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The Manufacture and Testing of Steel Forgings.

Abstract of a Lecture to the Junior Section

DELIVERED

By Dr. W. H. HATFIELD, F.R.S.

On Thursday, March 28th, 1935, at 7 p.m.

CHAIRMAN: Dr. S. F. DOREY (Vice-President).

Dr. Hatfield preceded his lecture by showing a film covering very briefly some of the essential stages in the melting of steel, and the forging and rolling to finished form. This film was put upon the screen with the principal object of giving those junior members who were not perhaps familiar with the processes of steel making some insight into the actual manipulation of steel for marine engineering requirements.

The first slide shown by the lecturer, Fig. 1, showed a longitudinal section of a large ingot. It will be seen that, although on the whole the material is homogeneous, it is not by any means completely homogeneous. There are lines of segregation both in the centre and to some extent towards the sides of the ingot, and there are areas of greater and less purity. These considerations make it imperative that the design of the ingot, and the precise conditions of casting the steel, should be under the most careful supervision; and further, that the forging be produced from the ingot in such a way that any areas of segregation which are compelled to come within the forging itself are, at any rate, in a position where they will cause no trouble.

The next slide was a photograph of an ingot weighing 169 tons, which gave an indication of the size of ingots cast in modern practice, and the forgings which could be made from them.

Fig. 2 is a cross-section of a 25-ton ingot mould and feeder head. The mould itself is hexagonal in section and made of cast iron. It rests on a heavy iron base, and a head lined with refractory material is placed on the top, so that a reservoir of hot steel is maintained to feed into the body of the ingot, as the steel cools and contracts. This provision is essential in order to avoid the formation of a contraction cavity in the "using" portion of the ingot.

Some reference had already been made to segregation in ingots and the slide reproduced in Fig. 3 shows in diagrammatic form the normal method of segregation of the impurities in a steel

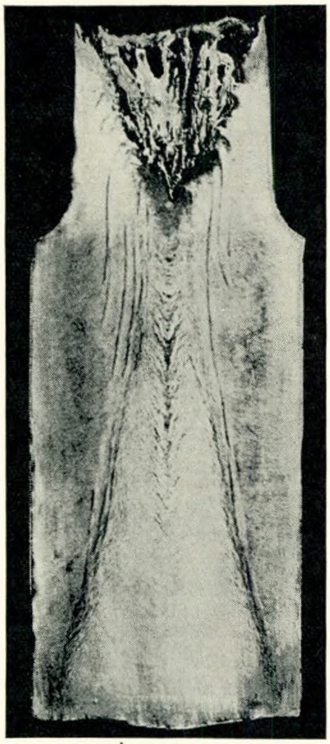


FIG. 1.—Longitudinal section through large forging ingot showing cavity in head and segregation. (1st Report on the Heterogeneity of Steel Ingots.—Iron and Steel Institute).

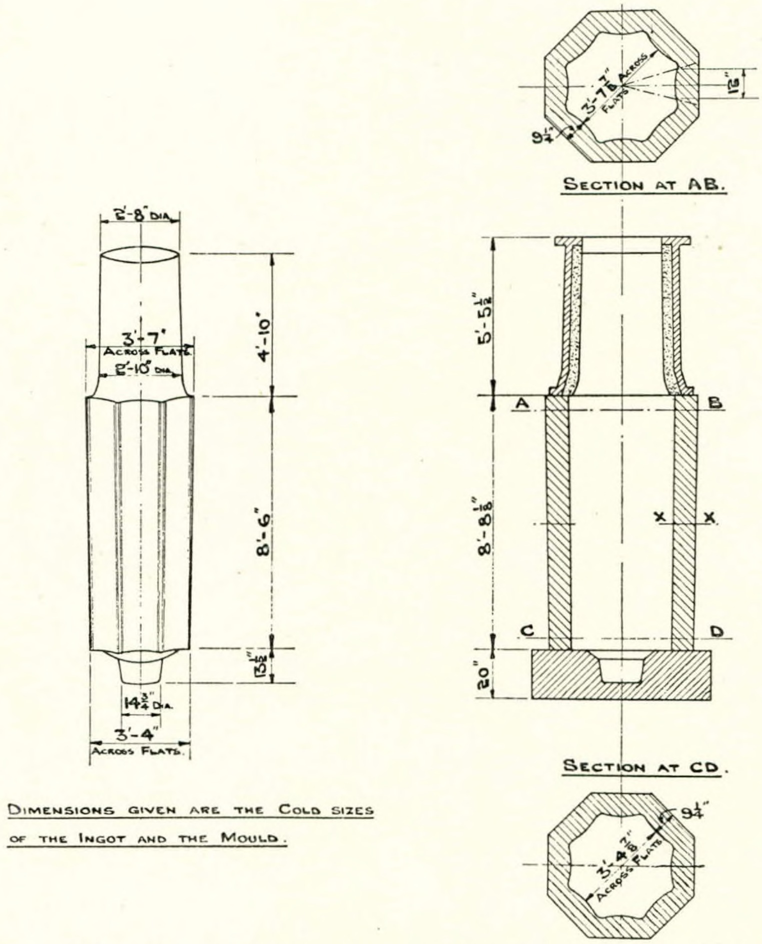


FIG. 2.—Drawings of 25-ton ingot mould. (Weight of steel covered by 1 sq. ft. of mould at section XX=414lb.; weight of mould per sq. ft. of surface of ingot at section XX=408lb.; sectional area of ingot at AB=1,606 sq. in.; sectional area of ingot at CD=1,383 sq. in.; sectional area of mould at AB=1,548 sq. in.; sectional area of mould at CD=1,481 sq. in.; total weight of ingot 25 tons; weight of chill portion of ingot 18 tons 15 cwts.; weight of chill portion of mould 17 tons 15 cwts.

ingot. The zone numbered 1 is the purest material which becomes progressively more highly segregated as zone 6 is approached. In practice it is arranged that the most impure material shall come to rest in the ingot head, which is ultimately cut off and discarded. A series of slides showing the exact crystal form of two ingots similar in all respects other than their casting temperature, illustrated the important fact that a low casting temperature promotes a fine primary crystal size.

The lecturer's remarks had, up to this time, been confined solely to "killed" steel, but he then explained how other types of steel were made for special purposes. At the opposite end of the range came "rimming" steel, an ingot of which is characterised by possessing a thick rim of extremely pure material, inside which is a zone containing gas holes bounding an internal zone comparatively high in sulphur, phosphorus and other impurities. This type of steel should be used only for the specialised production of thin sheet, and on no account for forgings or other highly stressed machine parts. Intermediate between "rimming" and "killed" come two types of steel known as "semi-killed" and "balanced". Ingots of these types of steel are in general structure more like ingots of "killed" steel, but they contain blow-holes, and although their use for the production of ships' plates may be justified on commercial grounds, they should on no account be used for forgings.

The lecturer now briefly considered the iron-carbon equilibrium diagram, and with its aid demonstrated the essential purposes of heat-treatment. It could not be too strongly emphasised, he said, that the correct heat-treatment of forgings was as important a feature as the quality of the steel itself, and the use of an alloy steel was completely nullified if not accompanied by the optimum heat treatment for that particular material.

He also showed slides which demonstrated the temperature lag in the centre of the ingot as the

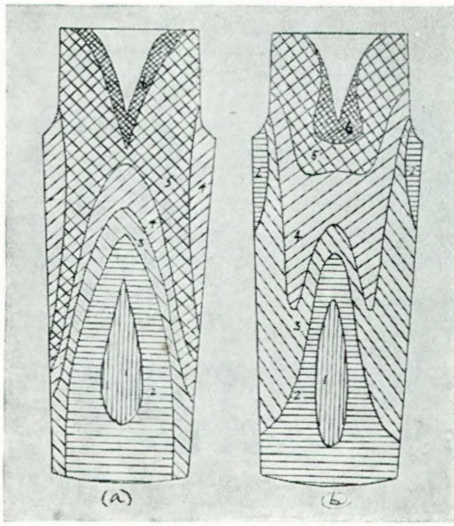


FIG. 3.—Diagrams showing the principal systems of segregation observed in ingots of killed steel.

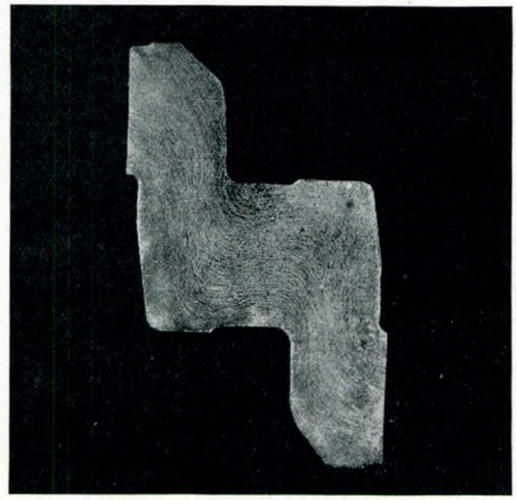


FIG. 5.—Cross section through crank shaft etched to reveal the macrostructure.

whole piece comes up to temperature. It is not sufficient simply to put a steel ingot in a furnace at the right temperature. It must be adequately "soaked", so that the whole mass is uniformly heated throughout.

Having covered in some detail the question of the raw material, and indicated some of the more important precautions which must be taken in forging, the lecturer next showed several slides illustrating the finished products: turbine wheels, rotor shafts, hollow forged steam drums, reaction chambers and hollow rolled rings, and then with the aid of further slides, one of which is reproduced in Fig. 5, illustrated the effect of the flow of metal in forgings. Fig. 5 shows a section through the web and journal of a crankshaft which has been forged under the press. It is clear how by correct design of the crank and control of the forging operations, the grain of the metal can be made to flow from one part of the forging to another in such a way as to give maximum strength to the parts of lightest section and heaviest concentration of stress.

In conclusion, the lecturer briefly considered the mechanical properties of ordinary forging steels of different carbon content and then showed how the addition of alloy elements raises the maximum stress, yield point and elastic limit without impairing the ductility. The fatigue stress is also raised and in general the addition of alloy elements promotes the penetration of heat-treatment throughout a large mass, which means that in practice more uniform mechanical properties can be obtained. References to the table reproduced overleaf will show the mechanical properties asso-

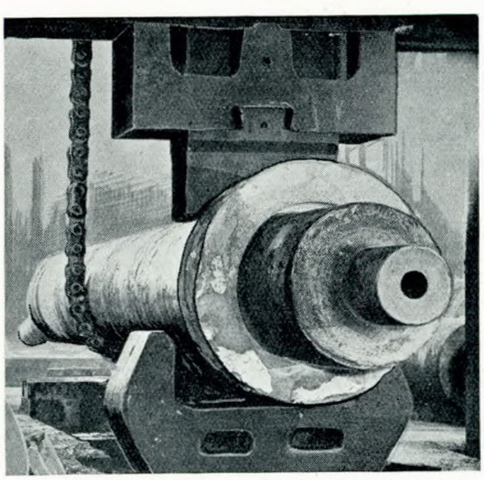


FIG. 4.—A large hollow-forged boiler drum in process of manufacture under a 6,000-ton steam intensifier press.

FIG. 6.—0.25 per cent. carbon steel; normalised 900.

ciated with a number of common carbon and alloy steels. Dr. Hatfield also showed a number of slides illustrating the microstructure of different steels, two of which are reproduced in Figs. 6 and 7. Fig. 6 represents an ordinary 28/32 tons tensile carbon steel in the normalised condition. It consists of pearlite set in a matrix of ferrite and is a very different structure from that illustrated in Fig. 7, which is a nickel-chromium-molybdenum forging steel, air-hardened and tempered to a tensile strength of the order of 55/60 tons.

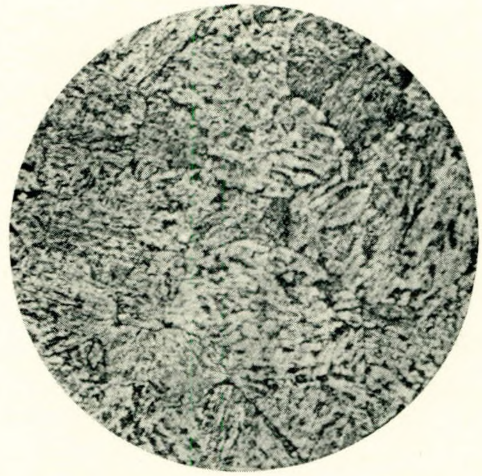


FIG. 7.—Nickel-chromium-molybdenum forging steel; A.H. 850°, R. 650°.

Class.		C.	Mn.	Si.	Ni.	Cr.	Mo.	W.	Va.	Condition.	0·1% Proof Stress. Tons/sq. in.	Y.P. Tons/sq. in.	M.S. Tons/sq. in.	El. %	R/A. %	Izod. ft. lb.	Fatigue. ± Tons/sq. in.
		Analyses.								Mechanical Tests in condition as used.*							
1. Carbon steels	(a)	·10	·72	·06	—	—	—	—	—	N.900°	16·2	17·5	28·5	37	64½	65	12·0
	(b)	·30	·67	·14	·21	—	—	—	—	N.850°	17·5	20·7	35·0	30	55	32	13·0
	(c)	·50	·70	·18	·10	—	—	—	—	N.820°	22·0	26·0	44·2	24	43½	18	17·0
	(d)	·76	·55	·19	·30	—	—	—	—	N.820°	28·0	45·0	63·0	16	25	3	19·5
2. High manganese steels	(a)	·41	1·5	·19	·12	—	—	—	—	W.H.850° T.620°	27·0	32·0	46·8	25	58	20	20·0
3. Chromium steels	(a)	·45	·66	·27	·23	·93	—	—	—	O.H.850° T.600°	52·0	58·0	66·5	20	52	40	28·0
	(b)	1·0	·38	·18	·15	1·40	—	—	—	W.Q.830°	Hardness>650 Br.			90 to 95 Scleroscope.			
4. Chrome-vanadium steels	(a)	·46	·57	·17	·15	1·40	—	—	·18	O.Q.850° T.490°	72·0	82·5	87·0	16	48	24	42·0
	(b)	·46	·57	·17	·15	1·40	—	—	·18	O.Q.850° T.650°	32·0	48·0	56·0	22	60	35	25·0
6. Nickel steels	(a)	·12	·40	·10	2·2	—	—	—	—	Refine 880° W.H.760°	16·0	23·0	38·0	32	65	80	15·0
	(b)	·14	·29	·16	4·9	—	—	—	—	Refine 840° W.Q.760°	27·0	41·9	60·6	17·5	47	24	26·5
	(c)	·39	·55	·11	2·96	—	—	—	—	O.Q.850° T.620°	35·0	41·7	49·5	24	64	70	21·5
	(d)	·43	·64	·19	3·58	·20	—	—	—	O.Q.830° T.570° (O.Q.)	53·0	56·4	63·8	22	61	68	27·0
8. Nickel-chromium steels	(a)	·31	·70	·14	3·2	·75	—	—	—	O.H.820° T.600° (W.Q.)	50·0	54·5	60·0	22	61	55	26·0
	(b)	·28	·50	·15	4·2	1·5	—	—	—	A.H.820° T.250°	65·2	85·0	106·0	12	45	12	45·0
	(c)	·14	·40	·21	4·49	1·2	—	—	—	O.Q.760°	48·3	73·0	89·0	18	64	30	39·0
9. Nickel-chromium-molybdenum-vanadium steel	(a)	·21	·54	·20	3·07	1·5	·56	—	·18	O.Q.850° T.640° (A.C.)	66·8	70·5	74·6	21	67	38	32·0
10. Silico-manganese steel	(a)	·52	1·05	1·95	—	·05	—	—	—	O.H.870° T.520°	65·0	76·9	88·2	15	36	13	43·0

* All tests on bar material.

Discussion.

Mr. W. D. Heck, B.Sc. (Member of Council) said that as a marine engineer one must hesitate to contest with Dr. Hatfield whether the engineer or the steel-maker was to blame for the present position in regard to forgings to which Dr. Hatfield had alluded.

Dr. Hatfield, of course, was an eminent metallurgist, but Mr. Heck wondered whether, from the commercial standpoint, it was good propaganda to make those remarks about heavy solid-forged crank shafts, because it seemed to be driving the marine engineer to use the smaller parts employed in built-up shafts. If this took place, some of the heavy machinery used in the manufacture of solid-forged shafts would not be necessary.

Dr. Hatfield also suggested that it was necessary that engineers should come to the rescue of the metallurgist by designing an instrument to measure the temperature of the molten metal when it was poured. They noticed from the slide that when the ingot was poured at 40° less there was a considerable amount of coarse structure. Did this coarse structure matter very much? Could it not be reduced by the work done on the forging and the heat treatment?

He had noticed with interest that the large ingots which were shown were all octagonal. He thought that he had previously seen a purely circular ingot in a forge, and he wondered whether the octagonal ingot had any special properties not possessed by the truly circular one. In the ingot showing the very fine structure, which they were told was suitable for forging, he noticed that the stock of the ingot was circular and, moreover, that the circular part was surrounded by refractory material, presumably to keep it hot as long as possible, thereby enabling the impurities to be concentrated as much as possible in that region. As a marine engineer, might he suggest that if it was desirable to keep that part of the ingot hot by means of a refractory material, something more might be done. For instance, it might be arranged to circulate hot gases round the upper part of the ingot mould while the lower part of the mould—and therefore the lower part of the ingot—was cooling down.

With regard to deformation, he assumed that this was valuable in that when a lot of work was applied to the steel, the crystals were broken down and eventually a finer structure was obtained. Did work produce finer crystals, or were they obtained by the heat treatment known as refinement of the grain?

He would also like to know whether deformation had been put on a mathematical basis. For example, they knew that the size of an ingot had a definite ratio to the diameter of the forging which was ultimately produced. Similarly, from his own observations he had noted that to make a good ship or boiler plate it was necessary that there should be a definite extension of the ingot both in regard to length and width. Thus one unit of length in the ingot should become about 5½ units in the plate, and in regard to width the ratio was about 2½ to 1. The point was whether in the manufacture of large solid-forged crank shafts similar ratios had been established as being essential to good quality in the finished forging.

Mr. C. W. Reed, B.Sc. (Lloyd's Register of Shipping) asked if the author, without delving too deeply into the question, would state whether, in general, the lines of segregation which had been shown so clearly marked in the ingot were more important in the case of a complex alloy steel than with a mild steel, or vice versa.

Eng. Lt.-Com'r. V. Lockney, M.Eng., S.R., R.N. (Member) emphasized the need for the closest co-operation between the engineer and the steel maker.

He suggested that the illustration showing the very marked lines of segregation in the ingot would cause a feeling of nervousness regarding the use of solid-forged drums for large boilers of high pressure. Would Dr. Hatfield say whether any progress had been made with the production of hollow ingots for this purpose?

Dr. Hatfield had referred to the different values obtained from tests taken at different situations in a forging. The speaker would like to have Dr. Hatfield's comments on the view that usually the poorest results were obtained from test pieces taken from between the two most-forged faces. (This was quite apart from segregation).

They all knew, of course, that the process of forging conferred a certain improvement upon the material, and that it was the practice to forge down to a certain ratio of the original ingot size with a view to obtaining a desired degree of improvement. In the event of forging not being carried out to a particular ratio, could the lack of improvement resulting from the deficiency of forging be made up by heat treatment? Heat treatment might, perhaps, be effective within limits, but, to quote an extreme case, if no forging were done at all, would it be possible by heat treatment to get a piece of material with the same properties as by forging?

Dr. Hatfield had suggested that marine engineers were rather slow in adopting alloy steels. He also mentioned the time element in heating up forgings for certain treatments to which they were subjected. The speaker believed that some of the alloy steels were subjected to heat treatment followed by quenching, and it occurred to him that they would not quite get the results desired with large forgings for marine work made of special steels where a quenching operation formed part of the heat treatment, on account of the mass effect in large pieces of material.

Mr. S. N. Kent (Member) said that he was very interested in the bent crank shafts. He believed it was the practice many years ago to bend crank shafts, but he had not heard of it recently. It occurred to him that, in bending, stresses were set up in the material which were worse than those originally there.

Like Mr. Heck, he desired to know if it was better to build up crank shafts rather than forge them from the solid, i.e. shafts from 6in. to 26in. in diameter.

Mr. H. S. Humphreys (Vice-Chairman of Council) said that crank shafts were most important forgings from the marine engineer's point of view. He had known crank shafts in large Diesel engines give perfectly good service for a number of years and then suddenly, after six, seven, or perhaps eight years, the shafts fractured. In most cases these were solid shafts.

He understood from the lecture that in the case of very heavy forgings one could not expect to get homogeneity and that, therefore, the shaft should be divided into several parts, i.e. that they should turn to the built-up type of shaft.

He thought a point which Dr. Hatfield might have stressed was that when dealing with heavy forgings such as crank shafts, the specification should be to the effect that the crank shafts should be annealed after forging, and normalised and tempered after rough machining. Apparently some forgemasters sent out forgings without proper heat treatment. Why should dowel pins be fitted in crank shafts if the surfaces were smooth machined and the shrinkage allowance correct in the first place? Surely dowel pins could not be of assistance, unless it was that the manufacturers had not faith in their own work.

When a shipowner placed an order for a set of engines for a vessel he was entitled to feel that the crank shaft would give good service for the life of the ship under normal working conditions at sea.

At a recent lecture he had heard that the Brinell hardness figure was not reliable, as it depended upon the way the test was taken, there being several different methods of obtaining this. Such a statement as this, as well as the question of fatigue, tended to make one nervous of the safety of machinery generally. He would like Dr. Hatfield to amplify his remarks regarding fatigue stress.

With regard to high tensile bottom-end bolts fitted to comparatively high-speed Diesel engines of the four-stroke type, he considered it good practice to renew them after about 10,000 hours running on account of fatigue. He also considered it imperative that all special bolts should have identification marks, and full information should be supplied by manufacturers. Some people annealed such bolts but, of course, they were asking for trouble. The marine engineer, through lack of information, might anneal the bolts not knowing they were of high tensile steel, with the consequence that there was a breakdown.

Mr. H. N. Pemberton (Lloyd's Register of Shipping) said that he wished to raise the question of electric fusion welding. This was quite relevant to the subject of the lecture because fusion welding was another form of steel making.

The illustration of the difference in crystal size caused by casting at different temperatures brought home to the speaker the importance of correct ampèrage control in electric welding.

With regard to rimmed steel, Dr. Hatfield had mentioned that this was out of the question so far as engineering purposes were concerned. In the case of welding, however, the speaker had been informed that rimmed steel had advantages as core wire in the manufacture of electrodes. Electrode manufacture was a very delicate operation, especially when high quality welds were desired, and he was led to understand that by using a rimmed steel core a certain control of the fluidity characteristics of the arc was obtained which could not be got with a fully-killed steel. Could Dr. Hatfield offer any explanation in regard to this matter? Would it be correct to say that in a fully-killed steel core wire gases would be locked up in some way in the material? It seemed possible that such gases might be violently liberated during deposition under the arc, causing the explosive spluttering which took place with some electrodes. It appeared, therefore, that rimmed steel might find a useful place in welding. He understood that right throughout the processes of rolling and wire drawing the rimming effect was maintained. Would Dr. Hatfield explain exactly what a rimmed steel was?

Another point was the solubility of nitrogen in mild steel. He understood that mild steel had a chemical affinity for nitrogen, and generally was in a super-saturated condition in this respect. It was extremely difficult to keep nitrogen out of weld metal, and therefore it was reasonable to suppose that most weld metal deposited was super-saturated with nitrogen. Was it possible, by the addition of some alloy, so to increase the solubility of iron for nitrogen that it would be possible to have a weld which would contain that element in the least harmful condition? And would Dr. Hatfield say what that alloying element might be?

The Chairman (Dr. S. F. Dorey) said that undoubtedly there was a great necessity for close co-operation between the engineer and the steel maker. He had in mind that it was not so much that the engineer should approach the metallurgist when a failure occurred, but rather beforehand so that failures could be prevented. The usual procedure was that the engineer, when a failure occurred, took a piece of steel to the metallurgist and asked him what was wrong with it, often neglecting to say what service it had experienced or anything about it. That attitude was wrong. The metallurgist should be given information about the conditions in which the specimen had been used, the stress conditions, the method of working, the time of working, and the tests carried out when the material was made.

Frequent mention had been made in the discussion of solid-forged crank shafts and in particular of shafts made up by combined webs and pins. He wondered whether the steel maker was giving the engineer the advice necessary in the case of this type of forging at the initial stages of design. The combined web and pin method of manufacture of shafts was brought about, of course, by the fact that it was impossible with the stroke adopted for a particular engine for the shaft to be of built construction, i.e., there was not room to shrink the pin and journal on the web. Perhaps the forgemaster might have said that, while this was a method of manufacture, he did not altogether recommend it. If that had happened at the early stages a lot of trouble now being experienced might have been avoided.

Dr. Hatfield had said that engineers were now asking for combined webs and pins of such sizes that the ingot could not be made of suitable size. Should engineers not have heard about this beforehand? A certain reduction of ingot according to the size and diameter of the finished shaft was specified, but it was evident that the finished forgings were not getting anything like the work they should. Most specifications stipulated the ratio of reduction from ingot to shaft, but he would like to know how the steelmaker satisfied the engineer as to what reduction he was getting in the case of the combined webs and pin forging.

Dr. Hatfield had said that the marine engineer had not taken advantage of the high tensile steels on the market. It must be remembered that the marine engineer was dealing with forgings of considerable size; was it possible for the forgemaster not only to cast ingots of the size required but to work and heat treat them so that uniform properties were obtained throughout? Some time ago a firm approached Lloyd's Register with regard to the use of a special high tensile steel for large shafts. The firm was told to make a shaft about 12 or 14in. diameter and 10 or 12ft. long and tests would be carried out. The tests showed a large range of tensile strengths and great differences in the impact values for each end of the shaft. It seemed to him that the marine engineer was not behind in this matter, but that the proposition had not been put to him that these materials were suitable for his purposes. For crank shafts of small engines for marine use, high tensile steels were used in preference to mild steel.

Mention had been made of dowel pins, and as an engineer he felt that he should answer the question raised rather than foist it upon the steel maker. The question of dowel pins had been discussed for many years. In the early days the dowel pin and the key came in simply because of the fact that the workmanship was not so accurate as it was now. Further, it was necessary to have rules which would apply to all degrees of workmanship. In one part of the country there would be a manufacturer who could not build crank shafts of the accuracy required for adequate shrinkage, while perhaps in another part of the country a manufacturer could do all that was desired. When preparing a specification it was necessary to take care that it was not too severe and yet to ensure that it was safe, and Lloyd's Register of Shipping had to cater for all. Provided the work was carried out properly, there was no need for dowel pins to be fitted. It depended on the whole method of manufacture, i.e., on how carefully the machined surfaces were prepared and on the shrinking operation being carried out in a proper manner. This had to be borne in mind, and there was reason for saying that in ordering a crank shaft from some firms it would be wiser to have dowel pins. In the case of a firm of repute there was no need for them.

What was Dr. Hatfield's opinion of the usefulness of the Izod test as an additional test to the usual tensile and bend tests?

In these days the tendency was towards greater accuracy and more careful examination of materials. Was it possible to overdo this? Experience was based on what had passed before. If new methods of examination came forward, while it was necessary to increase the standard they must, at the same time, not lose sight of the good work performed by these materials in the years before under less rigorous conditions of testing and inspection. Unless this was emphasized there would be a tendency to condemn material unnecessarily. An instance of this came to his notice last year when he was visiting a forge where they had a new boroscope. For some reason the maker had given double the magnification asked for and the forge people saw too much. They told the maker to reduce the magnification to that ordered as otherwise they might not get any shafts passed out of the shops, although the material was as good as what had previously given excellent service!

On the proposal of **Mr. H. S. Humphreys** (Vice-Chairman of Council), seconded by **Mr. H. R. Tyrrell** (Associate Member) a most cordial vote of thanks was accorded to Dr. Hatfield, who made a suitable brief reply.

The Author's Reply to the Discussion.

Dr. Hatfield, in reply, said that Mr. Heck rather suggested that what he had said about heavy crank shafts would tend to drive the engineer to smaller forgings. Surely the discussion between those present and the Chairman on dowel pins was the answer. Their inability to make a sound mechanical job of the built-up crank shaft would always give them a predilection for the solid forging. The situation was simply that with the development of engineering, larger and larger pieces of steel were required, and in these large cranks they had hit upon a design which, with the present facilities available in the metallurgical realm, was difficult to deal with.

Mr. Humphreys' remarks on crank shafts supplemented those of Mr. Heck. Fatigue phenomena were clearly indicated in the cases referred to by Mr. Humphreys where crank shafts had given good service up to about eight years, and had then suddenly failed in an epidemic of breakdowns. The stresses imposed in service were in excess of the elastic range of the material. That the shafts lasted as long as eight years meant that the stresses were not very much in excess, otherwise the epidemic would have occurred in one, two or three years as the case might be. They were using 28-tons tensile steel in very large masses for these crank shafts, without the certain knowledge on the part of the engineer that it had been given the optimum heat treatment. Dr. Hatfield doubted whether the fatigue limit of the cranks in question was above 12 tons. It was possible to give these cranks a fatigue range substantially higher, and with an increase in the fatigue strength of the material the breakages would be correspondingly postponed. Were they satisfied that the stresses imposed in service were the same as the theoretical stresses calculated in the drawing office? After eight years, of course, there was wear, possibly inefficient lubrication and other factors, the effect of which could not be computed. He suggested that the engineer did not know exactly what the stresses imposed were, but they were quite clearly above the elastic range of the material. He had had a most interesting experience in being told by Messrs. Swan, Hunter & Wigham Richardson, Ltd., about the failure of a propeller shaft of the "Mauretania" after 19½ years of service. He was assured that the shaft could not have been stressed beyond 2½ tons, but calculation showed that it had been subjected to 760,000,000 reversals of stress during its useful life. One must not, therefore, think of the elastic range of materials in terms of 10,000,000 reversals of stress. He thought they had a ready solution to the problem in employing a material with a higher elastic range, which should be supplied in an adequately heat-treated condition.

Mr. Heck mentioned the pouring temperature of steel and its measurement. It was quite possible to take the temperature of the pouring metal with accuracy, but the information which they desired concerned what was going on inside the furnace, which was less readily obtained.

As regards the octagonal ingot compared with the cylindrical, he would say that the octagonal ingot, which had a slightly concave surface on each face, was a very much stronger structure. The initial frozen cylinder of the half-cooled ingot when many-sided maintained itself more readily than a cylindrical shell under the contraction stresses set up in the mass. His experience showed that the octagonal ingot was a much safer and stronger structure than the cylinder, although it was true to say that some people claimed to be able to make the latter successfully.

Mr. Heck also spoke about big crystals being broken down by work. As a matter of fact the primary crystals were broken down, but it must be borne in mind that the original crystal structure was marked out by non-metallic matter, and whilst the actual metallic crystals themselves were transformed in structure, the original orientation was still defined by very fine non-metallic matter. This led to planes and zones of weakness.

With regard to the amount of work which should be put on a forging, he could not say definitely that it was on a mathematical basis. The basis was just practice but with regard to ship plates he would accept Mr. Heck's figures. In the case of big forgings, he thought that there should be 2½ to 3 times reduction.

Mr. Reed asked if the degree of segregation was greater in mild or alloy steel. Alloy steels were very much purer, but everything else being equal, the addition of nickel and chromium would not make the segregation less.

Commander Lockney asked what progress had been made with hollow ingots. They now had a method, which appeared to be very successful for casting them and they had gone up to about 50 tons in weight. It was obvious that the segregation effects would be less with a hollow ingot. The same speaker also asked if it had been found that test pieces taken from two faces would give the lowest values. That described the position very well.

Could heat treatment take the place of forging, was a question which could not be dealt with on a mathematical basis. If it could be arranged that a cast piece of metal froze in such a way that the structure built up to give a perfect and uniformly fine grain size, then it was conceivably possible that this material, when heat treated, would give results comparable with a forging. The forging, however, would always be expected to give better mechanical properties than the casting.

With regard to temperature gradients, he had given data on heating for forging and heating for tempering. When the forging was quenched there would be a temperature gradient in the mass and obviously different portions would be quenched at different rates, giving a variation in mechanical properties. They were overcoming this by modifying the alloy content of the steel in such a way as to decrease this "mass effect".

The bent crank shafts to which Mr. Kent had referred were only toys compared with those made to-day. The magnitude of the work carried out to-day was such that the mechanical operation was not possible with the tools available. The bending used to be done at temperatures at which the material was so plastic that the stresses should not have remained if, after bending, the forging was submitted to heat-treatment.

With regard to Mr. Humphreys' query regarding the unreliability of the Brinell test, Dr. Hatfield would not accept that. The Brinell test was very reliable and he would counsel Mr. Humphreys to take a lot of note of it. Mr. Humphreys had said the metallurgical aspect was likely to cause lack of confidence. Dr. Hatfield thought that he should emphasize how much there was in the metallurgist's part of the job. He hoped that the engineer, for his own peace of mind, would make the metallurgist understand his difficulties. If they put their heads together technology would advance.

He agreed that it was much to be regretted that special steel parts were fitted without any marks to indicate what quality they were. A very important bolt used in a steam plant had been sent to their laboratories. It was sent to him as a nickel-chrome-molybdenum steel bolt of 60-tons tensile, but actually it proved to be of mild steel. In these days when there were so many steels for different purposes, it was absolutely imperative to mark their origin.

With regard to Mr. Pemberton's remarks on welding, Dr. Hatfield was Chairman of a Committee which was organizing a symposium on this subject. There were 140 papers already offered and accepted, and while he hoped that the points Mr. Pemberton had raised would be dealt with there, he was not quite sure that they would. It was an interesting suggestion that rimming steel might have advantages for certain purposes. The outer layers were almost pure iron, and he dared say that the rimming effect had some merit, but that merit could not justify the use of that material for the purpose Mr. Pemberton had in mind. Dr. Hatfield felt that rimming steel should be crossed out altogether.

As regards the nitrogen content in a weld, all that he could say was that nothing much was known about this, but he doubted very much whether weld metal contained a lot of nitrogen. He pleaded ignorance on the matter, however.

He thought that Dr. Dorey would agree that the steel maker was in a difficult position. Whilst the original designer of the Diesel engine had an inspiration, subsequent progress was only made practicable by trial and error. The designer was not in a position to say what the stresses on the parts of the engine would be. Closer co-operation between the designer and manufacturer was necessary, and the metallurgist would do all he could to help.

The reason the marine engineer did not make greater use of alloy steels was that he trusted to mild steel, which was the cheapest form of steel available. The marine engineering industry used a large amount of steel which must be very strong, ductile and very cheap (especially cheap). If instead of working on the basis of the cheapest material available they went to the expense of obtaining the best that the steel maker could supply, many of the difficulties now experienced, which caused so much delay and expense, would disappear.

He thought that the Izod test was useful up to a point. It told how many ft./lb. of energy were absorbed in breaking a standard piece of steel, but it did not tell anything else.

Dr. Hatfield concluded by stating that so long as inspecting authorities had the outlook displayed by their Chairman, manufacturers would have no difficulty in joining with marine engineers in efforts to make their machinery as safe as possible.

INSTITUTE NOTES.

The Jubilee of King George V.—Loyal Address to His Majesty by Engineering Institutions.

Among the Loyal Addresses presented to His Majesty King George V on the occasion of the Twenty-fifth Anniversary of His Accession to the Throne was an Address by the fifteen leading Engineering Institutions and Societies of Great Britain, including the following:—

The Institution of Civil Engineers.
The Institution of Mechanical Engineers.
The Institution of Naval Architects.
The Institution of Municipal and County Engineers.
The Institute of Marine Engineers.
The Institution of Mining Engineers.
The Institution of Gas Engineers.
The Iron and Steel Institute.
The Institution of Electrical Engineers.
The Institution of Mining and Metallurgy.
The Institution of Water Engineers.
The Institution of Automobile Engineers.
The Institute of Metals.
The Institution of Structural Engineers.
The Institution of Chemical Engineers.

The Address, followed by sheets bearing the signatures of the presidents and secretaries adjoining the seals of the institutions, was bound in a royal blue morocco cover. A photograph of the Address is reproduced overleaf.

A letter of acknowledgment has been received from the Home Office, of which the following is a copy:—

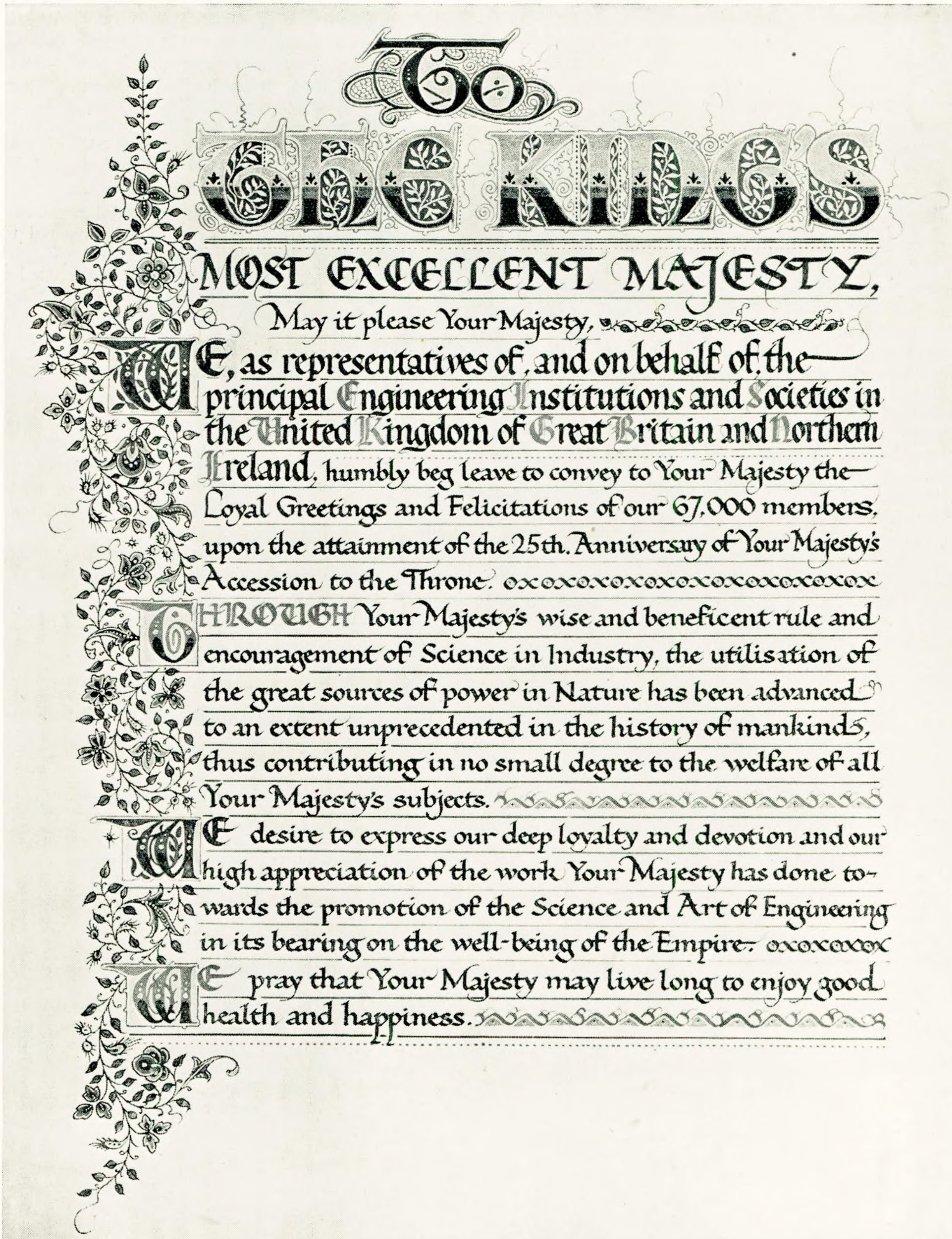
HOME OFFICE,
WHITEHALL.
17th May, 1935.

Sir,

I am directed by the Secretary of State to inform you that he has been Commanded by The King to convey His Majesty's thanks to the fifteen Engineering Institutions and Societies for their Address of Congratulation presented to His Majesty on the completion of the Twenty-fifth Year of His Reign. His Majesty much appreciates this expression of loyalty and devotion in which the President, Officers and Members of The Institute of Marine Engineers have joined.

I am,
Sir,
Your obedient Servant,
H. A. STRUTT.

The Secretary,
Institute of Marine Engineers,
85, Minories, E.C.3.



TO THE KING'S MOST EXCELLENT MAJESTY,

May it please Your Majesty,

WE, as representatives of, and on behalf of, the principal Engineering Institutions and Societies in the United Kingdom of Great Britain and Northern Ireland, humbly beg leave to convey to Your Majesty the Loyal Greetings and Felicitations of our 67,000 members, upon the attainment of the 25th. Anniversary of Your Majesty's Accession to the Throne.

THROUGH Your Majesty's wise and beneficent rule and encouragement of Science in Industry, the utilisation of the great sources of power in Nature has been advanced to an extent unprecedented in the history of mankind, thus contributing in no small degree to the welfare of all Your Majesty's subjects.

WE desire to express our deep loyalty and devotion and our high appreciation of the work Your Majesty has done towards the promotion of the Science and Art of Engineering in its bearing on the well-being of the Empire.

WE pray that Your Majesty may live long to enjoy good health and happiness.

Visit to the Works of Messrs. W. H. Allen, Sons & Co., Ltd., Bedford.

By the kind invitation of the Directors of Messrs. W. H. Allen, Sons & Co., Ltd., a party of fifty Members of The Institute visited the Company's well-known Queen's Engineering Works at Bedford on Wednesday, June 5th, 1935.

The majority of the party travelled by the 11 a.m. train from London (St. Pancras), arriving at the works approximately an hour later, where they were joined by the Members from other directions. The visitors were cordially received and welcomed by Messrs. Harold G. Allen, Deputy Chairman, Rupert S. Allen, Managing Director, and other prominent officials of the Company.

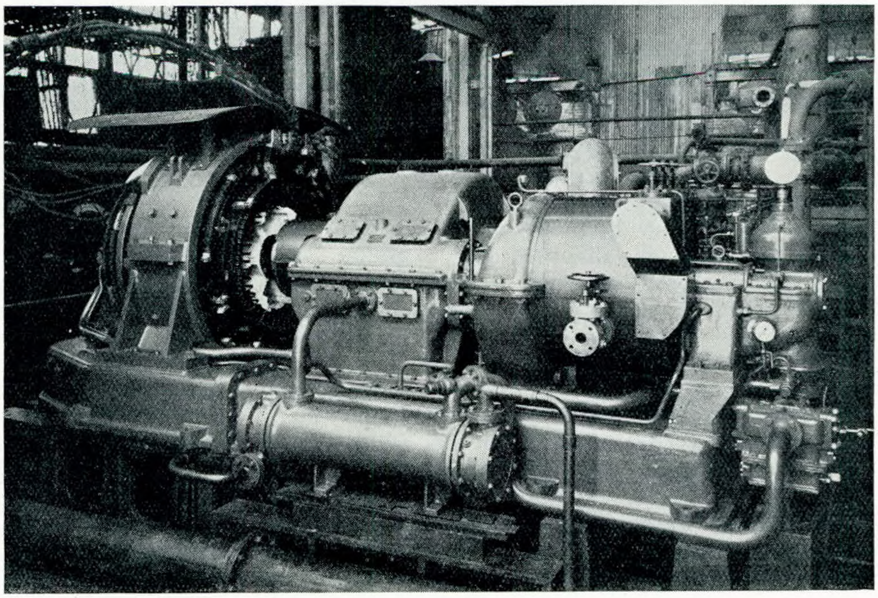
Before starting upon a tour of the works, the visitors were entertained to lunch, at which Mr. Harold Allen presided, supported by his co-director and the officials above mentioned. The repast was delightfully arranged and, as engineers would anticipate, the interesting conversations which took place during the lunch between visitors and hosts made keener the mental appetites of the former for the feast of technicalities awaiting them in the works.

The Loyal Toast having been drunk, the **Chairman,** addressing the company, said that in the first place it was his duty to apologise for the absence of the Chairman of the Company, Mr. R. W. Allen, C.B.E., M.I.Mar.E., as he was sure they were aware of the great interest which he took in marine matters. Unfortunately he had an important engagement in London which prevented him from being present. He had asked the speaker, however, to express his regret.

It was with very sincere pleasure that they welcomed the Marine Engineers to those works on behalf of the directors, staff and employees of the Company. They recognised amongst those present a large number of distinguished visitors, and there were also, he knew, amongst them, some of their competitors or those whom he might term "our friendly rivals", and to these he also extended a welcome with special pleasure. At the same time he extended to the party a welcome on behalf of the town of Bedford and also to the ancient Port of Bedford. It might be news to even some of the students of the town of Bedford to realise that the River Ouse, around which the town had been built, had been recorded in history right from the earliest days. There was in former days a very considerable trade on the river in timber, coal, wheat and other commodities, which were brought by water from King's Lynn and Yarmouth into the Port of Bedford; he mentioned this for the reason that they as a company were marine minded. It was actually recorded in history that there were buoys in the river adjacent to the old coaching hotel well-known as the Swan Hotel, which was still in existence to-day, and to those buoys were moored the barges which came from the sea. A name which frequently occurred in the records was that of a hostelry known as "The Buoy and Oar", a very famous house in the 17th and 18th centuries, and had it been in existence to-day, he had no doubt that he would have been tempted to have asked the party to spend an hour on the river and then adjourn to the "Buoy and Oar"!

They would not expect him to make any lengthy remarks as to what they were doing because the matters of design, material and methods of manufacture and research were all open for them to see in the course of their tour round the works that afternoon, but he would briefly mention that they were largely dependent in those works on Mercantile Marine and Admiralty work, and it would not be boastful to mention that products of their works were known throughout the seven seas as well as in the four corners of the world.

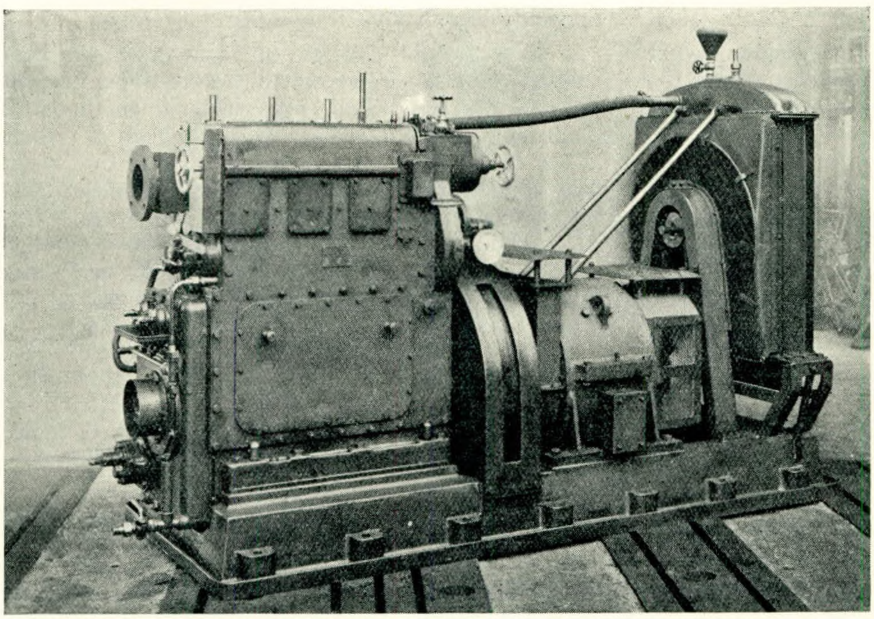
They would note during their visit that afternoon that the Company had no form of restrictions, quotas, tariffs or preferences, or any locked doors; one and all of the visitors were free to see the whole



Test bay picture of 500 kW. turbo-generator. One of three sets recently supplied for the new Orient Line vessel "Orion".

of the works and ask whatever questions they desired with regard to their machinery.

He would like just for a moment to deal with the subject of shipping and shipbuilding, and he knew that in the presence of so many distinguished engineers it might be a somewhat delicate subject, but he had had the interesting experience of residing for the past two years at Cowes in the Isle of Wight, and he had been very much impressed on seeing what was being done by various nations in the way of shipbuilding. He referred particularly to the vessels coming almost daily into the Port of Southampton—Dutch and German, and in some instances French and Italian ships—which led him to believe that those countries recognised the importance of being ready for the eventual recovery in world trade, and he would only express the hope that they in this country would progress sufficiently to enable them to take advantage of the recovery which must come.



25 kW., 800 r.p.m. self-contained marine emergency oil engine driven dynamo, complete with radiator for cooling the engine circulating water.

He was glad to say that last year their Company secured a portion of the marine work which was given out, and he hoped that in the not distant future they would see a full recovery take place, which would be of benefit to the whole country.

There was one other point he would like to deal with, and that was the ideal of their business. His father's idea in creating the business in 1880 was that it would always be a family affair, and fortunately, so far, this had been so, and he hoped their efforts would be sustained in the future and that it would continue as a family business; he used that term in its widest sense. He mentioned as a matter of interest, that they were now employing, both on the staff and in the works, a very large number of what he termed the third generation, and that was a wonderful record when one considered that the works had been established for over 55 years.

There were three Managing Directors of the Company—his brothers, Mr. Richard Allen, Mr. Rupert Allen and himself—whose ages reached nearly 200 years collectively. It had been their duty during the last few years and still was their duty constantly to give their attention to what they were going to do to enable the business to carry on when they themselves must pass on. He had no fear for the future, and he was very pleased to say that the family connection would continue with the help of the members of the staff, who were most enthusiastic, loyal, and delightful men to work with and who were to-day, in the main, carrying on the business.

He would like, with those remarks, to pay a tribute to their pupils and apprentices. They had had a very large number of pupils and apprentices through their hands since the works were inaugurated, and their opinion was that those who were going through their hands to-day were in every way as good if not better than those in the pre-War days, and he would like to emphasise that he entirely disassociated himself from and did not agree with the views that were expressed so frequently nowadays of the modern generation. He felt that modern young men and women were in every way as good if not better than those of pre-War days.

In conclusion, he would say that they were very much attached not only to their own business, but to the town of Bedford. The visitors might have seen it on record that so far as the Jubilee Celebrations were concerned, the town of Bedford stood out in its loyalty and its decorations, standing only second to London in this country, and he would suggest that the distinguished visitors whom they were welcoming there that day were adding lustre to the firm and to the town of Bedford. (Applause).

Mr. S. N. Kent (Past Chairman of Council), replying on behalf of the visitors, said that in the first place they were quite willing to accept Mr. Harold Allen's apology for the absence of Mr. Richard W. Allen, and they hoped that his absence in London would be of advantage to that distinguished firm.

He for one was interested to hear of the historical importance of the Port of Bedford, but they, the visitors, knew it for its important engineering works, and as he did not think that many of them had visited these works very often, he knew that as Marine Engineers they had still a lot to learn.

Messrs. Allen employed about 2,000 men, and were designers and constructors of steam engines, steam turbines, centrifugal and turbine pumps, continuous current dynamos, motors and switchgear, Diesel oil engines, condensing plant, and special auxiliary machinery for Naval purposes and the Mercantile Marine. He had been there several times and he could assure them that in the time at their disposal they could not possibly gain a complete idea of the firm's activities as there was so much to see.

He made complimentary reference to the Company's Chief Diesel Designer and the Diesel engine which they had developed, with which the visitors were no doubt as well acquainted as he was himself.

He congratulated the Chairman on the many years during which the family and the firm of Allen had existed and flourished, and they, as Members of The Institute of Marine Engineers, much appreciated the "freedom of the Port" and the courtesy which Messrs. Allen had extended to them that day.

They were very grateful to the Company for their kind welcome and for the opportunity they had given them to inspect their works. (Loud applause).

After lunch the visitors were formed into five parties, each under the guidance of two members of the staff, and proceeded upon a well-planned itinerary of the works, including the foundries, pattern shop, smithy and laboratory, machine shops, erecting shops, electrical, steam, hydraulic and oil engine testing departments. At the conclusion of the tour, tea was served in the reception room, the same genial hosts presiding. Before departing by train and road, the party was assembled for a photograph (here reproduced) thus ending a thoroughly enjoyable and instructive visit.

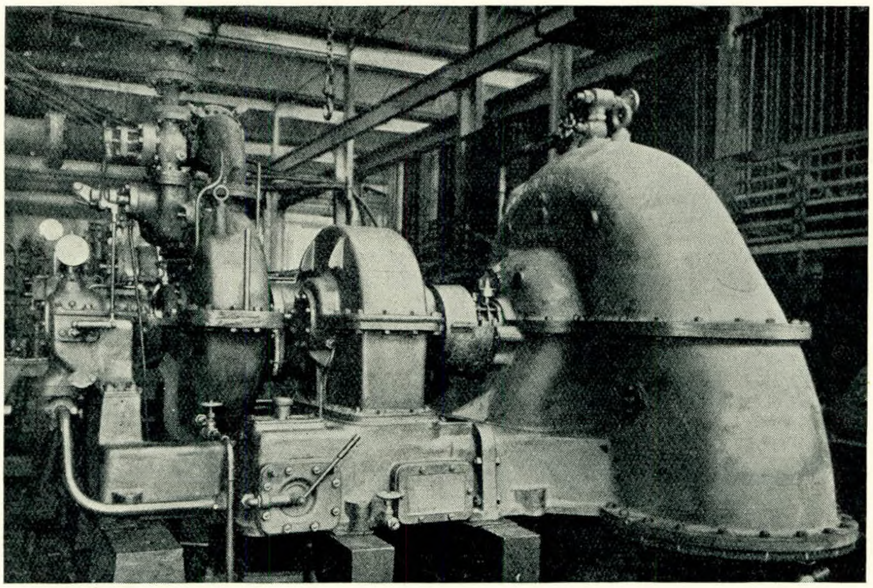
The following notes on some of the more outstanding items of the Company's current output may be of interest to Members generally.

At the present time, the Company has many orders in hand for mechanical, hydraulic and electrical equipment for marine and land purposes. In the large fitting shop there are under construction

The visitors and some of their hosts at Queen's Engineering Works, Bedford. Mr. Harold Allen is in the front (centre) with Mr. S. N. Kent on his right hand.

steam turbines, oil engines, steam engines, condensers and pumping plant of all types and sizes. Space does not permit a description of all the machinery seen during our visit, so the following notes must be confined to only a few of the different types of machinery.

Steam turbines in course of construction include a large number of units both for naval vessels and ships of the Mercantile Marine, as well as several interesting sets for industrial applications. The turbine driven auxiliaries for marine service include main and auxiliary circulating pumps, electric generators and forced draught fans, also a steam turbine for operating the steering gear of a large vessel now under re-construction. The total h.p. of steam turbines at present under construction for marine service is about 20,000.



Steam turbine driven main condenser circulating pump on test for the new Orient Line vessel "Orion".

One set among the industrial contracts is a 2,200 kW. 6,000 r.p.m. turbo-alternator for a self-contained power station at a Scottish jute mill, for which Messrs. Allen are the main contractors. The turbine is of the pass out type designed for steam at a pressure of 275lb. per sq. in. gauge, a total temperature of 750° F. and for passing out 20,000lb. of steam per hour at 35lb. per sq. in. gauge.

Another set seen was a 1,500/1,875 kW., 4,000 r.p.m. turbo-alternator, destined for a mining company's power station in Chile. This turbine is designed for steam at a pressure of 300lb. per sq. in. and a total temperature of 530° F. A 2,300 sq. ft. surface condenser of the regenerative type is also being supplied with the turbine.

Two 500 kW. and one 250 kW., 1,000 r.p.m. back-pressure d.c. turbo-generators were also seen nearing completion. These sets, which are for a private power station of a large undertaking in London, are designed for similar steam conditions, the stop valve pressure being 185lb. and the back pressure 30lb. per sq. in. gauge.

Amongst other steam turbines seen in course of construction in the main fitting shop were four 805 b.h.p., 2,400/3,600 r.p.m. sets with 775 sq. ft. condensers ordered by The M.W. Kellogg Co. for the Anglo-Persian Oil Co.; three 210/275 b.h.p., 6,000 r.p.m. turbines for driving blowers, each with surface condenser and auxiliaries for the Standard Yeast Co., Ltd., London and a 300 kW., 7,000 r.p.m. turbine with 540 sq. ft. "Awlinwun" surface condenser for the South African Torbanite Mining and Refining Co., Ltd.

In addition to the condensing plants being supplied for Allen turbines, a number of separate plants were seen under construction in the main fitting shop for use with other makers' turbines. These included two 4,200 sq. ft. condensers and auxiliaries to work in conjunction with B.T.H. turbines at the St. Anne's Board Mills, Bristol, and a 700 sq. ft. condenser for the Anglo-Transvaal Consolidated Investment Co., Ltd., South Africa.

In the steam engine section of the main fitting shop a large number of engine generating sets were under construction for both marine and land purposes. Briefly these included d.c. generating sets ranging from 15 kW. to 175 kW. destined for use on board ship; a 350 kW. d.c. generating set for the Australasian Tobacco Co., a 100 kW. a.c. generating set for John Thompson & Sons, Penrith, a 75 kW. a.c. set for the N.E. Lancashire Co-operative Society's Laundry, a 75 kW. a.c. set for Advance Laundries, Ltd., London, and a number of other sets for use in different industries. Amongst steam engines being constructed for mechanical drives, was a 175 b.h.p. unit for driving a pump at one of the waterworks of the Barnet District Gas & Water Co.

The pumping plant section of the main fitting shop also presented a busy picture. In this section numerous pumps of widely differing types and sizes were seen. To deal with every type of pump being constructed, a great deal of space would be required, but in brief the pumps ranged from large waterworks and sewage works units down to the smallest single suction pump for general use, as well as many pumps for marine purposes.

In the oil engine section there were seen under construction many engines of different types and sizes from 30-1,000 b.h.p. A prominent feature of the oil engines at present under construction is the wide adoption of the "C" frame design of engine cylinders and base. Engines of this type are built in units up to 800 b.h.p. and representative examples of these were seen in all stages of manufacture. A number of 600 b.h.p. slow speed 6-cylinder engines were under construction for dealing, in conjunction with Allen pumps, with the flood water in the London area.

Assembly of a 1,000 b.h.p. engine for driving shafting in a West Riding Mill was seen in progress. This engine will run at 275 r.p.m. and when completed will weigh no less than 60 tons.

Amongst the plant for shipment abroad were four 400 b.h.p., 4-cylinder engines direct-coupled to compressors, running at 560 r.p.m. Two similar 5-cylinder units for driving centrifugal pumps were destined for Aden, and a number of smaller engines were being despatched to Australia, South Africa and Spain.

We understand that the Company has constructed more Diesel driven generating plant for marine purposes than any other maker in England, and a number of contracts are at present in hand for important shipbuilders. Three 6-cylinder units each of 250 kW. are nearing completion for Messrs. Kincaid for a new Elder Dempster vessel. Three smaller 3-cylinder units running at 500 r.p.m. are being manufactured to the order of Messrs. William Denny for the Australasian United Steam Navigation Co. Each of these sets has an output of 70 kW.

Oil engines of the small high-speed type have now been in production for some years, and examples of these for marine emergency sets, pumps and locomotives were in evidence.

For marine propulsion purposes engines ranging from 60 to 300 b.h.p. were seen in various stages of completion. The smaller sets are provided with mechanically operated reverse gear of the epi-cyclic type built to form a single unit with the engine, and in certain cases reduction gears are also incorporated. The larger engines are built with oil operated combined reversing-reducing boxes.

The electrical shop is devoted to the construction of d.c. generators, motors, control gear, switchgear and switchboards. In this shop a large number of equipments were seen in various stages of manufacture, chiefly for marine applications, but again space does not allow dealing individually with the details of the equipments and their uses and destinations.

The smithy is provided with the latest welding and electric arc-welding sections, the use of electrically-welded fabricated steel sections for oil engines, condensers, generators, motors, etc., having been developed with great success by the Company's design engineers.

There are many other sections which must be left undescribed in this brief description of the works.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, June 3rd, 1935.

Members.

William Ellrington Campkin, Heybridge, Maldon, Essex.

Thomas Arthur Fawcett, 30, Leyburn Street, W. Hartlepool.

Norman Fieldhouse, 18, Raglan Road, Morecambe, Lancs.

George William Hill, The Hall, Airmyn, Goole, Yorks.

Hengest Hewlett Kemp, 80, Wells Road, Bath, Somerset.

George Preece, Eng. Rear-Adm'l., C.B., The Admiralty, Whitehall, S.W.1.

Robert Rodger, Wensley, Waterloo Park, Waterloo, Liverpool.

Thomas James Smith, 17, Nelson Avenue, Stoke, Devonport.

Bernard Francis Welch, 2, High Road, Swaythling, Southampton.

Associate Member.

James Cameron, 4th Engineer, c/o B.I. Engineers' Club, 15A, Kyd Street, Calcutta.

Associates.

Renny Bourdas Pinkney, 26, Eastbury Road, Northwood, Middlesex.

Thomas Welborn, United Engineers, Ltd. (Marine Dept.), Singapore, S.S.

Transfer from Associate Member to Member.

Thomas Whitehead, New Barn Farm, Rochdale, Lancs.

Transfer from Associate to Member.

Henry John Bishop, 26, Bar Terrace, Falmouth.

Transfer from Associate to Associate Member.

George William Oman, Goderich, Ontario, Canada.

Transfer from Student to Associate.

Kenneth Paul Harman, Vectis, Lower Road, River, near Dover, Kent.

Edwin John Moyse, 7, King's Road, Gosport, Hants.

ADDITIONS TO THE LIBRARY.

Purchased.

Treatment of Chimney Gases at the Townmead Road Power Station of the Fulham Borough Council. H.M. Stationery Office, 1d. net.

Report on the Examinations of Candidates for Certificates of Competency in the Mercantile Marine and the Sea-Fishing Service for the year ending December 31st, 1934. H.M. Stationery Office, 2d. net.

King's Regulations and A.I. Amendments (K.R. 1935). H.M. Stationery Office, 4d. net.

Board of Trade (Mercantile Marine Department) Staff of Surveyors, Inspectors of Ships' Provisions, etc. H.M. Stationery Office, 2d. net.

Department of Scientific and Industrial Research. Report of the Chemistry Research Board for the period ended 31st December, 1934. H.M. Stationery Office, 1s. 6d. net.

Presented by the Publishers.

Notice to Shipowners, Shipbuilders and Masters: Prevention and Extinction of Fire on Cargo Ships. Board of Trade Notice No. M.140.

"The Development and Progress of the High-Speed Diesel Engine in Road Transport", by W. H. Goddard. Diesel Engine Users Association.

"America's Cup Defenders", by C. P. Burgess and "Yacht Measurement", by W. P. Stephens. Advance proof papers issued by The Society of Naval Architects and Marine Engineers, New York.

"Pump Service and Problems" by Kerr. Henry Wiggin & Co., Ltd.

"Investigation of Bell and Spigot Joints in Cast-Iron Water Pipes: Part I—Pull-out Strength; Part II—Bell Strength; Part III—Harness Strength", by Prior. Ohio State University Bulletin No. 87.

Report on Heavy-Oil Engine Working Costs (1933-34). Diesel Engine Users Association.

The British Electrical and Allied Industries Research Association. Sub-Committee J/E: Joint Committee: Steels for High Temperatures; Bibliography of Literature on the Behaviour of Steels at High Temperatures, furnished by "The Engineering Index Service".

"Practical Hints on Patents", by M. E. J. Gheury de Bray.

"Recommended Materials for Mining Equipment".

The following British Standard Specifications:

No. 609, 1935. Multitubular Horizontal Boilers (Dryback and Waste Heat).

No. 599, 1935. Pump Tests. Corrigendum Slip C.D. (ME) 6511.

Transactions of the Barrow Association of Engineers, Vols. XX-XXI, 1934, containing the following papers:—

"The Development of Heavy Naval Gun Mountings", by Hefford.

"The Classification of Ships—Presidential Address", by Cowie.

"Engineering as Applied to Quarries", by Sky.

"Engineering Alloys", by Taylor.

"Observations on Ballistic Experiments", by Esparteiro.

"Pioneers of Engineering", by Wood.

"Applications of Electricity in Medicine", by Alexander.

"Diesel Electric Propulsion", by Watson.

"The Heat Treatment of Steel", by A. Craig Macdonald, B.Sc. The Draughtsman Publishing Co., Ltd., 44pp. illus., 2s. net.

The contents of this useful pamphlet have been concentrated on those points in connection with the heat treatment of steel which are of practical value to the engineer. Following a short review of the development of modern carbon-iron alloys, the author deals with the effect of quenching, forging, annealing, hardening and tempering. Reference is also made to furnaces and temperature control. The work is supplemented by some useful appendices and tables, among the latter of which the table giving the composition, heat treatment and physical properties of a few well-known alloy structural steels will be of special interest to marine engineers.

"Oil Tank Steamers and Motor Tankers", by H. J. White (5th Edition). Brown, Son & Ferguson, Ltd., 52-58, Darnley Street, Glasgow, S.1, 227pp., illus., 15s. net.

It is not always an indication of the value or popularity of a book that it runs through a number of editions, but in this case there can be no question of the fact that the author of "Oil Tank Steamers and Motor Tankers", Captain H. J. White, has again produced something of definite practical value to everyone interested in the operation of oil tank ships. It is a book, too, which the naval architect and the marine engineer will not find it a waste of time to study. To those who can remember the first paper covered edition of this book which was published, it is an indication of the expansion which has taken place in the tanker business to reflect that the present edition has been enlarged even from the fourth by the addition of 18 new chapters, making a total of 61 in all. It is also of value to note that 18 different types of tankers are described by chapter, and diagrams are placed in rotation thus showing the evolution of tanker construction from 1885 to 1933. The book contains everything that a man can want to know concerning the arrangement of piping on tank ships and an excellent idea of the characteristics of the different types of cargoes which tank vessels are called upon to carry. It is indicative of the change which is coming over modern bulk transportation of oil and in this connection it is significant that it should have been necessary to modify the title to "Oil Tank Steamers and Motor Tankers". In future editions it might be a good idea to shorten and combine the title to two words by calling it "Oil Tankers".

"Direct-current Machinery", by R. G. Kloeffler, J. L. Brenneman, and R. M. Kerchner. Macmillan & Co., Ltd., 403pp., illus., 17s. net.

This work of 400 pages is the result of the joint effort of three professors of electrical engineering at the Kansas State College, together with the acknowledged help and suggestions of three professors at the Massachusetts Institute of Technology. Such distinguished authorship leads one to expect perfection in production, and in this the reader is not disappointed.

The book is intended as a text in courses on direct-current machines, and is specially designed to suit the needs and intellectual level of the average junior engineering student. We have no hesitation in saying that the book, which does not treat of design, will also meet the requirements of a much higher standard of student than the above leads us to suppose.

The student is expected to have covered a considerable course in the fundamental theory of electricity and magnetism before starting this study of direct-current machines, but for those who have not had such a preliminary training an appendix on "Units and Fundamental Concepts" is given. This appendix of 38 pages is particularly comprehensive, concise and suited to the purpose of introduction to the subject of the book.

It is almost impossible to give in a brief survey an idea of the extent of the ground covered, or fairly to select any particular chapter or section of outstanding quality in this book, the whole of which is of a particularly high order of merit. Due probably to the joint authorship, theory, practice and manufacture are combined throughout the work in a way we would like to see more often employed in books dealing with similar subjects.

The line diagrams generally, and the graphical methods of illustrating the characteristics of direct-current machines are particularly well drawn and useful, but from experience we are rather inclined to doubt whether the excellent "Three-Wire System of Voltage" diagram (Fig. 125a), together with the accompanying text is quite sufficient to explain to the average junior student the "inherent voltage regulation" which may be puzzling when considered for the first time. Fig. 119g evidently represents a compound and not a shunt motor as stated and perhaps intended.

We are pleased to note that throughout the book the authors use the definitions laid down by international or A.I.E.E. standard codes, and these are such as generally to present no difficulty or misapprehension to the English reader. We note, however, a few terms such as "abampere", "abvolt", referring to C. G. S. units, with which we are not so familiar, but which indeed might be adopted by us with advantage. The particular use of the word "dynamo", however, may give rise to misapprehension. In the book this world is used to include generators and motors, both direct and alternating current; hence the chapter "Dynamos, Speed and Torque Characteristics" is unexpectedly discovered to refer entirely to motors and not generators as we should suppose.

The chapters on "Rating, Weight, and Cost of Dynamos" and "Special Applications of Direct-Current Machines" are perhaps rather unusual and therefore particularly interesting, whilst the subject of "Commutation" is dealt with at considerable length and in detail, and together with "Armature Reaction" and "Reactance Voltage" covers about 70 pages.

To the student, either junior or senior, who desires valuable and detailed knowledge of armature windings, operation and testing of direct-current machines, we can thoroughly recommend a study of the book, whilst the quality of the paper and general production even at the price of 17s. will give a feeling of satisfaction to the owner.

"The Electronic Structure and Properties of Matter", by C. H. Douglas Clark, M.Sc. Chapman & Hall, 1934, 373pp., illus., 21s. net.

This is not actually a textbook on atomic structure—it is mainly concerned, as its title suggests, with the structure and properties of matter in relation to the electronic properties of atoms. As such, it serves a most useful purpose and is, in fact, almost unique. It is the first of a series of three volumes which the author has in view, the remaining two, still in preparation, dealing with "The Fine Structure of Matter", and "The Interpretation of Band Spectra".

In regard to the present volume, the author is to be congratulated, from the point of view of the engineering reader not familiar with quantum mechanics, on the fact that the treatment is, in the main, non-mathematical, and that "methods of reasoning from the results obtained, rather than details of experimental procedure and technique, form the main concern of the present work". The book opens with a really excellent and concise summary of the main features of the Rutherford-Bohr atom. After a brief account of inter-atomic linkage, the author proceeds to deal with melting points, boiling points, atomic volumes, atomic radii, electrical conductivity, magnetism, cohesion and entropy. It is of course understood that it is impossible to deal in detail with such a wide field in one volume, and this explains, no doubt, why the author frequently confines himself to stating the views of various authorities, without critical comment but nevertheless with an admirable system of references.

For example, Chapter X requires no fewer than *thirteen pages* of references to various authorities which have been quoted in the text whilst there are sixty-nine pages of references in the entire book. This method of writing a scientific book is excellent for those who wish to be fully "au fait" with the bibliography of a given subject; but the reviewer hopes he will be forgiven for suggesting that it is not the best method of imparting knowledge, and in the present case, also, the result is that the extent of the references has curtailed unduly the text allotted to such important and practical subjects as the electrical conductivity of gases and the magnetic properties of alloys.

"Chromium Steels", by R. H. Greaves, M.B.E., D.Sc., F.I.C., Research Department, Woolwich. H.M. Stationery Office, 321pp., illus., 7s. 6d. net, postage extra.

This volume, which is concerned primarily with plain chromium steels, gives a detailed account of their history, constitution, mechanical and physical properties, and the principal uses to which these materials have been put. The first chapter deals with the early history of these materials, and it is shown that, although the first record of the use of chromium as an alloying element with iron was contained in an account of experiments conducted by Stodart and Faraday as long ago as 1820, it was not until towards the end of the century that steels of this character had any considerable vogue.

The constitution of the iron-chromium and chromium-carbon alloys are dealt with in ample fashion, and under this heading the enquiring metallurgical student will find the references and the many diagrams of very great assistance. The matter of heat treatment is dealt with concisely, but adequately; the tables illustrating the effect of the rate of cooling on hardness in terms of Brinell numerals will be found of particular value.

The chapter dealing with the mechanical properties of chromium steels is one which will no doubt make a special appeal to the engineer, and it is therefore gratifying to note that this phase of the subject has received its full share of attention. Numerous examples showing the effect of "mass" on the mechanical properties are given in this chapter, while the references concerning the important problems of fatigue and corrosive fatigue cannot fail to be illuminating and helpful. The physical properties of these steels are discussed in the succeeding pages.

The subjects discussed in the final chapter are clearly of great industrial importance. This chapter, which deals with the uses of chromium steels, is most informative and embraces in its survey the whole range of steels from the low carbon, case hardening steels, to the high carbon razor steels.

The appendix which provides a short but adequate survey of the methods commonly used in the chemical analysis of chromium steels will make a particular appeal to the metallurgical chemist.

The volume which obviously represents an immense amount of work is well illustrated and contains numerous graphs and tables. The bibliography has been compiled with commendable thoroughness while the indexing is on a similar adequate scale.

"The Operation of Motor Ship Auxiliary Machinery", Vol. II, by John Lamb. Charles Griffin & Co., Ltd., 265pp., 139 illus., 12s. 6d. net.

John Lamb has now completed the second volume of "The Operation of Motor Ship Auxiliary Machinery". It deals with matters of such importance to the sea-going engineer as liquid fuel firing and boiler management, waste heat recovery, reciprocating pumps, rotary pumps and pipe arrangements, refrigeration, steam engines, evaporators and condensers, telephones, storage batteries, electrical insulation testing and bell circuits, ships' telegraphs, revolution indicators and helm indicators, the gyro-stabiliser, compass and pilot and miscellaneous accessories.

Those whose bookshelf already includes Volume 1 will undoubtedly lose no time in placing Volume 2 alongside it. The two books will make an invaluable reference library in times of difficulty with auxiliary machinery and will enable engineers to make themselves acquainted with the peculiarities and knotty points of this type of machinery and apparatus, which is not perhaps as well studied and considered as main installations.

Mr. Lamb writes with a happy combination of practical knowledge and literary ability. He knows what the modern engineer requires and sets it out with admirable conciseness. Volume 2 of his work makes interesting and easy reading. The book gives practical hints and useful information regarding auxiliaries, which are often neglected.

ABSTRACTS.

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

Engineer Rear-Admiral R. Beeman, C.B., C.M.G., Vice-President, The Institute of Marine Engineers.

"The Engineer", 24th May, 1935.

On Friday, May 17th, the announcement was made that Engineer Rear-Admiral Robert Beeman had been appointed a special director of Vickers-Armstrongs, Ltd., and engineering manager of the firm's Barrow works. Since 1932, Rear-Admiral Beeman has been Deputy Engineer-in-Chief to the Admiralty, and he relinquished that position on May 14th. He joined the Royal Navy in 1901 and in the pre-war years saw considerable service both at home and abroad. He was present at the Battle of Jutland in the destroyer H.M.S. "Nerissa", and his services on that occasion were mentioned in despatches. Later in the war he was appointed to the Department of the Engineer-in-Chief, and in 1932 became Deputy Engineer-in-Chief. Rear-Admiral Beeman has been a naval *aide-de-camp* to His Majesty the King, and for some time he was instructor at the Royal Naval College, Greenwich. He is a member of the Council of the Institution of Naval Architects. There is no doubt that in his new appointment he will find new scope for his wide knowledge of marine engineering in all its branches. At the Admiralty he is succeeded by Engineer Rear-Admiral George Preece, who was Assistant Engineer-in-Chief at the Admiralty for six years up to December last, and served under Admiral Beatty in H.M.S. "Lion" during the war as engineer lieutenant-commander, and was mentioned in despatches for his services in the action off the Dogger Bank. After he was relieved in 1916 he served at the Admiralty and later on the staff of Keyham College. From 1923 to 1927 he was Professor of Marine Engineering at the Royal Naval College, Greenwich, and in 1927-28 was Fleet Engineer Officer on board H.M.S. "Nelson".

Block kindly loaned by "Shipbuilding and Shipping Record".

[We are pleased to record that the name of Admiral Beeman figures in the official list of Honours conferred by the King on the occasion of His Majesty's birthday on 3rd June. Admiral Beeman receives a Knighthood of the Order of the British Empire.

The Honours list also includes the name of another of our Members, Engineer Captain Dight, R.N., who becomes a Commander of the same Order.—EDITOR].

BOARD OF TRADE EXAMINATIONS.

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

Name.	Grade.	Port of Examination.
For week ended 16th May, 1935 :—		
Dale, Alan C. G.	2.C.	London
Fee, Thomas H. C. H. ...	2.C.	,,
Harding, Charles L. ...	2.C.	,,
Roughton, William J. ...	2.C.	,,
Turner, Bernard	2.C.	,,
Norris, Alan	2.C.M.	Liverpool
Cameron, Donald	2.C.	Glasgow
Ferguson, William W. ...	2.C.	,,
Paterson, Archibald ...	2.C.	,,
Robertson, Peter	2.C.	,,
Urquhart, John	2.C.	,,
Steele, Robert	2.C.M.	,,
Martin, James A.	2.C.	Newcastle
Nicholson, John H.	2.C.	,,
Selby, John R.	2.C.	,,
Thompson, Wilfred ...	2.C.	,,
Birkert, Frederick W. ...	2.C.M.	,,
Mower, Reginald T. ...	2.C.	Cardiff
Ryan, Thomas	2.C.	,,
Barrow, Thomas	2.C.M.E.	Newcastle
Sage, Arthur L.	2.C.M.E.	London
For week ended 23rd May, 1935 :—		
Arthur, John B.	1.C.	Cardiff
Dwyer, Timothy	1.C.	,,
Armer, John	1.C.	Liverpool
Briggs, Harley	1.C.	,,
Crane, Cyril	1.C.	,,
Duckett, Benjamin A. ...	1.C.	,,
McStay, Hugh R.	1.C.	,,
Mulloy, Henry C.	1.C.	,,
Parker, Henry L.	1.C.	,,
Clerk, Donald	1.C.	Glasgow
Cowper, John	1.C.	,,
Docherty, John	1.C.	,,
Graham, Robert N. B. ...	1.C.	,,
Guthrie, William	1.C.	,,
Macdonald, George D. ...	1.C.	,,
Wotherspoon, James ...	1.C.	,,
Forster, Arnold H. ...	1.C.	Newcastle
Merriman, Gordon N. ...	1.C.	,,
Smurthwaite, William ...	1.C.	,,
Wood, Alan C.	1.C.	,,
Molloy, William J. ...	1.C.M.	,,
Eves, William V.	1.C.	London
McDonald, William J. ...	1.C.	,,

Name.	Grade.	Port of Examination.
Thain, Alexander	1.C.	London
Fearon, Gordon	1.C.S.E.	"
Forbes, Norman	1.C.M.E.	"
Hill, George W.	1.C.M.E.	Newcastle
Wynne, Roy L.	1.C.M.E.	Liverpool
Harrison, William N. ...	1.C.M.E.	"
Cottington, George	1.C.M.E.	"
Kilpatrick, Charles	1.C.M.E.	Glasgow
Sharp, Frank	1.C.M.E.	"
Stevenson, William ...	1.C.M.E.	Liverpool
Barker, Robert N.	1.C.M.E.	"
For week ended 30th May, 1935:—		
Hutton, Thomas H. ...	1.C.	Glasgow
Christie, William G. ...	2.C.	Liverpool
Flynn, John	2.C.	"
Hughes, James	2.C.M.	"
Beattie, Alistair S. ...	2.C.	Glasgow
Day, Richard J.	2.C.	"
Nairn, James H.	2.C.	"
Woodward, Maurice ...	2.C.	London
Vann, Clarence R. ...	2.C.M.	"
Evans, Philip	2.C.	Newcastle
Goodfellow, William ...	2.C.	"
Talbott, Frederick C. ...	2.C.	"
Watson, John B.	2.C.	"
Norrie, Alexander	2.C.M.	"
Robinson, John G.	2.C.M.	"

Locomotive Boiler Explosion.

"The Engineer", 31st May, 1935.

In a recent report on the explosion of a locomotive boiler the cause is stated to have been the corrosion of the middle section of the barrel plating at the bottom which caused the plate to become so thin that it was unable to withstand the pressure to which it was subjected. The boiler was thirty-five years old and had been regularly inspected and overhauled. Examination after the explosion showed that in places along the line of rupture the material had wasted to paper thickness, but the wasting had been confined to a great extent to one section of the boiler shell and to the plate in the vicinity of the rupture. The severe pitting and corrosion in the barrel are attributed to the fact that the middle ring of the barrel plating was fitted outside at one end and inside at the other, thus giving a run to the plate at the bottom which, when the boiler was empty, formed a lodgment for sludge or water at the front end of the plate and against the edge of the adjacent plate. Since 1927 the engine was used intermittently only, the periods during which it was lying idle were often of many months' duration, and it was customary to run the engine into the shed, draw the fire, and to run the water out of the boiler. Owing to the formation of the barrel, a residue of water and mud would be left lying at the front end of the middle ring on the bottom, and local corrosion resulted. In the observations of the Deputy Engineer Surveyor-in-Chief, it is stated that at some time previously an attempt had been made to cover a portion of the wasted plate by depositing welded metal on the surface. Such practice applied to the shell plate of a boiler is strongly deprecated, as being in itself a possible cause of local stress, cracking and failure.

A Machining Tip.

"The Engineer", 31st May, 1935.

An interesting and effective method of avoiding the tool marks caused by chattering when machining thin-walled tubes and hollow parts is given in "Machinery". The tubes are plugged at both ends after being filled with a non-elastic liquid, such as water or oil, the liquid being at room temperature and air bubbles being carefully avoided when filling. This non-elastic filling, which also increases the mass of the part, prevents vibration and shock caused by the tool. Thus the outer surface can be machined without regard to the accuracy and shape of the inner surface.

The Completion of the "Normandie".

The Largest Mercantile Vessel in Service.

"The Shipbuilder and Marine Engine-Builder", June, 1935.

The hull and propelling machinery particulars and the illustrations showing the sectional elevation and plan of boiler rooms and the plan of the motor and alternator rooms are abstracted from "The Engineer" of 31st May, 1935.

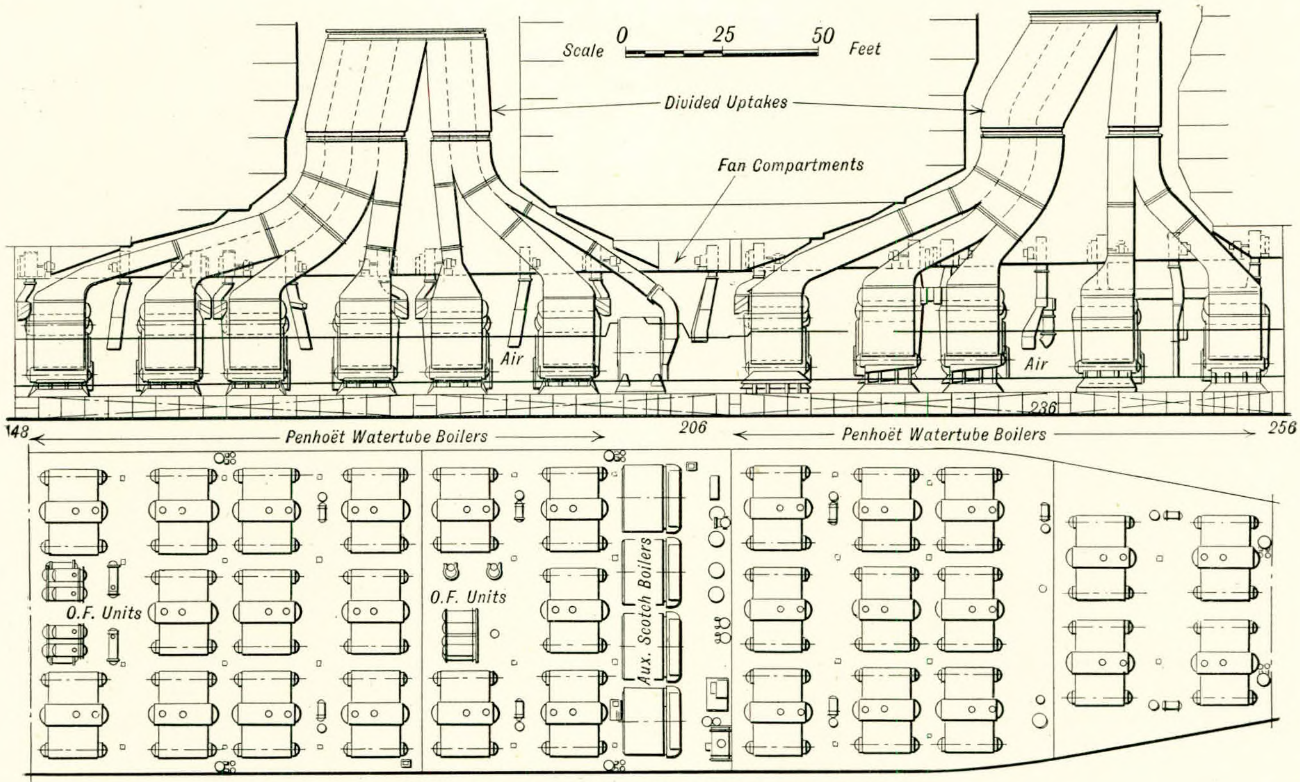
The quadruple-screw turbo-electric mail and passenger liner "Normandie", constructed at Saint Nazaire, France, by the Société Anonyme des Chantier et Ateliers de Saint Nazaire Penhoët for the Havre-Southampton-New York service of the Compagnie Générale Transatlantique, carried out sea trials during the month of May, which were eminently satisfactory in all respects.

Remarkable for her size and speed and no less for the adoption of electric transmission of her propelling power—she is the first electrically-propelled vessel to enter the regular North Atlantic service—it may be said that no shipbuilding undertaking in modern times has excited more widespread interest, both technical and popular, than the construction of this great French liner. From the laying of her keel on the 26th January, 1931, to her ultimate completion during the past month, attention has been focussed on Saint Nazaire. In the course of our several visits to the Penhoët yard during the fitting out period, we were particularly impressed by the competent and well-ordered handling of this immense contract, and the happy augury represented by the results of the sea trials is a matter for congratulation of all concerned.

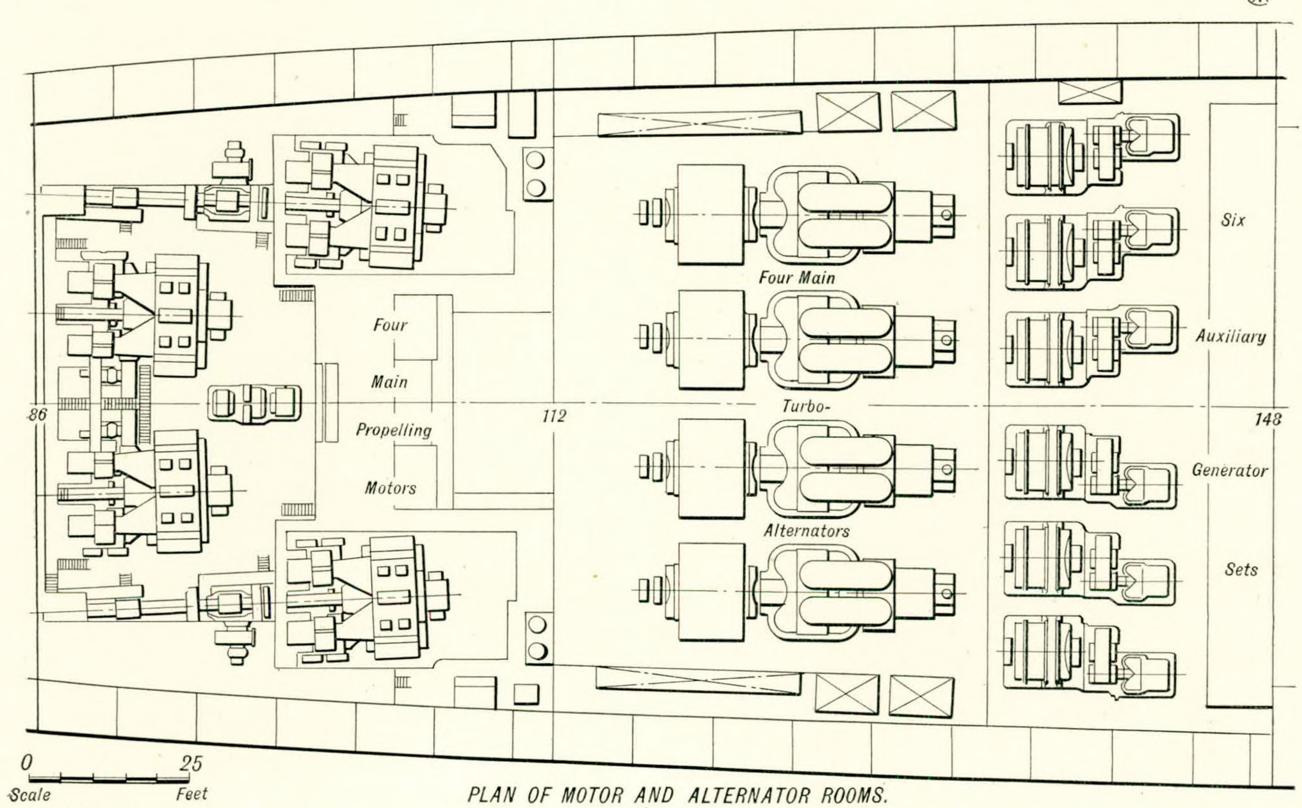
The principal hull and machinery characteristics of the "Normandie" are given in the accompanying figures.

Hull Particulars.

Length overall	1,029ft. 4½in.
Length between perpendiculars ...	962ft.
Breadth at water line	117ft. 9in.
Breadth at promenade deck ...	119ft. 5in.
Depth to promenade deck ...	91ft. 10½in.
Height from keel to top of wheel-house	127ft. 11½in.
Height from keel to top of forward funnel	183ft. 8¾in.
Height from water line to top of forward funnel	145ft. 2in.



SECTIONAL ELEVATION AND PLAN OF BOILER ROOMS.



PLAN OF MOTOR AND ALTERNATOR ROOMS.

Height from water line to top of after funnel	134ft. 6in.
Distance between masts	495ft. 5in.
Mean loaded draught	36ft. 7⅜in.
Approximate gross tonnage ...	79,280 tons
Approximate displacement ...	68,500 tons
Total deadweight capacity ...	12,000 tons
Total hold and 'tween deck cargo space	133,300 cub. ft.
Capacity of water ballast tanks ...	268,400 cub. ft.
Total oil and water carried—	
Fuel oil	8,930 tons
Fresh water	6,600 tons
Salt water	554 tons
Capacity of fuel oil tanks ...	339,000 cub. ft.
Designed service speed, over ...	28½ knots
Propelling Machinery.	
Type	Quadruple-screw, turbo-electric
Number of turbo-alternator sets (three-phase A.C.)	4
Type and voltage	"Alsthom" three-phase 5,500 to 6,000 volts
Designed output each set	34,200 kW.
Maximum running speed... ...	2,430 r.p.m.
Number of propelling motors ...	4
Type and voltage	"Alsthom" synchronous, 5,500 to 6,000 volts
Designed output each motor ...	40,000 s.h.p.
Running speed	238 to 248 r.p.m.
Total normal propelling power...	160,000 s.h.p.
Boiler Installation.	
Number of main water-tube boilers	29
Type	Penhoët oil-fired with superheater and air heater
Working pressure	400lb. per sq. in.
Total steam temperature ...	360° C. (680° F.)
Number of auxiliary Scotch boilers	4
Working pressure	142lb. per sq. in.
Auxiliary Geared Turbo-Generator Sets.	
Number of sets	6
Designed output each set	2,200 kW.
Turbine speed	5,300
Generator speed	530
Voltage	220
Total ampères capacity	60,000
Emergency Generator Sets.	
Two 150 kW., 220-volt oil engine driven dynamos.	

During speed trials carried out over a measured distance off Brest, the best run of the vessel exceeded 32 knots, while a mean speed of 31·33 knots was obtained with a substantial number of her boilers shut off. The fuel consumption was considerably lower than expected, and at 29 knots was approximately the same per mile as that of the "Ile de France". Under reduced running conditions, with two alternators out of circuit, a speed of over 24 knots was obtained, the fuel consumption per mile being then roughly the same as that of the "Paris" at 22 knots. The propelling machinery ran very smoothly throughout the trials, without the necessity for any adjustment.

The "Normandie" proved remarkably easy to handle, and when proceeding into Brest Harbour her commander—Captain René Pugnet—used the channel known as the Ras de Sein, the ship negotiating this rather narrow and tortuous channel at 30 knots with the greatest ease. Entering Havre, she was brought right up to the dock without assistance from tugs, which were only required to swing her round; and, in spite of a stiff northerly breeze, the complete turn occupied only nine minutes.

Exhaust Gas Utilization in Motor Ships.

New Combination Forced Circulation System.

"The Motor Ship", May, 1935.

Experience has shown that the most suitable waste heat and oil-fired boiler installation for a motor ship is sometimes difficult to install, because of the many factors which have to be considered, such as :—

1. The best position to suit the exhaust pipe (a very important point on account of back pressure).

2. The space available in the casing above the main engines.

3. The weight of the boiler to be supported and the effect on the stability of the ship.

4. The accessibility of the boiler for normal operation, particularly when it is oil fired.

From the points of view of support, stability and convenience, the best position is on the engine-room floor level; but from the waste-heat standpoint it is undoubtedly somewhere between the Diesel engines and the funnel.

Variable Steam Demands.

The steam demands in some motor ships vary considerably. Take, for instance, a passenger ship, where the steam is used for heating accommodation and supplying hot water for domestic services. There may be two or three periods during the day when more steam is required than is being generated by the exhaust gas, whilst during the night more steam is recovered than can be utilized. This is a case for the "composite" boiler, which can be operated with exhaust gas or oil firing, or simultaneously.

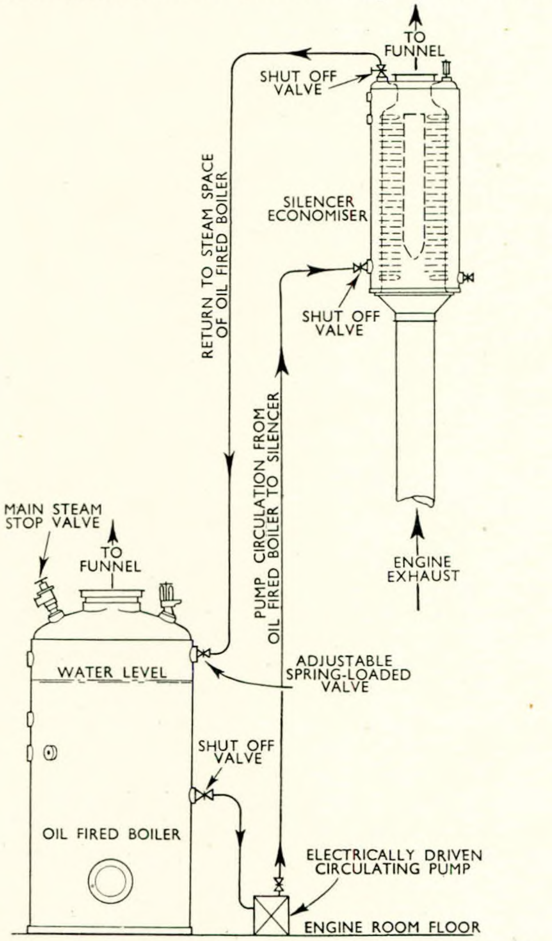
The water capacity should be large to provide thermal storage (and, incidentally, accessibility to the wetted surface). At the same time, it should be a compact vertical unit, so that it may be fitted in a corner, only requiring attention on the one side.

With a boiler of this type it has invariably been found that there is sufficient heat stored during the night, and part of the day, to carry over the peak demands without the necessity of lighting the oil burner; but if this has to be done, it is only for a short period. In fact, there are several instances where this operation is carried out automatically by the steam pressure falling, the burner remaining on until the pressure returns to normal, when it is automatically shut down.

To meet these requirements, the Clarkson Thimble Tube Boiler Co. has developed a system which has been proved on land installations and rail cars, and is now being installed in some new motor ships which are under construction in this country.

A standard Clarkson Thimble Tube oil-fired boiler is fitted on the engine-room floor, and is connected up to the steam range and with a feed pump in the usual manner. A Clarkson Thimble Tube silencer-economizer is installed between the vertical exhaust pipe and the funnel, as near to the main engine as convenient; the exhaust gases enter at the bottom of this unit and leave at the top. An illustration of the type is given below.

This economizer is connected up to the water



Diagrammatic sketch illustrating the arrangement of the new system.

of the oil-fired boiler through a special centrifugal pump, which circulates the boiler water through the economizer under moderate pressure at high velocity, returning it by means of a pipe to the steam space of the oil-fired boiler.

At this point a steam separator is fitted which returns the excess water to the boiler, liberating the steam which is taken off through the main stop valve. A non-return valve is provided between the silencer-economizer and the circulating pump, and a special spring-loaded valve between the silencer unit and the oil-fired boiler. The water level is maintained in the oil-fired boiler by means of an automatic feed water regulator.

This system has another point in its favour. When the engines are not working the circulating pump is stopped, and the exhaust gas heating surface is disconnected from the system, thereby reducing heat losses. When in port, the silencer-economizer and the pump may be inspected and overhauled without interfering with the oil-fired boiler, which is always under steam.

With this arrangement, one or several silencer-economizers may be connected up to the main oil-fired boiler, collecting heat from various sources, such as from the main engines and auxiliary engines, the latter having a particularly good load factor in some ships, both at sea and in port.

The silencer-economizer is a small standard Clarkson unit, of jointed construction having minimum water space and no steam space. Some hundreds of these units are in use as boilers and water heaters.

It should be noted that the water is all fed into the oil-fired boiler, in which it gives up its hardness and from which it can easily be removed. Very little scale can pass to the silencer-economizer, as the water is drawn from a point well above the mud space.

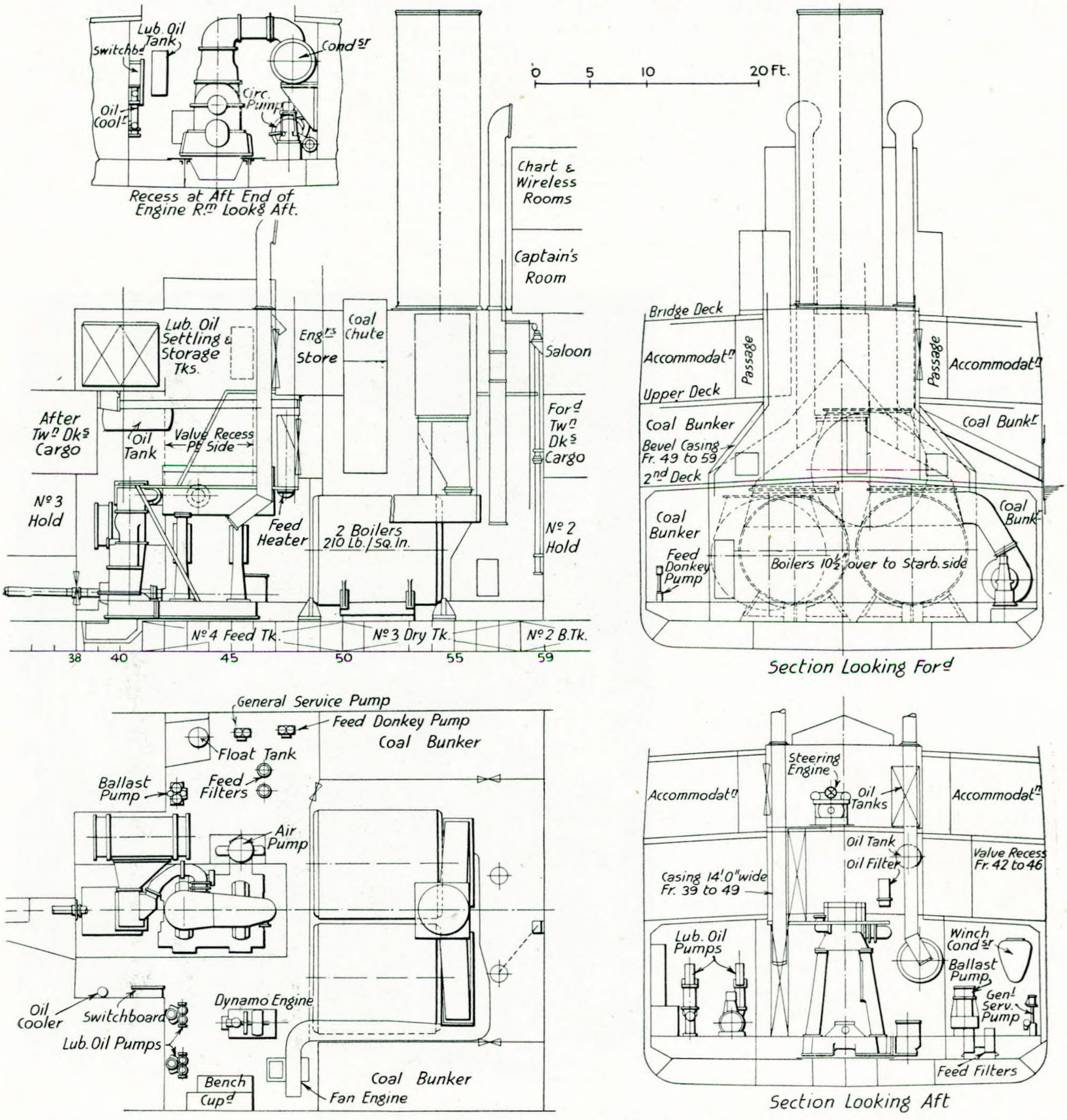
Turbo-compound Machinery of the "Puck".

"The Marine Engineer", April, 1935.

The turbo-compound engine is, as is well known, the most recent development of the Bauer-Wach exhaust turbine system. It was introduced principally for units of comparatively small power. In the more normal arrangement of the Bauer-Wach system, a three-cylinder triple-expansion engine works in conjunction with an exhaust turbine. In the turbo-compound system the triple-expansion engine is replaced by a two-cylinder compound engine, and the Bauer-Wach unit is so arranged that the turbine, first reduction gear and second reduction gear are vertically above one another. The net result is a unit of extremely small overall dimensions, this not only resulting in a great saving of space required for installation, but also a considerable reduction in first cost. The efficiency of the turbo-compound unit is very little, if any, less than that of the more usual Bauer-Wach arrangement, working under the same steam conditions, and the saving in coal which can be achieved, as compared with a straight triple-expansion engine, is about 20 per cent.

A considerable number of British and foreign-owned ships fitted with turbo-compound machinery are now in successful service, and many more are at present under construction at the Neptune Works of Swan, Hunter & Wigham Richardson, Ltd., and abroad. These will be installed in trawlers, cargo boats, oil tankers, etc. The latest example of a vessel fitted with turbo-compound machinery is the steamship "Puck", which has been built at the Neptune yard of Swan, Hunter & Wigham Richardson, Ltd., for Zegulga Polska, Gdynia. The vessel is a cargo ship of moderate size, intended for trading between Gdynia and Rotterdam.

The trials of this interesting steamship for Poland were successfully completed on March 22nd. The principal dimensions of the ship are: 243ft. length overall by 36ft. 6in. breadth, and is designed for carrying a total deadweight of about 1,450 tons. The hull and machinery have been built under the survey of Lloyd's Register of Shipping to their highest class for a complete superstructure type of ship, strengthened for navigation in ice. There is cargo-carrying capacity of about 102,000 cu. ft., and the shelter deck is specially strengthened for carrying timber cargoes. The ship is of the open shelter-



General arrangement of the machinery spaces of the turbo-compound-engined "Puck", which has been built and engined by Swan, Hunter & Wigham Richardson, Ltd.

deck type, with straight stem and cruiser stern, and is arranged with cellular double bottom all fore and aft for water ballast.

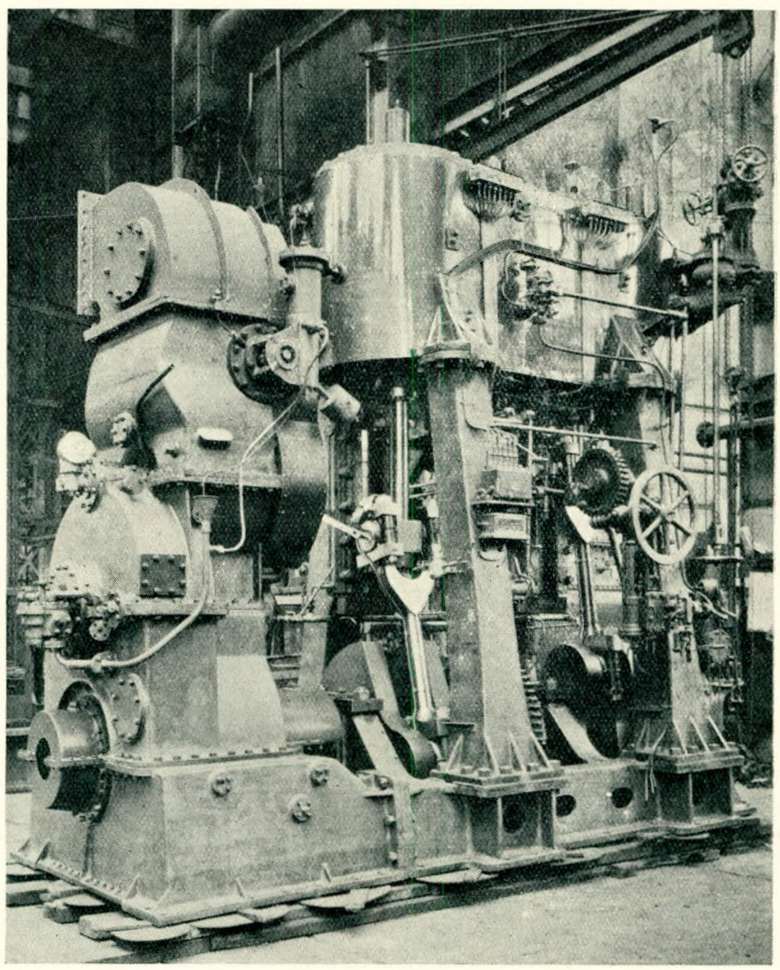
There are three holds and 'tween decks, with large hatchways served by seven derricks with seven steam-driven cargo winches by Clarke, Chapman & Co., Ltd., there is also a windlass of the horizontal direct-grip steam-and-hand-driven type, by Clarke, Chapman & Co., Ltd. The steam steering gear is of the horizontal type, by Donkin, fitted in the machinery casing, connected by rods and chains to a quadrant on the rudder head, and controlled by telemotor from the navigating bridge; the steering gear is fitted with Donkin's patent steam-saving valve. Current for electric lighting is provided by a steam-driven generating set by W. H. Allen, Sons & Co., Ltd., Bedford, consisting of a vertical engine coupled to a dynamo of the direct-current multi-polar type, having an output of 8 kW., at 110 volts.

The accommodation consists of a saloon and cabins for captain, deck and engineer officers, and petty officers. The captain's quarters, including separate sleeping and day rooms, together with the chartroom, are situated on the navigating bridge, rooms for the deck and engineer officers are arranged on the shelter deck below; seamen and firemen are berthed in separate rooms, each for two persons, on the upper deck aft. Steam heating is fitted in the saloon, chartroom, midship accommodation, and also in the crew's quarters.

Machinery.

The machinery, which is the first complete set of turbo-compound engives to be built and installed by the Tyneside firm, consists of a two-cylinder compound engine working in conjunction with an exhaust turbine on the Bauer-Wach system. The h.p. cylinder diameter is 17in., the l.p. cylinder is 34in. in diameter and the stroke is 28in. The machinery is designed to develop collectively 900 i.h.p. in service at about 105 r.p.m. of the screw, the distribution being approximately 585 i.h.p. in the compound engine and 315 equivalent i.h.p. in the exhaust turbine. The maximum output which was developed on the trial trip was about 1,050 i.h.p. Illustrations of the engine are given, together with a section through the turbine and double-reduction gearing (*see* page 72).

The design of the compound engine follows along well-established lines. The cranks are arranged at 90° and are provided with large balance weights forged integrally with the webs. The exhaust turbine unit operates in precisely the same way as in the more normal arrangement of Bauer-Wach machinery. The turbine, which in this case is provided with eight stages, runs at about 6,000 r.p.m., corresponding to 105 r.p.m. on the propeller shaft. The turbine drives the first reduction pinion, which gears with the first reduction wheel, this being mounted on the primary half of the hydraulic coupling. The secondary half of the coupling is connected to the second reduction pinion, which gears direct with the large wheel mounted on the line shafting. As in all Bauer-Wach units, the hydraulic coupling operates with lubricating oil, which is circulated to bearings, thrust block, gear teeth, coupling, etc., by means of two steam-driven pumps working on the direct-pressure system without gravity tanks. The main single-collar thrust block is incorporated in the



The neat and compact arrangement of the exhaust turbine and gearing is well shown in this view. Note the main bedplate extension for the turbine unit.

gear case, and the principal features of this unit will be clear from the examination of the section already mentioned.

Steam is supplied by two single-ended coal-fired Scotch boilers, the working pressure being 210lb. per sq. in.; the steam is superheated 200° F. in smoke-tube type superheaters. The boilers are designed to burn coal under Howden's system of forced draught, the location of the forced-draught fan being shown on the accompanying arrangement drawing.

The auxiliary machinery is very complete. The air pump, feed pump and bilge pumps are driven by levers from the main engine in the ordinary way. A large condenser of the regenerative type is installed, the designed vacuum under service conditions being about 28½in. (barometer 30in.). This is attained by means of a steam ejector working in conjunction with the air pump, which is of the normal Edwards' type. The independently-driven steam engines are supplied with steam at full boiler pressure.

The saving in coal achieved with turbo-compound machinery is not the only advantage. Due to the kinetic energy of the high-speed turbine, the tendency of the propeller to race in a heavy seaway is minimised, this resulting in a better average speed in service operation. This flywheel effect has been referred to in numerous reports which we have received from owners, chief engineers, etc., and is undoubtedly of considerable practical value. In trawlers, in which the ability to manœuvre rapidly and to maintain a steady pull on the trawl at all times is of great importance, it is found that it is possible to continue trawling under weather conditions which put all ships fitted with straight triple-expansion engines definitely out of action.

The independently-driven main circulating pump is of the centrifugal type.

A Weir feed heater is provided, and also direct-acting steam-driven forced-lubrication pumps.

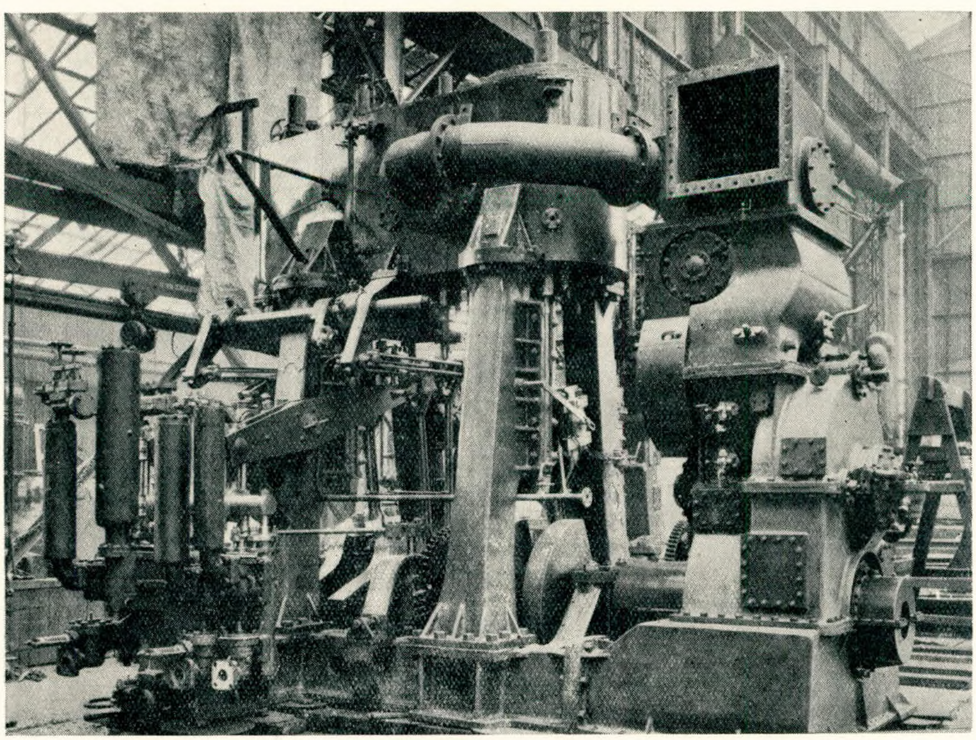
Naval Architecture (Mercantile).

By Sir Westcott S. Abell, K.B.E.
(Past-President of The Institute of Marine Engineers).

"Engineering", May 3rd, 1935.

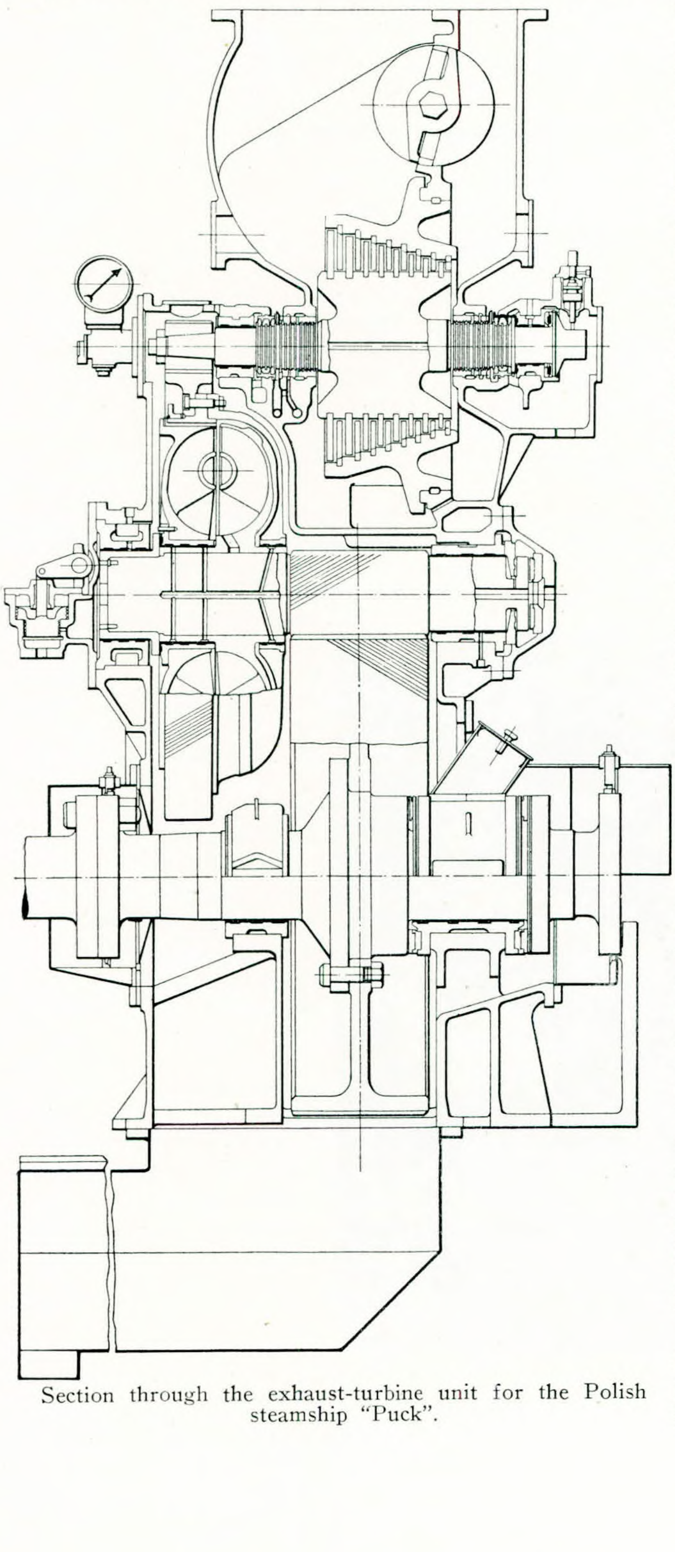
The beginning of the reign of King George V marked the close of several new developments in naval architecture and marine engineering. The Blue Ribbon of the Atlantic was wrested from the Germans when the Cunard Company launched the "Lusitania" and "Mauretania", which maintained an average speed of 26 knots across the Atlantic, burning coal in circular boilers. The reciprocating engine had reached its limit, and thus restricted the Atlantic speed to about 24½ knots; the steam turbine (first demonstrated at the Jubilee Naval Review of 1897) enabled the Atlantic record to be broken. The Parsons turbine first tried out on large merchantmen in the "Victorian" and "Virginian" of the Allan Line in 1904 and 1905, also made possible the new naval era characterised by the "Dreadnoughts" and "Invincibles". It is to be noted, however, that while the Navy used water-tube boilers, the merchant ship preferred to adhere to the Scotch circular design.

To encourage a scientific study of the resistance and propulsion of ships, the late Sir Alfred Yarrow, in 1908, gave an experimental tank to the National Physical Laboratory, and the work begun in 1911 developed to such an extent that a second and larger tank was built by the Government in 1932. Greater opportunity for research in propeller problems has been



Another view of the turbo-compound machinery of the "Puck", showing the crank integral balance weights, easy curve of the reciprocator's eduction pipe and other features.

made possible by the recent gift of Sir James Lithgow, who provided the funds for an enclosed water tunnel. It is now possible to examine experimentally the wave and friction resistance for any type of ship form, and to produce artificial waves so that a comparison may be made between both rough and smooth waters. The propulsive performance with different numbers and types of screws is reasonably determined by the use of self-propelled models, a distinct advance in experimental methods. Much work has been done in comparing the performances of the actual ships with the model experiments, so that the necessary allowances in proceeding to the full-size ship may be brought within as narrow limits as possible.



Section through the exhaust-turbine unit for the Polish steamship "Puck".

Ships for carrying bulk cargoes were built before the commencement of the century, and by 1910 two important developments had obtained a measurable degree of success: they were the oil tanker and the refrigerated meat ship. Both these types have increased greatly in the last quarter of a century.

It may be said that with oil ships built on the transverse system of construction, structural difficulties were considerable, and it is largely due to the introduction in 1908, by Sir Joseph Isherwood, of the longitudinal system of framing that much of the subsequent success in this type of vessel has been due. The longitudinal system itself like many other ideas was not new, but it fell to Isherwood to devise a proper balance between longitudinal and transverse requirements, which at the same time provided saving of weight and economy in the cost of erection of structure. The growth of oil-tanker tonnage was slow previous to the War, but it was encouraged by the adoption of oil fuel for naval vessels, the first so fired being only just ready for use in 1914. Progress in the general use of oil since the Armistice has been rapid, for in the last sixteen years the world's tonnage of these vessels has been more than trebled, increasing from 3 million tons in 1918 to about 9 million tons at the present time. This new construction has helped to keep the shipbuilding industry going during the severe depression, which has lasted from about the end of 1921 and which only now shows signs of alleviation.

Throughout the period the rules of the Classification Societies have been amended, firstly, in 1921-22, when Lloyd's Register of Shipping brought out their new rules for the construction of steel vessels. These rules, which embodied the experience of the War and the previous twelve years, simplified the application of the structural requirements for all sizes of merchant ships, and further allowed the scantlings to be adjusted both in terms of the weight of cargo carried and of the volume occupied. These rules were supplemented in 1925 by special regulations for the construction of oil tankers built on the longitudinal system. Throughout, endeavours were made as far as possible to indicate the minimum structural requirements, having due regard to the necessities of service, and as far as can be judged the subsequent ten years which have elapsed have indicated their general sufficiency.

Certain developments have taken place in structural material with a special quality mild steel, the principal mechanical improvement being a definite guarantee of a limit of proportionality, the material remaining elastic up to a specified load. Its use has been proved in a number of vessels, the higher limit of elasticity making permissible a certain reduction in the thicknesses of material subject mainly to tension. As it has only been produced in small quantities, its cost has been relatively high, but probably with increased demand, such or similar material may become the shipbuilding steel of the future. In 1917, a wide series of experiments were carried out by the writer, in his capacity of Chief Ship Surveyor of Lloyd's Register. These experiments indicated the satisfactory character of the electric welding process which at the time was being advocated by the Quasi Arc Company, and as a result, Messrs. Cammell Laird & Company built a coasting motor vessel, the "Fullagar", 150ft. in length, which still remains in service, the welding throughout having given excellent results, while there is not a single rivet in the ship. From that time the use of welding has continuously increased, and it is now recognised as a reliable process which, with proper care in construction, may result in appreciable saving of weight of structure.

The loss of the "Titanic", in 1912, called attention to the regulations for safety at sea, including therein the subdivision of passenger ships, load lines of cargo vessels and the life-saving appliances to be provided. Examinations and discussions of these problems lasted for some sixteen or seventeen years, finally culminating in the signing of two Conventions in London, the first, of 1929, dealing particularly with passenger vessels, which was known as "Safety of Life at Sea". The second was the Load-line Convention of 1930, in which the maritime nations practically all agreed on the load-lines which should be required for cargo vessels, a unique achievement, in that a very complicated problem was brought to a solution acceptable to all. War experience tested severely the appliances for saving life from vessels in distress, and indicated many improvements which were embodied in the Safety of Life at Sea Convention.

Of late, increasing study has been devoted to the resistance of the slower-speed vessels, more particularly of the tramp type. The tendency is to an increase of speed; for this type of steamer it is probable that speeds will be raised, perhaps to 12 or even 14 knots, seeing that for the longer voyages now required in Empire Trade there is as much gross profit on the faster ship, although the initial cost is obviously higher. The naval architect has done much to reduce the resistance of these slow-speed ships, but the efficiency of the machinery for the low powers required, say, of 1,500 i.h.p., still calls for improvement. The good performance of Diesel ships has caused much study to be given to the better utilisation of coal as fuel. The automatic stoker has been and is being tried out increasingly, and although its use is at present confined to water-tube boilers, there is no doubt that a very high efficiency is obtained. With a more general improvement in the burning of coal, especially for low-power ships, a stage is being reached at which the coal-fired ship is at least as economical as the oil engine. Many improvements have been tried since the war, some with success, and of these increased superheat with reciprocating engines becomes more and more general and offers a distinct gain at moderate cost.

Shipbuilding developments in the past twenty-five years have been few as compared with the first decade of the century. Larger ships have been built. The "Queen Mary", over 1,000ft. long and capable of a service speed of 30 knots, indicates that so far as size and speed are concerned technical achievement has not, as yet, been limited by the skill and material available. The future will show whether the changed circumstances of the travelling public will justify the large capital cost.

The New P. & O. Liner "Strathmore".

"The Engineer", 12th April, 1935.

One of the year's noteworthy ships is the twin-screw turbine-driven passenger liner "Strathmore", which is being constructed by Vickers-Armstrongs, Ltd., at Barrow-in-Furness, for the P. & O. Company's express service between the United Kingdom and Bombay. This fine ship was safely launched on Thursday last, April 4th, the naming ceremony being appropriately performed by Her Royal Highness the Duchess of York. The liner will, it is expected, enter her owners' service in the early autumn of the present year. The "Strathmore" is the largest ship laid down for the Peninsular and Oriental Steam Navigation Company, and she will be the largest and fastest vessel yet built for the Europe-India service.

Hull Design.

In the table given below we reproduce the principal hull dimensions and give some particulars of the passenger accommodation provided, and the propelling machinery. The ship has eight decks, alphabetically designated "A" to "H", including the promenade decks, all of which are intended for the use of passengers. The hull is sub-divided into twelve transverse water-tight compartments up to the level of "F" deck. It has a continuous double bottom from the collision bulkhead to the after end of the shaft tunnels, and is divided transversely and longitudinally to provide a large number of tanks for fresh water, boiler feed water, water ballast, and oil fuel.

Hull Particulars.	
Length between perpendiculars ...	630ft.
Length overall	665ft.
Breadth moulded	82ft.
Breadth overall	84ft.
Depth moulded to "F" deck... ...	38ft.
Depth moulded to "E" deck... ...	47ft. 6in.
Gross tonnage	24,000
Designed service speed	About 22 knots
Passenger Accommodation.	
First-class passengers	445
Tourist class passengers	665
Officers and crew	510

Propelling Machinery.

Type: Parsons twin-screw single-reduction geared turbines	
Designed output	24,000 s.h.p.
Astern power	Approx. 16,800 s.h.p.
Turbine speed	1,715 r.p.m.
Propeller speed	112 r.p.m.
Type of condenser	Weir regenerative
Total surface	25,000 sq. ft.
Working vacuum: 28in. at 30in. bar, and 86° F. sea temperature	
Type of boiler: Oil-fired Babcock and Wilcox water-tube	
Number of large boilers	Four
Number of small boilers	Two
Working pressure	440lb./sq. in.
Total superheated steam temperature	725° F.

Auxiliary Power and Lighting Sets.

Three B.T.H. 500 to 500 kW., 220-volt turbo-generators.

Further, the vessel, from the forward cross oil fuel bunker to the after end of the engine-room, is protected by a complete double skin up to the water line, thus providing a maximum margin for safety at sea.

Some Safety Precautions.

A full complement of lifeboats, including two motor boats, equipped with patented "skate" launching gear, and davits of the latest type, is carried on "A" deck. The boats are designed to accommodate the whole ship's company should necessity arise, and to provide the usual service of craft for the conveyance of passengers between the ship and the shore when she goes on cruises.

For the safety of the vessel in case of fire the Lux-Rich system of smoke detection and alarm has been adopted, together with a complete installation of Mather and Platt sprinklers, arranged so that a fire in any part of the vessel so protected shall be subdued automatically. For additional safety the whole of the woodwork in the passenger accommodation and crew's quarters is covered with fire-resisting paint, while fireproof doors are fitted in all the main alleyways. Air conditioning plant has been installed in the first-class dining saloon. Besides this, the Thermotank mechanical system of ventilation is to be fitted in all public rooms and in the accommodation of both passengers and crew.

Cargo Arrangements.

Insulated cargo will be carried in Nos. 1, 2 and 3 holds and in the 'tween decks forward, and Nos. 4, 5, 6 lower holds aft will be used for the stowage of general cargo, with provision for the carrying of passengers' motor cars. The cargo will be worked by means of derricks served by 3-ton and 5-ton winches distributed throughout the vessel, while in addition four 10-ton derricks are provided. The arrangements are of the latest and most efficient type for the rapid handling of cargo.

Propelling Machinery.

The vessel is to be propelled by twin screws, driven by two sets of Parsons turbines, through single-reduction gearing, each set comprising one high-pressure, one intermediate-pressure, and one low-pressure turbine, working in series and driving separate pinions engaging with the main gear wheel. We saw the machinery in course of construction in the works.

The high-pressure turbine is of the impulse reaction type, the first stage consisting of an impulse wheel with two rows of blades, and the remainder of this turbine comprises six stages of reaction blading mounted on a hollow drum of forged steel. The intermediate-pressure turbine is of the reaction type, having seven stages of blades mounted on a hollow forged steel drum; while the low-pressure turbine is of the single-flow type, with sixteen rows of reaction blading mounted on forged steel disc wheels. The astern turbines consist of one high-pressure and one low-pressure turbine, working in series, the h.p. astern turbine comprising one impulse three-row wheel, being incorporated in the intermediate cylinder. The low-pressure astern turbine is incorporated in the l.p. casing and consists of one two-stage impulse wheel, followed by five stages of reaction blading. We noted that the rotor shafts of all the turbines are packed with both labyrinth and carbon packing, and that "Michell" type pivoted adjusting blocks are fitted to the turbines.

The turbines are connected by flexible couplings to nickel steel pinions, which engage with the main wheels on the propeller shafts. Double helical single-reduction gearing with Vickers-Bostock-Bramley patented "enveloping" gear teeth is used, the gear wheels consisting of cast iron centres with forged steel rims shrunk on and securely fastened to the gear wheel shaft. Central bearings are not fitted to the pinion shafts. The shaft bearings for both the turbines and the gearing are supplied with forced lubrication, and the thrust blocks, which are of "Michell" type, are placed on the shafts close up to the gearing. Propellers of the built-up type are employed, each having four blades of manganese bronze, which are secured to the cast steel bosses by mild steel studs and gun-metal cap nuts. A cast iron cone is fitted over the propeller nut. Electrically operated turning gear is provided for the turbines and shafting.

Boilers.

The steam generating installation consists of Babcock and Wilcox high-pressure type boilers, four large and two small, fitted with superheaters and tubular air heaters. The working pressure at the boilers is 440lb. per square inch, superheated to 725° Fah. The total generating surface of the four large boilers is 29,860 square feet with a total superheating surface of 7,440 square feet, the total generating surface of the two small boilers being 7,170 square feet, with a total superheater surface of 2,140 square feet, while the air heating surfaces for the large and small boilers are 32,000 square feet and 8,000 square feet respectively.

All the boilers are arranged to burn oil only, under the forced draught closed air duct system with open stokeholds. Air is supplied to the boilers by five Howden double inlet electrically driven fans.

Naval Engineering.

By Engineer Vice-Admiral Sir Harold A. Brown, K.C.B.
(Member of The Institute of Marine Engineers).

"Engineering", May 3rd, 1935.

In few branches of engineering does obsolescence exact its toll more speedily or rigorously than in naval engineering material, and it is not, therefore, a matter of surprise to find that no fighting vessel figuring in the Navy List of 1910 appears in the lists of 1935. It is, however, of interest to record that there is one survivor, in the shape of H.M. Yacht "Victoria and Albert", to afford the present generation, accustomed to oil fuel and geared turbines, a glimpse of past engineering achievement, as exemplified in the coal-fired Belleville boilers and reciprocating steam engines, which still continue to do duty in this vessel.

At the beginning of the period under review, although designs with reciprocating steam engines and coal-fired boilers predominated, the capital ship, based upon the all big-gun prototype, H.M.S. "Dreadnought", fitted with direct-driven turbines and coal-fired water-tube boilers with supplementary oil firing, and the oil-fired Tribal torpedo-boat destroyers, constituted the greater part of the First Division of the Home Fleet, where their performance left little doubt as to the marine-engineering types of the future. The submarines of the time were propelled by petrol engines, and the compression-ignition engine as a means of propulsion was represented by but one example, the Vickers design in submarine A.13, somewhat immature in detail but important since it provided the basis for the early development of the D class of submarine, which were all equipped in this way.

The s.s. "Vespasian", fitted with mechanical reduction gearing by Sir Charles Parsons during 1909, had proved the practicability and the advantage of this method of providing a satisfactory compromise between the fast-running turbines and the slow-running propeller, the data being quickly applied to naval installations, first in a partly-geared design in 1911, followed in the next year by a completely-geared design for the torpedo-boat destroyers "Leonidas" and "Lucifer", which yielded, by comparison with their directly-driven sister ships, a gain in propulsive efficiency of some 20 per cent. and a marked improvement in economy of fuel throughout the whole range. This change, destined to spread to the propelling machinery of all surface war vessels, was the outstanding event of the immediate pre-war period. Coupled with this was the adoption of the single-collar Michell thrust block, the theoretical principles of which were first enunciated by Osborne Reynolds in 1886 and which facilitated, if it did not alone render possible, the high-powered propelling units later used in the world's navies and mercantile vessels.

As regards fuel, the successive classes of torpedo-boat destroyers following the Tribals continued to be oil-fired, excepting the "Beagle" class, in which, owing to the oil fuel supply situation, a temporary reversion to coal was made. The "Beagles" and their predecessors, the "Acorn" class, afford a striking comparison of the influence of "liquid" fuel on the design of war vessels, since, with a superior armament, the "Acorns" required 20 per cent. less displacement, cost 16 per cent. less, and attained, on average, a higher speed to the extent of $1\frac{1}{2}$ knots.

The development of machinery designs was necessarily somewhat checked by war conditions but, nevertheless, the intensive experience obtained during the War influenced design and hastened the application of some of the relatively untried innovations, notably the all-geared turbine, the use of which was extended, in turn, to most of the torpedo-boat destroyers constructed from 1916, to all cruisers and finally to the battle-cruisers of the "Hood" class. The use of oil fuel was similarly extended to all classes of vessel, including the battle-cruisers "Renown" and "Repulse", of 112,000 shaft horse-power, the highest powered vessels afloat durir g the War period, and to the "Hood", of 144,000 shaft horse-power, which came on service just after the War. The exclusive use of oil fuel and satisfactory war experience in the torpedo-boat destroyers permitted in H.M.S. "Hood" the use of the small tube water-tube boiler, and thus, by reason of the reduced weight and space demands for machinery, led to ship speeds otherwise unattainable, except by sacrificing fighting or defensive qualities. In particular torpedo-boat destroyers reached 40 knots, a speed which incidentally was exceeded in the coastal motor-boats, a special development of the war period, provided with fast-running petrol engines developing up to 750 brake horse-power. A particularly noteworthy design of the War period was the K-class submarine, of 10,000 shaft horse-power, which continued a pre-war effort to produce a much faster vessel than was possible with the oil engines then available.

Since the War, the advantage for naval purposes has, as in the case of high-speed liners, contiued to rest with steam-driven designs for surface warships, with mechanical reduction gear, as distinct from the electrical transmission which has found favour elsewhere; and the use of higher steam pressures and temperature, in association with means of conserving heat and improving combustion, has continued to improve performance. The use of higher-quality material and higher running speeds has led to lesser demands for machinery weight and space and, coupled with improved design, to an ever-advancing standard of reliability and durability. A noteworthy feature of modern design imposed by the need for economy in weight, space and personnel is the increased output of the individual boilers, which now reach to an output of 20,000 shaft horse-power, a result facilitated by the advances in design of accessories, notably the safety valve, whose limitations in its earlier form threatened a halt on further advance in boiler size.

The auxiliaries and accessories have changed in type more rapidly even than the main units, with a view to securing lesser attention in operation and maintenance; rotary auxiliaries have almost entirely replaced the reciprocating type, and for the first time during the century of steam in the Navy a large design is afloat without a single crankshaft in the installation. In parallel with these changes in type of auxiliary and actuated by the same motives, the feed and other systems have been developed to attain an ever-increasing degree of automatic action. The mention of reliability and durability brings to mind especially the great improvement in condensers made possible by the development of copper-nickel tubes, and we have sufficient experience to say with confidence that this weakness of War and pre-war design is in course of elimination.

The advances in the compression-ignition engines necessarily employed in submarines are striking in so far as the power per cylinder has advanced from 100 in the war-time vessels to 500 in the Fleet submarine Thames, this progress having been made possible by the application of the patient and continuous research work carried out at the Admiralty Engineering Laboratory since its inception in 1917.

Apart from the particular problems attending the development of the heavy-oil engine itself, the dynamic problem involved by the submarine machinery lay-out is a matter of some complexity which has required close attention in the design stage in order to avoid serious difficulties from torsional vibration.

The advancing standards of living, and the increased complexity of fighting appliances and accessories, tend more and more to require the use of a machine in one form or other, and in this connection the re-introduction of that ancient device, the catapult, to launch the aircraft now carried in all large cruisers and capital ships, is of special interest.

It is not possible within the compass of a short article to touch upon more than the high spots, so to speak, of progress, but enough has been said perhaps to show that engineering material and fuels have continued to be used to better and better advantage, while concurrently therewith the demand for man-power has steadily lessened, and to indicate in a general way how engineering progress has been utilised to the growing advantage of H.M. Service. These advances might in conclusion be summarised, in so far as they can be illustrated in statistical form, by the following comparison between a cruiser of 1935 and its predecessor of 1910:—Fuel demands as expressed in B.Th.U. required per shaft horse-power has been reduced by 40 per cent.; machinery weight per shaft horse-power reduced by 60 per cent.; machinery space per shaft horse-power by 60 per cent.; and engine-room complement per shaft horse-power reduced by 75 per cent.

Engineering in Scotland.

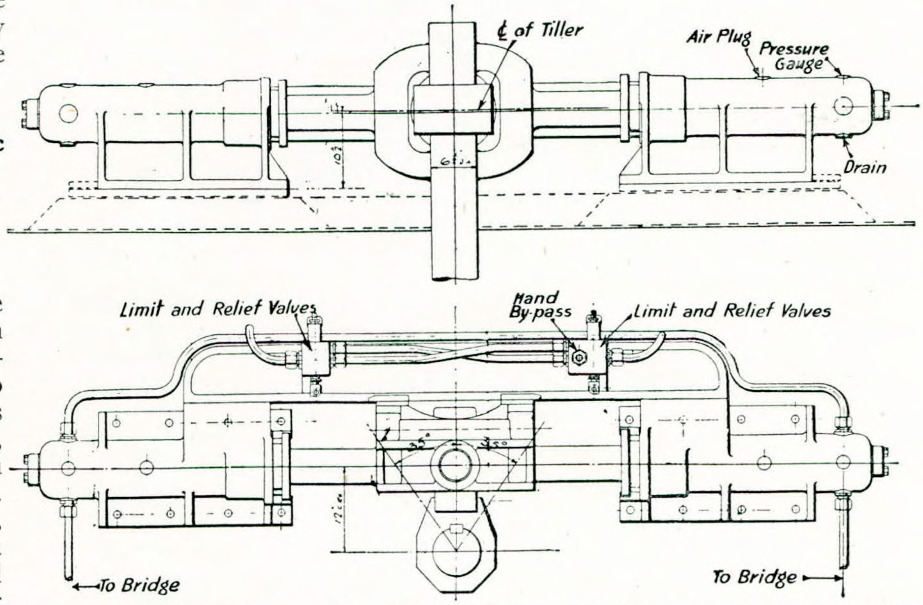
"The Engineer", 17th May, 1935.

With the Spring issue of its official journal, the Scottish National Development Council starts a series of special Areas Supplements, the first of which deals with the engineering trades. In the section discussing progress in iron and steel, it is stated that co-ordination of production and centralisation of control have been noteworthy developments in Scotland during the past few years. Steel-making especially has seen a definite unification, while various inter-branch agreements have been arrived at throughout the industry as a whole. In the realm of pig iron, while no amalgamations of outstanding importance have been effected, a much closer basis of working has been reached, especially as regards the buying of ore and similar material. The position of other branches of the industry—shipbuilding, marine engineering, boiler-making, locomotive building, and structural work—is also briefly considered, and the supplement concludes with a survey of the development prospects. The principal point made in this section is the "unique advantages" as a munition centre possessed by the Glasgow district in the distance it is situated from the Continent of Europe. The much-talked-of "drift South" of industry can, it is thought, be overdone. "Convenient geographical location of industry", it is pointed out, "is a factor of the utmost significance for the British Empire, and in the past this question of location has received something less than the attention it deserved. The Committee of Imperial Defence will one day take more than a mild interest in the geographical position of engineering industries". The possibilities of a great development of aerial warfare is, the review continues, a fact which cannot be ignored, and it is therefore of the first importance that a large amount of the engineering industries of this country should be kept as far as possible from the Continent. The district around Glasgow and the West of Scotland, being the only great heavy industrial area in this country which is more than 400 miles from the nearest Continental port, offers, it is maintained, advantages which in this respect are unequalled.

A Lubrication Item.

"The Engineer", 17th May, 1935.

Dealing with the influence of colloidal graphite on bearing surfaces in a recent paper before the North of England Institute of Mining and Mechanical Engineers, Mr. H. Shaw said that during some tests at the N.P.L., when the oil supply to a shaft running with a plain oil was cut off, the bearing only ran for about 45 min. before seizure showed signs of taking place, whereas a similar bearing previously run with a colloidal graphited oil ran for some 26 hours after the oil supply had been cut off before seizure seemed imminent.



Elevation and plan of opposed hydraulic cylinders and the crosshead on the rudder head of the new hydraulic electrical steering gear, showing pipe connections to bridge.

New Hydraulic Electric Steering Gear.

Special Development for Small Craft.

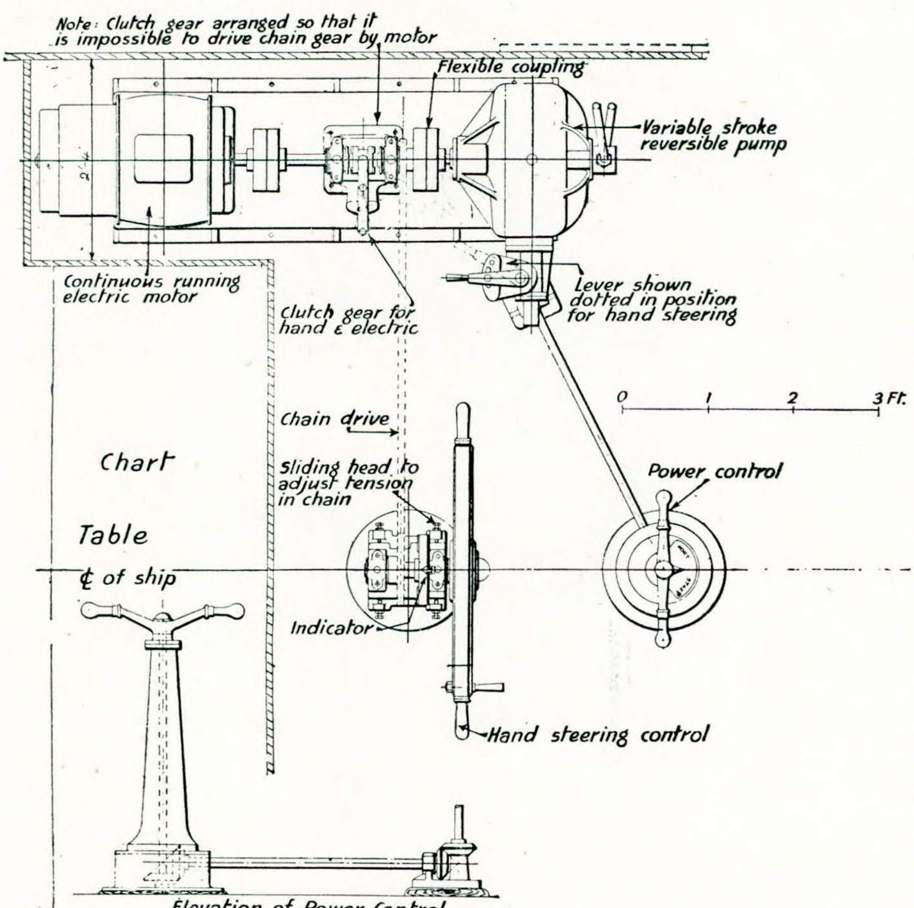
"Journal of Commerce", 23rd May, 1935.

In order to reduce the steam consumption of steam engines employed for steering, and at the same time to eliminate the use of chains or rods to control the rudder, much research has been carried out in recent years.

Messrs. Donkin & Co., Ltd., have now developed a new type of combined hand and power-driven steering gear. This gear has primarily been evolved for use when steering is effected by hand in the open sea and by power for harbour and docking work when frequent movements of the rudder are necessary.

This new gear, when operated by hand, is hydraulic, and when worked by power the hydraulic pump is driven electrically. On the bridge, there is a reversible variable stroke pump which, by means of a clutch, can be driven by the continuously running electric motor or directly from the steering wheel as shown in the accompanying drawing. When power steering is used, the pump is connected to the electric motor by the clutch, and the mechanism of its stroke adjusted to give free movement in each direction from the no-stroke position.

The mechanism of the pump is then controlled from a horizontal lever on a pedestal, and is spring-loaded in such a way that the spring forces the pump to a no-stroke position when it is not otherwise being



Plan of arrangement of motor-driven reversible pump unit and steering pillar control as fitted in the steering position of the new Donkin steering gear.

moved by hand. The motor drives the pump continuously, and when it is wished to displace the rudder the control lever is moved, putting stroke on the pump in the desired direction.

A rudder indicator driven from the rudder head is placed on the bridge, and when the helmsman sees it move to the position which he wishes the rudder to take up he releases the lever, which springs back to the no-stroke position. The rudder retains this position until another movement of the control lever is made.

To avoid damage due to driving from hard-over and maintaining stroke on the pump in this position, a mechanically-operated limiting valve is fitted which, when operated in the hard-over position, allows the pump to by-pass freely so long as the stroke mechanism is held over.

Immediately the lever is reversed, thus reversing the stroke mechanism and direction of pumping, the rudder is moved over from the hard-over position, thereby allowing the limiting valve to come on to its seat again.

When steering by hand, a lever on the pump is moved over and pinned to a full-stroke position, so that when the hand-wheel is rotated it drives the pump, and the direction of rotation of the handwheel determines which side of the pump is delivery and which suction.

An important feature of this new gear is that the only connection between the bridge and the rudder head is by two small pipes which eliminate the chains and fairleads which are associated with bridge steering control. These two pipes are connected to two horizontally-opposed hydraulic cylinders, between which is fitted a type of Rapson slide, as shown in second drawing reproduced herewith. The crosshead on the slide controls the rudder head so that the rotation of the handwheel on the bridge pumps oil from one cylinder into the other and moves the rudder head and the rudder in the process.

There are several points in the operation of this gear which are worthy of note. It is silent in operation, and owing to the rudder being continuously held by fluid friction instead of mechanical chains and spring mechanisms, the wear and tear in heavy weather is not so great.

It is also of interest to note that this new type of steering gear is to be fitted in the "Moira", the all-welded ship for Norwegian owners now under construction at Messrs. Swan, Hunter & Wigham Richardson's yard.

There are alternative arrangements of this steering gear. The power unit, for example, can be placed in the engine-room or, if desired, in a special steering compartment. When the gear is used for small craft a special feature is the simple change-over from hand to power or vice-versa. The movement of a change-over cock is the only operation, and is practically instantaneous.

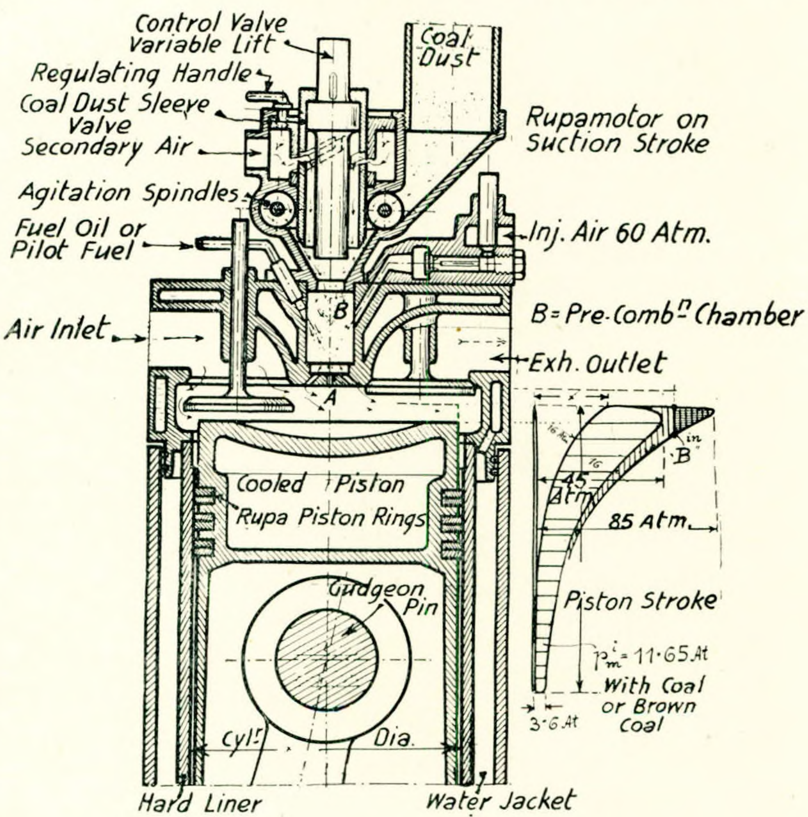
Rupa Coal-dust Engine Performance.

By W. Hamilton Martin, M.I.N.A., M.I.Mar.E., V.D.I.

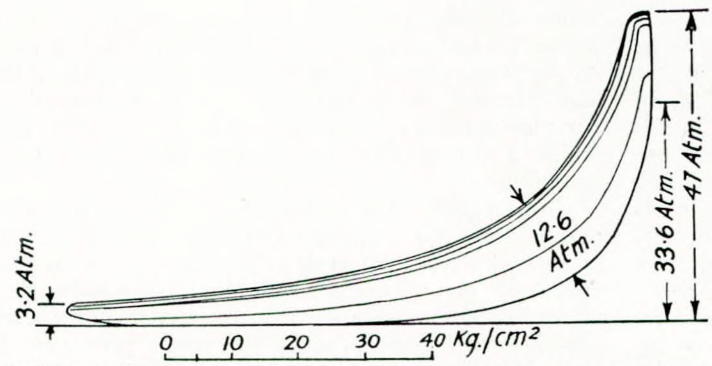
Interest Performance Figures Revealing most Encouraging Results, are Given.

"Gas and Oil Power", May, 1935.

Some statements appeared recently in a certain journal in regard to the fuel and lubricating oil consumptions of the Rupa coal-dust engine which may have created an erroneous impression I would like to take this opportunity to correct. Reference was made to the No. 7 Rupa engine, tested at a Rupa engine licensee's works on the Continent, of which I gave a photograph as well as a chart showing the consumption and mechanical efficiency at various outputs. This engine is a single-cylinder



Section through cylinder of a typical Rupa coal-dust engine showing fuel injection arrangements, special piston rings, and other features. A typical indicator diagram for the pre-combustion chamber (*b*) and the main cylinder (*a*) is shown alongside.



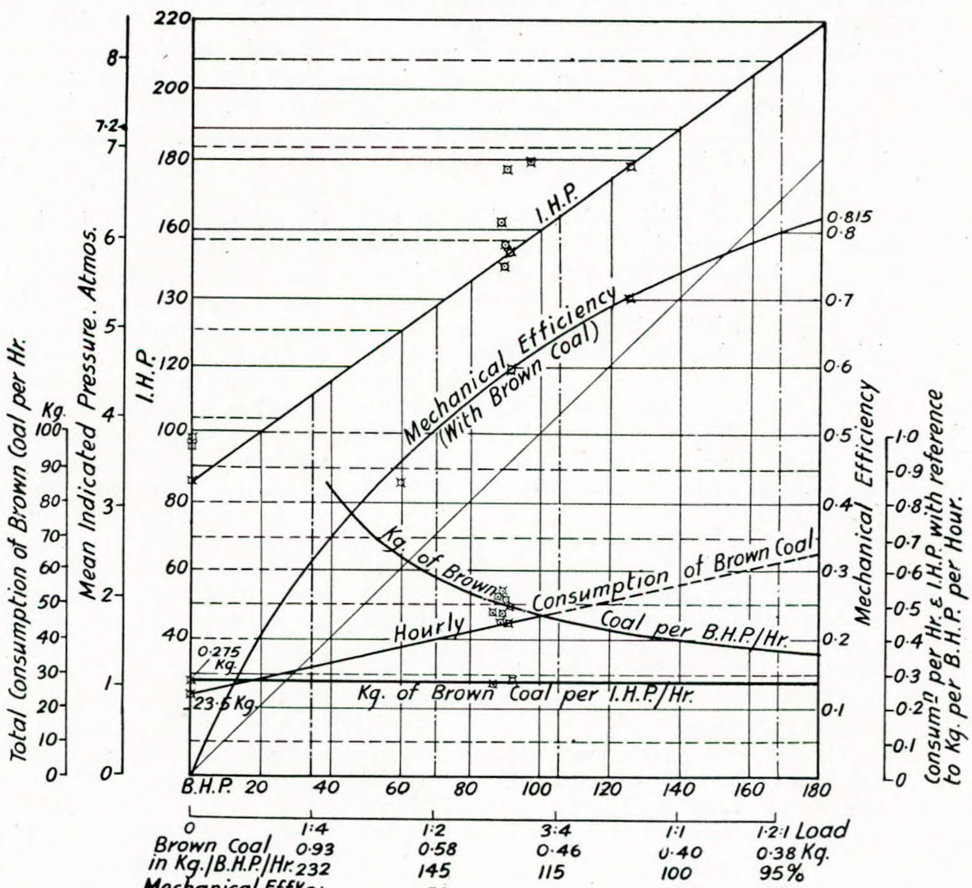
Indicator diagram for a 150 b.h.p. three-cylinder Rupa engine running on Northumberland coal The mean indicated pressure is about 163lb. per sq. in.

vertical four-stroke cycle type of 500mm. bore and 720mm. stroke and 140 b.h.p.

In the article to which I have referred the average coal-dust consumption was said to have been 0·91lb. per b.h.p. per hour, the best figure being 0·86lb. per b.h.p. per hour, while the piston-lubricating oil consumption was stated to be 6gr. per b.h.p. per hour.

The correct fuel consumption figures for this engine were published by Mr. Pawlikowski in "The Internal Combustion Engineer" for January, 1934. It will be seen from the accompanying chart that the fuel used was brown coal, of only 5,000 calories per kg. per hour lower calorific value, and not coal, as referred to in the above-mentioned article. Mr. Pawlikowski has found, during his eighteen years' investigation, that the Rupa engine always consumes approximately the same calories per b.h.p. per hour for various solid fuels. The pre-combustion chamber of the Rupa engine consumes practically the same heat value of fuel per i.h.p. per hour for all loads, namely 0·275kg. (0·608lb.), or 1,375 calories, in the 140 b.h.p. size, corresponding to $\frac{632}{1,375} = 4{\cdot}61$ per cent. indicated thermal efficiency, a figure which compares very favourably with the large double-acting A.E.G.-Hesselman Diesel engine, which consumed 135 to 138gr. of fuel oil per i.h.p.-hour (heating value 10,000 calories per kg.), corresponding to 1,350 to 1,380 calories. The consumption of British coal of, say, 7,310 calories per kg. lower calorific value and 2·4 per cent. ash content, as used in certain tests with the Rupa engine, may hence be taken to be equal to $\frac{5,000}{7,310} \times 0{\cdot}91$ to 0·86lb. per b.h.p. per hour, or 0·68 to 0·59lb. per b.h.p. per hour.

In "Gas and Oil Power" for May, 1934, the writer contributed an article entitled, "Cost Comparison Between Steam, Diesel and Rupa Power", which plainly showed the superiority of the Rupa engine to produce power at low cost. No future improvement in Diesel engines can be foreseen which would enable it to equal the Rupa engine in flexibility of fuel choice and low cost of producing power. It should, moreover, be borne in mind that the Rupa engine is to-day only at that



Test results obtained with the Rupa No. 7 140 b.h.p. at 165 r.p.m. single-cylinder experimental coal-dust engine.

stage of development where the Diesel engine was, say, thirty years ago, and should reasonably, be capable of further material improvement. As to the fuel required, British coals containing from 2-3 per cent. ash are quite suitable for use in the Rupa engine. Piston lubricating oil does not thicken so much as with brown coal containing 5-10 per cent. of ash, or even mid-German coals with their paraffin wax and high monton contents, which are apt to distil out. When operating with British 2-3 per cent. ash coal on the ordinary four-stroke cycle principle (i.e., non-supercharged), the Rupa engine attains mean indicated pressures up to 183lb. per sq. in. at maximum loading. Similarly, with German brown coal m.i.p. figures up to 179lb. per sq. in. are obtained; and with flour made from Indian rice husks up to 161lb. per sq. in. is possible, and with fuel oil up to 144lb. per sq. in. is obtained.

All kinds of coal and fuel mixtures have been brought to perfect ignition, and have been sufficiently quickly consumed to be found usable, even including Italian lignites containing about 30 per cent. ash. Flame effects, behaviour of mineral substances, fusion temperature, exhaust and power cards, etc., have been thoroughly analysed and recorded. Ignition temperatures, ignitability, effect of moisture, balling, air pressure, temperature and compression or air for combustion, excess air, injection air pressure, coal fineness, blending, quality, ash content, etc., have all been exhaustively investigated. Indicator diagrams obtained with many fuels appeared in "The Internal Combustion Engineer" for January, 1934.

In the article to which reference has already been made the consumption of piston lubricating oil was said to have been 6gr. per b.h.p. per hour, although capable of reduction by the employment of a centrifugal purifier. This also needs correction. The lubricating oil consumption actually obtained during prolonged tests of the 140 b.h.p. engine worked out at 1·53gr. per b.h.p. per hour. Surplus oil was collected by a lead-off from the lower end of the liner, and this oil can be filtered and re-used along with a certain amount of fresh make-up lubricant.

When operating on brown coal with 8 per cent. ash content, cylinder liners of special material and design give a life of about 4,000 hours, after which they still show reasonable piston-tightness. It may be assumed, therefore, that with British coals containing from 1½ to 2½ per cent. ash, a life from 12,000 to 16,000 hours can be expected from liners of good quality material.

The cleaner the coal, the less degree of pulverisation will probably be required. This point seems well worth close investigation, so as to define the maximum particle size to produce good combustion. As smaller particles are bound to act as igniters for the coarser ones, the writer is of the opinion that good economy should be possible by blending coals of varying fineness and quality. Rates of combustion, flame propagation, ignition temperatures, moisture content, balling and hygroscopic tendencies, fusion temperatures, ignitability, and their effects, should all be given further study for any particular range of fuels or fuel mixtures which a prospective Rupa engine user may have available.

In practice, the extra outlay on Rupa liners and piston ring renewals becomes insignificant in comparison with the saving obtained in the cost of fuel over the oil engine, and does not appreciably affect this engine's superiority over steam or Diesel power, which will become the more pronounced, once de-ashing below 1 per cent. to total ash content becomes a commercial proposition. Incidentally, several de-ashing methods are already available.

The No. 1 Rupa engine which has been subjected to extensive heavy testing since 1916, and has run some 10,000 hours on almost every kind of coal, good or bad, still has its original liner and piston. The upper part of the liner has worn out from 420mm. to 427·5mm., while the piston has worn down 3mm. Notwithstanding this excessive total maximum play of 10·5mm. between liner and piston, equivalent to 2½ per cent. of the bore, this engine still holds 485lb. per sq. in. compression pressure, and will drive its maker's shop reliably. An indicator diagram from this engine, using picked Northumberland low ash bituminous coal and showing a very high mean indicated pressure, is herewith.

Production Stage Approaching.

It will thus be appreciated that the stationary type Rupa engine has been thoroughly tested out during many years in the inventor's works, and it is now ready to go into production. Tests are also proceeding to apply it to other fields, such as marine and traction work. Although removal of the mineral substances from coal would seem highly desirable, it does appear that further cleaning of good British low-ash coals is not so necessary as would at first appear to be the case.

The Rupa engine exhaust shows no unburnt particles or traces of tar and appears as a light grey cloud free from any signs of lubricating oil-vapour, while the very fine, dry dust particles become invisible about 10ft. from the outlet through dispersion into the atmosphere. Combustion is complete and regular, and one cannot help but feel impressed by the very real possibilities this engine holds out. Pistons and liners, when inspected, show a glossy, clean surface.

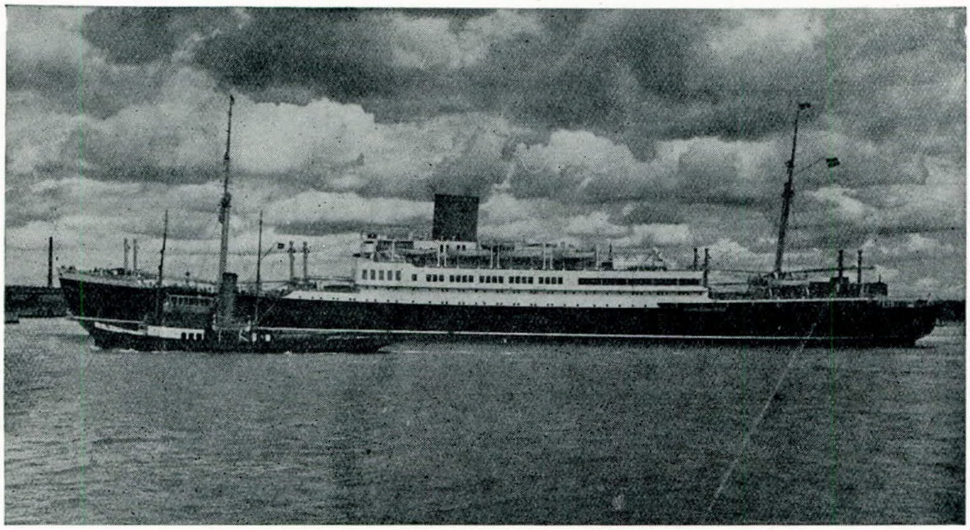
The engine is past its laboratory stage and teething troubles, and now only needs a first-class engineering firm to build it and finance its final commercial development.

N. D. L. Turbo-electric Liner "Scharnhorst".

The First of a Notable Trio of German-built Passenger Steamships for the Far Eastern Service has just entered Service.

"The Marine Engineer", June, 1935.

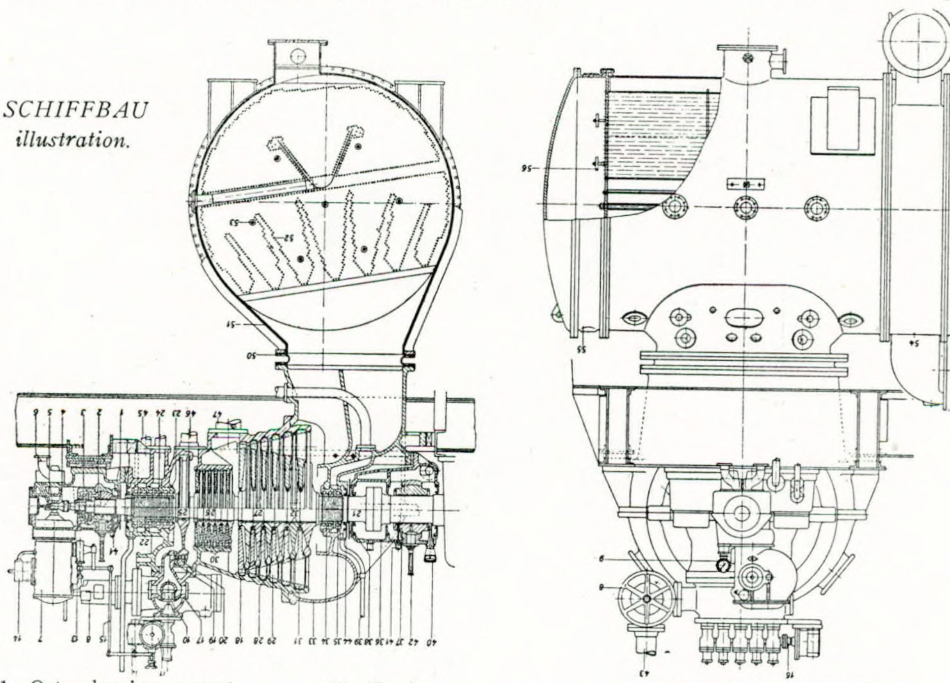
We have previously referred to the three large,



The appearance of the "Scharnhorst" is distinctly modern with her Maierform bow, cruiser stern, low funnel and rounded front to the amidships deck erection. The vessel is one of the most interesting ships, from a marine engineering standpoint, to be completed for several years, and is being followed by two equally notable sisters.

make, and it is not improbable that the N.D.L. will have some very interesting data available when all three ships have been in service for a while.

The "Scharnhorst", the first of the three ships to be completed, sailed on her maiden voyage to the Far East last month, and as space does not allow of our having a full description of the ship, the present article will be confined to her propelling machinery. Built by the Deutsche Schiff- und Maschinenbau A.G., Bremen, the vessel is noteworthy in comparatively fast passenger steamships "Scharnhorst", "Gneisenau" and "Potsdam", which comprise the important current building programme of the Norddeutscher Lloyd. The first and last-mentioned ships are turbo-electrically propelled, and the "Gneisenau" has Wagner-Bauer geared turbine machinery. The turbo-electric equipment of the "Scharnhorst", which entered service last month, has been supplied by the A.E.G., Berlin, and her boilers are of the Wagner-Bauer water-tube type. The "Potsdam", on the other hand, has Siemens-Schuckert main machinery and boilers of the Benson type. It will be appreciated, therefore, that the three ships differ appreciably in respect of machinery type and

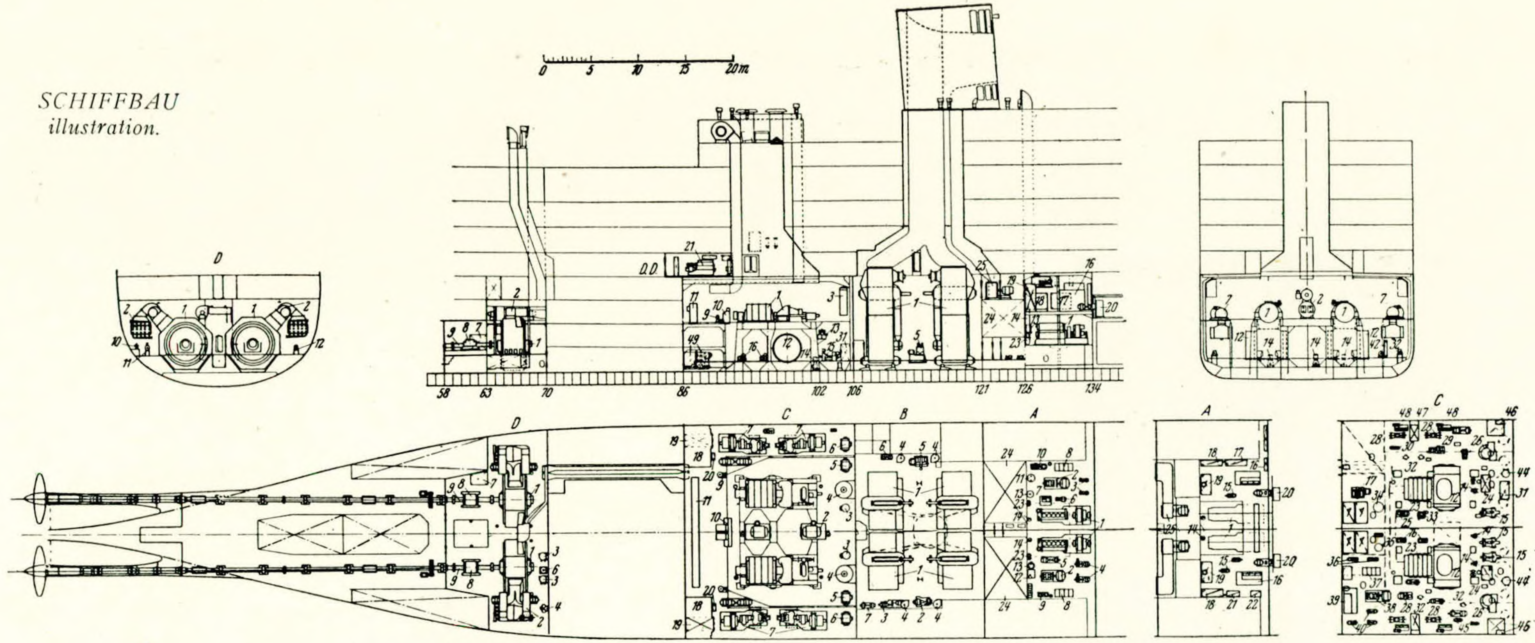


SCHIFFBAU illustration.

1. Outer bearing support.
2. Outer bearing shell.
3. Turbine thrust.
4. Safety governor.
5. Worm gear for tachometer.
6. Oil pumps.
7. Governor spring housing.
8. Emergency governor inlet valve.
9. Tachometer.
10. Control valve.
11. Control cylinder.
12. Control slide.
13. Operating cylinder for control lever.
14. Operating cylinder for speed adjustment.
15. Control rods.
16. Control shaft.
17. Steam inlet.
18. Turbine casing inlet.
19. Nozzles
20. Guide vanes.
21. Turbine shaft.
22. Labyrinth packing.
23. H.P. gland.
24. H.P. gland packing ring.
25. Turbine wheel No. 1. two stage.
26. Turbine wheel No. 2-7, single stage.
27. Turbine wheel Nos. 8-13, single stage.
28. Moving blades, wheels 1-13.
29. Guide vanes.
30. Diaphragm discs, 1-6.
31. Diaphragm discs, 7-12.
32. Inner glands.
33. Turbine casing outlet passage.
34. L.P. gland.
35. L.P gland ring.
36. Middle bearing support.
37. Middle bearing shell.
38. Bearing ring.
39. Gland leak-off.
40. Axial clearance gauge.
41. Wear-down gauge.
42. Bearing oil thermometer.
43. Live steam pipe.
44. Casing ring.
45. Gland drain.
46. First steam tapping.
47. Second steam tapping.
48. Bearing oil inlet.
49. Bearing oil outlet.
50. Compensator.
51. Condenser shell.
52. Condenser tubes.
53. Condenser support.
54. Water box.
55. Water box.
56. Zinc plates.

One of the new vessels' A.E.G. main turbine and its condenser.

SCHIFFBAU illustration.



A.—Forward auxiliary engine-room.

1. Diesel generators.
2. Refrigeration compressors.
3. Cooling-water pumps for cargo refrigeration plant.
4. Cooling-water pumps for Diesel generators.
5. Deck and fire pumps.
6. Standby lubricating-oil pumps.
7. Oil purifier.
8. Condensers.
9. Auxiliary compressor.
10. Soot-blower compressor.
11. Soot-blower tank.
12. Foam generator.
13. Lubricating-oil cooler.
14. Starting-air receivers
15. Brine pumps.
16. Brine cooler.
17. Dirty-oil tank.
18. Lubricating-oil tank.
19. Fuel daily supply tank.
20. Cold storage fans.
21. Scale-softening tanks.
22. Soaking tanks.
23. Lubricating-oil filter.
24. Boiler-room fuel tank.
25. Boiler-room fan.

B.—Boiler-room.

1. Water-tube boiler.
2. Boiler-feed pump.
3. Harbour feed pump.
4. Primary air fan and fuel pump.
5. Fuel-oil transfer pump.
6. Fuel-oil sludge pump.
7. Bilge pump.

C.—Main engine-room.

1. Main turbo-generators.
2. Evaporator.
3. L.P. preheater.
4. Hotwell—with de-aerator.
5. H.P. preheater II.
6. H.P. preheater I.
7. Auxiliary turbo-generators.
8. Convertor set.
9. Oil separators.
10. Manœuvring platform.
11. Switchboard.
12. Main condenser.
13. Steam jet air ejector.
14. Condensate pump.
15. Feed pump.
16. Evaporator auxiliary pump.
17. Bilge pump.
18. Store.
19. Dirty-oil tank.
20. Lubricating-oil heating tank.
21. Emergency dynamo.
22. Ventilator.
23. Air cooler.
24. Main lubricating-oil drain tank.
25. Air compressor.
26. Cooling-water pumps.
27. Ballast pump.
28. Cooling-water and condensate auxiliary pump.
29. Plunger drinking-water pump.
30. Centrifugal drinking-water pump.
31. Condensate tank.
32. Auxiliary lubricating-oil cooler.
33. High-pressure water pump.
34. High-pressure water tank.
35. Water drain tank.
36. Centrifugal cooling-water pumps.
37. Condenser.
38. Compressor for refrigeration plant.
39. Brine cooler.
40. Centrifugal pump for refrigeration plant.
41. Compressor.
42. Domestic hot-water centrifugal pump.
43. Deck, fire and lavatory centrifugal pump.
44. Main lubricating-oil cooler.
45. Circulating pump.
46. Sea intake boxes.
47. Sea intake for auxiliary engines.
48. Auxiliary lubricating-oil drain tank.
49. Lubricating-oil storage tank.

D.—Propelling Motor Room.

1. Propelling motors.
2. Air-cooling plant.
3. Oil cooler.
4. Lubricating-oil filter.
5. Bilge pump.
6. Emergency bilge pump.
7. Stern tube oil-storage tank.
8. Thrust bearing.
9. Propeller shaft.
10. Standby lubricating-oil pump.
11. Lubricating-oil and cooling-water pumps.
12. Drinking-water pump.

Plan and elevation of the "Scharnhorst's" main and auxiliary engine-rooms and boiler-rooms.

(The left sectional view is through the main motor room, looking aft, at frame 63; the right section is through the main engine-room, at frame 102, looking forward).

having a cruiser stern and a fore body and bow according to the now popular Maierform design. The main dimensions of the vessel are as follow :—

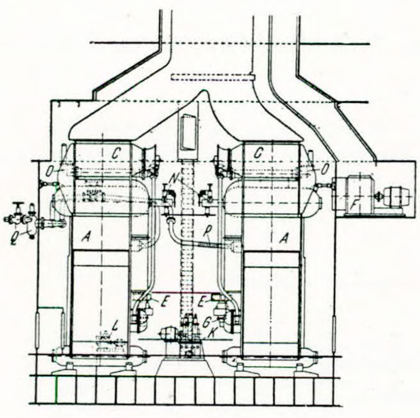
Length overall	652ft.
Length on L.W.L.	625ft. 7in.
Length between perpendiculars	610ft. 3in.
Beam	73ft. 10in.
Depth to "B" deck	44ft. 11½in.
Draught	28ft. 10½in.
Load displacement, tons	23,900
Deadweight, tons	10,800
Gross tonnage, tons	18,300
Service speed	21 knots
Speed on trial, about	24 knots
Machinery output, normal	26,000 s.h.p.

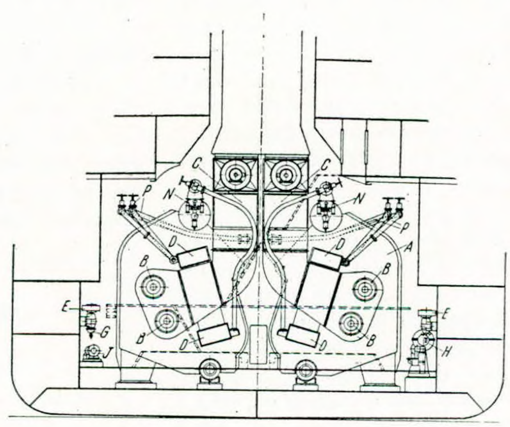
Plans of the machinery spaces accompany this article, and for these we are indebted to our German contemporary, "Schiffbau", as we have indicated on each of the three line drawings we reproduce. The machinery is noteworthy in having been supplied by the A.E.G. (the ship is actually the first large German vessel to be turbo-electrically-propelled), and the high steam pressure and superheat carried are particularly interesting, being appreciably in excess of anything previously adopted in a vessel of any great size. The machinery is the result of close co-operation between the A.E.G., Berlin, and the Weser Works of the Deschimag, Bremen, and the following are its leading characteristics :—

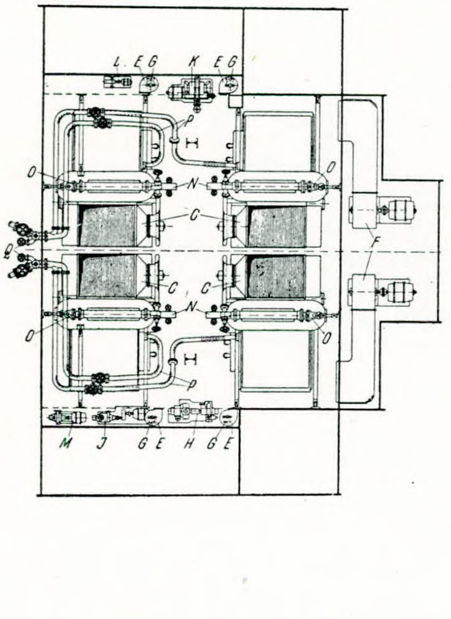
Number of main turbo-alternators ...	Two
Normal output of each main generator	10,000 kW.
Maximum ditto	12,400 kW.
Speed of main generators	3,120 r.p.m.
Voltage	3,120 volts.
Output of propulsion motors	2×13,000 s.h.p.
Speed of propulsion motors	130 r.p.m.
Diameter of three-bladed propellers...	18ft. 1in.
Number of water-tube boilers ...	Four
Heating surface of each boiler ...	7,000 sq. ft.
Superheater surface, per boiler ...	2,240 sq. ft.
Air preheater surface, per boiler, about	11,200 sq. ft.
Number of burners per boiler ...	Two
Boiler pressure	710lb. per sq. in.
Pressure at manœuvring valve ...	640lb. per sq. in.
Superheated steam temperature at boiler	470° C. (878° F.)
Steam temperature at manœuvring valve	455° C. (851° F.)

Each underslung main condenser is of the two-pass type, and has 10,200 sq. ft. of cooling surface. The centrifugal circulating pumps are motor-driven units, each with an output of 800,000 gallons per hour against a 20ft. head. Each condenser has a two-stage steam jet air-ejector. There are three motor-driven condensate pumps (one is a stand-by unit) and each has an output of 13,000 gallons per hour against a head of 65/80ft.; the speed is 1,500 r.p.m. Turbo feed pumps are used, there being four A.E.G. pumps of 12,000 gallons per hour normal capacity against a head of 2,025ft.; the speed is 4,720/5,100 r.p.m. Three stages of feed heating are provided, there being two heaters in each stage.

Electricity for various auxiliary purposes, lighting, hotel services, etc., is supplied by four direct-current turbo-generator sets of 675 kW. capacity, 230 volts. These are A.E.G. geared machines, the turbine speed of 7,000 being reduced to 1,500 r.p.m. at the dynamo shaft. Each set has its own three-pass condenser, of







SCHIFFBAU illustration.

A. Boiler.
B. Saacke burner.
C. Air preheater.
D. Superheater.
E. Primary air fan.
F. Secondary air fan.
G. Fuel pump.
H. Boiler-feed pump for harbour use.
K. Fuel-oil transfer pump.
L. Fuel-oil sludge pump.
M. Bilge pump.
N. Feed check valve with water level regulator.
O. Safety valve.
P. Superheated steam main.
Q. Blow-down valve group, with water separator.

Arrangement of the boiler-room of the "Scharnhorst".

645 sq. ft. cooling surface. There are also two 350 kW. at 230 volts Diesel-generator sets, each A.E.G. generator being driven at 400 r.p.m. by the two-stroke cycle single-acting engine. The 75 kW. 230 volt., emergency dynamo is driven by a four-stroke cycle 750 r.p.m. Diesel engine.

The engine-room plans show the location of the main and auxiliary machinery units and, with the very complete key provided, give a very good idea of the disposition of the various units, such as the three-phase turbo-alternators, main condensers with auxiliaries, propelling motors, high-voltage switchgear, manœuvring platforms, d.c. converters for the excitation of the main machines and electrical gear between generators and motors, along with the necessary safety and indicating devices.

The main turbo-generators are of the A.E.G. multi-stage type, as shown in one of the illustrations, and are rigidly coupled to two-pole three-phase alternators, each complete unit being bolted directly to its seating without any special bedplate. Particular attention has been paid to the control gear for the turbines. A feature of this gear is that the turbines can be run at any speed between 750 and 3,360 r.p.m., the variation being effected by a hand-control acting, through the medium of oil under pressure, on the governor. The governor itself maintains the momentary speed within a certain percentage of the particular speed for which the controls are set. The rotors of the main electrical machines carry fans which circulate air for cooling, this air then passing to air coolers through which sea water circulates. Steam for all purposes is supplied from four large oil-fired water-tube boilers of the Wagner-Bauer type, arranged in two sets of pairs. Each boiler, as shown in one of our illustrations, has an upper and a lower drum, and the water-tubes are arranged in three groups, two of which are rising groups surrounding the combustion chamber, and the third acts as a downcomer around the superheater, the location of which is shown in the drawing. In the front of each boiler there are two oil burners which pulverise the oil, not by pressure, but by centrifugal force.

Each propelling motor is connected to its propeller by a single-collar thrust shaft, five lengths of tunnel shafting, and, lastly, a tail shaft. Self-aligning roller bearings are used to carry each section of the tunnel shafting, and to permit of these bearings being drawn on to the shafts, the lengths of the latter are provided with a flange at one end only, the other ends being arranged for a muff coupling.

The "Scharnhorst" called at Southampton last month on its maiden voyage and was visited by a party of shipping and Press representatives.

Inertia Supercharging.

"The Motor Ship", June, 1935.

In the April issue of this journal the Wibu system of inertia supercharging for Diesel engines was described. Mr. E. S. Dennison, of the New London Ship and Engine Works, in a letter which is published in these pages, refers to a paper which he presented before the American Society of Mechanical Engineers three years ago, dealing with the subject.

Inertia supercharging, briefly, takes the form of attaching to the suction pipes to the cylinders of a four-cycle engine straight lengths of pipe of suitable dimensions, and delaying the opening of the inlet valves, so that the velocity of the air supplied in the mid portion of the suction stroke is greatly increased. An excess of air is thereby introduced into the cylinder, and a higher power can be developed, as is the case with supercharging, in which the extra air is delivered from the blower.

The mechanical efficiency apparently remains practically unaltered, and Mr. Dennison's tests with a high-speed engine showed that the maximum increase in compression pressure was about 20 per cent. The best results were apparently obtained with high air velocities, approaching one half the velocity of sound. In Mr. Dennison's opinion, the system seems to be specially suited to low-speed engines, and further experimental work with such units might reveal some interesting results.

Tests with the Twin Rudders of the "Bloemfontein".

"The Marine Engineer", June, 1935.

The Atlas Werke A.G., of Bremen, in co-operation with the owners, carried out rudder tests on the motorship "Bloemfontein" (described in our columns last year) during a trip from Rotterdam

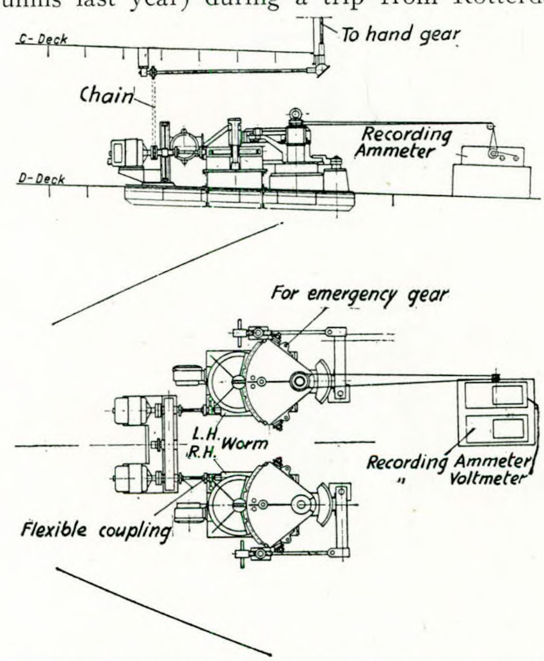


FIG 1.—Layout of "Bloemfontein's" steering gear, showing test recording apparatus.

FIG. 2.—Current consumption of steering gear during one manœuvre.

to Amsterdam and Hamburg. The tests were undertaken to obtain figures of "steerability" to compare with those from other ships with conventional rudder layouts, and also to measure the maximum rudder torque and how the torque varied between one full helm and the other. The "Bloemmontein" is of 17,503 tons displacement, and 10,733 tons d.w. capacity, the length, it may be recalled, being 455ft., beam 63ft., and service speed 15 to 16 knots. During the tests the draught forward was 25ft. 6in., and aft 26ft. 1in. (The loaded draught is 30ft. 8in., and the light draught 14ft. 7in.).

Aft of the two propellers there are two balanced rudders having inclined stocks, the steering gear being completely duplicated, i.e., it has two quadrants, two sets of gearing, two motors, and two electric controls. The two motor shafts are coupled so that either motor can operate both rudders, and the whole of the other electrical control is a reserve. The first diagram illustrates the method of measuring the rudder turning moment and is self-explanatory.

The second diagram shows one complete cyclic manœuvre, and indicates that the rudder is almost balanced, because the current consumption is nearly the same for both full port and full starboard helms (apart from peak currents at starting). From the

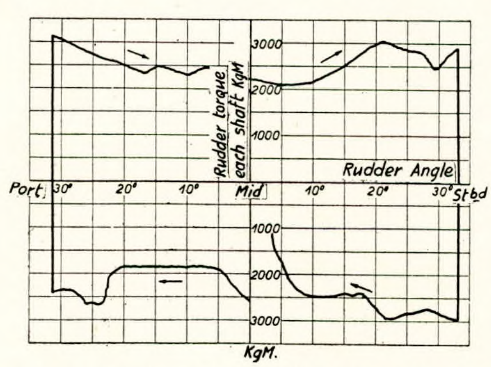


FIG. 3.—Rudder torque during one manœuvre.

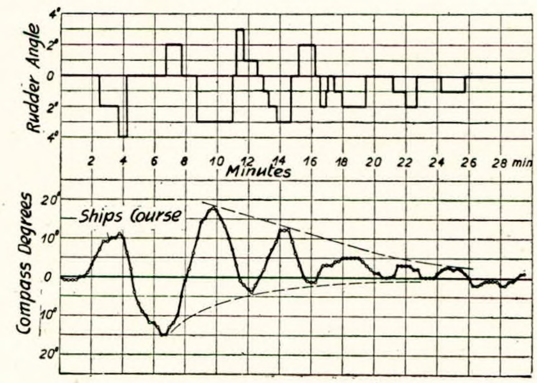


FIG. 4.—Compass and rudder angle readings.

maker's shop tests, the turning moment corresponding to any current consumption was known, so that the curve of the rudder torque shown in the third diagram could be arrived at from the second diagram.

To test the quality of the steering, the compass reading was taken every 15 seconds and the rudder movement noted. The fourth illustration shows these results. From the ship's course curve it can be seen how a few minutes determined the smallest rudder angle which sufficed to keep the ship on its course; the dotted lines show how the deviations from the course became less from one rudder movement to the next, and that, despite a wind strength of 4-5 it was easy to keep the variations down to ±2°—3°, with only 1° of rudder angle.

Measurements taken during a complete circle first in one direction and then in the opposite sense, are given in the fifth diagram, and allow of the following deductions:—

1. The turning speed, i.e., the course alteration per minute, reached a peak rate of 80° per minute at the beginning of the first circle, and then quickly dropped to a steady 50° per minute. At the beginning of the second circle the turning rate went up to 56° per minute and then dropped to 44° per minute.

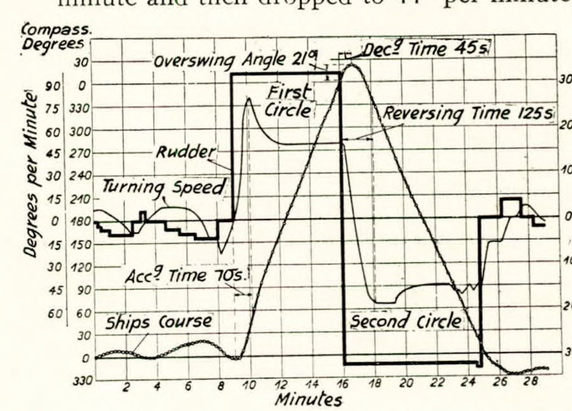


FIG. 5.—Turning-speeds, etc., during double circle manœuvre.

2. Accelerating time from rudder being put over until time when maximum turning speed (80° per minute) was reached, was 70 seconds.

3. Decelerating time from instant when rudder brought back till turning speed was reduced to zero was 45 seconds.

4. Overswing angle, being the angle the ship continued to turn after the rudder was reversed, was 21°.

5. Reversal time from instant when rudder was reversed to reaching maximum turning speed was 125 seconds.

The author deduces from the results that the quality of the steering was very good. Moreover, it was possible to take the ship through the Canal from Amsterdam to Ijmuiden with only one main engine operating.—*H. Schade, "Schiffbau", April 15, 1935.*

Scavenging Arrangements with High-powered Engines.

"The Motor Ship", June, 1935.

Within the course of the next nine or ten months there will be three twin-screw passenger ships afloat, with machinery of 24,000 s.h.p. to 26,000 s.h.p. The vessels are the "Saturnia", "Vulcania" and the first of the new 25,000-ton Union Castle liners.

The engines are of three different types (Fiat, Sulzer and Harland-B. and W.). The following table gives particulars of the cylinder dimensions and speeds, and the brake mean effective pressure is worked out on a basis of an output of 12,000 b.h.p. per engine :—

DETAILS OF 12,000 B.H.P. ENGINES.

Type of Engine.	No. of cylinders.	Cylinder diameter. mm.	Cylinder diameter. ins.	Piston stroke. mm.	Piston stroke. ins.	R.P.M.	B.M.E.P. for 12,000 b.h.p. lb. sq. in.
Harland-B. & W.	10	660	25·9	1,500	58·9	102	78
C.R.A.-Sulzer	10	760	29·8	1,200	47	128	56
Fiat	10	750	29·4	1,250	49·1	128	56

If the ratings are increased, the brake mean effective pressures are correspondingly raised. The Fiat engines are apparently to be rated at 13,000 b.h.p., in which case the mean effective pressure will be 61lb. per sq. in.

In the three classes of engine, entirely different scavenging arrangements are provided. In the Union Castle liners with the Harland-B. and W. machinery, the scavenging blowers will presumably be driven from the engines. In the C.R.A.-Sulzer units, to be installed in the "Saturnia", three electrically-driven turbo blowers will supply the necessary scavenging air, whilst with the Fiat machinery in the "Vulcania", two 1,300 b.h.p. Diesel engines will drive reciprocating scavenging pumps.

In all three ships, the exhaust gases from the propelling engines will be utilized to save fuel. In the "Vulcania", apart from the steam used for the normal ship's requirements, a 400 kW. steam turbo generator is to be installed in the engine-room, and a proportion of the electricity required on board will be obtained from this unit. With these vessels it should be possible to recover from the heat in the exhaust gases a power equivalent to some 3 per cent. to 4 per cent. of the total output of the Diesel propelling machinery, and the fuel consumption will accordingly be reduced at least to this extent.

It is of much interest to the engineering, shipbuilding and ship-owning communities that three ships should be placed in service about the same time, with almost equal machinery power, but of entirely different types with widely varying auxiliary arrangements.

Exhaust-gas Turbine By-pass Arrangements.

"The Motor Ship", June, 1935.

In the course of a somewhat lengthy review relating to the development of the well-known supercharging system which bears his name, Mr. Büchi mentions to us his disagreement with the practice, still frequently adopted, of employing a by-pass arrangement, thereby allowing the exhaust-gas turbine, and consequently the pressure-charging blower, to be placed out of action. Mr. Büchi states very emphatically that this represents quite an unnecessary complication, and he insists that the use of exhaust-gas turbines is so safe to-day, after nine years' experience of their employment, that the arrangement in question is no longer justified.

There would certainly seem to be every reason why Mr. Büchi's contention should be supported. Troubles with exhaust-gas turbines have been, so far as we can ascertain, decidedly rare occurrences, and in the light of present-day knowledge they should now be practically, if not wholly, non-existent. Anything which can be done to simplify and cheapen the system of pressure-charging, provided such modification can be done with safety—or, in other words, without impairing the reliability of the whole engine—should be adopted as a matter of course. One of the points which Mr. Büchi makes is that no owner of a turbine-driven steamer would entertain the idea of carrying a reserve group so that it could be used in the event of damage to the original engine.

The National Physical Laboratory.

"The Shipbuilder and Marine Engine-Builder, June, 1935.

During the years which have elapsed since its establishment in 1900, the National Physical Laboratory has won a dominant position in the scientific and industrial life of Great Britain. The Laboratory is now an institution occupying 14 large buildings in grounds of some 50 acres, a staff exceeding 600 being employed.

The activities of the Laboratory include research and test work in the various branches of physics and engineering, such as heat and refrigeration, sound, optics, radiology, electricity and magnetism, radio, fine measurements, mechanical engineering, metallurgy, aerodynamics, and ship design. It is responsible for, or assists in, the maintenance of the majority of the official physical standards of the country, e.g., length, mass, temperature, candle-power and the electrical standards. The Laboratory is a Government institution under the Department of Scientific and Industrial Research.

The Report of the National Physical Laboratory for 1934,* which was published on the 13th May, contains 260 pages and 59 illustrations devoted to the activities of the Laboratory during the past year, and the following summary deals with that part of the report which mostly concerns the readers of this journal.

The increasing prosperity of the country has been reflected in the increased demand for industrial investigations at the Laboratory during 1934. This increase has been most marked in the work called for by the shipbuilding industry, and the number of ship designs submitted to model tests has been the greatest in the life of the Laboratory.

Metrology Department.

Standard Leading Screw Lathe.—Alterations have been made to the standard lathe, which should make it more generally useful for the rectification of the pitches of lead screws and other precision screws. By the introduction of change gears, the teeth of which have been specially ground to correct form and pitch, it is now possible to correct screws having any of the ordinary English or metric right-hand pitches. In addition, the traverse of the lathe has been extended from 3ft. to 5ft.; and, with the help of an auxiliary support which is being made, it should shortly be possible to correct screws up to 10ft. in length, the screw being turned end for end between the two threading operations.

A calibration of the lathe after its reconstruction showed that its cumulative pitch is correct throughout the 5ft. traverse to within 0·0003in.

Engineering Department.

Fatigue of Metals under Combined Stresses.—The new National Physical Laboratory combined-stress fatigue-testing machines have been continuously employed on a comprehensive investigation of the strength of metals under combined alternating stresses, the main objects of the work being the determination of the stress criterion which produces failure, and the provision of design data for such important engineering components as engine crankshafts.

The fatigue resistance has been determined of three materials, viz., (I) 0·1 per cent. carbon steel, (II) 3½ per cent. nickel-chromium steel, and (III) Silal cast iron, representing two ductile steels of different types and a "brittle" material. For each material, the fatigue resistance has been determined under reversed plane bending and reversed torsional stresses, and under five combinations of these types of stressing actions. The results of the tests show that the fatigue limits of cast iron are in close accordance with the criterion of maximum principal stress. The results obtained on the two steels show that the fatigue limits of these ductile metals can be expressed by a simple relation of a general form.

Mechanical Properties of Materials at High Temperatures.—The investigation of the mechanical properties of materials at high temperatures continues to be actively pursued. One portion of the work has been concerned with the determination of the tensile, creep, impact and hardness properties of commercial steels and non-ferrous metals at high temperatures. Alloy cast irons have been examined for creep and growth at 850° C.; a study of the behaviour of a series of magnesium and aluminium alloys over the range 20 to 150° C. has been commenced; and the investigation of the influence of mechanical working and various heat treatments on the creep and other mechanical properties at high temperatures of single melts of carbon and molybdenum steels has proceeded.

Work of a more fundamental nature has included an investigation of the creep and stress redistribution of a lead beam under pure flexural stresses. It has been established that plane sections in the beam remain plane as creep proceeds, and that the stress redistribution may be calculated from knowledge of the creep properties under simple tensile stress. The nature of creep under a system of complex stress has been under investigation for the case of combined tensile and torsional stresses in a thin-walled tube.

Strength and Causes of Failure of Lifting-gear Components.—A comprehensive investigation has been carried out of the mechanical properties of electrically-welded mild-steel chain from a wide variety of sources. Chains of ⅝in. diameter from the United States, Germany, Belgium, Czechoslovakia and Switzerland have been tested, together with British and American hand-welded, wrought-iron chain of different qualities, for comparison. The results show that some electrically-welded chain is being produced which is at least equal to the best quality of wrought-iron chain. In general, the electrically-welded chains show greater variations in mechanical properties than do hand-welded chains.

Application of Electric Welding.—During the past few years, marked advances have been made in the use of electric welding in place of riveting for all forms of steel construction. This relatively new and undoubtedly economical method of construction has received attention at the Laboratory for two or three years, and with the help of the welding industry rapid progress is now being made

*H.M. Stationery Office, price 13s. net.

in a co-operative investigation which should provide data on the general reliability of welding as applied to steel-framed structures. Over 60 British welding firms have welded a number of large test plates under specified conditions, and these are now being tested at the Laboratory. In all, nearly 2,000 complete mechanical tests on welds are being made, and the results should permit an authoritative pronouncement to be made on the use of electric welding in the erection of steel structures in this country.

Strength of Thin Sheet-metal Panels.—When thin sheet material is loaded by compressive or shearing forces in the plane of the sheet, the relation between the load and the deformation may be very much affected by the occurrence of buckling. Thus, in the case of a plane rectangular panel of thin sheet material having all its edges supported, and loaded in compression parallel to one pair of edges, buckling will cause an immediate reduction of the stiffness to one-third of the stiffness before buckling, and further increase of load will cause a further reduction.

Tests on curved panels carried out at the Laboratory have shown that, in this case also, buckling causes an immediate reduction of the effective stiffness, and empirical formulæ describing the behaviour of the panels before and after buckling are being devised.

Research on Pipe Flanges.—Recent developments in the manufacture and use of alloy steels have permitted modern steam power plants to utilise higher working temperatures and pressures, with a corresponding gain in efficiency. A consequence of this, however, is that an increasing amount of trouble is being experienced with the flanged joints of steam mains, and the Institution of Mechanical Engineers have appointed a committee to investigate this problem.

A programme of work is being carried out at the Laboratory on behalf of this committee, which comprises (I) an experimental investigation into the component parts of a flanged joint, such as the behaviour of the packing material and the creep of the stud bolts and nuts of various materials, and (II) full-scale tests on flanges attached to 10in. diameter pipes, in which the various deformations of bolts and flange are observed while under full-load conditions. In the latter tests, the system contains steam at temperatures and pressures up to 1,000° F. and 1 ton per sq. in.

The William Froude Laboratory.

Increase in Shipbuilding Activity.—The increase in the number of ship designs tested at the William Froude Laboratory which was recorded in 1933 has continued throughout 1934. No fewer than 60 different designs of ships have been tested, this number being the highest since this Laboratory was opened in 1911. The modifications in these designs which have been suggested and carried out by the Laboratory have effected very large improvements in the resistance of a number of these vessels. Assuming that only one ship of each type is built, that each of these ships is steaming for only 200 days per year, and that the life of these ships is 20 years, the net saving to the industry in coal bills alone will be £500,000.

Designing Ships to secure Minimum Pitching in Rough Weather.—An investigation on the behaviour of ships in rough weather has recently been completed, which gives data enabling the shipbuilder to design for good behaviour in rough weather. The best ship lengths to secure good weather qualities are given both for cargo and passenger vessels. As a result of this work, it may be said that a first-class high-speed passenger ship for Atlantic service should be more than 700ft. in length, and this length is, of course, considerably exceeded by modern vessels of this type. For cargo vessels, the length should be 450ft. or more.

Interesting observations were made of the height of waves in the Atlantic and the distance from crest to crest. In an Atlantic storm, the waves may be up to 25ft. high, rising to 40ft. in a hurricane. The distance from crest to crest may be about 275ft.

Propellers for Single-screw Ships.—During the past year the results have been published of an investigation on the design of screw propellers for use on single-screw vessels, such as intermediate liners, express cargo ships and ordinary tramps. During this research, over 30 propellers have been tried behind a large 24ft. model to determine the best combination of rake, pitch, shape of blade section and blade outline to give the highest efficiency under working conditions. The results have indicated the definite possibility of effecting improvement in the efficiency of such propellers.

Backing of Propellers.—A number of vessels with either turbo- or Diesel-electric propulsion have been designed in recent years for British owners, and a paper recently published from the Laboratory giving details of the power absorbed by propellers, and the thrust obtained from them when the propellers are reversed, should be of considerable interest to designers of such machinery. One of the problems of this type of machinery is to ensure that the propeller does not overload the machinery, through its capacity to absorb, when going astern, a torque much higher than when going ahead. The data given in this paper enable a rough estimate of this torque to be obtained under certain assumed conditions.

Design of Coasting Vessels.—Research work previously completed on coasting vessels had shown that the shape of hull could be modified to give an average improvement of some 10 per cent.; and during 1934 it has been found that, by suitable design of the propeller, a further gain of some 7 to 10 per cent. can be obtained on these vessels. Incidentally, a check on the model results has recently been obtained on full-scale trials of two vessels, showing that the improvements obtained on a model are actually achieved on the ship itself.

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An appendix to the Report gives a list of 220 papers published from the National Physical Laboratory in the scientific and technical Press during 1933 and 1934.

S.s. "Bessemer".

"The Engineer", 10th May, 1935.

On Saturday, May 8th, 1875, there took place the long-expected trial trip of the steamship "Bessemer". A representative of this journal attended and described his experiences in our succeeding issue. The vessel was remarkable for more than the swinging saloon with which Sir Henry, or Mr. Bessemer as he then was, proposed to eliminate the distressing effects of a Channel crossing. In the first place she was of unusual size as cross-Channel steamers went in those days. She had a length of 350ft. and over the paddle-boxes a width of 65ft. Her main deck was 270ft. long with a beam of 40ft. Forward and aft, or rather at each end for she was double-ended, the main deck ended in a peak or bow and standing at this point the passenger looked down on a lower deck carrying capstans and anchor gear. These lower decks had a very low freeboard, so low in fact that on the trial trip there were many occasions on which they were submerged to a depth of 2ft. by the bow wave pouring over them. They were not intended to be habitable but were designed to assist the fore and aft stability of the ship. Two entirely independent pairs of paddle wheels driven by two separate engines propelled the ship. Longitudinally between the paddles the hull accommodated the famous swinging saloon. This saloon consisted of a room 70ft. long, 30ft. wide and 20ft. high. It weighed between 170 and 200 tons and was mounted on a pair of fore and aft trunnions. Its motion about these trunnions was counteracted by hydraulic machinery under the manual control of a sailor. On its top the saloon was formed as a passenger deck. The engines of 4,000 h.p. were situated in two separate engine-rooms about 100ft. apart and were supplied with steam by eight boilers. The paddle wheels were 30ft. in diameter. Hydraulic power was used not only for controlling the motion of the saloon but also for reversing the engines, for steering the ship, and for operating the capstans. The saloon was however the dominating feature of the ship. It and it alone was Bessemer's contribution to the vessel, the general design of the ship being Mr. E. J. Reed's. The ship was built round the saloon, so much so that everything had to be made subservient to it. It was very heavy and consequently the engines had to be made unduly light as compensation. Even so the draught of the vessel as finished was nearer 9ft. than the originally intended 7ft. 6in. On the trial trip the weather was disappointingly calm and the saloon was not operated. It was admitted by Mr. Bessemer that the operating gear was not all that it might have been and that, in any event, the man charged with its control had, so far, had little or no opportunity of familiarising himself with it. The basis of operation depended upon the observation of a spirit level. Although it is not mentioned in our article we know that Bessemer at one time intended to use a gyroscope as a means of obtaining automatic control. The fundamental error in his gyroscopic device was pointed out to him by Macfarlane Grey, who patented a correct application but a difference of opinion arose between the two men and Bessemer eventually gave up the idea of using automatic control. On the trial trip while the ship was entering Calais harbour the current and wind caught her at one end and swung her round against the jetty. In a few seconds about 50 yards of the jetty were demolished. A second mishap of the same kind occurred on a succeeding trip. The bill for damages submitted by the French authorities led to the end of the company organised to build and operate the vessel.

An Inventions Exhibition of 1835.

"Engineering", 19th April, 1935.

A hundred years ago, at the Adelaide Gallery in the Strand, an exhibition was held under the auspices of a Society for the Illustration and Encouragement of Practical Science. The exhibition was called the Gallery of Practical Science, and was described as comprising "Models of Inventions, Works of Art, and Specimens of Novel Manufactures". The accounts of some of the exhibits are not without interest to the present-day engineer. They included, for instance, the first gas-cooking stove, by which, it was claimed, "meat may be boiled or roasted, baked, stewed, or fried", the various culinary operations being demonstrated at intervals. With its smoky and inefficient flames, twenty years before Bunsen invented his burner, it must have been a very crude apparatus, compared with the efficient and economical stoves, with nicely-regulated ovens and arrays of jets, in the modern kitchen.

Among the models of engineering achievements then recent was one of the Liverpool and Manchester Railway, with the "Dart" engine, tender, and train of carriages. The well-known Dr. Lardner, whose treatise on the steam-engine was so long a standard work, had supervised the construction of this model. There was another model of the great breakwater at Plymouth, which was not completed until 1841; yet another was of Smeaton's Eddystone lighthouse.

Very interesting exhibits were those of Jacob Perkins, the American inventor, who had come to this country with his plans for the steel-engraving of bank-notes which proved so successful. One of his achievements was the compression of liquids, and he invented a piezometer to measure compressibility. His apparatus for effecting compression was shown, together with a new type of steam-engine boiler, in connection with which it is interesting to remember that half a century later his grandson was a pioneer in experiments with high-pressure steam-engines. Another of Perkins' inventions shown at this exhibition marked a stage in the evolution of the marine screw-propeller. In a large tank there was a model of a ship, fitted with clockwork, with "Perkins's Patent Paddle-Wheel" fitted to the stern.

The exhibition grouped together inventions since developed with immense success, together with others that were obviously, in the light of later knowledge, absurd. Thus there was an apparatus for warming a room by passing the entering air through an arrangement of steam pipes —the germ of modern air-conditioning plants—and by its side was a device for preventing ships foundering at sea by an installation of copper pipes, the air in which was to make the ship too buoyant to sink. A sectional model of an 80-gun ship was exhibited, showing the tubes in position, and no one appears to have realised that the tubes were as vulnerable as the rest of the ship, and so afforded no protection at all.

Examples of ornamental work for the interior of buildings included products of papier-maché, for which purpose this material came into very wide use, but perhaps the most striking instance of an invention exhibited as a novelty in 1835, which had an immense future before it, was Aspdin's "Artificial Stone", as it was called. This was the "Portland cement" invented by Joseph Aspdin, the bricklayer of Leeds, since developed into one of the most important industries of the world.

In quite another field was the exhibit of a model of an electro-magnet. William Sturgeon—who, himself, was showing a so-called Ferro-Electric-Magnetic Sphere for illustrating the phenomena of terrestrial magnetism—had invented the electro-magnet some ten years before, and Joseph Henry, in the United States, had made one which lifted a weight of 3,000lb. Apparently this was the first model of an efficient magnet to be made in this country. Reference may be made to one more exhibit, viz., a model of "the great American Steam Raft, 'Emma of Troy' ". This was a river-boat with which experiments had been made in America, a speed of 20 miles an hour having been reached. The idea embodied in the design was to minimise the resistance by supporting the deck on two long, very narrow, tapering, hollow hulls, with the paddle-wheel between them. The hulls were 300ft. long and 8ft. in diameter at the thickest part, where they were 16ft. apart, and working in the space between there was a 30ft. paddle-wheel.

Heat Carried Away by Moisture in Flue Gases.

By E. W. Geyer, B.Sc.

"Engineering", 15th March, 1935.

In drawing up the heat balance of a boiler trial it seems to be an established custom to determine the heat carried away by the moisture in the flue gases on the assumption that the moisture will wholly condense at 212° F. This, however, could only be justified if the products of combustion consisted entirely of steam at atmospheric pressure, as it would only be under this condition that condensation would occur at 212° F. The actual amount of steam is very much less than this, and depends on a number of factors. It will be found, in general, that, for ordinary boiler trials, the proportion of steam present in the flues at exit from the boiler is about 4 per cent. by volume, so that, for a flue-gas pressure of 14·7lb. per square inch absolute, the partial pressure of the steam is $0{\cdot}04 \times 14{\cdot}7 = 0{\cdot}588$lb. per square inch absolute, for which the corresponding saturation temperature is 84·5° F. Condensation, for this amount of moisture, thus begins when the flue gases are reduced in temperature to 84·5° F., instead of to the generally-accepted figure of 212° F. It should also be noted that as soon as a part of the steam condenses, the partial pressure of the remaining steam is reduced so that, for continuous condensation, a continuous reduction in temperature is required. In view of these facts, it is interesting to compare the actual amount of heat carried away by the moisture with that obtained on the assumption that condensation occurs at 212° F. In the following treatment, the general method of solving this problem is first considered, after which a particular example is dealt with.

When the flue gases leave a boiler, the steam present is always superheated. From the known flue-gas temperature, t_{g1}, and the calculated value of the partial pressure of the steam, the total heat H_{ss} of this superheated steam can be determined. Denoting the weight of steam in the flues per pound of fuel burned by W_s lb., the total heat in the steam at this point per pound of fuel burned is $H_1 = W_s H_{ss}$ B.Th.U. When the flue gases have been reduced in temperature to the boiler-room temperature, t_a, it will generally be found that a partial condensation has occurred, since the saturation temperature of the steam is usually higher than t_a. With the fuels generally used, however, the larger portion of the steam remains uncondensed. The steam is no longer superheated, however, and its weight can be determined from its specific volume V_2 and the volume occupied by W_g lb. of dry flue gases, where W_g is the weight of dry flue gases per pound of fuel burned. The pressure p_{s2} exerted by the steam is now reduced, since some of the steam has been condensed, hence the partial pressure p_{g2} of the dry flue gases is increased and is given by $p_{g2} = p_a - p_{s2}$ where p_a is the total pressure recorded at the flues. The volume occupied by W_g lb. of dry flue gas at this pressure p_{g2}, and at the temperature t_a, is found from the characteristic equation, provided the gas constant R is known. The latter can be determined accurately from the flue-gas analysis, but in most general cases it is about 52·2ft.-lb. per lb. per ° F. This then gives the volume of the dry flue gases as,

$$V_g = \frac{52{\cdot}2\ W_g\ T_a}{144\ p_{g2}} \text{ cub. ft per lb. of fuel.}$$

The specific volume V_2 of dry saturated steam at the temperature t_a is found from steam tables, and hence the weight W_{s2} of dry saturated steam associated with the above volume of dry flue gases is found from $W_{s2} = \frac{V_g}{V_2}$ lb. per lb. of fuel.

Since the weight of the superheated steam at exit from the boiler is W_s lb., the weight of steam condensed in cooling the products down to the boiler-room temperature t_a is,

$$W_c = (W_s - W_{s2}) \text{ lb. per lb. of fuel}$$

Denoting the total heats of water and of dry saturated steam at the temperature t_a by h_2 and H_2, respectively, the total heat of the steam and condensate at t_a is,

$$H_2 = (W_c h_2 + W_{s2} H_2) \text{ B.Th.U. per lb. of fuel.}$$

The amount of heat given up by the steam in the flue gases, when cooled from t_g to t_a, is thus,

$$H_1 - H_2 = \{W_s H_{ss} - (W_c h_2 + W_{s2} H_2)\} \text{ B.Th.U.}$$

per lb. of fuel.

The following example, in which representative figures have been used, serves to show how serious the error may be in assuming that condensation of the steam in the flue gases occurs at 212° F.

With a temperature of the flue gases at exit from a boiler of 580° F. and a partial steam pressure of 0·588lb. per square inch absolute, the range of superheat is (580−84·5)=495·5° F. The total heat per pound of this steam is thus,

$$1094{\cdot}4 + 0{\cdot}45 \times 495{\cdot}5 = 1317{\cdot}4 \text{ B.Th.U.}$$

From the test figures, the weight of dry flue gases per pound of fuel is 17·5 lb., and the weight of steam associated with this is 0·452lb., so that the total heat of the steam in the flue gases at exit from the boiler is $H_1 = 0{\cdot}452 \times 1317{\cdot}4 = 595{\cdot}5$ B.Th.U. per lb. of fuel. Since the boiler-room temperature is 80° F., it is now necessary to find the total heat of the steam and condensate in the flue gases when these have been lowered in temperature to 80° F. The pressure of saturated steam at 80° F. is 0·51lb. per square inch absolute, so that the partial pressure of the dry flue gases is 14·7−0·51=14·19lb. per square inch absolute. The volume occupied by 17·5lb. of dry flue gas is,

$$V_g = \frac{52{\cdot}2 \times 17{\cdot}5\ (460+80)}{144 \times 14{\cdot}19} = 241{\cdot}4 \text{ cub. ft. per lb.}$$

of fuel.

The specific volume of dry saturated steam at 80° F. is 632 cub. ft. per lb., so that the weight of dry saturated steam present in the flue gases at 80° F. is,

$$W_{s2} = \frac{241{\cdot}4}{632} = 0{\cdot}382 \text{lb. per lb. of fuel.}$$

The weight of steam condensed is thus $W_c = W_s - W_{s2} = 0{\cdot}452 - 0{\cdot}382 = 0{\cdot}070$lb. per lb. of fuel. The total heats for water and dry saturated steam at 80° F. are 47·9 B.Th.U. per lb., and 1,092·4 B.Th.U. per lb., respectively, so that the total heat of the steam and condensate in the flue gases at 80° F. is,

$$H_2 = 0{\cdot}07 \times 47{\cdot}9 + 0{\cdot}382 \times 1092{\cdot}4 = 3{\cdot}4 + 417{\cdot}3 = 420{\cdot}7 \text{ B.Th.U. per lb. of fuel.}$$

The heat given up by the moisture is thus,

$$H_1 - H_2 = 595{\cdot}5 - 420{\cdot}7 = 174{\cdot}8 \text{ B.Th.U. per lb. of fuel.}$$

In the 1927 report issued by the Heat Engines Trials Committee of the Institution of Civil Engineers, the heat carried away by the moisture in a boiler trial is given as "moisture per lb. of fuel× (heat content of 1lb. of steam at atmospheric pressure and the temperature of the flue gases leaving the boiler less the heat content of water at the temperature of the air supply)". For the example quoted above the I.C.E. method gives $0{\cdot}452\ \{1330{\cdot}1 - 47{\cdot}9\} = 0{\cdot}452 \times 1282{\cdot}2 = 579{\cdot}6$ B.Th.U. per lb. of fuel. The error due to assuming that condensation of the steam in the flue gases occurs at 212° F. is thus

$$\left(\frac{579{\cdot}6 - 174{\cdot}8}{174{\cdot}8}\right) \times 100 = 232 \text{ per cent.}$$

Considering the thoroughness which is called for in the other items of the I.C.E. Report, there seems little justification for accepting an assumption which can lead to such serious error.

New Safety Valves for the "Majestic".

Striking Reductions in Valve Size and Weight are being made by adopting Cockburn-MacNicoll High-lift valves throughout the Boiler-rooms of the famous Cunard White Star Liner.

"The Marine Engineer", June, 1935.

The Cunard White Star Line has decided to replace the original safety valves on the main boilers of their large liner "Majestic" with modern high-lift valves. An order has been placed with Cockburns Ltd., Cardonald, Glasgow, for 47 sets of 3in. double cast steel valves, and these will be fitted in the near future.

The "Majestic", it may be recalled, was built by Blohm & Voss, of Hamburg, as the "Bismarck". She is 915ft. long by 100ft. broad, and has a gross tonnage of 56,599 tons. Her four screws are driven by turbines, taking steam from 48 water-tube boilers at a pressure of 240lb. per sq. in. Originally, each of these boilers had a triple safety valve, 4¼in. diameter, of German design and make. Details of these valves may be obtained from the accompanying drawing.

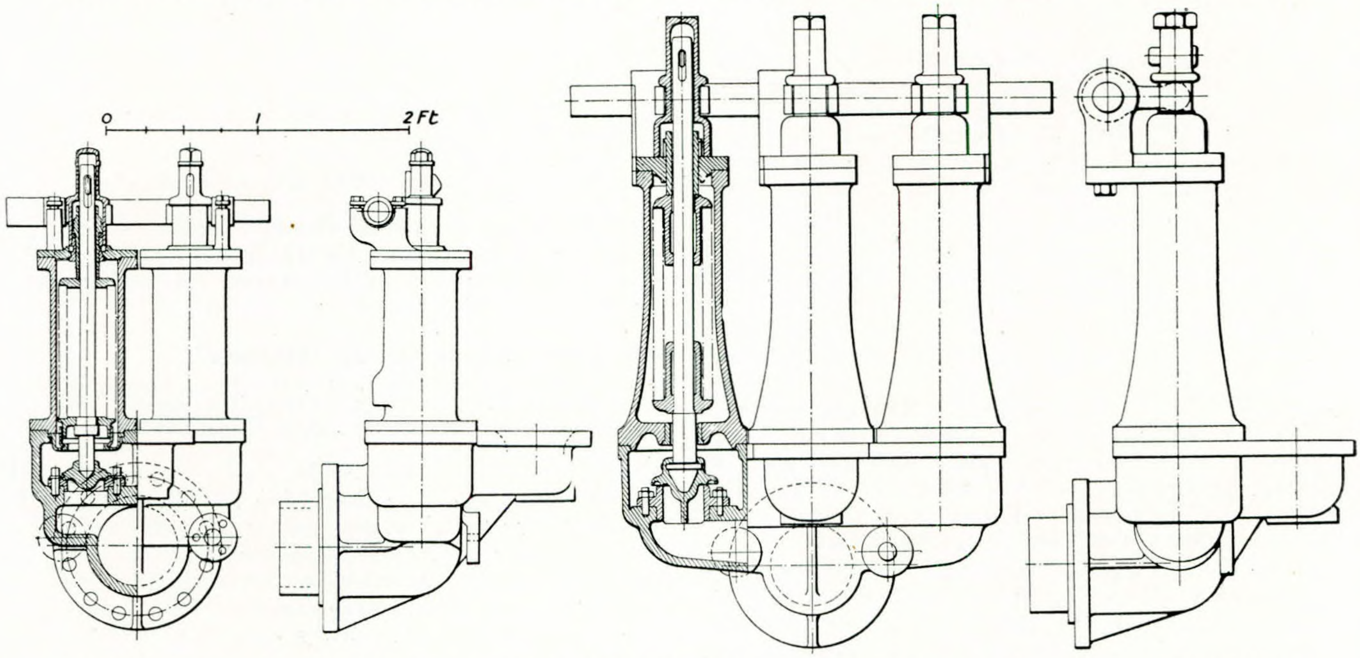
After a period of service with the White Star Line, it was found by the late Mr. Blake, the line's superintendent engineer, at Southampton, that there was a considerable steam wastage through the feathering of the safety valves, actually over 100 tons of water per 24 hours being lost through leakages. Translated into fuel consumption, this represented approximately 10 tons of oil per 24 hours. Additionally, the evaporators from time to time had to make up the water loss, again using fuel.

With a view to stopping or minimising this serious leakage, Mr. Blake decided to fit Cockburn-MacNicoll high-lift double safety valves to all the boilers, and these are also shown in our sketch. These 3in. double safety valves have a disc area of approximately one-third of the triple safety valves, and the smaller double chest and smaller diameter of valve, as compared with the original triple fitting, not only reduce distortion, but are considerably lighter and smaller than the original pre-war German valves.

A Cockburn 3in. double valve was then fitted and an accumulation trial carried out to one of the boilers under Board of Trade observation, in order to see that the valve could discharge all the steam that the boiler could generate without the steam pressure exceeding 10 per cent. of the working or blow-off pressure. This condition was successfully fulfilled, and during subsequent voyages the valve was found to be absolutely tight.

As a result of the satisfactory experience with this Cockburn-MacNicoll safety valve it was decided to return the German valve chests, blank off the centre valve seat, and fit Cockburn-MacNicoll improved high-lift safety valves and seats to the wing valves. New square section springs were adopted in place of the original round section springs. This alteration was made to the 47 German safety valves, and the vessel has been in service for some years with this conversion, which undoubtedly reduced the feathering losses. At the same time, there was still a considerable leakage, although the 3in. double valves remained consistently tight. In the triple chest there is a long flat bridge which accommodates the valves' seating, and it is virtually impossible to prevent this long flat surface from distorting and causing leakage. In view of this it has been decided to replace these converted valves with modern 3in. double cast steel Cockburn-MacNicoll high-lift safety valves.

The general construction of these valves is fairly well known to marine engineers, and so it is not proposed to give a description of the new fittings. Accompanying this article, however, is a drawing which not only shows the detail construction of the Cockburn-MacNicoll valves as adopted for the "Majestic", but also gives, to the same scale, the constructional features of the original safety valves. The reduction in size (and incidentally, weight) is considerable, it will be appreciated.



The new Cockburn-MacNicoll high-lift safety valves for the "Majestic" are shown on the left with the original German valves, to the same scale, alongside.

The Measurement of Frictional Wake.

"Engineering", 29th March, 1935.

A ship under way carries with her an envelope of water which is maintained in forward motion by the frictional resistance of the plating, and the viscosity of the water causes the layer in contact with the hull to entrain other successive layers, moving with velocities which decrease with increase of distance from the hull until the point is reached at which the transmitted frictional drag has no measurable effect upon the main body of water in which the vessel floats. The total thickness of the belt varies with the degree of roughness or fouling of the surface and also at different points around any particular immersed section, but always increases towards the stern and near the free surface of the water.

In 1929, Mr. G. S. Baker, O.B.E., Superintendent of the William Froude Tank, described before the North-East Coast Institution of Engineers and Shipbuilders a series of experiments with models and on two sea-going steamers, designed to evaluate the fore-and-aft flow conditions in the frictional belt. The investigation has since been continued with two further models, and also at sea on the cargo steamer "Ashworth" and the motorship "Pacific Trader", and a further paper on the results obtained was read by Mr. Baker before the same society on March 22nd. In the earlier series, the Pitot tubes were located in the forebody or about amidships. The later series was directed to the study of the flow around the afterbody, and especially to the effect of the free water surface and the form of the afterbody. The two new models, 21·6ft. long between perpendiculars, were similar in forebody lines, having vertical sides and a constant bilge radius at all sections. One No. 1112, had a wall-sided afterbody, almost identical with the forebody, but the other, No. 1113, was so formed that, at any given distance from the forward perpendicular, its half-section was equivalent to that of No. 1112 turned through 90°. The wetted surface was thus the same in both cases and its fore-and-aft disposition the same relatively to the free surface of the water. The models were towed at 4·3ft. and 6·5ft. per second, and the wake velocity measured by taking readings with extensible Pitot tubes of the total head and the pressure head of the water. As a test of the form effect the experiments gave only general indications, but the effect of the free water surface was clearly shown. The stream lines of the frictional wake were plotted and their effect upon the general flow at the stern examined; the results, when considered in conjunction with those of other investigators, giving reason to believe that, in time, it should be possible to reduce to exact knowledge the distribution of wake over the stern of a ship.

The full-scale tests with the "Ashworth" were in continuation of those previously made, and were made when the ship was homeward bound from Mauritius. She was then 242 days out of dock, the bottom being covered with about 6in. of "grass". It was found that the presence of this fouling added greatly to the width of the wake belt, the forward velocities of the water at any distance from the skin being increased by nearly 50 per cent. The readings plotted in the paper extended to 34in. from the skin and were taken to 304ft. from the forward perpendicular. The "Ashworth" being 400ft. long, this point is a little abaft the after end of the parallel body. The Pitot tube was immersed 5ft. The "Pacific Trader" (420ft. long between perpendiculars) carried two Pitot tubes, placed respectively 388ft. and 350ft. aft of the forward perpendicular, and 7·8ft. and 8·75ft. below still water surface. Two sets of readings were taken when the ship was, respectively, 2 days and 111 days out of dock. As with the "Ashworth", the effect of fouling was to widen the wake belt considerably. The maximum extension of the Pitot tube was 4ft., but this did not reach the fringe of the wake.

Steam Production.

By Sir John Dewrance, G.B.E.

"Engineering", May 3rd, 1935. Silver Jubilee Supplement.

The past twenty-five years of steam production must be looked upon as being the most important years in the history of that industry. There has been a steady improvement and approach to the theoretical heat cycle, by the employment of increased pressure and temperature heads, by the increased use of interstage feed heating, and by the obtainment of a flat efficiency curve throughout a wide range of load on the steam-generating unit. In 1910, the bulk of the boilers manufactured for land work were for pressures below 200lb. per square inch, a number being fitted with superheaters for a temperature of about 550° F., and an average output capacity below 15,000lb. per hour per unit. Electric generating stations of that day possessed only a few boilers for evaporations as high as 20,000lb. per hour, and in one or two instances only a pressure of 235lb. per square inch with a final temperature of about 650° F. As a measure of efficiency at that time, it may be taken that about 17,800 B.Th.U. were required per kilowatt-hour, whereas now there are plants requiring only 14,000 B.Th.U. or less.

In 1913, the Carville "B" Station of the North-East Coast Electric Supply Company advanced the pressure to 300lb. per square inch, which was followed in 1917 by North Tees "A" Station, of the same company, at 500lb. per square inch, whilst in 1922, Waukegan and Philo, Ohio, in the United States, took pressures to 650lb. per square inch, and in 1924, Great Britain supplied boilers for 800lb. per square inch in the first high-pressure power station in the world—at the Langerbrugge Station of the Société Anonyme d'Electricité de Flandres. Subsequent to this, the working pressure in the super-pressure power stations has increased to 1,100lb., 1,200lb., and 1,400lb. per square inch.

It will be appreciated, therefore, that European boiler practice has led the world in the matter of steam pressures, and the same is true of steam temperatures, and it is sufficient to record that Battersea Power Station, of the London Power Company, and a subsequent installation of the St. Denis Power Station, of the Société d'Electricité de Paris, are now in operation at a final steam temperature of 875° F. The capacity of these modern units has increased to the extent that 200,000lb. per hour is quite a normal output.

The year 1924 may be taken as approximately marking the successful introduction of pulverised fuel for steam-raising purposes, which led to a proper appreciation of the value of ample furnace volume for all methods of firing, so that the height from the grate to the boiler tubes has increased from the 5ft. to 6ft. of 1910, to as much as 23ft.

at the present day; and to take care of the larger capacities now common, travelling grate stokers as large as 33ft. wide by 20ft. long are now being installed, compared to a stoker 7ft. wide by 12ft. long, which would have been considered large in 1910. In addition, stokers have been improved so that the rate of fuel consumption has risen from 20lb. to 22lb. per square foot of grate per hour under natural or induced-draught conditions, to more than double this figure under forced-draught conditions.

The increase of furnace height of boilers necessitated a thorough investigation not only into the principles of combustion, but led to a more intimate knowledge of fuels and to a great appreciation of the ash-fusing temperature in its relation to permissible rates of heat liberation, amount of excess air, and heat absorption of the furnace. In order to reduce maintenance costs of these large furnaces, various methods of cooling the walls were tried, and the year 1924 may also be looked upon as denoting the introduction of the water-cooled furnace, out of which has emerged the predominant type of the fully-protected tube.

To meet the increases in steam pressure and temperature, much change has taken place in the design of boiler pressure parts, although the main principle remains the same. The sectionalised boiler still holds considerable advantages where high rates of evaporation and high steam pressures have to be utilised. Prior to the acceptance of high-pressure steam, riveted drums were utilised for the whole range of boiler design, but in spite of the fact that much satisfactory service has been obtained from such structures, the pressure range for riveted drums is limited by the plate thicknesses and rivet sizes which can be handled satisfactorily. Riveted drums were installed on the first three 800lb. per square inch units at Langerbrugge, and have given more than ten years' satisfactory service, but it is now generally considered that for over 550lb. per square inch, some other form of drum is desirable.

Seamless drums forged from a single ingot were introduced as far back as 1921, and have been utilised in boilers suitable for steam pressures as high as 2,200lb. per square inch. Such drums are forged from a single ingot, and in the case of the 1,420lb. per square inch boilers installed at the Dagenham plant of the Ford Motor Company, were as much as 45ft. in length, 48in. internal diameter, 5in. thick, and weighed in finished condition 62 tons—the ingots from which these were forged each weighed about 150 tons. For pressures in excess of 1,400lb. per square inch, drums made from special nickel-chrome-molybdenum steel have been used, it being possible by the use of this material to reduce the drum wall thickness to approximately one-half that which would be necessary in a drum for the same pressure made in the standard quality of a medium carbon steel. The production of seamless drums from large ingots is expensive, and, in consequence, the metallic-arc fusion-welded drum has been developed, made from medium-carbon steel plates, and capable of being put into service in a condition free from any of the inherent stresses which arise in the fabrication of a drum of the riveted type.

High steam temperatures have brought about considerable changes in superheater construction, and have necessitated the provision of single-tube lengths much in excess of the maximum length which it is possible to draw in the present-day tube mill. Means for joining together lengths of tube have been found in the process known as flash welding, so that it is now possible to make up tube lengths of even more than 150ft., which can be bent to form the multi-loop elements of which superheaters are now composed. Mild-steel tubes are being used for steam temperatures as high as 875° F., the temperature of the tube walls being maintained within a safe limit by the use of high steam velocities through the tubes and satisfactory steam distribution to the steam inlet headers supplying the tubes.

The increase in pressure has, of course, led to the use of mild-steel economisers in place of the cast-iron vertical-tube economisers which were such a familiar feature of the installations of 1910. Interstage feed heating has resulted in the feed water being supplied to the economiser inlet headers at temperatures as high as 350° F., and, in consequence, economisers have been introduced in which steam generation actually takes place. This condition has necessitated a marked advance in the design of economisers, which may now be built up from flash welded tubes and return head pieces incorporating only the well-known internal form of handhole joint for cleaning and inspection of the inside of the tubes.

The introduction of interstage feed heating has not only affected economiser design, but has also made it necessary to recuperate, by means of air-heaters. Early types were built on the tubular principle, in which hot gas passed through the tubes, and air for combustion around the tubes. Whilst this type has proved satisfactory as regards both design and maintenance, the maximum transfer rate available with normal resistance to the path of both air and gas is low, compared with the results obtainable with air-heaters of the plate type, and also of the rotary regenerative type. In consequence, in the very large steam-generating units installed in recent years, the latter types have been largely adopted, as in many cases the space required for the tubular type of air-heater has not been available. In the period under review very few radically new forms of boilers have been adopted, and the natural circulation boiler continues to hold the field. The necessity of supplying boilers with water as pure as possible is more and more appreciated, and a large industry has developed for the manufacture of apparatus for purifying feedwater. In spite of the development of other forms of power the production of steam has continuously increased, till it is more than twice as great as it was when His Majesty came to the Throne.