

Before pouring the metal thorough preparation of the shell is necessary. Bronze shells should be dipped or cleaned in hydrochloric acid and tinned with pure tin. Should tin be out of the question, a 50-50 solder may be used, but consistent results will not always be obtained. Steel and cast-iron surface should be machined; the former should be tinned, but the latter requires no further preparation. With all bearings good anchorage of lining must be secured, and shells should be recessed with dovetail ribs, or have undercut grooves to grip and hold the bearing metal. Fig. 1 is a sketch of a heavy bearing shell showing dovetail ribs, which may be cast or machined in position.

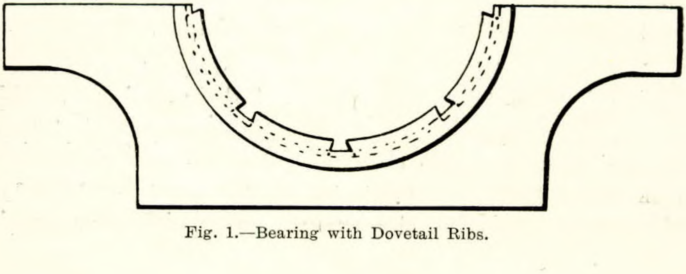

Fig. 1.—Bearing with Dovetail Ribs.

Where circumstances are such that bearing shells cannot be machined, grease and moisture can be removed by heat, afterwards cleaning with acid and tinning if necessary. Should it not be possible to heat the shell, thorough cleaning by acid should be resorted to.

Failure in service frequently occurs owing to molten metal being poured into a cold shell. The liquid bearing metal is run into position, causing the rate of solidification to vary; and, due to air pockets, blowholes may occur. Premature shrinkage due to contact with the cold mould may also take place, forming an imperfectly filled bearing, liable to flaking or working loose.

To avoid these defects, bearings must be preheated whenever practicable, and the temperature employed will vary according to the shell metal. Bronze shells, tinned, should be heated to approximately 120° C., while steel and iron casings allow good formation of bearing when heated to 230° C. Where steel mandrels are used as cores, it is advisable to preheat these to somewhat lower temperatures, thus giving a very slight chilling effect to the bearing surface. A temperature of 120° C. will suffice in most cases. Proper preheating will give more uniform shrinkage and cooling, settlement of the heavier constituents will be largely prevented, and smoother flow of metal take place.

Shafting, hard wood, or steel plate formed to the required curvative may be employed as cores, and should be coated with plumbago to prevent sticking of the metal.

A fireclay basin should be built around the top to act as a head, and will assist in guiding the molten alloy into the recess.

Not the least important part of the operation is the pouring of the metal. When ready for use all dross should be skimmed from the surface and thorough stirring of the metal take place to ensure that layers of the heavier metals have not settled at the bottom. A clean ladle is essential, and one fitted with a bridge piece is much the best. The bridge tends to prevent passage of dross and helps to regulate rate of flow. When pouring a position close to the entrance hole should be adopted, so as to avoid chilling the metal and carrying in air with the stream of liquid. A steady even flow prevents formation of air pockets, and surplus metal should always be added to partially counteract any shrinkage and allow slag to overflow.

Many authorities recommend that linings be hammered after pouring to tighten the grain and thoroughly close up the pores of the metal. While this may have no deleterious effect on some of the softer alloys, it is a moot point whether it improves those possessing hard crystals. Hammering will undoubtedly tend to shatter and crush the hard copper-tin crystals, and if the lining is of a coarse crystal structure, incipient cracks may be formed which later may result in service failure. In any case peening should be most carefully carried out, and only entrusted to skilled hands.

Recovered metal from turnings may be used again, but should always be added to a large proportion of new metal. Scrap should be thoroughly clean and magnetted to remove any ferrous particles.

A poor bearing may give effective service when well lubricated, but filling of the oilways due to flow of metal under pressure or flaking of the lining may have disastrous consequences on the functioning of the machine.

Dr. E. F. W. Alexanderson, of the American General Electric Company, addressing the International Civil Aeronautics Conference in the United States, claimed to have devised apparatus which will dispatch a wireless wave from an aeroplane to the ground and, by the speed of its rebound, indicate to the airman with the aid of coloured lamps on the dashboard the height of his machine. A mechanical attachment for use at 10ft. or 15ft. will indicate in a similar way when to begin landing with safety in darkness or fog.

MODERN OIL ENGINES.—I. By F. Johnstone Taylor.—In this, the first part of a practical series of articles on Modern Oil Engines, the author deals with the Diesel Engine, describing examples of the four and two-stroke types; Semi-Diesel Engines, High-speed Diesel Engines, etc.

Principle of the Oil Engine.—The oil engine is by far the most versatile of prime movers. It ranges in size from marine engines, which are now being built to develop as much as 2,000 h.p. per cylinder and over, to lightweight, high-speed engines, which are quite likely in the near future to replace the heavier petrol and paraffin motors. It has certainly not yet reached the stage of being suited to light motor vehicles or motor cycles, nor has the gas turbine, designed to utilise oil fuel, made its appearance as a machine of practical utility; but there is no reason why such developments might not in the future take place.

The oil engine must not be confused with the paraffin engine. The latter is an explosion motor of the petrol-engine fitted with a means for vaporising the less volatile fuels. The fuel, inducted into the cylinders with the requisite amount of air, has to be ignited by electrical means. There are about a dozen distinct types of oil engine in common use at the present day, but they all function on one basic principle—that of automatic ignition. Air only is drawn into the cylinder and compressed in accordance with the usual cycle of the internal combustion engine. It is at the end of the compression stroke that the oil—a heavy viscous fuel which can be collectively referred to as "Diesel" oil—is forced through an atomiser or spray-maker into the combustion head, where the heat present ignites it. The fuel burns rather than explodes, and thus gives the working stroke. The different principles of injection give rise to different types of engine, known as Diesel or air-blast injection engines, or airless or solid injection engines. Then, again, the necessary heat for ignition may be generated by high compression in what are sometimes referred to as high-compression engines, or by a hot bulb in the case of hot-bulb engines, sometimes classified as semi-Diesel engines. Again, a large number of airless injection engines work with low compression, and depend upon principles to be set forth presently for efficient combustion. They fall into the category of surface ignition engines. Further, there is an arrangement known as a pre-combustion chamber, which provides, so to speak, automatic injection, and is a system made use of on light-weight engines. Then, again, the two-stroke and four-stroke cycles are universally in evidence, while double-acting engines are now becoming quite commonplace for large powers.

The oil engine, speaking generally, is capable of providing the cheapest power, notwithstanding the relatively high cost of what, in this country, is imported fuel. That is the only argument against the oil engine. The gas engine, even if the oil engine had not stunted its development twenty years ago, could never have appeared as a practical proposition in the powers now attained by oil engines. Oil is a concentrated fuel, and the amount which can be burned per cylinder per stroke is only limited by the heat stresses in the cylinder; whereas gas—especially cheap power gas—is a weak, diffused fuel which limits the size of a gas engine to the practical size of its cylinders.

There is no indication of the oil engine ousting steam power. While finality has not been reached in their size, oil engines do not yet approach those of the large turbines used in the power stations or aboard ship, and, compared with the turbine—and especially with the turbo-generator—it is a formidable machine, and as the power increases, its superiority on the fuel cost per b.h.p. hour basis decreases, until it becomes, in countries where coal is cheap, either negligible or non-existent. That is why we, in these islands, have nothing approaching the 18,000 h.p. sets at Hamburg, for instance, in the electrical field. The problem of the marine oil engine and its competition with steam involves questions other than mere running costs; but these concern naval architects and shipowners, and need not be discussed here. Up to about 1,000 h.p. for land work, at all events, oil power, as a rule, is prospering at the expense of steam power; but this must not be taken as any indication that either the steam engine or steam turbine of moderate output is anything approaching a back number. In many instances local circumstances weigh heavily on the side of steam. For industrial power plants, however, pumping plants and electric power stations of moderate size, the oil engine builders can usually show quite conclusively that their engines can produce power more cheaply than steam turbines or gas engines, and—what is more important—more cheaply than power purchased under the most favourable conditions. The latter might appear as rather paradoxical in view of the favourable generating conditions which the power stations have, or ought to have; but what they save there, the engineers themselves know only too well, is largely lost in transmission.

Fuel.—When, in a later article, the all-important question of running costs comes to be considered, the figures given must be construed as being based upon the use of a good grade of fuel. Oil engines of the present day are often collectively referred to as crude-oil engines—a term which leads to the assumption that they operate on crude oil. This is not so. Fuel oils, classified generally, are residual oils left over after refining processes, during which the light volatile substances and other constituents are abstracted by distillation and otherwise. " Fuel " oils are those grades chiefly employed for boiler and furnace firing, while " Diesel " oil, a product now universally available, is specially prepared by the oil-marketing concerns for use in oil engines, and it is now supplied to meet standards recognised by such bodies as the Diesel Engine Users' Association, etc.

Leaving out of consideration such special fuel as refined gas oil on the one hand and tar oils on the other, which are only at present used under special circumstances, the choice of a practical fuel is limited to two alternatives known to the trade as: (*a*) Diesel oil, (*b*) boiler oil. There is no perfectly hard and fast scientific definition of these two grades, but in practice their differences are generally fairly sharply defined and well known to all users of heavy oil, and may be summarised briefly by saying that the typical boiler oil has a slightly higher specific gravity, very much higher viscosity, contains more impurities, has in general a greater sulphur content and slightly lower calorific value than Diesel oil, and gives a greater residue on evaporation at a fixed temperature.

The price of boiler oil is generally about 20% lower than that of Diesel oil at most European and American ports. At a considerable number of Eastern ports, however, the prices of Diesel oil and boiler oil are identical, and therefore motor-vessels bunkering in these oversea ports for the round voyage will naturally buy Diesel oil quality only. This ability to bunker for the round voyage at oversea ports where fuel oil can be obtained cheaply, is, of course, one of the important advantages conferred by the large radius of action of motor vessels as compared with steamers.

The economic problem for the fuel-oil consumer is to determine which will yield the best return for the price paid, taking all relevant considerations into account.

While there is no difficulty attending ignition and combustion of boiler oils in a well-designed engine, their use necessitates more or less elaborate arrangements, such as purifiers, to eliminate dirt and water, etc., heating apparatus to reduce the viscosity of the oil, and allow it to flow freely through the pipes, and to admit of proper operation of fuel pump and fuel valves, and special heating arrangements for the ship's storage tanks.

The further disadvantages attending the use of boiler oil are those associated with the sticking and clogging of piston rings (and the consequent need of more frequent overhaul) and increased wear of liners, due to the interference with proper lubrication caused by gummy deposits on the cylinder walls.

In the vast majority of cases there can be no doubt that the simplicity of the fuel arrangements and the minimum demands for overhaul which result from the use of Diesel oil enable an over-all economy to be secured in excess of anything that can be obtained with boiler oil, with its attendant expenditure on heating and purifying, and also the extra attention and maintenance which the use of the latter fuel involves.

The difference of cost of the two kinds of fuel is so small that the apparent saving of anything up to 20% of the fuel bill, which appears at first sight to be available by using the cheaper fuel, practically disappears in reduced calorific value, foreign matter, higher coking figure, and higher water content, apart from the considerations mentioned above, so that actually, the consumption of an engine using boiler oil, when reckoned on a b.h.p. day basis for fuel only, will usually be practically as much as that of an engine using the nominally more expensive Diesel oil.

Properties of Fuel Oils for Internal Combustion Engines.—Other things being equal the fuel consumption of an oil engine varies inversely as the calorific value of the oil, so that the maximum economy results from the use of oil with the highest heating value. Published results ought to state what this value is if a true comparison between engines is to be made; at the same time the calorific value of suitable fuels does not vary to any great extent, a good Diesel oil, for instance, having a value between 19,000 and 19,500 B.Th.U. per pound. In reference to their productions, Shell Mex state that Diesel oil is produced with a regard to the exact requirements of the modern heavy oil engine. In use it will be found to give maximum combustion efficiency at all load factors with minimum cleaning and maintenance costs. Its physical characteristics show that in all respects it complies with the specification "A" of the British Standards Fuel Oil No. 1 for heavy oil engines. This oil requires no preheating or filtration. Fuel oil is a heavy fuel primarily intended for furnace firing, and may be used on those engines where special provision is made for the utilisation of this type of oil.

In respect of a third grade, classified as gas oil, they state that gas oil is a distillate fuel which vaporises readily, and is consequently most suitable for old-type engines not possessing perfected injection devices of modern types, and for certain medium-pressure engines in which the temperature conditions do not permit of heavy fuels being employed. With regard to the physical characteristics of this grade, attention is drawn to its particularly high calorific value, and its entire freedom from hard asphalt and impurities. Needless to say, Shell gas oil complies with the specification "A" of the British Standards Fuel Oil No. 1 for heavy oil engines. This oil requires no preheating or filtering.

Viscosity: *Impurities*.—The facility with which the oil may be pumped and otherwise handled by the fuel system depends upon its viscosity. Heavy fuel oils require heating before they can be efficiently handled; but Diesel oils of good grade should not require this under normal conditions. The temperature at which oil will cease to flow is technically termed the "setting point," and heavy fuel oils require heating even at a temperature considerably higher than their setting point before pumping is possible.

As regards impurities, these may be cited as asphalte, sulphur, and solid mineral matter. Oils with a high asphalte content are not in general use for I.C. engines, being chiefly used for boiler firing. While fuels with a high asphalte content can be efficiently burned in engines suited to them, they always contain a relatively large proportion of water and solid mineral matter, and it is generally undesirable for the hard asphalte content to exceed 2%, which is the allowable content in British Standard Fuel B. 2. Sulphur is not now considered sufficiently harmful to warrant desulphurisation of fuel. The corrosive products due to sulphurous and sulphuric acids are only formed when the products of combustion are cooled sufficiently to allow of sulphur dioxide and trioxide being dissolved in water. At temperatures above 210° the presence of sulphur compounds in the exhaust gases cannot exert any harmful effects, and so far as the engine cylinder is concerned, no part will be at a temperature at which corrosive liquid would form; but the point should be borne in mind when it is proposed to use the exhaust gases for low-temperature heating. The presence of mechanical impurities is far more important. All mechanical impurities should be removed before the oil is admitted to the fuel system. If this is not done the larger particles will cause sticking of the fuel pump and clogging of the atomiser, while any fine particles which may pass into the cylinder will become deposited and cause rapid abrasion of the piston and cylinder liner. Water is a frequent cause of erratic running, the same as it is in the petrol engine. Any good standard Diesel oil should be practically free from impurities and from water, and should show an ash content, which is indicative of the amount of impurities present, not exceeding 0·01%. If it is required to use oils in which impurities are known or suspected to exist, resort must be had to the centrifugal system of purification, though heating, filtering, and settling will effect a certain amount of purification in an emergency.

Diesel Engines.—From what has been said it will now be appreciated that the basic principle of the oil engine is that of burning oil, much of the consistency of tar, directly in the cylinder. There are a good many considerations leading up to the efficient combustion of this fuel so that the engine will function regularly, as modern types do, with a consumption of 0·4 lb. to 0·5 lb. per b.h.p. hour according to type; but these are deferred for the moment until the subject of airless injection is dealt with. There are two principal means of handling the fuel in an oil engine. One is the aforementioned airless injection, which has been all but perfected during the last fifteen years, and the air-blast injection which was used bv Diesel. The term " Diesel engine " is, in American parlance, applied indiscriminately to all oil engines; but in this country it is used in its proper significance, for engines with air-blast injection. Whether the engine be two-stroke or four-stroke, single-acting or double-acting, the main point of difference lies in the fact as to whether it is a Diesel engine or an airless-injection engine. While airless injection is a more recent development than air-blast injection, it is not necessarily a better proposition. It eliminates the necessity for a high-pressure air compressor, and has thus, amongst other things, been the means of simplifying and cheapening the oil engine of moderate power, and, in fact, of popularising its extended use; but for large engines and those which operate on the very lowest grades of oil, the air-blast system remains supreme, despite the fact of the high-pressure air compressor adding to the cost of the engine and absorbing a certain amount of power. It thus comes about that the use of the Diesel principle has declined for powers under 1,000 h.p. or thereabouts, and it may eventually be superseded altogether by airless injection.

The representative four-stroke Diesel engine produced in this country for general industrial work and electrical power generation is that built by Mirrlees, Bickerton and Day, of the four-cylinder, vertical, trunk piston, open type, working at a speed of about 200 r.p.m. and developing on an average 50-100 h.p. per cylinder. It is practically a standardised engine of world-wide reputation. An important feature is the fuel valve, upon which so much depends. It is shown in Fig. 1.

The valve, which is of the packingless type in general use, consists of two main parts—an upper part A and a lower one B. These are joined together by means of a double ball-and-socket joint C. The provision of this joint removes the necessity for the absolute alignment of the upper part of the valve with the lower. Hence, should it happen that the bolts D securing the fuel valve casing are unequally screwed down, tilting the upper casing and causing a slight error of alignment, this error will not affect in any way the proper working of the fuel valve.

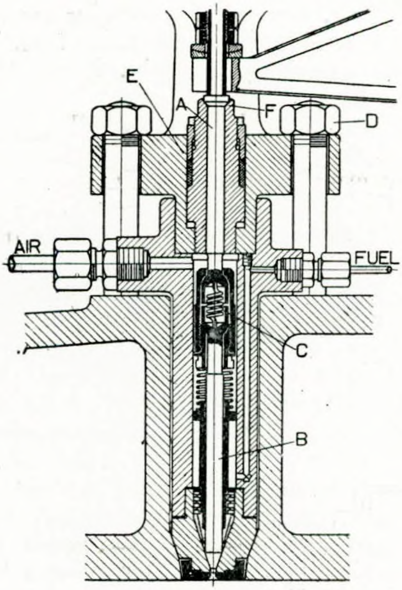

Fig. 1.—Diesel Engine Fuel Valve (Mirrlees).

At the top of the upper fuel valve casing a valve face F, resting on a lower seating, will be noted. It is this face which prevents air leakage past the fuel valve. When the valve face is in position on its seating the lower end of the fuel valve also rests on its conical seat above the flame plate. To ensure accurate seating a slight amount of play is allowed between the top and bottom face of the fuel valve spindle, and, furthermore, a spring is provided between the two parts of the valve stem.

When the valve lever lifts the fuel valve spindle the top valve face F, already referred to, is raised from its seating, and any air leakage then depends on the quality of the fit of the fuel valve spindle in its bush. The lifting period constitutes, however, only a fractional part of each stroke, and any leakage past the spindle which may occur during these very short intervals of time is quite negligible.

Space does not admit, under this heading, of details of other good designs of Diesel engines being given, although other types will be dealt with in due course, but mention might be made of the Tosi director valve, a feature of the Beardmore-Tosi marine engine, but not necessarily confined to marine work. With this arrangement one valve functions as the inlet and exhaust valve, as shown by Fig. 2, and tends to simplify the cylinder head.

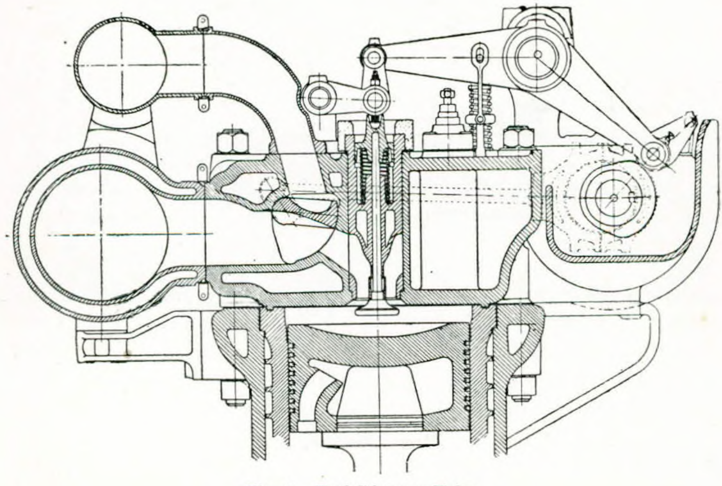

Fig. 2.—Tosi Director Valve.

The valve functions in the usual manner, and is shown open to exhaust. On the completion of the exhaust stroke the director valve on the left is moved by the eccentric shown dotted, and worked by the camshaft to close the exhaust passage and open the air passage above, the poppet valve closing after the suction stroke.*

FLEXIBLE PIPE JOINTS. AN INTERESTING INSTALLATION OVER THE TAY BRIDGE.—Extended use is now being made of the ingenious "Victaulic" flexible pipe joint described some time ago in these columns. In this connection we give an interesting view of a 10in. water main fitted with these pipe joints and laid across the Tay Bridge. This pipe-line belongs to the Dundee Water Commissioner, the engineer and manager being Mr. George Baxter, A.M.I.C.E.

In the early part of 1927 it was necessary to renew the water pipe-line crossing the Tay Bridge, and the original specification, drawn up by the London and North-Eastern Railway Company, stipulated that the spigot and faucet joints should be employed. However, it was pointed out by Mr. Baxter that the latter was not the best method, especially as the main had to be replaced as quickly as possible, the work being mostly undertaken on Sunday, when the railway traffic was at a minimum, and for this reason "Victaulic" joints were used instead, one of the well-known advantages, of course, being the rapidity of fixing, which only requires 2-3 minutes per joint. Originally 137 joints were fitted on this new main, but subsequently it was extended still further, and 206 additional joints were delivered.

The main is of steel, $10\frac{1}{2}$in. outside diameter by 5/16th in. thick, supplied by Stewarts and Lloyds Limited, with the usual lip or shoulder to suit the "Victaulic" ring housing, whilst also the main was lined inside with bituminous composition $\frac{1}{4}$in. thick.

One noteworthy advantage of the joint, shown by this installation over the Tay Bridge, is the considerable amount of end play possible without any sign of leakage, thus allowing the whole pipe-line to expand or contract longitudinally to a considerable degree in accordance with the natural movement

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* To those interested in the progress of the Internal Combustion Engine, it may be noted that the Papers read at the Institute, afterwards reprinted and bound, are still available at 12/6 per volume.

of the bridge itself. This, of course, is impossible with any form of rigid joint, which therefore entails the provision of expensive and complicated expansion bends of special types of expansion joint which are notoriously a troublesome and costly addition.

From "The Electrical Review" of February 8th:—

THE SHANNON WATER-POWER SCHEME. THE RIVER SHANNON HYDRO-ELECTRIC POWER DEVELOPMENT SCHEME AND ITS ECONOMIC CONSEQUENCES TO THE IRISH FREE STATE. (Extract from a paper read before the Royal Society of Arts).—Without entering into much electrical or general mechanical detail, Mr. George Fletcher described the main hydraulic and electrical aspects of the scheme and gave a short account of the history that has led up to its adoption. The author was a member of the Sub-Committee of the Board of Trade which dealt with the water-power resources of Ireland, concerning which he read a paper before the Royal Society of Arts in 1922. The Committee agreed that such large rivers as the Shannon should be in the control of a Department of State, and the paper related how in September, 1924, the Free State Government submitted the scheme prepared by the Siemens Schuckert Co. to four experts (Messrs. Waldemar Bergquist, of Stockholm; Eugen Meyer-Peter, of Zurich; Thomas Norberg Schulz, Christiania; and Arthur E. Rohn, of Zurich) for report, and the scheme now in progress was passed by the Dail Eireann on April 3rd, 1925, the Shannon Electricity Act being passed in June of the same year.

After a general account of the hydraulic and civil engineering features of the scheme, it was pointed out that electricity would be generated at 10,500 volts, the pressure being then stepped up to 110,000 and 38,000 volts for distribution over nearly the whole of the Free State. The 110,000 volt lines, which formed the primary distribution system, would run from Ardnacrusha to Dublin (six conductors) and from Ardnacrusha to Cork (three conductors), distances of 116 and 59 miles, respectively; at each of those points would be installed 110,000/38,000 volt transformers. The 38,000 volt secondary system was arranged for loop distribution which, when completed, would cover some 1,040 miles; at certain points would be installed transformers of 38,000/10,000 volts, which would supply other subsidiary networks serving various towns and villages where the pressure would be transformed down to 380 and 220 volts adopted for industrial and domestic users. The 110,000 volt lines would be supported on lattice steel masts in the southern area and on wooden poles in the northern area, whilst wooden poles were used exclusively for the 10,000 volt lines. The erection of the transmission lines was the first work taken in hand and was now in a very advanced stage. Rapid progress had been made with the generating station and it appeared to the author probable that supplies would be available by October of this year.

The latter part of the paper was concerned with the economic effect of the scheme upon the national life of the Irish Free State, which point was dealt with mainly also in the discussion. Although some people were still most concerned about whether the scheme would pay, the author's view was that the water-power resources of Ireland should be utilised without waiting for a mathematical demonstration that any such scheme as the Shannon would be a financial success; at the same time he thought that financial success was assured. The position to be faced was that the population of Ireland was still declining, notwithstanding that it had already fallen from over eight millions to slightly over four millions in 50 years and the area of land under crops had also fallen at about the same rate. Many once-flourishing towns were falling into decay and had ceased to provide for the needs of the rural areas surrounding them, and articles which they once manufactured were now imported. That unhappy state of things was due largely, but not entirely, to lack of fuel resources; to-day industry in the Irish Free State called for cheap power. Therefore, the primary need of the Free State was cheap electricity for power and lighting, which it would be the function of the Shannon scheme to provide. There were approximately 130 towns and villages with a minimum population of 500 in which no electricity was available at present, but contracts had been placed for the erection of distribution networks in more than 30 of them. It was not possible at this stage, continued the author, to estimate to what extent the supply would be availed of by the agricultural industry, but with adequate propaganda it was certain to play a very important part in the staple national industry.

Prof. T. Wibberley said that not only was it necessary to electrify industry in Ireland, but also to electrify the mentality of the people to get a new outlook and to encourage them to live for the future. He looked to the scheme playing an important part, not so much in the application of electricity to agriculture, as to the manufacture of synthetic nitrogen for the purpose of fertilisation. He spoke of the many ways in which electricity could also be applied with successful results to the farm, and instanced many of the things which some people have had the opportunity of seeing on Mr. R. Borlase Matthews' all-electric farm.

Mr. Ll. B. Atkinson said that a few days prior to the meeting he had had the opportunity, with the president of the Institution of Electrical Engineers, of going over the Shannon scheme and the work being carried out, and in one respect the paper had disappointed him, inasmuch as it did not deal so much with the economics of the scheme as the title would lead one to hope. The whole thing was on a much more vast scale than the author's illustrations indicated, and in many respects he had not seen elsewhere in Europe such wonderful machinery as was being used in connection with the Shannon scheme. Eventually 180,000 h.p. would be available and the great question was what was going to be done with it. Prof. Wibberley had spoken of its connection with the manufacture of synthetic nitrogen, but the more advanced processes of manufacture of synthetic nitrogen had nothing to do with water power utilisation and the production of electrical energy, but were rather catalytic processes for uniting nitrogen with other materials. At the same time, the feature of the Shannon scheme was that it was a gesture of a change which was coming over Ireland, and from that point of view the scheme was more than an engineering scheme. It was an economic and psychological gesture that Ireland intended to change her methods and come into line with modern conditions. If that was the case, then the whole outlook for industry and farming in Ireland would change in a remarkable way, due to the influence of the supply of electricity which would soon be available from the Shannon scheme. It might interest constructional and electrical engineers to know that of the total cost of roughly £5,000,000 no less than £2,500,000 was being spent on the civil engineering work; another 40 per cent., or £2,000,000, would represent the overhead lines, and only £500,000 was represented by the moving machinery; thus there would be very little maintenance of machinery. The moving parts of the turbines weighed 480 tons and revolved 150 r.p.m. One of the most interesting features of the turbine plant was the bearings, but in spite of the heavy weights involved it had been found that the Michell type acted perfectly satisfactorily without the need for pumping oil into the bearings.

Mr. R. Borlase Matthews said he had been particularly interested in watching the Shannon works grow. One point that had appealed to him was that the first thing the contractors did was to build generating plant for use on the works and the whole of the constructional work had been carried on with the aid of electrically-operated machinery. A number of difficulties had been encountered which had probably delayed the work for six months; first there had been a strike, then trouble arose because what had been thought to be rock turned out to be soft earth, whilst earth which was thought to be soft turned out to be rock. It was quite likely that a series of small stations throughout the country would have been more economical, but he doubted whether such a policy would have made the wonderful psychological appeal to the nation that the present one had. The statements of the enormous amount of power available would, he believed, lead people to adopt electricity much more rapidly than they would if small local steam stations had been erected. In the Irish Free State he believed the agricultural load would eventually be greater than the industrial load, and that one of the great uses would be for electric ploughing. There were rumours of model all-electric farms being equipped in Ireland, and there was no better form of propaganda.

Mr. Theodore Stevens asked the author whether the figures quoted in the experts' report on the Shannon scheme were to be taken as applying to the manufacture of nitrogen compounds. They spoke of from 0·35d. to 0·15d. per kWh at the Shannon works, but he happened to know that the carbide which had to be made before the cyanamide could be produced was made by the Albic Carbide Co. in Norway when its electricity was costing 25s. per h.p.-year. Would the present Shannon plant have sufficient power available, after supplying the needs of Dublin, for manufacturing nitrogen compounds? The figure in the experts' report was an annual output of 150,000,000 kWh, which represents 48,000 kW as the peak load. The average load worked out at about 17,000 kW, and therefore there did not appear to be a lot left for manufacturing nitrogen compounds.

The Author, replying to the discussion, said that, although he was a great believer in synthetic nitrogen, he was not sure that it would be made by the Shannon plant. The question at issue was the price, and he did not see how the Shannon could compete with Norway; moreover, he believed that nitrogen would be obtained eventually from peat in Ireland before it was obtained from water power, because in the peat deposits there were conditions very favourable for the manufacture of calcium carbide and calcium cyanamide. Whilst agreeing with Mr. Borlase Matthews that electricity must be got on to the farms by introducing labour-saving appliances, he did not think the agricultural use would become greater than the industrial use of electricity.

CONDENSER TUBE PLATES.—In " British Machine Tool Engineering " of March/April, 1928, there is a descriptive article, with illustrations of a condenser tube plate drilling machine, made by Messrs. Kendall and Gent, Manchester. It is an interesting machine.

CARRIAGE OF FRUIT.—Some time ago we noted and directed attention to the inward condition of some good looking apples, the outward appearance was tempting, but the heart was bad. The causes leading to the deterioration led to investigations into a cold storage disease and its prevention, and the following appeared in " Ice and Cold storage," October, 1928, on the subject, with illustrations showing how apples are affected by conditions under which they are carried in transit. Dr. Kapadia invented a machine to carry ripe fruit from the East many years ago, and from the tests witnessed it seemed reliable for the purpose, but it does not appear to have been adopted to any extent:—

SOGGY BREAKDOWN IN APPLES.

The Iowa Agricultural Experiment Station has recently issued a bulletin by H. H. Plagge and T. J. Maney on " Soggy Breakdown of Apples and Its Control by Storage Temperature." A low temperature type of breakdown on apples that occurs at the cold storage temperatures usually employed is described in the bulletin. This disease, which was previously noted by Plagge,* the writers believe to be the same as the "internal breakdown" reported in England by Kidd and West† and in New Zealand by McClelland and Tiller.‡ As the disease occurs prematurely and always at temperatures below a certain level, it is considered different from the breakdown occurring as a result of senility. Although the disease is somewhat similar to internal browning reported chiefly on Yellow Newtown as grown in the Pajaro Valley in California, it is not identical.

This type of breakdown has, therefore, been termed "soggy breakdown," in order to distinguish it clearly from the so-called "internal breakdown" or "physiological decay." The writers have also adopted the term "mealy breakdown" for the latter to distinguish it from soggy breakdown.§

Effect of Temperature.—Experimental results for three years have shown that soggy breakdown is caused by low storage temperatures, which, however, are not sufficiently low to cause freezing injury. It has been found that Grimes which have been held in common storage houses or at slightly higher temperatures than those usually recommended for cold storage have kept considerably longer than the fruit held at the usual cold storage temperatures. Grimes stored at 34° to 36° F. kept much more satisfactorily with respect to soggy breakdown, eating quality, and sale value, and were superior to Grimes stored at 30° and 32° F. While low temperature was found to be the main causal agent of soggy breakdown; other contributing factors have considerable influence.

Influence of Picking Time.—Maturity at harvest time and delayed storage at ordinary temperatures have affected the development of the disease. Fruit picked at the beginning of the harvest was found to be more susceptible with delayed storage treatment than when stored immediately; while fruit picked at the close of the harvest season was found to be more susceptible with less delay before storing. Wenatchee district Grimes, which had reached eating maturity when placed into cold storage, became proportionately less susceptible to soggy

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* Plagge, H. H. 1925. Soft-Scald and Breakdown of Apples as Affected by Storage Temperature. In Proc. Amer. Soc. Hort. Sci. 22:58-66.

† Kidd, F., and West, C. 1925. Functional Diseases of Apples in Cold Storage. Dept. Sci. and Indus. Res., Food Investigation Bd., Spec. Rept. 23.

‡ McClelland, N., and Tiller, L. W. 1925. Cold Storage Investigations, Season 1925. Cawthorne Institute, Nelson, N.Z.

§ Inasmuch as the term "breakdown" has already been applied to the disease, the writers conclude that it is preferable to retain this term. The term "soggy" has been adopted as it denotes the sogginess or sponginess of affected fruit. This also is in contrast to the mealiness of "old age decay" or "mealy breakdown."

breakdown as the delayed storage period was lengthened. Grimes from Iowa and Michigan, which had not yet reached an edible maturity, became proportionately more susceptible to the injury as the delayed storage period was lengthened.

In another experiment Grimes were stored immediately at 36° F. and held there for four weeks before removal to a room having a temperature of 30° F. In this particular lot more soggy breakdown developed than in either of the check lots, which were stored at 30° and 36° F. continuously. Two other lots, one held at 36° for six weeks and the other for eight weeks at 36° before placing at 30° F., showed a proportionate reduction in soggy breakdown according to the time in storage at 36° F. Apparently apples may become peculiarly susceptible to soggy breakdown when the storage temperature is lowered below a certain level after periods of exposure to rather high temperatures.

The Respiratory Activity.—Kidd and West have shown that after an apple is picked the respiratory activity (which previous to picking had reached a minimum) increases very rapidly at ordinary temperatures. This rate of increase continues until a maximum is reached, after which a minimum is again approached. The time required for the respiration rate to rise from the minimum to the maximum is greatly influenced by temperature. Magness and Ballard have shown that a similar condition exists in the case with Bartlett pears held at 59° F. They reported that the respiration rate, as measured by carbon dioxide output, was greatly accelerated from the time the fruit was picked until it become soft yellow ripe.

Burroughs found that Wagener and Wealthy apples, when held at 68·5° F., decreased in the respiration rate after a maximum had been reached. When Wageners had been held at 68·5° F. for three to four weeks after picking there was a marked decrease in the respiration rate. Magness and Burroughs have shown that the respiration rate of apples at 32° and at 35° F. is very nearly constant throughout the storage season, and that the rate at 35° F. is about one and one-half times the rate at 32° F.

When the Grimes were placed immediately into cold storage at the temperatures of 30°, 32°, 34° and 36° F., soggy breakdown made no significant development during years when the fruit was picked at the beginning of the harvest season. When the fruit was delayed at ordinary orchard temperatures, the same seasons, soggy breakdown appeared abundantly at the two lower temperatures, while it was practically controlled at the two higher temperatures. At 30° F. the amount of the disease present was in proportion to the amount of delay. Apparently the fruit which was delayed went into storage as it was approaching a higher rate of respiration, while that which went into storage immediately was still at a minimum rate. The fruit held at the orchard for several weeks before storage probably reached a high respiration rate and, therefore, as it was placed into storage, an abundant supply of certain respiratory products were likely present within the tissues and the internal atmosphere. These respiratory products probably consisted of certain essential oils or other deleterious substances, as well as carbon dioxide. Fruit with presumably high respiratory activity when stored at 36° F. was found to be without injury, while the same fruit when stored at 30° F. became seriously affected.

An Explanation.—A feasible explanation as to why the breakdown resulted at the lower temperatures and not at the higher may be the differences possibly existing in the permeability of the apple tissue at different temperatures. A possible increase in the permeability of the apple tissue stored at 30° F. is suggested as the cause of the injury occurring at this temperature. When there was a change in the permeability or resistance to certain deleterious substances which may have been present within the fruit, browning and breakdown of tissue resulted. This was not the case at 36° F., since, in this case, it is assumed that the permeability of the cells remained at a certain level. However, in searching for the explanation of the cause of soggy breakdown, it should be remembered that the respiratory processes were able to continue at a considerably more rapid rate at 36° F. than at 30° or 32° F. Magness and Ballard have shown that Bartlett pears ripen about twice as rapidly at 37° F. In their experiments the writers have noted that the Grimes stored at 36° F. ripened much more rapidly than at 30° or 32° F. This was evident in comparing the colour, hardness, and eating quality of the fruit at the end of the storage period.

With the fruit picked at the end of the commercial harvest, in 1924, evidently a condition was attained before picking which made the fruit susceptible to soggy breakdown, for the fruit so harvested was found to be affected with soggy breakdown when stored immediately, as well as when given delayed storage treatment. However, this same fruit became more severely affected when it was delayed at the orchard. The time of harvest then, enters into the consideration of the control of soggy breakdown.

Prevention by Air Movement.—Exposing the surfaces of the fruit to free and forced circulation of the storage room atmosphere gave satisfactory results in preventing soggy breakdown during one storage season. This tends to support the hypothesis that the disease was caused by an accumulation of deleterious substances, with an accompanying increase in cell permeability, since the benefit derived from the air movement was likely that of removing these substances from the apple tissue.

Permitting the fruit to have free access to air by placing it in open slatted crates during the delayed storage period did not reduce susceptibility to soggy breakdown.

The effect of gas absorbents, other than that of commercial oiled paper, on the prevention of soggy breakdown was not tried. Oiled paper gave no better results than unoiled paper in a series of experiments on the control of soggy breakdown.

Influence of Locality.—The development of soggy breakdown in apples appears to be affected by locality as locality may affect growth and maturity. Grimes and Wenatchee, showing evidence of higher maturity when stored, developed the disease earlier than the Grimes from Iowa. The disease appeared to develop most severely on the fruit from the Wenatchee region, and least severely on Grimes from south central Iowa. However, evidence is insufficient to show that this invariably would be the case. The data do show that the disease may develop on Grimes from various apple regions other than Iowa.

Soggy breakdown is clearly a cold-storage disease that occurs at the usual cold-storage temperatures, such as 30° to 32° F. It is particularly severe on Grimes, Golden and Wealthy. Other varieties show similar tendencies. It is felt that in the prevention of soggy breakdown the storage life of Grimes apples, and possibly a few other varieties, may be prolonged at least one month and perhaps longer.

As many of our members are concerned in the problems of refrigeration, the foregoing will be of interest.—J.A.

Light Alloys for Motor Pistons.—The author tabulates the composition of a series of Al-Cu alloy pistons ranging between 91·9 : 3·11 and 82·5 : 15·8, and discusses their heat-conductivity, expansion, running qualities, strength, and hardness, and their resistances to the products of combustion in the cylinder; he also indicates the influence of alloying elements such as Fe, Zn, Pb, Sn, Mg, Sb, and Si upon the physical properties mentioned. Some of the pistons were cast in sand and others in chills; the surface of the castings from the latter had a hard, finely crystalline structure, whereas the sand casting required heat treatment by quenching at 450°-500° C. (842°-932° F.) in cold water; thus confirming the earlier experiments of Guillet and Galibourg with Al-Cu alloys ranging from 7% to 45% Cu, which indicated that the hardness of the alloy could be increased by suitable heat treatment. The life of the alloy piston is stated to be about 85-90% of that of cast iron, which it is suggested is no detriment considering its lightness. The action of Cu in hardening the alloy is due to the formation at the freezing-point of a hard compound $[Al(CU) + CuAl_2]$. Fe also hardens the alloy by the formation of a brittle substance $FeAl_3$, which in specimens containing 3% was detrimental to machining. Ni and Mn produce similar effects. Tin increases liquidity without improving other qualities. Mg, in the presence of Al and Zn, forms a hard compound $Al_3Mg_7Zn_6$, and in quantities amounting to not more than 3·5% tends to increase hardness, the hardening effect being about double that of Cu. The author also discusses the influence of lead, antimony, zinc, and silicon as alloying elements.—H. Reininger ("Masch.," 7, 370-373; Inst. C.E. Engineering Abstracts).

The number of patent applications filed during the past year in the United Kingdom reached the record total of 38,593, an increase of 3,124 over the year 1927, and was the largest ever taken out in one year, the preceding record being in 1920, when 36,672 patent applications were filed.

Boiler Explosion Acts.

Report No. 2846. S.S. *Dungeness*. O.N. 118468.

Report No. 2846 deals with an explosion from the main boiler of the *Dungeness*, and the investigation of the case was carried out by Mr. J. Clark, Board of Trade Surveyor, Belfast.

The boiler was of the usual cylindrical multitubular type, of steel, 15 feet external diameter by 10 feet in length. It was fitted with three corrugated furnaces of the Morison pattern. The combustion chamber wrapper plates were 11/16th inch in thickness, at the sides and top; the bottom plate was $\frac{3}{4}$ inch in thickness. The combustion chamber back plates were 11/16th in. in thickness, supported by stays $1\frac{3}{4}$ ins. diameter, spaced $9\frac{3}{4}$ ins. by 9 ins. apart, except some of the margin stays, which were two inches diameter. The tops of the combustion chambers were supported by girders and stays $1\frac{3}{4}$ inches diameter, spaced $9\frac{1}{2}$ inches apart, the girders spaced $9\frac{1}{4}$ inches apart on the wing combustion chambers and $8\frac{1}{2}$ inches apart on the centre combustion chamber. Four girders were fitted to each of the combustion chambers. All the screwed stays were fitted with nuts at the combustion chamber end. The combustion chamber tube plates were 13/16th inch in thickness. The wing combustion chambers were fitted with 89 smoke tubes, of which 29 were stay tubes $3\frac{1}{4}$ inches external diameter by 5/16th inch in thickness, and the centre combustion chamber with 102 smoke tubes, of which 30 were stay tubes. The stay tubes passed through clearance holes in the front tube plate and were secured by a nut on both sides of the plate; they were screwed through the combustion chamber tube plate, caulked both sides of the plate and beaded over in the combustion chamber.

The boiler was fitted with the usual mountings, including two direct acting spring-loaded safety valves adjusted to operate at 160 pounds per square inch, and a water gauge mounting fitted with three test cocks.

The boiler was made by Messrs. Blair and Co., Ltd., Stockton-on-Tees, in 1904. It is therefore 23 years old.

In March, 1922, a number of screwed stays in way of centre combustion chamber bottom were renewed. In December, 1924, 36 plain tubes in top rows of centre and starboard furnaces were renewed, and in May, 1925, the centre and starboard furnaces were jacked up and faired in place and several fractures in the furnaces were cut out and welded up.

The vessel is classed with the British Corporation Register, and the boiler was inspected by one of their surveyors at Hull in September, 1926, and subsequently by the Chief Engineer when at the River Plate and Londonderry.

The ship, including the machinery and boilers, was insured with Underwriters at Lloyd's.

The upper part of the tube plate in the port combustion chamber of the starboard boiler was bulged over an area of about 2ft. by 1ft. 9ins. to a maximum depth of about 1¼ins., and within that area was forced off a number of the smoke tubes, thus allowing part of the contents of the boiler to escape into the combustion chamber. There was also a smaller bulge extending over an area of about 9 inches by 8 inches by ⅜ inch deep lower down on the same tube plate, but the plate had not been forced off the tubes in this area.

The explosion does not appear to have been a violent one. The fireman, who was on the point of opening the furnace door of the combustion chamber at the moment when the explosion occurred, escaped without injury, and reported to the second engineer, who was on watch in the engine room, and who had not apparently heard the explosion.

The explosion was caused by overheating of the tube plate, due, in my opinion, to shortness of water; no one was injured.

The *Dungeness* is a steel single screw cargo vessel of 2,748 tons gross. She is fitted with triple-expansion, surface-condensing engines of about 1,050 indicated horse-power. There are two main boilers, each having three furnaces, which are coal fired and working under natural draught. The boilers are arranged athwartships, side by side, and are fired from the forward end. There is a screen bulkhead of corrugated iron separating the engine room from the boiler room, and entrance to the boiler room is by means of a passage between the starboard boiler and a bunker at the ship's side.

The vessel left Hull in September, 1926, for Antwerp to bunker, and then proceeded to Norfolk, Va., U.S.A., to load coal for Rosario, from which port the vessel sailed for Londonderry, where she arrived on 10th January, 1927. On the passage to Rosario the second engineer stated that the water gauge glass on the starboard boiler occasionally showed false indications of the water level, and on several occasions the screw plugs on the water gauge cocks were taken out and the passages in the cocks cleared by means of a wire. When at Rosario the water gauge cocks were taken out of the columns, cleaned and repacked, but as the screwed plugs in the top and bottom of the cast iron columns were immovable, the columns themselves were not cleaned out. The water gauges gave no further trouble during the passage to Londonderry. After discharging at Londonderry the vessel left at 8 a.m. on the 25th January for Swansea in a light condition, the chief engineer being on watch. He stated that after leaving Lough Foyle the vessel encountered a heavy gale and rolled and pitched heavily. During the watch he observed that the level of the water in the boilers was rising, and on making examination found that the water in the hotwell was brackish, from which he concluded that the condenser was leaking. Before handing the watch over to the third engineer at 12 midnight the level of the water in the boilers was reduced by switching the feed water overboard. He gave instructions that if it was necessary to reduce the water level in the boilers again it was to be done by the second engineer.

The third engineer stated that when he came on watch there were about five to six inches of water in the gauge glass of each boiler. During his watch the vessel was labouring heavily and the engines raced occasionally. He blew the water glasses through two or three times during the watch and was satisfied they were working satisfactorily. At the end of his watch the water had risen about four or five inches more in each glass, but apart from regulating he did not during his watch interfere with or divert the feed water delivered to the boilers.

At 4 a.m. the second engineer came on watch. He stated that, following the usual practice, he blew the water gauge glasses through before taking over the watch, and found everything satisfactory. At the time of the explosion he stated that the water gauge showed half glass in the starboard boiler and five-eights glass in the port boiler. No evidence was given as to the leakage of the condenser, nor how the level of the water in the boilers, which at 4 a.m. was 10 to 11 inches as stated by the third engineer, had fallen to half and five-eights glass at 5.30 a.m. (The length of these gauge glasses was 13½ inches).

When I examined the boiler a few days after the vessel had arrived in Belfast, I found in all the combustion chambers distinct evidence of overheating; the tube plate in the port chamber was bulged as stated above, and the upper part of the plates in each of the chambers for a distance of about 2 feet to 2 feet 6 inches downwards from each crown bore the appearance of having been greatly overheated. On the water side the boiler was fairly clean, the crown and sides of the combustion chamber were found to be covered with a uniform scale of about 1/16th inch in thickness. On the tube plate the scale was about $\frac{1}{8}$ inch in thickness, and on the tubes from $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness. In order to examine the condition of the water gauge, the water gauge column was removed from the boiler. When this was done a large quantity of loose scale, some of which had probably been detached by the hammering necessary to remove the column, was found in the lower passage. The passage in the lower gauge glass mounting was found to be partly closed by incrustation, and the upper and middle test cocks on the column were completely choked. The part of the column between the upper and middle test cocks was found to be closed solid with incrustation, to remove which it was necessary to drill out the top and bottom plugs and use drifts. I am therefore of opinion that at the time of any test previous to the explosion the water gauge glass in this boiler was not recording correctly, and that the second engineer at some time during his watch, in order to reduce the water level in the boilers, had turned the feed water overboard, being deceived by the false reading of the water gauge glass. The water in the starboard boiler had therefore fallen to a level considerably below the combustion chamber crown. The tube plate would thus become overheated and unable to withstand the pressure to which it was subjected.

The following repairs were carried out:—The tube plate was faired in place; the boiler has been completely re-tubed and a part of the combustion chamber back plate which had been previously buckled between the stays was cut out and a new piece of plate welded in. After these repairs were completed the boiler was satisfactorily tested by hydraulic pressure to 240 pounds per square inch, and the safety valves were adjusted to lift at 160 pounds per square inch. The condenser was opened up for examination, and several tubes which were found to be pitted through were renewed and a number of defective wood ferrules were replaced. The condenser was afterwards tested and found satisfactory.

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

The boilers in this case were provided with a type of water gauge which can be thoroughly examined when opened up for inspection and very easily tested for accuracy when under steam. The damage done through shortness of water indicates that the water level at the time of the explosion must have been well below the lower opening to the gauge column, and that the boiler must therefore have been short of water for a considerable time. Those in charge cannot be acquitted of negligence in their management of these boilers as their attention to the condition of the gauge should have been attracted by its behaviour.

The need for careful examination of water gauges when being overhauled and for equally careful and intelligent testing when in use cannot be too strongly impressed upon those in charge of all boilers.

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Books added to Library.

British Standard Specifications.—For British Standard Whitworth (Small Hexagon), (B.S.W.S.) Bright Hexagon Bolts, Nuts and Set-Screws, Split-Pins, Washers and Studs. No. 193-1929. For Phosphor Bronze Turbine Blading. No. 352-1929. For the Testing of Hydraulic Turbines. No. 353-1929.

Purchased: —

"Exhaust Steam Engineering," by Charles S. Darling. Published by Chapman and Hall, Ltd.

"The Enlarged Callendar Steam Tables," by Professor H. L. Callendar. Published by Edward Arnold and Co.

"Present-day Shipbuilding," by Walton. Price 25/-. Published by Charles Griffin and Co., Ltd., 1921.

National Physical Laboratory—Report for the year 1928. Published by H.M. Stationery Office for the Department of Scientific and Industrial Research. Price 9/- net.

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TITANIC ENGINEERING STAFF MEMORIAL—BENEVOLENT FUND. —The Committee acknowledge with thanks a donation of 21/- from Mr. F. A. Trigg, Member 1685, Western Australia.

Election of Members.

List of those elected at Council meeting of May 13th, 1929 :—

Members.

George William Barnes, Engr.-Lieut., R.N.R., 92, Mayfield Street, Hull.

William Turner Cromby, *c/o* Butterfield and Swire, Shanghai.

John Reginald Davis, Engr.-Lieut., R.N., H.M.S. *York*, *c/o* Messrs. Palmers S. and I. Co., Ltd., Jarrow-on-Tyne.

James Joseph Devine, Eng.-Lieut., R.N.R., 79, Upper Georges Street, Kingstown, Co. Dublin.

John Dixon, 2, Fairlie Place, Calcutta, India.

William Owen Gardiner, Melstock, Dorchester Road, Weymouth.

Cecil Harry Gibbs, 18, Shaftesbury Avenue, Highfield, Southampton.

Wilfrid James Griggs, 152, Coventry Road, Ilford, Essex.

Paul Hansen, Burmeister and Wain, Copenhagen, Denmark.

John William Henderson, 49, Randolph Gardens, Broomhill, Glasgow.

Ernest Henry Lucas, *c/o* Speirs, 1301, Argyle Street, Glasgow, C.3.

James Alexander Redpath Mann, 35, Kingswood Road, Wimbledon, S.W.19.

Robert Wallace McFarlane, Ivy Bank, Port Glasgow.

Andrew William Richardson, *c/o* Babcock and Wilcox, Ltd., 4, Bankshall Street, Calcutta, India.

Robert Smeaton, 4, Uplands Crescent, Swansea.

Thomas George Stone, 269, Crogan Hill, Barry, Glam.

Alfred William Tookey, 48, Maryon Road, Charlton, S.E.7.

Associate Member.

Kenneth John Melrose McLennan, 10, Selborne Road, Ilford, Essex.

Associates.

Francis P. Kennedy, *c/o* British Tanker Co., Ltd., Britannic House, Finsbury Circus, E.C.2.

Norman Alexander MacLeod, Aldersyde, Cyprus Avenue, Bloomfield, Belfast.

Horace Horatio Augustus Tate, 32, Egmont Road, New Malden, Surrey

Francis Clarence Walter Wilkinson, The Haven, Station Estate, Taplow.

Transferred from Associate Member to Member.

Khujesta Kaikobad Batlivala, 74, Churchill Road, Rangoon, Burma.

Henry Russell Smith, 102, Maida Road, Luton, Chatham.

Transferred from Associate to Associate Member.

Carl Albin Hallgren, *c/o* The Institute of Marine Engineers.

Gordon Hugh Stanbury, Gwengor, 16, Foulser Road, S.W.17.

Transferred from Student-Graduate to Associate Member.

John Knapp Barrow, 27, St. James Avenue, Sutton, Surrey.

Transferred from Graduate to Associate Member.

Roy M. Gibbs, 23, Vaughan Gardens, Ilford, Essex.

Transferred from Graduate to Associate.

Robert A. Batey, 30, Kenilworth Road, Monkseaton.

Board of Trade Examinations.

List of Candidates who are reported as having passed examination under the provisions of the Merchant Shipping Acts.

For week ended 23rd March, 1929:—

NAME.	GRADE.	PORT OF EXAMINATION.
Noble, Thomas P.	1.C.M.E.	London
Struthers, William	1.C.M.E.	Glasgow
Waggott, William H.	1.C.M.E.	London
Helliwell, Clive E.	1.C.	,,
Minnis, Frederick C.	1.C.	,,
Barrow, John A. R. K.	2.C.	,,
Burgess, Jack H.	2.C.	,,
Hall, Edward A.	2.C.	,,
Lavington, Arthur H.	2.C.	,,
Northey, Reginald H.	2.C.	,,
Herron, William A.	1.C.	Glasgow
Kerr, Robert W.	1.C.	,,
MacKinnon, Neil	1.C.	,,
Wright, Thomas H.	1.C.	,,
Small, James	1.C.M.E.	,,
Hutton, Thomas H.	2.C.	,,
Lees, David B. B.	2.C.	,,
McKinnon, Robert B.	2.C.	,,
Middleton, William	2.C.M.	,,
Mundie, James D. B.	2.C.M.	,,
Downey, Lawrence	2.C.M.	Liverpool
Browne, William G. E.	1.C.	,,
Kyffin, Edward	1.C.M.E.	,,
Hyde, Percy	2.C.M.E.	,,
Arden, James V.	2.C.	,,
Darbyshire, Arthur R.	2.C.	,,
Hall, Eric S.	2.C.	,,
Pounder, James S.	2.C.	,,
Cessford, Edwin W.	1.C.	Sunderland
Hutchinson, James H.	1.C.	,,
Burnham, Gordon	2.C.	,,
Hepple, Thomas	2.C.	,,
Langley, William A.	2.C.	,,
Longmore, Samuel J.	2.C.	,,
Scott, Frank	2.C.	,,
Wright, Edward D.	2.C.	,,

For week ended 23rd March, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Buchanan, John N.	2.C.	North Shields
Dunn, George P. S.	2.C.	,,
Pottinger, William M.	2.C.	,,
Cameron, Alexander	2.C.M.	,,

For week ended 30th March, 1929:—

Borthwick, James	1.C.	Glasgow
McGregor, William W.	1.C.	,,
Brisbane, William	1.C.	,,
Baker, Thomas T.	2.C.	,,
Macdonald, Alexander T.	1.C.M.E.	,,
Clark, Thomas	2.C.	,,
Frew, Harry	2.C.	,,
McIntosh, Neil McK.	2.C.	,,
McBride, Andrew	2.C.M.	,,
Downie, David M.	1.C.	Leith
Stephen, William O.	1.C.	,,
Gibbons, Thomas F.	1.C.M.E.	Cardiff
Nicholls, Charles E.	1.C.	,,
O'Callaghan, John H. B.	1.C.	,,
Kelly, Gilbert	2.C.	Liverpool
Parr, Ralph A.	2.C.	,,
Ford, Charles E. S.	1.C.M.E.	,,
Jones, Alcwyn M.	1.C.M.E.	,,
Wood, Gavin J.	1.C.M.E.	,,
Jones, William H.	1.C.M.	,,
Clough, Edmund	1.C.	,,
James, David A.	1.C.	,,
Lees, Thomas H.	1.C.	,,
Nagel, Bernhard C.	1.C.	,,
Nicholson, James C.	1.C.	,,
Bull, Herbert G.	1.C.	London
Barnard, Jack L.	2.C.	,,
MacGregor, Ronald	2.C.	,,
Richardson, Thomas D.	2.C.	,,
Russell, Rickard A.	2.C.M.	,,
Davison, James J.	1.C.	North Shields
Biggins, Robert	2.C.	,,
Donaldson, Joseph	2.C.	,,
McKinnon, John V.	1.C.M.	,,
Henderson, William G. N.	1.C.M.E.	,,
McClarence, James	2.C.M.E.	,,

For week ended 6th April, 1929:—

NAME.	GRADE.	PORT OF EXAMINATION
*Newell, Ronald	2.C.	Belfast
*Sheils, Patrick	1.C.M.E.	,,
Holmes, Thomas E.	1.C.M.E.	London
Manger, Edwin C.	1.C.M.E.	,,
Campbell, George	1.C.M.E.	Glasgow
Kennedy, Neil	1.C.	,,
Simpson, Alexander	1.C.M.	,,
Kennedy, Donald S.	2.C.	,,
Broughton, Frank	2.C.	Hull
Munson, Harold J.	2.C.	,,
Smith, Frederick M.	2.C.	,,
Done, George T. S.	1.C.	Liverpool
Fitzsimmons, George	1.C.	,,
Winterbottom, James	1.C.	,,
Elias, John	2.C.	,,
Jennings, John S.	2.C.	,,
Ritchie, William M.	2.C.	,,
Roulson, Harold	2.C.	,,
Shea, Rowland W.	2.C.	,,
Doyle, John J.	1.C.M.E.	,,
Johns, Alfred E.	1.C.M.	,,
Fell, William P.	2.C.M.	,,
Harvey, William S.	1.C.	London
Johnston, Alexander R. B. ...	1.C.	,,
Millar, Frederick E.	1.C.	,,
Chubb, George E.	2.C.	,,
Livesay, William L.	1.C.	North Shields
Sisterson, Gilbert	1.C.	,,
Cleghorn, George	2.C.	,,
Johnston, John T.	1.C.	Southampton
Corner, Philip I.	1.C.M.E.	,,
Gandy, Frederic B.	2.C.	,,

*Passings for week ended 30th March received too late for publication.

For week ended 13th April, 1929:—

Craig, Robert K.	1.C.M.E.	London
Court, Arthur L.	1.C.	Cardiff
Michael, Stanley B.	1.C.	,,
Angel, Walter B. S.	1.C.	London
Cooper, James B.	1.C.	,,
Horlock, Horatio N.	2.C.M.	,,
Fyfe, Robert T.	1.C.	Glasgow
Brown, Myles McI.	2.C.	,,

For week ended 13th April, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Doig, James	2.C.	Glasgow
Scorer, Sydney D.	2.C.	,,
Phillips, William	1.C.E.	,,
Ingold, Stacey R.	1.C.M.	,,
Hall, William E.	1.C.E.	North Shields
Forbes, Victor G.	1.C.	,,
Welch, George E.	2.C.	,,
Dustan, Frederick	1.C.	Leith
Cramond, Gordon	2.C.	,,
Scott, Henry	2.C.	Southampton
Targett, Reginald F.	2.C.	,,
Galloway, Frederick E.	1.C.	Liverpool
Mudd, Charles A.	1.C.	,,
Kaighen, Joseph R.	2.C.	,,
James, David A.	1.C.M.E	,,
Kagan, Reginald	1.C.M.E.	,,

For week ended 20th April, 1929:—

Opie, Cecil M.	1.C.M.E.	Liverpool
Chapman, Charles E.	1.C.	,,
Green, Sidney F.	1.C.	,,
Myles, William O. S.	1.C.	,,
Woods, Eric	1.C.	,,
Owen, John	1.C.M.	,,
Martin, Donald	2.C.	,,
McCallum, Robert McA. ...	1.C.	Glasgow
Black, John	1.C.	,,
Henderson, James A.	1.C.	,,
Jarvie, Joseph D.	2.C.	,,
Lynas, Samuel	2.C.	,,
Bradley, Alexander	2.C.M.	,,
Campbell, Ean N. MacC. ...	2.C.M.	,,
Morrison, John R.	2.C.M.	,,
Arnold, Arthur A.	1.C.	North Shields
Caygill, Arthur	1.C.	,,
Hutchinson, William	1.C.	,,
Lee, Norman	1.C.	,,
Temple, William A.	1.C.	,,
Munson, Arthur	2.C.	,,
Dainton, William E. B.	1.C.M.E.	,,
Russell, Henry	1.C.	London
Russell, Samuel T.	2.C.	,,
Third, Henry J.	2.C.	,,

For week ended 20th April, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Elliott, William D.	1.C.	Sunderland
Meldrum, William N.	1.C.	,,
Barker, Harold W.	2.C.	,,
Beckton, Frederick H.	2.C.	,,
Musther, George H.	2.C.	,,
Lynn, David K.	Ex.1.C.	Leith
McLaren, Thomas	Ex.1.C.	Glasgow
Smith, Sydney P.	Ex.1.C.	London
Ward, Jervis S.	Ex.1.C.	North Shields

For week ended 27th April, 1929:—

NAME.	GRADE.	PORT OF EXAMINATION.
Armstrong, James	1.C.M.E.	London
Jones, Henry N.	1.C.M.E.	,,
Richards, Ronald M.	1.C.M.E.	Cardiff
Cook, William J. M.	2.C.	,,
Crosby, William E.	2.C.	,,
George, Alfred	2.C.	,,
Maurice, Frederick A.	2.C.	,,
Tidman, Frank E.	2.C.	,,
Williams, Enrys	2.C.	,,
Brown, John R.	1.C.	Glasgow
Phoenix, Samuel	1.C.	,,
Chisholm, Roderick A.	1.C.M.	,,
Peebles, Andrew	2.C.M.	,,
Paterson, John McN.	2.C.M.	,,
McConkey, William	2.C.	Belfast
Phillips, Albert M.	2.C.	Southampton
Davison, Arthur H.	1.C.	London
Redding, Douglas	1.C.	,,
Smith, Henry R.	1.C.	,,
Watson, David M.	1.C.	,,
Matthews, Thomas R.	2.C.	,,
Meader, Frank N.	2.C.	,,
Thornton, John W. N.	2.C.	,,
Woods, Cyril J.	2.C.	,,
Rundle, John	1.C.M.E.	Leith
Haggart, Robert	1.C.	,,
Millar, Hugh W. M.	2.C.	,,
Wilkie, Alexander	2.C.	,,

For week ended 27th April, 1929—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Haining, William M.	1.C.	Liverpool
Henderson, Charles	1.C.	,,
Roberts, John E.	1.C.	,,
Breakey, James	2.C.	,,
Davidson, David	2.C.	,,
Hallgren, Carl A.	2.C.	,,
Newman, Cyril G.	2.C.	,,
Routledge, James	2.C.	,,
Batlivala, Khujesta D.	1.C.	North Shields
Hiles, Arthur E.	1.C.	,,
Archbold, Arthur L.	2.C.	,,
Sedgwick, James P.	2.C.	,,
Wrangham, William S.	2.C.	,,
Burrell, Albert	2.C.M.	,,
Paul, Sidney	2.C.M.E.	,,
Chester, Alfred E.	2.C.	,,