The INSTITUTE of MARINE ENGINEERS

Founded 1889. Incorporated by Royal Charter, 1933.

SESSION 1947. *Transactions* Vol. LIX. No. 8.

Patron : His Majesty The King. President : Sir Amos L. Ayre, K.B.E., D.Sc.

THE PRESIDENT'S ADDRESS.

By Sir AMOS L. AYRE, K.B.E., D.Sc.

Delivered on Tuesday, September 9th, 1947, at 5.30 p.m. at 85, Minories, E.C.3.

Chairman: W. Sampson (Chairman of Council).

Mr. Chairman of Council and Gentlemen,

That I should have been asked to continue as your President for a second year was an honour which I much appreciated and would now acknowledge. I thank the membership for their renewed confidence.

On the occasion of making an address last year, I endeavoured to cover some of the technical features of marine engineering as I had seen them from my particular angle in the industry. These were mostly matters that affected us in a close and particular sense. Having regard to the future economic outlook for this country, I have felt it appropriate to the present occasion to refer to some matters rather more of a general nature, but which also have a profound influence on the industries—not unimportant in the national aspect—in which we serve.

The building of ships and their engines has not, in our past experience, been an industry free from anxiety as to the course of its trade and employment. No other industry has known such violent fluctuations in the course of the trade cycle. We have had the bitter experience, as recently as the year 1933, of a demand for our services in shipbuilding and marine engineering falling as low as only about five or six per cent. of the capacity of the available physical means of production. The experience of the shipping industry has also been one of very severe fluctuations in the demand for its services, resulting, from time to time, in abnormal amounts of tonnage having to be laid-up. Our inability to sell abroad our staple product, coal, has brought about an increasing proportion of ballast voyages. For all these reasons, we must more than ever be concerned for the future. It is not the time to prophesy slumps, either minor or major, but it is the time to consider the possible ultimate post-war condition and to benefit from the knowledge of the experiences of those conditions that followed the short period of high demand that occurred after the 1914-18 war.

The contribution which an Institute such as ours makes in opposition to trade recession, is that form of research out of which is achieved valuable technological progress or advancement in design, production and operation, so bringing about greater efficiency and economy in the service performed, and a consequent stimulation of new demand for same.

An item of duty for your President is not only generally to follow all the various subjects of technical interest and the references to the general activities of the Institute that are referred to in our published transactions, but, particularly, to take close note of the papers which are read and criticised at the ordinary meetings. Whilst I cannot lay any claim to being fully versed in the marine engineering side of our science, a modest general knowledge has enabled me to realise the very high quality of the papers which the Institute has been grateful to receive and proud to include in its records, many of which contributions have been of profound value.

The extent of thought, study, research and the long hours given to the various subjects that have been presented to us for consideration, as indeed applies to the many others of our scientific societies, is such that one wonders if the part played by such institutions to the great and vital interest of our industries and their maintenance and expansion, is generally realised. The opportunity which is so provided for discussion and collective thought has, in fact, a most valuable effect on the economics of this nation in which the scientific institution has for so long been so closely linked with industry.

In these days those whose lives are given in such manner, so intensely and devotedly to the application of science in the technical and practical planning and development of industry, have frequently to listen to others whose life experience and current interest is only academic or political and without any knowledge or experience in the technical problems of production, but who would, nevertheless, direct how things should be planned and done. One feels that some of them should examine the transactions of our scientific institutions if only to obtain a general indication of what is involved in that vital background of all industry, and the real dependence of each industry on those of its participants who, by hard work, learning, training, and experience, have thereby attained the qualification technically to direct and administer.

As in the case of all of our national industries, whether large or small, such outside critics would be surprised to learn of the thought and care which is given to the science and practice of marine engineering, and the time that is given to its constant development under conditions in which shorter working weeks do not apply in the exertion of all that effort to keep abreast of the times. It is usually a condition of continuous intensive study in the solution of problems throughout a seven-day week and with the aid of much "midnight oil". Without such devotion, industry could not, in fact, develop and prosper.

If nationalisation of some of our industries is to be successful, those who bring it about must have regard to such features. Merely to have had experience in a sectional part of an industry is not sufficient; it is vitally essential that those who are put in the new positions of authority must have had comprehensive training, experience and proved ability. Without such attributes, which means full scientific knowledge covering the design of the particular product, all the technical and economic ramifications of its production, the commercial aspects which commence with the purchase of the raw materials, and finally the selling of the product in the world's markets, those who are put in authority must inevitably fail, with accompanying disastrous consequences nationally.

British industry has a valuable goodwill in many of the markets to which we export, in the feature that considerable faith is held in the dependability that can be placed on British technical knowledge and ability as has been derived from the intensive thought, study and research such as is seen in the contributions that are made to our scientific societies, and which have emerged from personal enterprise and initiative. Should any of our newer methods of dealing with the administration of our basic industries destroy that enterprise and initiative of the individual, it will be a sorry day for this country, depending for its life and welfare, as it does most vitally, on the efficiency of its exporting industries.

The wealth of a nation normally lies in that which is produced from its soil by way of agriculture or by mining. On these largely depend the maintenance of its people, either directly or by the indirect manner in which some of its surplus of such natural products provides the means of payment for those other materials that can only be obtained as imports from other nations. We have nothing of an agricultural nature to export and, in fact, fall far short of feeding ourselves. The coal which was hewn out of our soil, in excess of our home needs, used to be a most valuable export and went a long way in meeting payments for our imported foreign food. This condition of exchange no longer applies and we are, therefore, left with practically only two outstanding means with which to meet our foreign payments, these being:

(a) the labour and general production content of our manufactures, many of which at the first stage depend on imported raw materials;

(b) the various services performed on behalf of other nations, usually termed "invisible exports", to which our shipping industry normally makes a most important contribution.

Our present inability to export our natural product, coal, calls for every effort to increase the two remaining principal items. If we are to maintain our existence on this densely populated island, there must, without any further delay be a keen recognition by all of the hard fundamentals of our national economy. We must re-assert our British initiative, enterprise and adventure. Those in positions of leadership must realise their very serious responsibility and boldly tell the naked truth to those they lead. This will mean that making a fetish of merely academic theses, without regard for the hard facts of the fundamentals of our existence on this island, must cease. There are many to-day, carrying what may turn out to have been a terrible responsibility, who should pause to think of where, apparently for the sake of temporary popularity, they are leading.

There would seem to be little desire to benefit from the knowledge that was provided by our experiences following the 1914-18 war, particularly those which emerged on the termination of the sellers' market, which condition we are now told might again be near at hand. In recent times we have heard much concerning the vital need to increase the volume of our exports, but little has been said as to the ability to export being ultimately dependent on the price of our products. If our production cost, compared with that of our competitors, is too high, the volume will actually fall. It is this feature on which emphasis should be placed as the first rational step towards the effort to increase the volume of our exports. Whilst we can place much dependence on the ultimate commonsense of the British people, the mustering of such thought must not be delayed until shocks, similar to those that were experienced at the end of the rake's progress we lived through during the inter-war period, particularly in 1921 and again in 1931, occur. In the case of 1931, it was fortunate for us that the world possessed large stocks of foodstuffs and the exporting countries were willing to accept our depreciated sterling for these, but that fortuitous relationship of conditions might not again apply. Steps should be taken now to prepare against the universal condition of a buyer's market that will inevitably emerge, and perhaps as suddenly and unannounced as it did after the first world war. The elementary fact that this country's ability to support its relatively large population depends on efficient and economical production must be realised by all if we are to survive.

The effect of a shorter working week also calls for very serious thought. Even with the 47-hour week, assuming no absenteeism, the capital assets of plant, buildings and machinery, in an industry working on a one-shift basis, were only in operation for 28 per cent. of the total time available. A week of 44 hours reduces the net time to 26 per cent. Productive plant that now ceases its five-day operation on a Friday evening, remains dormant for over 60 hours before the restart on Monday. Under such conditions there is the need more than ever to make the fullest use of methods of production based on the scientific researches and studies of those whose responsibility it is technically to direct, and all traditional restriction should make way for their introduction.

At the same time, because of the many current handicaps in our efforts to export our products, and which it must be our constant effort to overcome, our invisible exports become more than ever vital and important. Having regard to the large part that can be played by our shipping industry relative to this item, this Institute has a particular interest. But it is somewhat remarkable that amongst all the speeches and debates of recent times as to the need to redress the balance of trade, nothing has been developed in regard to the advisability of extending to the utmost the contribution of our shipping services. In this connection it is sad to think that, because of the shortage of materials, our deliveries of new ships during the twelve months to 30th June, 1947, fell short of the programme which the industry had planned, by more than half a million gross tons. In the succeeding twelve months the fall will be even greater unless there is an immediate improvement in all supplies.

A further point to remember is that there are now more competing countries to contend with than in 1939 when the U.K. portion of the world total of tonnage afloat was about 26 per cent. Our proportion is now only about 20 per cent., whilst more and more countries whose fundamental economics do not lend themselves to engaging in maritime transport nevertheless pronounce their intentions of building up merchant fleets capable of carrying fifty per cent. of their imports and exports under their own flags. This is a doctrine under which the other countries that now provide the maritime transport services would be prevented from earning the necessary amount of foreign exchange with which to buy the products of the same nations that aspire to the conditions given in such pronouncements.

In the midst of all the economic difficulties at this time the importance of earning as much of our living as possible by way of providing shipping services to other countries has become very great, and as marine engineers we must continue to design and produce the very best possible so that this island country may continue to be a large and efficient maritime nation, and by so doing we will have the satisfaction of contributing our professional and industrial portion to the national welfare.

Mr. W. Sampson (Chairman of Council), opening the proceedings at the General Meeting at which the foregoing Address was presented, said that it would be with great pleasure that members would listen to a second Presidential Address by Sir Amos Ayre.

When he accepted office for the second year it was possible that the President had not realized that he would be asked to deliver another Address. However, with a thoroughness that was typical, he had prepared an Address which he (the Chairman) was sure they were all eager to hear. He would therefore now call upon Sir Amos to deliver it.

Mr. W. Sampson (Chairman of Council), at the conclusion of the Address, said that he was sure they would recognise that the President had just delivered a direct sequel to the brilliant Address he had delivered to them last year. Then he had summed up the great progress that had been made in marine engineering and had indicated, with his typical long vision, the paths by which future engineering advances should proceed, and the whole Address had been very stimulating indeed to all marine engineers.

His present Address, however, was particularly timely at this juncture in the nation's affairs, and had been written with intense earnestness and a sense of urgency in every paragraph.

Engineers were shown that not only must they progress technically but they should apply the whole of their experience and skill to help solve the present economic difficulties, and he felt sure that every member of the Institute, and all engaged in shipowning, shipbuilding and engineering, would take action to apply the sane and urgent advice which the President had given.

It was with most sincere feeling that he proposed a vote of thanks to their President, Sir Amos Ayre, and he would call upon Mr. Craig to second this motion.

Mr. R. K. Craig (Vice-Chairman of Council), seconding, said that the President had delivered a very significant and interesting Address on the economic situation of the country and particularly on the aspects of this situation which had bearing on the activities of their profession, and he had great pleasure in seconding the vote of thanks proposed by the Chairman.

The President, rising in response to the enthusiastic applause with which the vote of thanks was received, thanked the Chairman and Vice-Chairman for their kind remarks and the members for the manner in which they had been received.

He apologised that a good portion of his Address was concerned with a subject which had been rather hackneyed in recent times, but in that connection he would point out that when he had been asked to continue as President for another year the thing which had deterred him, as the Chairman remarked, was the prospect of having to write another Presidential Address. Therefore, before he had succumbed to pressure he sat down and wrote out the headings of the sort of things he might write about, and those headings formed the Address which he had just delivered.

Design of Stacks to Minimize Smoke Nuisance.*

By Robert W. Nolan[1]

Background.

The funnel has come to occupy a unique position in the design of a ship. So much importance has been attached to its appearance that, in many respects, it has taken on the functions of the figurehead of the old-time sailing ship. The figurehead however, was entirely symbolic and the artist could have a free hand, although the results achieved sometimes cast doubt on the use of the word artist. The funnel, on the other hand, has a basic engineering function which must be fulfilled. This function is to discharge the products of combustion in such a manner that they will stay clear of the ship. The stacks on many ships built in recent years have failed to meet this requirement and objectionable quantities of gas and soot have come down on deck and sometimes entered the ventilation system. This results in soiled clothing and dissatisfaction of the passengers, and greater cleaning effort on the part of the crew. If sulphur fumes from the stack get into the ventilation system, the situation is both disagreeable and unheathful.

In ships built forty or more years ago, smoke stacks were what the name implied and nothing more. They were high for the purpose of obtaining at least enough natural draught to keep the firebox under negative pressure. The "Mongolia", built in 1904, is typical of the ships of that era. Her stack stood 52 feet above the fidley and 94 feet above the water. The smoke velocity was about 12 feet per second. No smoke nuisance was encountered on this ship and the author does not know of any on contemporary ships of similar design.

The "Mongolia" had eight Scotch boilers and it was not difficult to bring the uptakes together into a single stack. On the high-powered ships of that day, however, the situation was different. The "Lusitania", for example, had boilers spread over a fore and aft distance of 336 feet. Since it was impractical to bring all the uptakes together, the use of four stacks was a practical engineering expedient. A similar situation existed on many large ships such as the "Deutschland", "Aquitania", "France" and others. Soon the public came to associate multiple stacks with large fast ships. The more stacks the better the ship, and even the immigrants are said to have been quite particular about the number. Since streamlining was unheard of at that time, there was no objection to the high stacks which were used. In fact, in most ships built before 1914 the fidley top was about halfway between the water and the top of the stack.

When water-tube boilers began to supplant Scotch boilers and machinery became more compact, it was possible to develop sufficient power in a much smaller space. The most powerful ships needed only two stacks and those of moderate power usually only one. With such strong prejudices well established in the public mind, however, it was only natural that shipowners would hesitate to tamper with anything as sacred as the number of stacks. Nevertheless, progress could not be denied entirely. The four stacker is gone and probably the last three stacker has been built. A prospective passenger no longer counts the number of stacks, although the author knows of one such instance as late as 1935. This change of attitude required a number of years and in the meantime the expedient of using a dummy stack became quite common. This practice started quite early, the "Imperator" (1912) and "Titanic" (1911) each using one dummy stack.

With the decrease in number of stacks, designers began to increase the girth and decrease the height. What the designers had in mind is of course a matter of guesswork, but apparently they tried to compensate with mass for the lack in numbers. The decrease in height began during the twenties and reflects the influence of automobile and aircraft design. This trend gained momentum during the thirties with the result that a number of smoky ships were built. The British alone have opposed this change and held to their high stacks; for example, the "Queen Mary".

Finally, the streamline era has come. People associate speed

TABLE 1

Item	Ship	Date	Horse-power	Gross tons	Length b.p. (L), ft.	Speed, knots	Approx. outer stack section, ft.	Number of stacks total	Number of stacks active	Fidley height above water, hf	Stack height above water, hs	Stack height above fidley	Ratio hs/L	Ratio hs/hf	Smoke velocity (S), fps	Smoke velocity ÷ wind velocity,*a* S/W
1	"Deutschland" ...	1900	36,000	16,500	663	23·5	....	4	4	39	84	45	0·127	2·15	...	...
2	"Mongolia" ...	1904	10,000	13,600	600	16	11·75×15·25	1	1	42	94	52	0·157	2·24	12·3	0·45
3	"Lusitania" ...	1907	70,000	30,800	760	25·5	16·6 ×23·6	4	4	53	117	64	0·154	2·21	9·3	0·22
4	"Imperator" ...	1912	62,000	52,200	884	22	....	3	2	80	150	70	0·170	1·88	...	...
5	"Aquitania" ...	1914	56,000	45,600	869	23·5	17·5 ×24	4	4	66	126	60	0·145	1·91	8·1	0·20
6	"California" ...	1928	17,000	20,200	575	18	19 ×24	2	1	57	98	41	0·170	1·72	7·4	0·24
7	"Europa"	1928	90,000	49,700	890	26·25	20 ×47·5	2	2	85	114	29	0·128	1·34	11·2	0·25
8	"Talamanca" ...	1931	11,000	7,000	415	17·5	12 ×17	1	1	37	79	42	0·191	2·13	10·5	0·35
9	"Lurline"	1932	22,000	18,000	605	20·5	17·5 ×25·5	2	2	62	102	40	0·169	1·64	8·7	0·25
10	"Queen Mary" ...	1936	200,000	81,200	975	30	20 ×35	3	3	86	142	56	0·146	1·65	17·3	0·34
11	"America"	1940	34,000	26,500	664	22·75	20·5 ×42	2	1	65	113	48	0·170	1·74	28·6	0·74
12	"President Monroe" (C-3 type ship) ...	1940	8,500	9,300	465	16·5	18 ×35	1	1	49	76	27	0·163	1·55	13·4	0·48
13	Liberty ships ...	1941	2,500	7,200	417	11·5	9 ×11	1	1	33	53	20	0·127	1·60	15·6	0·80
14	Victory ships ...	1943	6,000	7,600	437	15·5	9·83×12	1	1	34	62	28	0·142	1·82	15·4	0·59

a Assuming wind velocity W to be equal to ship speed in feet per second.

* Paper presented at the November, 1946 meetings of the Society of Naval Architects and Marine Engineers, New York, and reproduced by kind permission of the Council of the Society.

[1] Engineering Technical Division, Newport News Shipbuilding and Dry Dock Company, Newport News, Va.

Mr. Nolan was born in Albany, N.Y., in 1906 and graduated from Rensselaer Polytechnic Institute in 1928 with the degree of Civil Engineer. Since August, 1928 he has been employed in the Engineering Department of the Newport News Shipbuilding and Dry Dock Company with the exception of four months in 1930 when he served in the engine-room crew of the S.S "President Fillmore". He is a member of the Society of the Sigma Xi.

with the appearance of the airplane and the streamline train. This idea has become so well rooted that even such sedentary articles as refrigerators and furniture are given lines that suggest speed. It is only natural that sooner or later this trend should affect ship design. At the present time a number of streamline designs have been proposed for post-war ships. In most of these, the stack has been cut down to a mere suggestion.

Information on stack proportions of some typical ships built between 1900 and 1943 is shown in Table 1. Some of the dimensions are only approximate, having been scaled from photographs.

Fig. 1 (a) shows a model of the S.S. "America".

Object and Scope of Investigation.

The question of what is artistic, and what is not, is a matter of opinion and is beyond the scope of this paper. How far the engineer can go safely in compromising with the artist and what expedients will help to keep smoke clear of the ship are the subjects under consideration. In order to reduce the guesswork involved in proportioning stacks, the Newport News Shipbuilding and Dry Dock Company recently undertook a series of tests. An extensive investigation by the United States Maritime Commission also has been under way for several years. At the present time, the investigation at Newport News is only well started and much of the effort, to date, has been spent in overcoming numerous obstacles which arose in connection with testing procedure. These problems will be discussed in the following pages. The influence of the more fundamental factors affecting stack performance, however, has been determined. Since so many ships are being designed now, it was felt that the results of these tests should be published without waiting for completion of the programme. This paper is, therefore, more in the nature of a preliminary report. It is hoped that the discussion by the members of the Society will bring out numerous unreported data on the stack performance of ships at sea under adverse conditions.

The Newport News tests have been confined to the gaseous and finely divided products of combustion rather than the coarse particles which sometimes come from stacks. Nevertheless, the tests do have some value in dealing with problems of coarse material, in that the expedients which are used in dealing with gases will also improve conditions with coarse particles. Coarse particles, however, settle faster and therefore require more drastic treatment.

No attempt has been made to investigate the various methods of removing solids from the stack gases, although some of these methods will be discussed briefly.

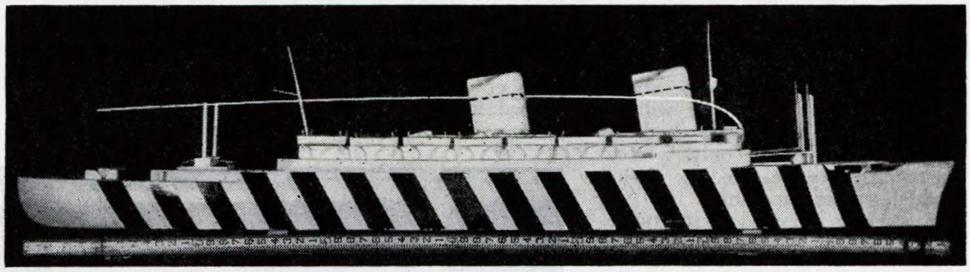
Apparatus and Methods.

The tests have been conducted principally by placing ship models in a wind tunnel and discharging the proper quantity of smoke through the stacks. The wind tunnel is of simple construction. The bellmouth entrance, 10 feet $9\frac{1}{2}$ inches by 12 feet $9\frac{1}{2}$ inches, is covered by window screening plus seven layers of cheesecloth. The pressure drop through the cheesecloth (about 0·10 inch) eliminates coarse-grained turbulence from the entering air. The test section was orginally 4 feet by 6 feet but it has been decreased to 3 feet 2in. by 4 feet 6in. in order to obtain higher wind velocities.

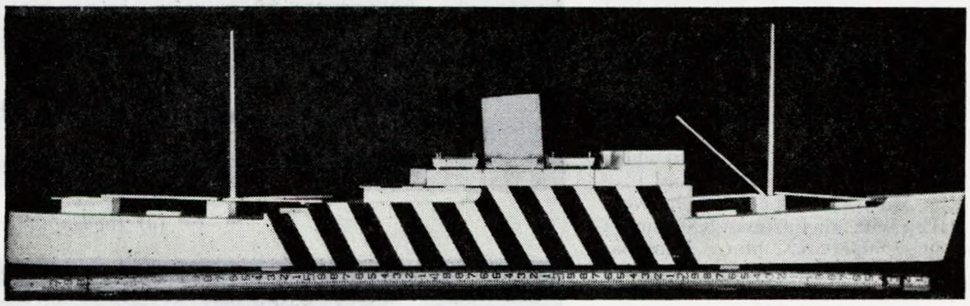
The fan, which is rated at 50,000 cu. feet per minute at 0·5in. water pressure, is driven by a constant-speed motor. The air velocity is varied by means of a screw-operated cone valve installed in the discharge trunk. The maximum velocity with the reduced tunnel cross-section is 50 feet per second.

The smoke is produced in a 4-in. diameter steel cylinder with a hinged cover. To operate, it is filled with fine wood shavings (usually pine) and lighted. After the lid is clamped on, the desired quantity of air is supplied through a hose connection near the top. Orifices in the air line are used to meter the air (and consequently the smoke). A tar trap is mounted directly under the cylinder and the assembly is cooled by placing it in a tank of water. The smoke is led to the model through a flexible metallic hose.

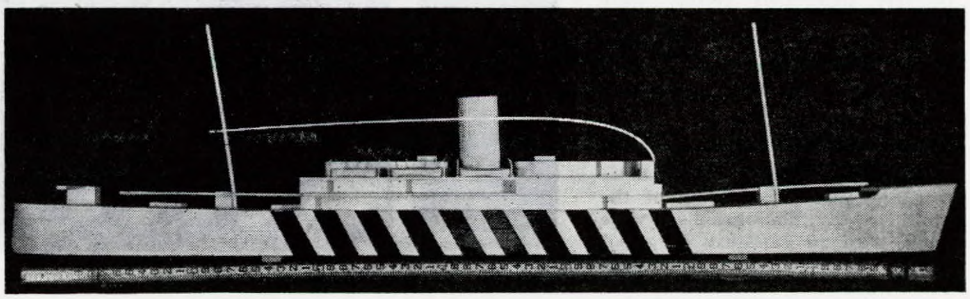
Models were made of the hulls above the waterline. The S.S. "America" was chosen for the first investigation because she was a ship on which smoke trouble had occurred and had been corrected by raising the stack 15 feet. The model was built to a scale of $\frac{1}{8}$ inch to the foot (1 to 96). A reasonable amount of detail such



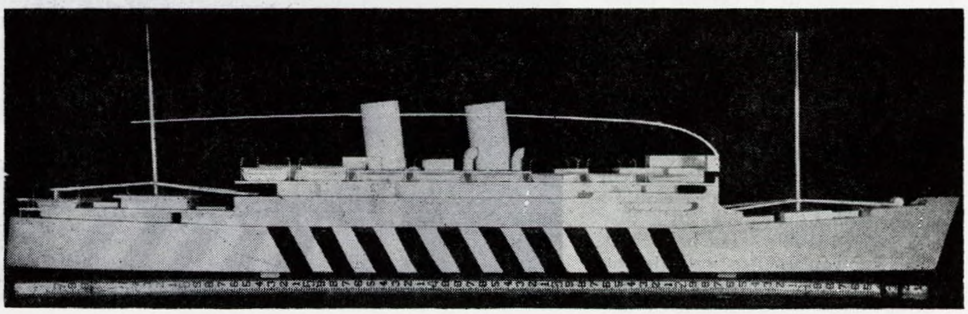
(*a*) *"America".*



(*b*) *Proposed ship—P.S. 1633.*



(*c*) *"Talamanca" superstructure mounted on hull of P.S. 1633.*



(*d*) *"California" superstructure mounted on hull of P.S. 1633.*

FIG. 1.—*Models used for smoke tests.*

as lifeboats, deckhouses, masts, booms and rigging was included because it was realized that such appendages might have an important effect on the performance. Rigging was omitted from later models because it collected considerable tar from the smoke. A model of a proposed passenger and cargo ship of 14,700 tons displacement, hereafter designated as P.S. 1633, was built to a scale of $\frac{3}{16}$ inch to the foot. This gives a hull length the same as the S.S. "America" model. The superstructure of this model was made removable so that it could be replaced by a superstructure representing the S.S "Talamanca" (United Fruit Company) or the S.S. "California" (now the "Uruguay"). The "Talamanca" and "California" were studied because they had been in service a number of years and were considered satisfactory. In simulating these two ships, it is believed that no appreciable error will be introduced by the discrepancies which result from using the hull of another ship. Photographs showing the profiles of the four models are shown in Figs 1 (a) through 1 (d). The line drawn above the superstructure on three of the models is used to illustrate test results which are discussed later. Stack openings were made to scale so that the smoke plume would simulate that on the ship. A number of stack models were made, and some of them will be described in connection with the tests in which they were used.

In most tests, only a few instruments were needed. Wind velocity was measured by an anemometer mounted in the tunnel and operated by wires. Smoke velocities were determined by the orifices in the air supply line to the smoke generator. A check of the smoke temperature indicated that it was usually about 130 deg. F. Since the effect of velocity was not too critical, no attempt was made to correct the volume for the effect of temperature or the presence of the products of combustion except in the tests which were run at 300 and 500 deg. F.

Most of the photographs were taken with an Eastman 620 camera using Super XX film. Illumination was obtained by five number 2 photoflood bulbs placed on the tunnel floor, behind the smoke. In a few cases, where exposures of less than 0·01 second were desired a speed graphic camera was used.

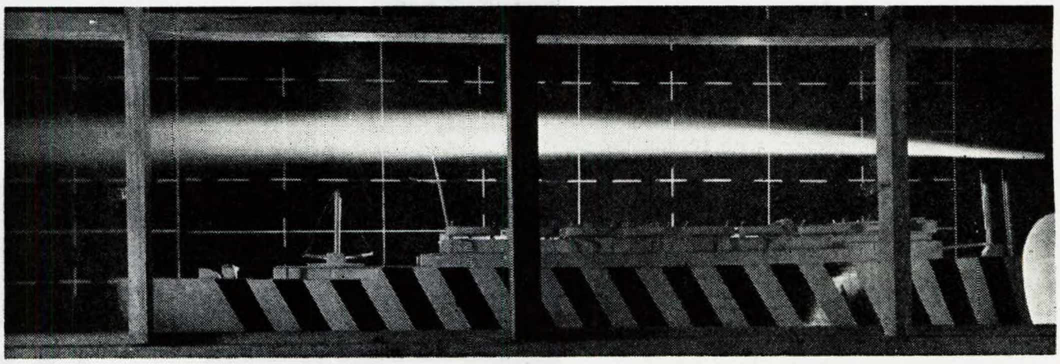
For studying turbulence, wires were strung from the model to the roof of the tunnel. No. 30 white cotton threads, 5in. long were cemented to the wires at 2-in. intervals. The whipping of these threads gave an indication of the turbulence. Photographs were taken with an exposure of about 0·2 second.

Another method used for determining the location of turbulent regions was to release a single jet of smoke at a certain point. The smoke jet was discharged from a ½-in. dia. round nozzle attached to the end of a ¾-in. pipe. The nozzle discharged in the direction of the air flow, at a velocity a little above that of the air. The riser which carried the smoke to the nozzle was carefully faired, and was located 18in. upstream so that it would cause as little disturbance as possible. The behaviour of the jet was used to indicate the location of the turbulent regions.

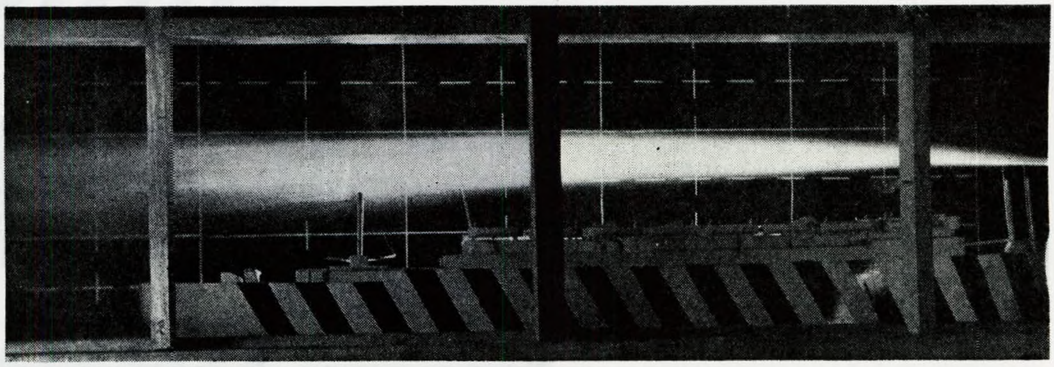
Most ships' superstructures are roughly rectangular in shape. In order to study the flow around a superstructure without the complication of the hull or of small details, tests were run with a series of rectangular wood blocks of varying height. These were 11½in. by 29in. and the heights were varied from 3 to 10in. The smoke usually was released a few inches aft of the forward edge of the block. From this point it spread throughout the turbulent region.

Turbulent Air Flow.

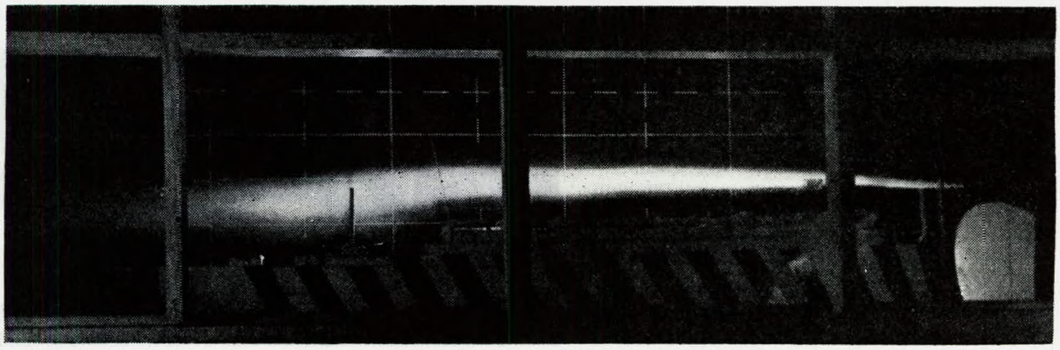
The subject of turbulence is very complex and no attempt was made to measure it quantitatively in this investigation. The following short discussion is not intended to be a text on the subject, but is merely to clarify certain aspects of the smoke-flow problem. When flow is turbulent, there are a number of vortices which consist of rotating masses of air. This rotation produces velocity components at right angles to the main flow. The type of turbulence caused by small wires or a fine screen is known as fine-grained turbulence. Smoke which is present in an air stream with fine-grained turbulence will flow along without much spreading. On the other hand, large bluff bodies, such as the pilot house of a ship, produce coarse-grained turbulence. A smoke jet which is released in a region of coarse-grained turbulence will spread out over a wide area instead of remaining as a narrow jet. In some locations the smoke even may be carried in a direction opposite to that of the main stream.



(*a*) *Jet height 15 inches.*



(*b*) *Jet height 14 inches.*



(*c*) *Jet height 12 inches.*

FIG. 2.—*Smoke jet technique applied to model of "America", wind dead-ahead, 30 feet per second.*

This type of flow is found directly behind a deckhouse which ends abruptly, and also above and just behind a vertical obstruction such as a pilot house. In these two cases, a large vortex forms and remains in one place. In other instances, a series of vortices may detach themselves from a fixed obstacle, such as a mast or stack, and move along with the stream so that an observer stationed at a fixed point will see an irregularly fluctuating flow. The fluttering of flags is an example of this. Both types of flow are encountered around the hull of a ship.

Nomenclature.

The following nomenclature will be used throughout this paper:

Symbol.	Quantity.	Unit
V	Velocity	feet per second
L	Length (or some other linear dimension as noted)	feet
D	Diameter (in the case of a stack, D represents the fore and aft dimensions)	feet
v	Kinematic viscosity	feet squared per second
Rn	Reynolds number	dimensionless
S	Smoke velocity leaving stack ...	feet per second
W	Wind velocity relative to stack ...	feet per second
H	Velocity head corresponding to W	pounds per square foot
hs	Height of top of stack above water	feet
hf	Height of fidley top above water	feet

Process by which Smoke Reaches the Deck.

In order to understand how smoke is brought down to a ship's deck, it is necessary to study the behaviour of the air currents around the ship. The use of threads, which has been described, is quite helpful. This method was applied to the S.S. "America". In this test the stacks were removed from the model. We have found that their effect on the flow pattern around the ship is rather local and prefer to consider the performance of hull and stack separately before combining them. The turbulence decreases with an increase in distance from the hull.

The amount of whipping of the threads at any point is an indication of the magnitude of the turbulence. The threads give an interesting picture of the gradual transition from coarse to fine-grained turbulence but they do not tell what degree of turbulence will cause trouble by bringing down the smoke, and what degree can be tolerated. To investigate this, the smoke jet technique is useful. The series of photographs in Figs. 2 (a) through 2 (c) shows this procedure applied to the S.S. "America" model. In Fig. 2 (a) the jet is released 15in. above the wind tunnel floor and continues over the model as a distinct jet, although it curves some in following the flow lines. Some spreading of the jet, due to fine-grained turbulence, can be observed. When the jet is released at an elevation of 14in., the upper boundary is still well defined but smoke is beginning to break away from the lower side and diffuse downward. It thus appears that the lower edge of this jet is at the elevation where turbulence is becoming important. In the next photograph, the smoke jet, which was released at an elevation of 12in., comes down on the stern of the ship. By repeated application of this technique, the boundaries of the region of harmful turbulence for the model can be determined. Any smoke which finds its way into this region will be carried down rapidly and, unless it is quite far aft, it will reach the deck.

So far, the stack has been ignored, because its effect is local. The fact that the influence of the stack is local, however, does not mean that it is unimportant. When air flows past a cylinder whose axis is perpendicular to the direction of flow, there is an increase of pressure at the front of the cylinder and a decrease at the sides and back. If the cylinder is of finite length as in the case of a ship's stack, air from the region of increased pressure will flow over the top and down into the low-pressure region at the back. When smoke is discharging from the stack, some of it will be drawn down into this low-pressure zone. In this report, the term "downwash" will be used to designate the down-flow of smoke behind a stack. The extent of the downwash is governed by a number of factors among which are stack shape, wind velocity and smoke velocity.

By superimposing the flow pattern of the stack upon that surrounding the hull, the overall picture is obtained. The stack causes a certain amount of downwash, which in some cases may be considerable. If this downwash carries the smoke into the turbulent region surrounding the hull, smoke will be brought down to the deck. If, on the other hand, the downwash does not take the smoke down far enough to reach the turbulent zone, it will float clear of the ship, much to the advantage of all on board.

The Problem of Similarity.

Comparison with Towing Tests.

The use of any model test is based upon the assumption that the behaviour of the model resembles the behaviour of the prototype sufficiently closely for the purposes of the test. Since the determination of ship resistance by model tests is familiar to most naval architects and marine engineers, a brief review of the similarity problems involved will aid considerably in understanding the similarity problems of smoke testing. The resistance of a ship is made up of the two factors, wave-making resistance and skin friction. For wave formation, and consequently wave-making resistance, of model and ship to be similar, the speed-length ratio ($V \div \sqrt{L}$, where V= speed and L=length) must be the same for both. The skin friction, on the other hand, is governed by the Reynolds number ($VL \div v$, where v is the kinematic viscosity of the water). It is impractical to try to meet both of these requirements in a single test. The established procedure, in this case, is to determine the wave-making resistance by running at the correct speed-length ratio, and then calculate the error in skin friction which results from not using the correct Reynolds number. Since many years of application of this method have shown that it gives sufficiently accurate results, naval architects use it with confidence.

The situation with respect to smoke tests is less fortunate because the practice of testing models with smoke is relatively new, and there is no well-established correlation between the model test and the actual ship as in the case of towing tests. The speed-length ratio has no application in smoke testing because the air has no free boundary on which to form waves.

The criteria of similarity for smoke tests will be discussed in the sections which follow.

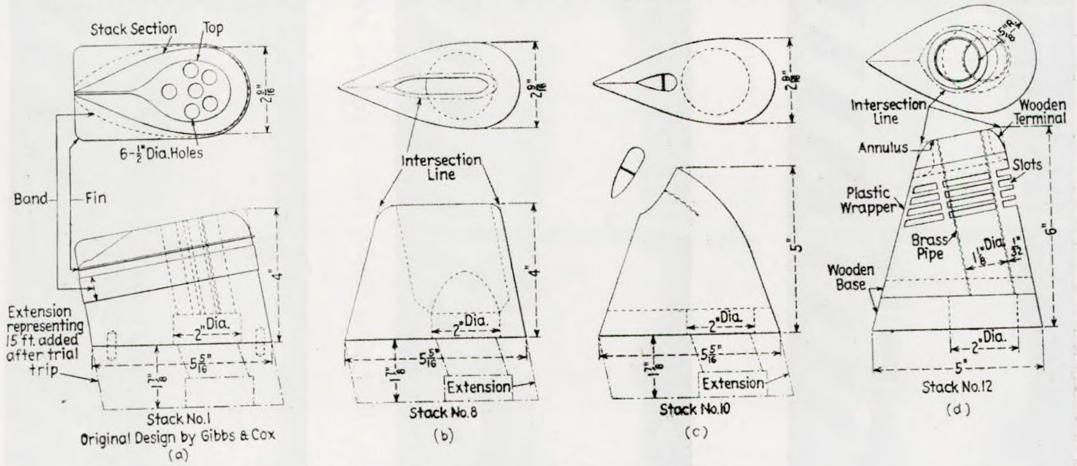
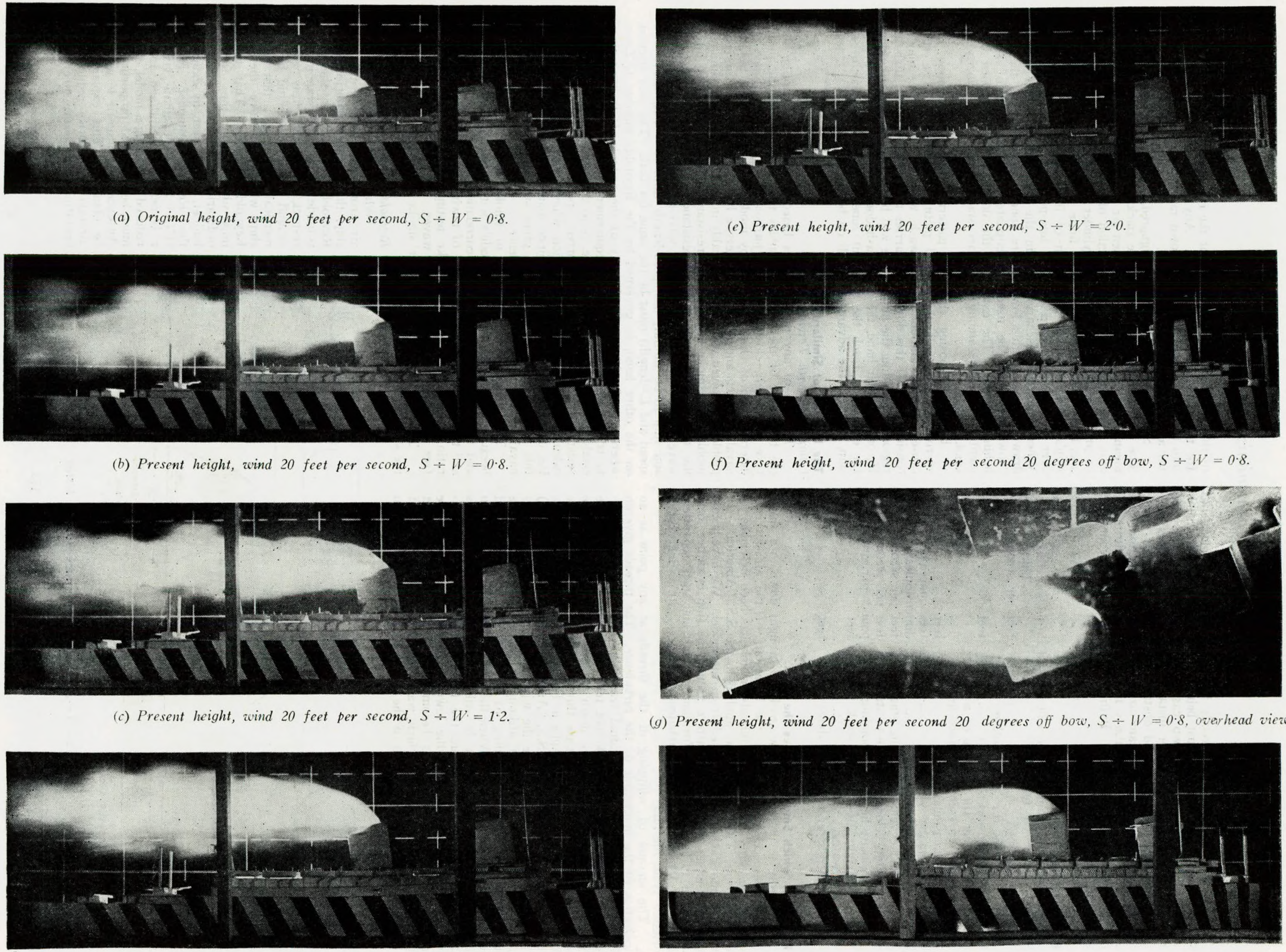


FIG. 3.—*Four of the 14 stack models tested.*

Reynolds Number for Stack Tests.

When dealing with the flow of air around an object such as a ship, the accepted criterion is the Reynolds number. If the model is made accurately to scale in every respect, then the flow pattern around the model should be geometrically similar to that of the ship when both have the same Reynolds number. That this is impossible, with the facilities ordinarily available to a shipbuilder, can be seen by examining the Reynolds number formula ($VL \div v$). The kinematic viscosity v is nearly constant and, if L is reduced by making a model, then V must be increased proportionately. An excessive value of V will thus be obtained. This explains why aircraft laboratories reduce v by operating variable-pressure tunnels



(a) *Original height, wind 20 feet per second,* $S \div W = 0{\cdot}8$.

(b) *Present height, wind 20 feet per second,* $S \div W = 0{\cdot}8$.

(c) *Present height, wind 20 feet per second,* $S \div W = 1{\cdot}2$.

(d) *Present height, wind 20 feet per second,* $S \div W = 1{\cdot}7$.

(e) *Present height, wind 20 feet per second,* $S \div W = 2{\cdot}0$.

(f) *Present height, wind 20 feet per second 20 degrees off bow,* $S \div W = 0{\cdot}8$.

(g) *Present height, wind 20 feet per second 20 degrees off bow,* $S \div W = 0{\cdot}8$, *overhead view.*

(h) *Present height, wind 20 feet per second 30 degrees off bow,* $S \div W = 0{\cdot}8$.

FIG. 4.—*Performance of stack No. 1 on the "America" model.*

at 300lb. per sq. in.

Since the correct Reynolds number cannot be maintained, the question naturally arises: What error is introduced by the lack of similarity? As far as the turbulent region around the ship is concerned, it is doubtful that any error is introduced. The hull of a ship presents a very rough exterior with numerous projections such as the bow, masts and cargo booms, pilot house, lifeboats and many smaller structures. Although we have no experimental proof, a study of the existing literature leads to the belief that there is little change in the extent of the turbulent zone in the range of Reynolds numbers in which we are interested.

When the flow around the stack is considered, complications arise because this flow probably goes through a critical region at some Reynolds number lying between that of the model and that of the ship. For a circular cylinder of infinite length the critical Reynolds number (in this case $Rn = VD \div v$) lies between 50,000 and 200,000. In passing through this critical, the negative pressure behind the circular cylinder changes from $1{\cdot}3H$ to $0{\cdot}5H$ (H = velocity head of air stream). For a cylinder of finite length such as a stack, the downwash alters these pressures. Pressure measurements made on short pieces of steel pipe tested alone in the wind tunnel showed the presence of criticals and a change in negative pressure from $0{\cdot}8\,H$ to $0{\cdot}6H$. There is, therefore, reason to think that the model stack may have somewhat more vacuum behind it (and, therefore, more downwash) than the full-scale stack. Sherlock and Stalker [1][2] made a number of investigations on circular cylindrical stacks and concluded that there was no change in the downwash in passing through the critical Reynolds number. We, however, do not feel that their tests were exhaustive enough to be conclusive.

$S \div W$ Ratio.

The next condition of similarity to be considered is the ratio of the velocity of the smoke discharging from the stack to the velocity of the air moving past the ship. This ratio is designated as $S \div W$. The smoke velocity S is, of course, the stack gas volume per second divided by the discharge area of the stack. W, the wind velocity relative to the ship, is the resultant obtained by combining vectorially the ship velocity and the wind velocity.

Since the smoke velocity S and the wind velocity W represent two intersecting streams of fluid, it is logical that the ratio of velocities of the two streams should be the same on both model and prototype. This ratio is one of the most powerful factors determining stack performance. In all of these tests a definite value of $S \div W$ was maintained.

[2] Numbers in brackets indicate references listed at the end of the paper.

Stack Gas Temperature.

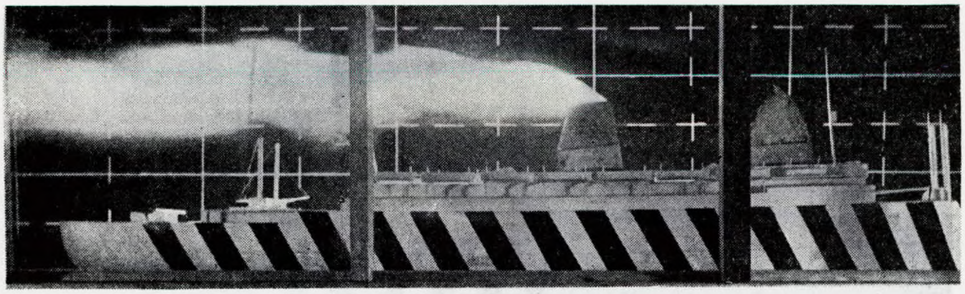
The temperature of the stack gases affects the path they follow after leaving the stack. For a considerable time we were unable to account for the fact that certain ships ("Talamanca" and "California"), which were considered satisfactory in service, had smoke on their decks when tested in the wind tunnel. When we began to suspect that the buoyancy of the hot gas leaving the stack was of importance, the question of similarity arose again.

When smoke leaves the stack with a temperature between 300 deg. F. and 600 deg. F., it will have buoyancy because of the greater density of the surrounding air. Of course, mixing of stack gas with the atmosphere will reduce this temperature rapidly, but nevertheless the total buoyancy of the combined mass will remain the same. The buoyancy will tend to accelerate the heated air in an upward direction. The upward motion, however, will be resisted by the surrounding air which has no upward motion. The effect of these two forces will modify the initial upward velocity which the smoke has when it leaves the stack. In order to meet the requirements of similarity, the ratio between wind velocity and upward velocity of the smoke must at all times be the same for the model and for the ship. The $S \div W$ ratio maintains the proper similarity at the instant the smoke leaves the stack, but the subsequent changes in velocity also must be in the proper ratio. We know of no method for calculating the behaviour of a buoyant mass of free gas and the problem is obviously one of extreme complexity. Consequently, we simplified the problem by making some rather drastic assumptions, and then derived a relationship. The resulting equation indicates that similarity will be maintained if the ratio $W \div \sqrt{D}$ is maintained the same for both model and ship (gas temperature assumed the same for both model and ship). Thus, for a model stack built to a scale of 1 to 100, the wind velocity for the model test would be one-tenth of the wind velocity for the ship. This results in a very low Reynolds number and obviously both criteria cannot be satisfied at the same time. The only solution is to run separate tests at low velocity to determine the influence of heated smoke and then repeat them at high velocity to obtain as high a Reynolds number as possible.

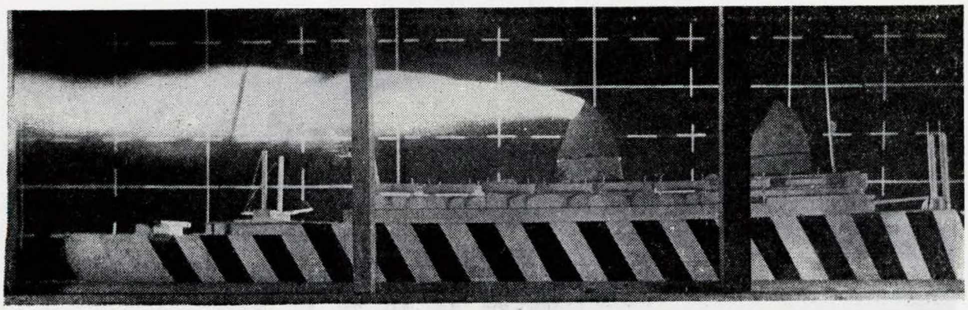
Miscellaneous.

The criteria discussed in the foregoing are believed to be the only ones which have an important influence on stack performance. Water waves of moderate size probably do not have any effect on air currents other than to increase the turbulence. Although the roughness of waves was simulated by wood blocks nailed to the wind tunnel floor, no change was found in the stack performance.

From the foregoing account of the similarity problems involved it can be seen that the application of model tests to the design of stacks is far from an exact procedure. If, however, a reasonable margin of safety is used, it should be possible to obtain satisfactory results.



(*a*) *Stack No. 8.*



(*b*) *Stack No. 10.*

FIG. 5.—*Performance of stacks 8 and 10 on "America" model, wind, 20 feet per second, $S \div W = 0{\cdot}8$.*

Test Results.

Stack Tests on the "America" Model.

Since it is impractical to present all of the data from hundreds of tests, typical cases have been chosen to illustrate the principles which are involved.

The initial tests were run on the "America" model with raised stacks (as modified after the trial trip). The smoke stayed reasonably clear of the decks and, at this stage of the investigation, it was believed that the tests simulated service conditions with reasonable accuracy. Consequently, the effort was devoted to testing the performance of various stack designs, the effect of various angles of approach of the wind, and the influence of the $S \div W$ ratio up to values of 2. Fourteen stack models were tested, starting with the original design. Several of them are shown in Figs. 3 (a) through 3 (d). All of these stacks were made the same height as those originally installed on the "America", but in testing them the 15-foot (1⅘in.) extension was used. The trend in these models was toward reduction in the size of the top of the stack.

The performance of the original stack is shown in Figs. 4 (a) through 4 (h). The effect of height is shown by Figs. 4 (a) and 4 (b) and the influence of $S \div W$ can be seen by a comparison of Figs. 4 (b), 4 (c), 4 (d) and 4 (e). In this case downwash disappears at an $S \div W$ of about 1·5. When the downwash is eliminated, the smoke stays clear of the turbulent zone.

The effect of wind at an angle can be seen in Figs. 4 (f), 4 (g) and 4 (h). When the wind is at an angle, stacks usually show serious downwash because they have a greater projected area normal to the wind. The streamlining of the stack is useless when the angle is large. The hull also adds to the difficulties by developing on the lee side a large vortex which holds any smoke which becomes entrained. Sometimes smoke may go over the side of the ship only to be brought back on deck farther aft. The 20-deg. condition shown is considered to be about the worst because smoke must travel a considerable distance above the hull before it is clear of the ship.

Fig. 5 shows the results of tests on stack models 8 and 10. Number 8 is considerably better than the original when there is a head wind. Number 10 appears to be a promising design. It has good performance with the wind in any direction. The form shown is quite ugly because it was built to fit the extension used on all of the stack models. It is, however, susceptible of artistic treatment. Considerable additional investigation will be required before this design can be recommended. The small size of the top is probably the reason for its good performance.

Stack number 12 was tested because various forms of slots and vents have been used in attempts to correct smoke difficulties on some ships. This model was built so that the annulus or any group of the slots could be covered with tape in order to vary the arrangement. Of the variations which were tried, the only effective one was that which admitted air through the forward slots and discharged it through the annulus. The German liner "Gneisenau", built in 1935, used this system.

It is believed that the design of the top of the stack has much to do with the downwash but the tests on the "America" model, which have just been described, have not progressed far enough to permit many conclusions. These tests were interrupted to proceed with other urgent stack development and to investigate the problems of similarity which were encountered.

Tests on Proposed Ship (P.S. 1633).

Since P.S. 1633 was a passenger and cargo ship, it was considered important to avoid smoke nuisance. The stack had been drawn with a rather large cross-section to allow for engine and boiler room exhaust ventilation and for fan intakes at the base. The "America" tests had taught the importance of using high values of $S \div W$, so the smokepipe was proportioned to give a velocity of 5,000 feet per minute at full power. This resulted in a small opening in the top of a large stack. The $S \div W$ ratio was 2·6 in still air at the ship speed of 18·7 knots, but would be considerably less at reduced power, or with a head wind. The results obtained with $S \div W$ ratios of 1, 2 and 3 are shown in Fig. 6. With an $S \div W$ ratio below 2, if the wind was at an angle of even 5 deg., the smoke at times went all the way to the base of the stack. Other stacks were tested with this model but none of them was very satisfactory unless the $S \div W$ ratio was at least 2. One which was tapered to a much smaller section at the top gave a better performance and it is believed that the large unused area at the top of the other stacks contributed to their poor performance. The tests shown in Fig. 6 were run with a constant smoke flow and the variation in $S \div W$ was obtained by changing the area of the opening. The variation in $S \div W$ was obtained by changing the area of the opening. The variation in $S \div W$ on the "America" (Fig. 4) was obtained by varying the smoke flow with a constant stack area.

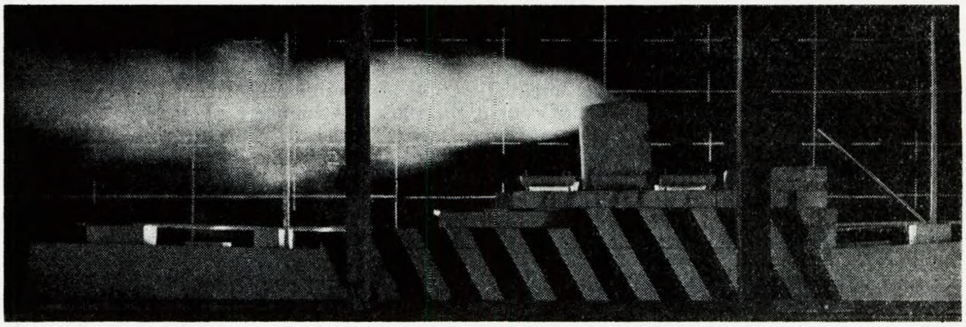
Stack Tests on the "Talamanca" Model.

The difficulty in avoiding downwash on P.S. 1633 led to an investigation of the "Talamanca" and "California" in order to see whether the model tests would duplicate the satisfactory behaviour which these ships had shown in service. At full speed in calm air, the "Talamanca" has an $S \div W$ ratio of 0·35. When the model tests were run at this condition, the smoke came down and broke over the stern periodically, thus demonstrating that the model did not simulate the ship properly. To determine the cause of this, a series of investigations was undertaken which lasted about six months. During this time various devices were tried for altering the turbulence in the wind tunnel; the size of the tunnel was changed to increase the Reynolds number; and a much smaller model of the "Talamanca" was built. None of these expedients made any change in performance.

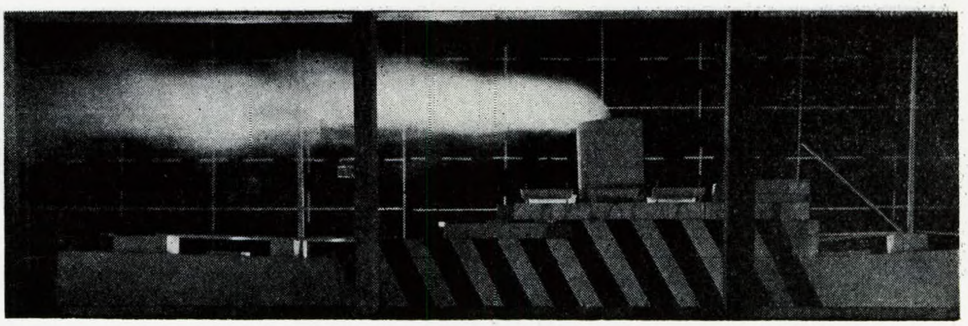
Finally, heated smoke was used. The temperature of the smoke previously had been about 130 deg. F. It was somewhat heavier than air, as shown by the fact that it would fall slowly when released in a low-velocity air stream. Both steam and electric heaters were used to raise its temperature to 300 deg. F. for most tests and to 500 deg. F. for a few.

The scale of this model was 1 to 59 and the ship speed was 17·5 knots. In accordance with the discussion of similarity for heated gases, the model wind velocity corresponding to ship speed would be $17{\cdot}5 \div \sqrt{59} = 2{\cdot}28$ knots (3·8 feet per second). In the tests, wind velocities were varied from 2 to 6 feet per second with $S \div W$ ratios between 0·33 and 1·33.

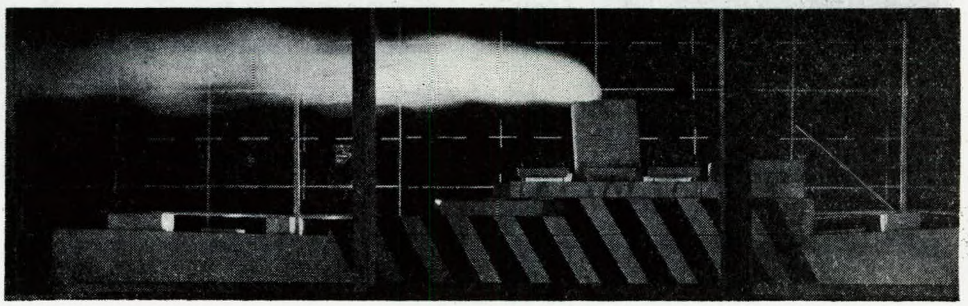
A typical comparison between heated and unheated smoke showed that the heated smoke floats clear of the ship. It is con-



(*a*) *Wind 20 feet per second, $S \div W = 1{\cdot}0$.*



(*b*) *Wind 20 feet per second, $S \div W = 2{\cdot}0$.*



(*c*) *Wind 20 feet per second, $S \div W = 3{\cdot}0$.*

FIG. 6.—*Stack tests on P.S. 1633.*

cluded from this that the buoyancy of the smoke exerts considerable influence on the performance of a ship's stack. Our conclusions concerning the effect of heated smoke are not in agreement with those of Sherlock and Stalker [1]. Most of their tests, however, were run at velocities above those at which the temperature would have an important influence.

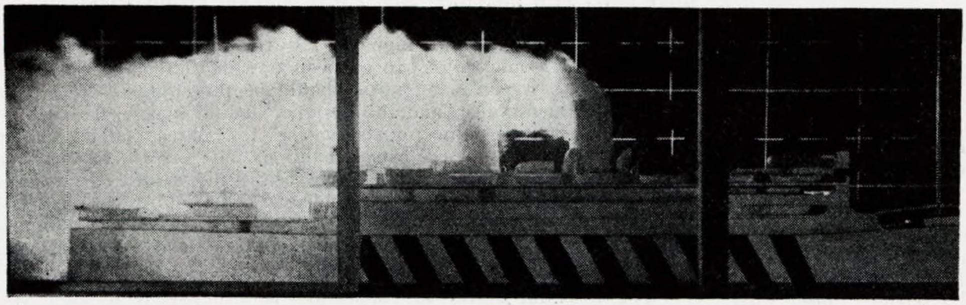
Stack Tests on the "California" Model.

At full speed in calm air, the "California" has an $S \div W$ ratio of 0·24. Model tests on this ship are of particular interest because they deal with the forward stack.

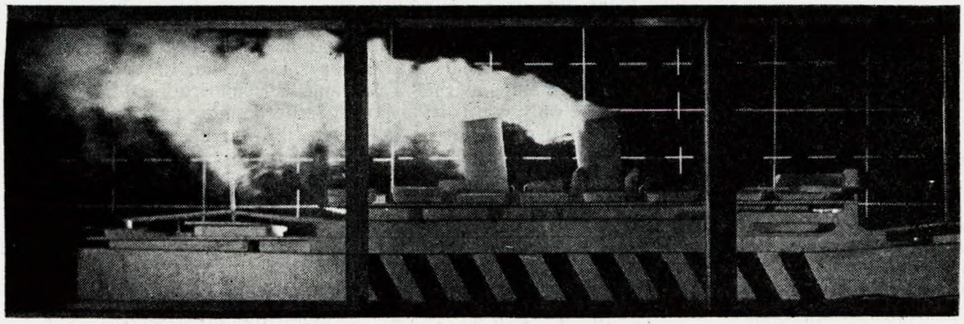
The results were similar to those on the "Talamanca". With unheated smoke the performance was very poor. The smoke came down low enough to strike the dummy stack, which scattered it and brought much of it into the turbulent region. When the smoke was heated, most of it cleared the dummy stack and all of it cleared the ship.

Comparison of these tests with those run with smaller smoke flows on the "Talamanca" showed that the buoyant effect is less with the small smoke flow. This is a qualitative confirmation of the principles employed in deriving the expression $V \div \sqrt{D}$ which was used as a criterion of similarity in these tests. Typical photographs of some of the "California" tests are shown in Fig. 7.

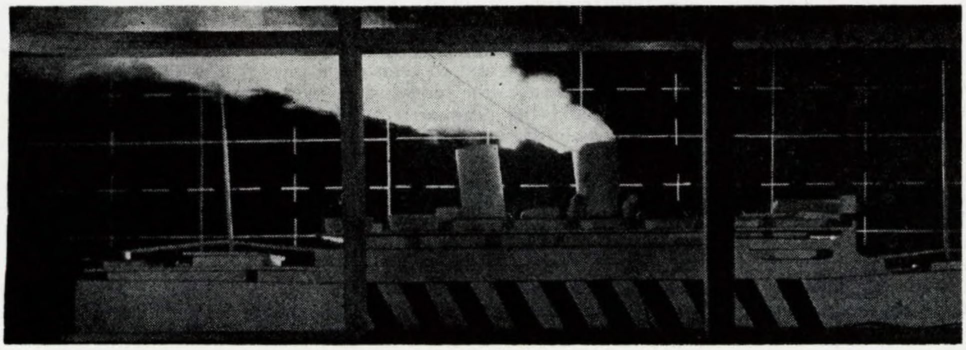
There are probably a large number of ships in which the buoyancy of the hot gas keeps it clear of the decks most of the time. On the more modern ships, which use either air heaters or economizers, the gas temperature is lowered and the buoyancy is reduced correspondingly.



(*a*) *Wind 3 feet per second, smoke temperature 130 degrees F.,* $S \div W = 0{\cdot}33$.



(*b*) *Wind 3 feet per second, smoke temperature 205 degrees F.,* $S \div W = 0{\cdot}33$.



(*c*) *Wind 3 feet per second, smoke temperature 270 degrees F.,* $S \div W = 0{\cdot}33$.

FIG. 7.—*Model tests on the "California"—effect of temperature.*

Tests to Determine the Boundaries of the Turbulent Region Around the Hull.

Smoke jets have been used to study the flow around three of the models (the "America", "Talamanca" and "California"). In each case the model was tested without stacks and with the wind dead-ahead. The behaviour of the jets has been illustrated in Fig. 2. Another method, which is also helpful in determining the boundaries of the turbulent zone, is to release the smoke on the deck. In this case the smoke is inside the turbulent zone, instead of outside, and it will diffuse rapidly until it reaches the zone boundaries. Since the limits of the turbulent region are somewhat arbitrary, considerable judgment must be used in interpreting both types of test and it is best to release smoke at various locations both inside and outside of this zone. A number of smoke jet photographs have been studied to determine the outline of the turbulent zone for the "America". This has been plotted on her profile, Fig. 1 (a). The dotted line on the stack shows the original height. The top of the original stack was approximately at the boundary of the turbulent zone. Smoke discharged at this level entered some of the ventilation openings and resulted in an objectionable concentration of sulphur fumes in the tourist-class quarters. Much soot was deposited on the decks. Reports from the operators indicate that with the stack raised there is no objectionable smoke condition although some smoke occasionally reaches the stern of the ship with the wind dead-ahead.

The turbulent zone of the "Talamanca" has been determined in a similar manner and is plotted in Fig. 1 (c). The stack projects about 0·5 diameter (diameter is fore and aft dimension) above the turbulent region. This ship is reported to have no smoke on the decks.

The stack of the "California", Fig. 1 (d), likewise projects above the turbulent region. No reports of smoke trouble were received in the eleven years that this stack arrangement was used.

Judging by these three cases, it appears that smoke may be kept reasonably clear of a ship by determining the turbulent zone and then carrying the stack above it.

It may be possible to lower the turbulent zone by suitable hull design or by streamlining, but we have not investigated this phase of the problem.

Tests on Individual Parts of a Ship.

Although it is believed that the final determination of stack performance must be made with the complete model, nevertheless the work frequently can be expedited by the testing of individual parts of the ship. Tests on rectangular wood blocks have been run for the purpose of determining what effect the height of the pilot house has on the height of the turbulent zone. To date, not enough of these tests have been run to draw definite conclusions.

The testing of individual stacks is another application of this idea. When it is possible to resume the investigation of stack shape, many of the tests will be run in this way.

Special Devices for Preventing Smoke Nuisance.

Annuli.

A very effective method of preventing the downwash of stack gases is to surround the discharging smoke plume with a high-velocity air jet. This is done by forming an annulus of appropriate size between the inner and outer stack. The air may be obtained from ventilation exhaust from machinery spaces, or it may be drawn from the atmosphere. The volume of air discharged through the annulus should approach that in the stack and a velocity of 4,000 to 8,000 feet per minute is needed. The annulus acts as an ejector and also as an isolating belt which helps to prevent the stack gases from being drawn into the zone immediately behind the stack. One of the principal advantages of using an annulus is that it is effective at all powers. When the ship is operating at low power, as when it enters a harbour, the stack gas velocity will be too low to be of much use, and, unless the stack is quite high, there would be considerable chance that smoke would come on deck. In such a situation, the annulus would be valuable.

The use of an annulus has been investigated extensively by the United States Maritime Commission. Therefore, only a few such tests have been run at Newport News.

Special Stacks.

There have been many attempts to design stacks that will prevent downwash. We have not had the opportunity to investigate many of these. The use of slots cut in the front and rear of the outer casing has already been mentioned. Some arrangements of slots may be beneficial although the particular ones tested at Newport News did not produce any noticeable improvement.

Another device is the "Moore-McCormack" stack. In it, the outer stack casing is cut off short of the top, and the remaining space is fitted with radial vanes which give the illusion that the outer stack continues to the top. We are not familiar with the performance of this stack.

In one case where a stack had excessive downwash, a horizontal plate was attached to the after side some distance above the deck. The plate prevented smoke from passing down the after side of the stack.

Kingposts.

Some ships use kingposts as smoke stacks. Where this expedient can be used conveniently it offers an excellent solution to the smoke problem although there may be some question concerning the public reaction to seeing smoke discharging from a kingpost.

Filters.

Although no attempt will be made to discuss this subject in detail, a few remarks are pertinent. There are many types of separators—electrical, mechanical and water spray—some of which have been used on shipboard. If these can remove a large part of the coarse carbon particles, they would be beneficial at times when quantities of soot are being discharged.

Water sprays may remove not only the soot but also the sulphur. There is no objection to this, provided it is not used as a substitute for good stack design. Cooled stack gas with the soot and sulphur removed would be invisible and odourless. Passengers might then, unknowingly, breathe toxic quantities of carbon dioxide and carbon monoxide.

Observations of Stacks in Service.

During the course of these investigations, observations have been made of the performance of power plant stacks, ships at dock, harbour craft, and a few ships at sea. Much more sea experience is needed because the most adverse conditions for stack performance are seldom encountered. These observations indicate that any stack will have severe downwash if the wind velocity is sufficiently high. In two cases, with the wind more than twice the smoke velocity, the downwash amounted to about four diameters. Most stacks have a downwash of at least 0·5 diameter under normal operation, although this will not be true of the high-velocity stacks being considered for some post-war ships.

Interviews with ships' operating personnel indicate that Victory ships have some soot on the after decks and stack gases occasionally reach the after portion of the ship. On Liberty ships, which have shorter stacks, this condition is more pronounced.

The "Bremen" is reported to have had considerable smoke and soot on deck.

Wind Velocities.

In connection with the problem of smoke elimination, the Maritime Commission has studied weather reports to determine wind speeds on three trade routes—the North Atlantic, the South American East Coast, and the Pacific. This information is of interest to the stack designer because it may affect his choice of an $S \div W$ ratio. A 40-knot head wind with 20-knot ship speed would give a relative wind velocity of 60 knots. If the 40-knot wind is on the beam of a 20-knot ship, the relative wind is 44·6 knots, 63·5 degrees off the bow. The Maritime Commission uses a 40-knot wind for design purposes. With respect to the use of the deck by passengers, this value appears high, since passengers would hardly stay out in a 40-knot wind, 25 appearing more reasonable. If, however, ventilation inlets are located far aft on the ship, where smoke might reach them, then a design for 40 knots or more is needed.

Recommendations.

What constitutes a satisfactory ship from the point of view of smoke is, to a considerable extent, a matter of opinion. In the more extreme cases, such as the entrance of smoke to the quarters, there is no doubt about the existence of objectionable conditions. On many other ships, however, smoke may reach the deck only when the wind is in a certain direction and then, possibly, only when the wind is strong. In other cases, the gases may stay off the deck most of the time but the soot, which is occasionally produced, settles over the after portion of the ship. Are these ships satisfactory or not? The question of whether to accept a little smoke and soot now and then in preference to making the stack taller and slimmer is one which can be answered only by the operators, on the basis of experience. Complete elimination of all smoke at all times is probably impossible with stack heights which will be acceptable to the public. This situation, along with the fact that the problems of similarity prevent an exact comparison between model and ship, make recommendations particularly difficult. Nevertheless, the following general recommendations are applicable to those designs in which better performance is desired:

1. Stack Gas Velocity.

Past practice on merchant ships has held the stack velocities usually between 10 and 20 feet per second. Even with the old system, in which the natural draught of the stack was required to maintain a small suction in the boiler furnace, these velocities could have been doubled in most cases. With air-encased boilers, which are to be used in nearly all of the ships built in the immediate future, there is no such limitation and it is a question mainly of how much extra power the designer is willing to use in the forced-draught fans. Stack velocities as high as 150 feet per second are being considered for some ships. In connection with these high velocities, the possibility of producing noise should be investigated. We have no data on this subject, and the designer should make sure that he does not substitute objectionable noise for objectionable smoke. Under the worst assumed wind conditions, an $S \div W$ ratio above 1 is preferable. This is considerably below the value indicated by some model tests but it is a reasonable compromise between fan pressure and stack performance. A ratio of 1 at the worst conditions will result in a ratio of 2 or more most of the time.

2. Height.

The essential object in connection with height is to keep the smoke above the turbulent zone. This can be accomplished to a certain extent by high stack velocities but the more reliable method is to make the stack sufficiently high to allow for a downwash of about 1 diameter. The determination of the turbulent zone requires a model test. If model tests are not run, the best policy is to be guided by the performance of other ships which have similar proportions. Such ships as the "Talamanca", "America" and "California" appear to be only comfortably out of the danger zone. Their ratios of stack height to height of fidley ($hs \div hf$) are 2·13, 1·75 and 1·72, respectively. The high ratio on the "Talamanca" is somewhat misleading because the stack is located in a depression between two deckhouses. The effective value is nearer to 1·75. The use of this parameter is a crude approach to the problem but it should work well if used with caution. Even when model tests are used, it serves as a check on the conclusions.

3. Top of Stack.

The term "Top of Stack" includes the cross-section near the top, and any special configuration which is used to terminate the stack. This will be the source of most of the conflict between the requirements of utility and those of appearance. Since our tests on stack shape are incomplete, only tentative recommendations can be made at the present time. These are to keep the diameter as small as possible and to reduce the unused area at the top. Large diameters increase the downwash, which usually is measured in diameters, and the dead area at the top apparently collects smoke which is easily drawn into the downwash. The problem of dead area at the top of the stack becomes troublesome when high stack gas velocities are used. The high velocities require a small smokepipe and, consequently, a small stack diameter. On the other hand, the designer usually is trying to make the diameter large because of appearance. This calls for a compromise.

Acknowledgments.

The author wishes to acknowledge the assistance of W. E. Hammond and T. L. Woolard of the United States Maritime Commission, through whom he obtained information and test data in connection with the Maritime Commission's smoke test programme, and of John Stack of the Langley Memorial Aeronautical Laboratory,

for assistance at all stages of the investigation.

The work of Sherlock and Stalker [1], which expounds the theory of stack behaviour, is a valuable reference which has saved us much effort.

Reference.

[1] "A Study of Flow Phenomena in the Wake of Smokestacks", R. H. Sherlock and E. A. Stalker, University of Michigan, Research Bulletin No. 29, March, 1941.

JUNIOR SECTION.

*The Care and Operation of Water-tube Marine Boilers.

By Com'r(E) J. H. Middleton, R.N. (Member).

Written from the viewpoint of the sea-going engineer, this essay has two main objects—to pass on to other sea-going engineers some of the knowledge gained in ten years' experience of this type of boiler and to draw the attention of superintendent engineers and designers to certain points where improvements can be made.

The water-tube boiler is largely superseding the Scotch boiler in modern merchant vessels because it enjoys the following advantages:—

(a) By permitting the use of higher temperatures and pressures, it allows a higher overall plant efficiency to be realised.

(b) It has enormous inherent overload capacity, which is in practice only limited by the performance of the firing equipment and the boiler auxiliaries.

(c) A very great saving in weight and space can be attained by its use.

(d) It is a tremendously flexible steam generator, its flexibility again being limited by the performance of the firing equipment and boiler auxiliaries.

It must not be imagined, however, that these advantages are secured without penalty. The fundamental rule "Nothing for nothing, and damn little for sixpence" has to be obeyed.

The principal demands made by the water-tube boiler in comparison with the Scotch boiler are:—

(a) More frequent maintenance, and a more meticulous standard of work in carrying it out.

(b) Better "drill", and a higher degree of alertness on the part of the boiler-room crew.

(c) Closer control of feed-water quality and boiler-water level.

(d) Closer combustion control.

These demands will now be considered separately, to see what detailed work they involve.

(a) Maintenance.

Maintenance in a water-tube boiler means cleaning, the repair of furnace brickwork, and very little else. Cleaning falls into two parts—internal and external work. Considering internal work first, it may be noted that no hard-and-fast rule can be laid down regarding the frequency with which a boiler should be cleaned. It depends mainly on the boiler rating, the circulation factor, and the purity of the feed. An empirical figure is usually selected by the superintendent in consultation with the designers, and modified as a result of boiler cleaning reports. For highly-rated medium-pressure boilers, operating under reasonably good feed conditions, a figure of 1,000-2,000 hours steaming is considered satisfactory.

If possible, the boiler should be emptied while warm, as this will leave the interior dry when the men go in. The water from a boiler opened for cleaning should normally be run to bilge; if feed water is acutely short, about three-quarters of it can be run to reserve feed tanks if the alkalinity and salinity figures are satisfactory, but it is as well to run the first few tons to bilge anyhow, as this will contain most of the sludge, which is better kept out of the feed system.

The work to be done involves opening out the boiler, removing all internal gear, and cleaning all the internal surfaces. The internal gear of a water-tube boiler is fairly considerable—feed pipes and pots, steam pipes or separators, troughs and so on, and it is surprising how seldom provision is made in the boiler-room layout for the safe stowage of this gear while cleaning. Many accidents have been caused by manhole doors and such like heavy parts falling from the upper galleries onto men working below.

Before cleaning commences, the boiler should be examined to note the nature of the deposits on the principal parts, as from these can be told, to some extent, the predominant type of feed contamination being experienced, oil or grease being especially easily identified, and should be sought along the normal water level. The plain parts of the drums should be wire scrubbed and tubes cleaned and searched with flexible wire brushes, either hand or power operated. All exposed pitting should be picked out to the base metal, and its position noted. Finally, all the accessible parts should be coated with black lead and polished.

Before the internal gear is replaced, all tubes should be "sighted" by a responsible person, to see that they are not blocked by a broken searcher, or similar obstruction. When the tubes are so curved that literal sighting by means of a light cannot be carried out, the work may be conveniently done by means of a wire searcher without its brush, or by dropping marbles down the tubes. In a well-designed boiler the securities and fastenings of the internal gear are of such a size that they will not enter a tube, but it is prudent to check this, and muster any parts which might cause trouble by finding their way into a tube.

The internal gear can now be replaced, having been wire scrubbed and black-leaded while out of the boiler.

It is wise to renew all boiler door joints when closing up the boiler, and to see that studs and nuts are liberally coated with black lead before hardening up. While the boiler is being cleaned it is usual to refit boiler mountings. The ideal is to do all, but if this is not possible, attention should be confined to any known to be defective, to the gauge glass mountings and the feed regulator. The latter fitting rarely requires anything more than cleaning, but it is of such paramount importance to the satisfactory working of the boiler, that it should never be neglected. When all mountings have been replaced and the boiler closed up, it should be water pressure tested to approximately one and a half times the normal working pressure, care being taken to see that the safety valves are gagged before pressure is raised, and the gags removed after test.

Boilers should be cleaned externally whenever the opportunity arises. It is seldom that time and labour is available in sufficient quantity to do a complete external cleaning; hence the work must proceed piecemeal.

The object in view is to clean the generating surfaces, casings and uptakes of carbon, soot and scale. The deposits found depend very largely on the type of fuel used, the forcing rate, and the boiler design, together with the efficiency of the soot blowers fitted. Normally speaking, they vary from a hard black lustrous scale on the fire row tubes to loose soot and scale in the cooler parts of the boiler. In small ships, after bad weather, and in large ones if the fan intakes are badly placed, the fire row tubes may be found to be coated with a white powdery deposit of salt. This need cause no alarm, as no cases are known where damage has arisen from this cause.

For satisfactory cleaning, a considerable number of casing panels must be removed for access purposes, and here it may be remarked that the design and construction of boiler casings seems to have been stagnant for some fifty years. These parts are still made heavily and inaccurately, no thought having apparently been given to the need for making "portable" panels, which have to be handled in restricted spaces, of light alloy. The fastenings are seldom other than the stud and cotter, the crudity of which cannot in this instance be justified on the score of suitability.

Again, a water-tube boiler is a highly flexible structure, subject to considerable movement due to expansion and contraction, variation in deadweight loading and other factors, but all too often it will be found that it is literally "tied together" by means of the casings. The inevitable result is that the casings quickly distort or even tear away from their fastenings, so that considerable air leakage takes place, to the serious detriment of boiler efficiency and the confusion of funnel gas analysis readings, where such are attempted. Such leaks are most difficult to locate, much less remedy, as they are leakages inwards, and even a duck lamp test is of doubtful value due to the considerable air movement in the boiler room. It is high time that designers made a fresh approach to this problem, prepared to bring to it modern methods and materials, having viewed for themselves the condition of casings after prolonged service.

Brickwork repairs are usually undertaken during boiler cleaning. Apart from the purely mechanical damage to cone bricks, caused by the removal of carbon accumulations while steaming, the majority of brickwork defects in a three-drum boiler will be found in the back wall. These are most frequently caused by insufficient rigidity of the back casings, which are inclined to "flutter" if there is any suggestion of pulsation in combustion, aggravated by racking and distortion when inadequate allowance is made for the necessary relative movements between the casings and pressure parts.

* A prize-winning essay in the Sir Archibald Denny, J. Stephen and Lord Inverforth Combined Award Essay Competition, 1946.

FIG. 1.—*Scab pitting on the external surface of a fire tube in a Scotch boiler.*

The other main causes for brickwork defects are rapid changes of temperature, severe local temperature gradients, and the presence of exposed metal or metallic scale. It is well to remember that while raising steam rapidly is unlikely to injure the pressure parts of a water-tube boiler, serious damage can be done to the brickwork by this practice, since the brickwork consists of comparatively large, flat surfaces, has a very low thermal conductivity, and is often mechanically restrained from normal expansion. Particular care is necessary after extensive brickwork repairs have been carried out, when a considerable amount of moisture is present in the stoppings and groutings. If time permits it is well to dry out and warm the furnace thoroughly with coke bogies—otherwise extra time should be allowed for raising steam.

Providing the combustion is reasonably efficient and normally distributed, severe local temperature gradients are usually attributable to air leakage. Thus, failure to shut off the air supply to a burner which has been extinguished will almost certainly cause trouble in its own ring of cone bricks, if nowhere else.

Any exposed metal or metallic scale fuses at furnace temperatures, and cuts deep gutterways through the brickwork. The remedy, of course, is a careful inspection of the furnace when work is completed to see that no nuts, bolts, spanners, etc. are left behind, and to see that all scale which has been swept down from the uptakes has been removed. If the stopping falls out of a brick bolt hole, the bolt head will fuse and gutter the wall. Particular care is therefore necessary to see that stopping is thoroughly mixed and carefully applied. It may also be worth mentioning that tightening up brick bolts demands more care than it often gets—too tight a bolt will split the brick, too slack will allow it to hammer and break up. It is well worth while having all bolts "run down" and graphited before fitting, and trying them with a spanner after the furnace has reached working temperature. An experienced man soon gets to know the right "feel" of a bolt.

FIG. 2.—*Scab pitting on the internal surface of a water tube in a water-tube boiler. The corrosion products have been removed from the pit at "A" to show perforation of the tube wall. Scab incrustation is undisturbed at "B".*

The cleaning of the tubes externally and of the funnels and uptakes, calls for little comment except, perhaps, to remark on the need for checking all possible sources of the entry of moisture. Dry soot or carbon is comparatively harmless, except that it reduces boiler efficiency, but if it is damped it can cause serious wasting and corrosion. Rain-water catchments in funnels and uptakes should be carefully cleaned and tested, and steam valves to soot blowers checked tight. Funnel covers should always be worn if bad weather threatens. Superheater header closing plates should be removed, and the tube roots examined, as corrosion is often found here, due probably to the ingress of water from header air cocks, if these are not piped well clear of casings.

The generator tubes should be examined for swelling and distortion, bearing in mind that the "heat centre" of the furnace is usually about two-thirds of the length from the furnace front and in this area trouble will usually first appear. Local bulges or swellings on a tube are generally serious and should be thoroughly investigated, but slight general deformations involving a change in curvature can generally be ignored, providing the tube remains clear of its fellows, and shows no tendency to draw from the tube plates.

(b) Drill.

In comparison with a Scotch boiler, a water-tube boiler requires a higher standard of operational drill and general alertness because its very much smaller steam and water capacity demand a far

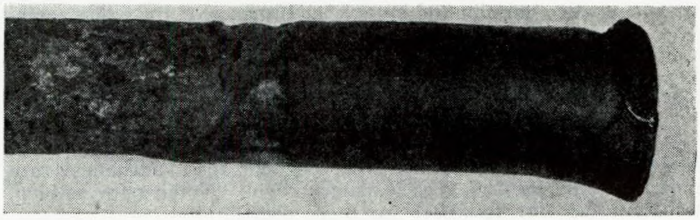


FIG. 3.—*Drastic corrosion of the outside of a boiler tube by damp soot deposits which have collected where the tube enters the water drum. Perforation of the tube occurred just above the surface of the water drum.*

quicker alteration in feed, air and fuel supplies to correspond with variations in the steam load. Automatic combustion control systems have been used on shipboard, but it is not intended to discuss them here, as their increased cost and complexity, together with their present inability to respond satisfactorily to manœuvring conditions make it unlikely that they will be widely adopted in British merchant ships.

The successful operation of the boiler room hinges very largely on the satisfactory layout of the control position. The man in charge of the boiler or bank of boilers must be able to see at a glance the conditions obtaining in the boiler or boilers, and have, under his hand, the essential primary controls for varying feed and combustion conditions. The conditions which must be kept under continuous observation are:—the boiler water level, the steam-drum pressure, the final steam temperature, the clarity of the uptake, and the funnel-gas temperature.

The necessity for continuous observation of the water-level gauge glasses will be better appreciated when it is realized that, in a boiler of moderate size and high forcing rate, the water will disappear from the gauge glasses in 21 seconds and the steam drum will empty in 68 seconds if feed fails while steaming at full power.

There are many proprietary devices on the market for increasing the visibility of the water level gauge, and even for remote reading, but the plain gauge glass is perfectly satisfactory if the glass is kept clean, is adequately illuminated, and in the direct vision of the operator. Regarding illumination—visibility will be much improved if the light source is placed approximately level with the lower gauge glass mounting, as with this arrangement the meniscus appears to the operator as a bright line, due to the reflection downward of the light by the water surface. The watchkeeper taking over should invariably assure himself that the gauges are working correctly by actually blowing them down. To guard against a shut down caused by any feed failure, it is prudent to have an auxiliary feed pump, with suction open to a reserve feed tank, warmed through and ready to feed through the auxiliary check valve.

Steam pressures must not be allowed to drop unduly when steaming at high outputs, or the risk of local overheating of the tubes will arise. A considerable drop in the boiler pressure will upset the circulation equilibrium of the boiler, as evaporation will start in tubes which were acting as down casts at the higher pressure, and the consequent reversal in flow may not become fully established before local temperature gradients reach excessive figures. A permissible drop of 10 per cent. of the normal working pressure can be regarded as a safe figure.

A final steam temperature is a useful check on both water level and combustion conditions—a fall usually indicates priming, and a rise is caused by after-burning of fuel in the tube nests.

A light shining through two glass panels in the uptake and reflected to platform level by mirrors gives a most useful qualitative indication of combustion conditions, and with experience a good operator will secure optimum CO_2 figures more quickly by this means than with more elaborate—and too often less reliable—quantitative instruments. A smoke mirror used in conjunction with an uptake thermometer will allow of sufficiently close combustion control for all practical purposes.

The essential controls at the central position are mainly concerned with combustion, as the maintenance of the boiler water level is normally in the hands of one man, who has no other duties. The air supply is normally controlled by altering the fan speed, and provision should be made for both large and rapid alterations needed when manœuvring, and for fine regulation to meet the minor load fluctuations while steaming steadily.

The fuel pump discharge pressure should also be capable of fine control, large changes being dealt with by altering the number of burners in use. Fuel oil temperature lends itself to control by thermostatic means, and the present trend is in this direction. It is wise to have a standby oil fuel pump, sucking from a separate tank, ready for service to prevent a "black out" should the tank in use empty or be water contaminated, or in the rare event of pump failure.

(c) Control of Feed Water Quality.

The water-tube boiler is extremely fastidious. If it is fed with anything but chemically pure feed water, corrosion, priming, foaming or overheating will almost certainly follow in time, that time being largely dependent on the degree of contamination. The subject is so wide, and the amount recently written about it so great, that no attempt can be made within the limits of this essay to cover the whole ground. All that can be done is to touch on the salient points, and even in doing this, it is unlikely that over-simplification can be avoided.

The principal enemies of the marine water-tube boiler which are likely to be found in its feed are oil, air and salt. Measures against the effects of these intruders can be split into two main types—exclusion and transformation. Exclusion can be effected by sound design of the installation and intelligent operation of its components. Transformation is effected by the introduction of various chemicals into the boiler, which react with the contaminants to form innocuous substances.

The most obvious source of oil is reciprocating auxiliary machinery. The present trend is to eliminate this type of auxiliary, but where this is not done, scrupulous attention must be paid to condensate filtration, and care taken to keep lubrication to the barest minimum, bearing in mind the possibility of using graphite in suitable applications. If extensive retubing has been carried out in a boiler, it will contain a fair amount of oil which has been used on the expanders. It would therefore be prudent in such cases to give a boil out with soda ash or common soda, and subsequent wash through. Oil can come from even more obscure sources; in one ship it was found that the evaporators were making water with a distinct oil film on its surface. This was traced to the evaporator feed pump suction drawing in oil fuel residue from under the bilge keel. Moral—shut down evaporators when pumping out bilges forward of evaporator pump suctions. On another occasion, oil reached a reserve feed tank through a drainage pig's ear, which was chosen as a convenient place into which to empty the duck lamps!

In a modern closed-feed ship, there is little risk of air reaching the boilers while steaming, though care should be taken to vent the feed heaters shortly after main feed pumps are run up. Pumping up boilers after cleaning is the operation which requires the greatest care if aeration is to be avoided. Assuming that warm-de-aerated feed is available, there are two popular alternatives—to exhaust the air from the boiler before filling it by the main or auxiliary feed check, or to leave the boiler open to atmosphere and to introduce the water at the lowest point, so that it rises quietly through the tube nests instead of falling pell-mell from the steam drum through the tubes. In many ships such procedures remain counsels of perfection for want of suitable provision being made to allow of their easy execution.

Vacuum will rarely be raised in a boiler if this involves the use of special adaptors and the running of lengths of hose to a probably remote bilge pump suction. What is required is a small electrically-driven air pump for each boiler with one portable pipe connection to fit a boiler mounting provided for the purpose. Similarly with bottom feeding, if a hose and adaptor connection has to be extemporised between the feed line and the running down valve, the job will seldom get done, whereas a fixed line with a small portable pipe hard by the running down valve would leave no excuse for neglect.

It is almost impossible to prevent a small amount of salt finding its way into the boiler feed unless exceptional precautions are taken to exclude it. Apart from fortuitous contamination, such as that coming from leaking condensers or auxiliary feed tanks, it must be borne in mind that few evaporators working on sea-water feed will produce made water with a lower chlorine content than 0·05 grains per gallon. Ships which can carry large reserves of shore water are in better case, but even here re-evaporation is desirable, and some carry-over must be anticipated.

The engineer can only effect exclusion of salt by constant feed tests, for which purpose there are few better than the simple silver nitrate test, so far as presenting a quick and sensitive qualitative indication is concerned. Once contamination has been found, both zeal and imagination are required to trace the source. That this is not always as easy as the text books imply may be inferred from the case of a new ship which produced a definite, heavy cloud on each occasion of raising steam, which did not persist for more than an hour or so. After several weeks of patient and exhaustive investigation, this was traced to the air vents on the salt water side of the air ejectors, which had been piped to a pig's ear which led to the reserve feed tank instead of the bilge. As the condensers normally required supplementary feed before trying main engines, the contamination was transferred to the main system.

Transformation is achieved by the use of a "boiler compound" as described in B.S. 1170-1944, comprising sodium carbonate, sodium phosphate (or tri-phosphate) and a coagulent such as starch, tannin or sodium aluminate. It is not intended to discuss the action or merits of this compound, upon which points there is much available literature, but merely to remark on some of the practical aspects of its use, as they affect the sea-going engineer.

The first point that arises is the method of introducing supplementary supplies of the compound into the boiler whilst steaming. In default of special fittings for this purpose, the current practice is to set aside one reserve feed tank as a "boiler compound tank", in which is a mixture of feed water and compound in fairly strong concentration. Boilers requiring extra doses of compound are fed from this tank until a satisfactory alkalinity figure is reached, the approximate figure being first arrived at by simple arithmetical methods.

Sooner or later it will be found that virtually the whole of the feed system contains boiler compound in various concentrations. This is quite harmless, but has the drawback that the readings of the normal electric salinometer are affected by all salts in solution, so that an abnormal reading may imply salt or boiler compound. The only way of discriminating is by chemical test, which should, therefore, be employed whenever abnormal readings are noted.

The use of boiler compound requires the frequent and regular chemical testing of the water in the boilers. The first possible cause of error is in the method of sampling used. The concentration of the sample varies with the volume of water which has "flashed" while the sample is being taken. In the interests of uniformity and reliability it is considered that a simple, standard sampling condenser should be provided, by which means a definite quantity of boiler water could be secured without variation due to "flashing".

It is claimed that the actual chemical tests are simple and quick to perform. This cannot be denied while the ship is in harbour, but it is a very different story when bucking into a gale of wind in the Western Ocean, perhaps in ballast. Then the handling of glass bottles and beakers, and the accurate measurement of liquid volumes becomes a job for an octopus with an acutely developed sense of balance. These test sets will not be used with the frequency and freedom which close feed-water quality control demands until they have been made "seaworthy" in the broadest sense of the word. Obvious improvments in this direction which can be suggested are the substitution of "perspex" glasswork, to reduce the risk of breakage, and the provision of a "fiddled" bench for sample and reagents.

(d) Combustion Control.

Attention must be paid to closer combustion control because the quantities of oil fuel being handled are far greater than with Scotch boilers—a figure of 144,000lb./hour through eight burners being quite common in high-rated boilers. Furthermore, it is important that combustion shall be completed in the relatively small furnaces which are found in water-tube boilers, consequently the standard of combustion efficiency must be maintained at a high level.

An oil-fuel burner is designed to atomize fuel to the necessary degree for satisfactory combustion with a certain oil viscosity and a certain oil pressure. While most fittings will give satisfactory results over a fairly wide range of viscosities and pressures, it is clearly desirable to use the burner as often as possible at the designed conditions. For this reason it would be a very great help if burner designers would state clearly in their instructions the optimum pressure and viscosity conditions for their burners, and if oil companies would supply a temperature/viscosity curve for the fuel being bunkered.

It must be emphasized here that the prime function of the oil-fuel heater is to reduce the oil viscosity to that required for satisfactory atomization—the closer approach to the fire or ignition point of the fuel being purely coincidental.

With the very heavy fuels now in use, it will often be found that the temperature required to produce the ideal viscosity may be so high as to cause "cracking" of the fuel in the heater, which fouls the elements and promotes pulsation in the furnace—temperatures above about 220 deg. F. should only be used under skilled supervision.

For satisfactory combustion, the burner must be co-axial with both the register and the brick quarl, and the burner tip must be at the correct distance from the register. Axial alignment is usually secured by means of a simple trammel when the boiler is cold, the "distance" adjustment being made "by eye" with the burner alight, so that the flame ring is filled with flame and combustion is steady and without flutter. Even when the greatest care is taken, uneven expansion and distortion of the furnace front (or air casing) can bring the quarl, register, and burner out of alignment, so that carbon is formed on either flame ring or brick tube. A design permitting the universal adjustment of the burner carriage would be helpful here.

Mention has already been made of the important part pressure plays in securing satisfactory atomization; it should be borne in mind that this is the pressure at the burner, which may be well below the pump discharge pressure. Where excessive drops between pump discharge and burner pressures are found, they are often accounted for by faulty coring of the battery valve body casting.

Normally, a boiler front is fitted with several burners, all of equal output. This presumes a uniform air distribution over the front, which often is not the case in practice. If certain burners—often those in the wing positions—invariably make smoke, an improvement will often result from fitting slightly lower capacity tips to them.

Smoke making is often caused by dirty burners; and this is not surprising when one considers the work involved in changing a burner, quite apart from the attendant fire risk. It is considered that the time has come when burners should be connected to battery valves by flexible hoses fitted with self-sealing orifice valves and quick-release connectors.

For many years, the initial ignition of burners has been carried out with a "torch" of shale-soaked waste, and subsequently from an adjacent burner, or during manœuvring from the hot brickwork. This has been reasonably satisfactory with three-drum boilers having large refractory surfaces. With the introduction of boilers having extensive water walls—some have no brickwork save the front wall—the situation has changed, and a torch must be used for ignition whenever all burners are extinguished. This is most unsatisfactory under manœuvring conditions, as it causes unacceptable delays and creates an appreciable risk of furnace explosion. With this type of boiler, it would appear desirable that provision should be made for fitting a small "pilot" burner, which would have a negligible effect on evaporation, but would provide a permanent ignition point for the main burners.

Before leaving the oil-burning arrangements, a note of warning concerning the dangers of furnace explosion must be struck. Probably the most effective single step which can be taken to combat this risk is to insist that the fireman checks by actual inspection that the burner has in fact ignited immediately it is turned on. If ignition is delayed by more than about twenty seconds, it is essential that the fuel shall be shut off, and the furnace thoroughly purged with air before any further attempt at ignition is made.

In conclusion, it is desired to stress two points. The first is that the care and operation of water-tube boilers is not a difficult matter, provided that their requirements are understood and met. The second is that all practical progress in marine engineering rests with the sea-going engineer. The most advanced types of machinery are usually evolved and initially operated by shore engineers. When such designs are converted for marine use, the work is seldom done by men with the necessary experience and imagination to produce a completely seaworthy arrangement. It ultimately depends on the ingenuity and skill of the sea-going engineer to make these plants successful, so that it behoves him to lose no opportunity of drawing the designer's attention to points which render the design unseaworthy, and to suggest improvements which his knowledge and experience of seafaring conditions lead him to believe will stand up to conditions afloat.

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ADDITIONS TO THE LIBRARY.

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The following publications of the British Standards Institution:—

B.S. 1374:1947. Log-Sheets for Steam Boiler Plants, 13pp., 2s. net, post free.

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Examples in Engineering Mathematics for Students.

(Book II). By I. R. Vesselo, B.Sc. and S. H. Glenister, M.Coll.H. George G. Harrap & Co. Ltd. London. 1947. 87pp., 3s. 6d. net.

The welcome given to "Examples in Engineering Mathematics, Book I", which catered for first-year National Certificate Courses, has prompted the publishers to complete a series of books which will cover the three-year course in mathematics for the ordinary National Certificate in Engineering. It is hoped to publish the third-year course (Book III) at a later date.

As the syllabuses for National Certificate Courses vary greatly in the various technical colleges throughout the country it is difficult to compile a syllabus which will satisfy all lecturers in this subject; the authors have, however, attempted to prepare a scheme of work which should satisfy most syllabuses.

Another difficulty was found in the arrangement of the order of the lessons, but the exercises have been arranged in what the authors consider to be the most suitable sequence.

The book is particularly well printed, and the whole series should find a wide field of users, comprising not only National Certificate candidates but many private students, including junior seagoing engineers.

Manual of Foundry and Pattern Shop Practice.

By Otis J. Benedict, Jnr. Assistant Professor, Department of Shop Practice, Pratt Institute, School of Engineering. McGraw-Hill Book Company, Inc. New York and London. 1947. 361pp., profusely illus., $3.25, 16s. 6d. net.

The author of this book is Assistant Professor, Department of Shop Practice, Pratt Institute, School of Engineering. The book consists of two parts. The first, entitled "Foundry Practice", is of eleven chapters and 182 pages. The second part, entitled "Pattern Shop Practice", is of twelve chapters and 157 pages, together with the remaining pages made up of appendix, bibliography, list of visual aids (films and film strips) and index.

The author's presentation of his subject is clear and definite, though the book is in the main devoted to elementary foundry practice and is more particularly useful for engineering students. It deals mainly with cast iron, and gives relatively little information on the non-ferrous metals. It is, in many respects, a little too ambitious for one volume of this size and is consequently rather incomplete, little mention, for instance, being made of the malleable irons, steels and magnesium alloys or of foundry mechanisation.

The author has rightly placed emphasis on two important points in stating that many students and engineers erroneously believe that castings are being rapidly replaced by parts fabricated by other methods. The many technological advances made in the foundry industry in recent years have enabled it to more than hold its own as a method of fabrication. In Chapter 12, dealing with Pattern Shop Practice, the author emphasises that in order to understand the principles of good pattern design, it is necessary to have a knowledge of the fundamental operations of moulding. The book reinforces these statements with a general survey, showing that, in the author's own words in the preface, "because of the close alliance between pattern design and moulding practice, this book has been prepared with the intention of supplying a text in the fundamental principles of foundry and pattern practice".

The book can be warmly recommended and should be in the possession of every engineering student and apprentice. Many older readers would also benefit from its contents.

The excellence of the drawings is a feature of the book and characteristic of the Publishers, whose eminence in the production of technical literature is everywhere acknowledged.

Fundamentals of Engineering Drawing. For Technical Students and Professional Draftsmen.

(Revised Edition). By Warren J. Lazadder, Associate Professor of Engineering Drawing, Purdue University. Member of Society for the Promotion of Engineering Education. Prentice-Hall, Inc. New York. 1946. Sole Distributors in Britain—W. H. Allen & Co. Ltd., 43, Essex Street, London, W.C.2. 623pp., 1,006 Figs., 25s. net.

This is a very complete manual, which being an American publication, of course deals primarily with American practice, but many of the aspects of this subject are common to this country and America, and these aspects are dealt with very fully. The book should prove useful to young draughtsmen, students and engineers who, while not working at the drawing board, deal with drawings, and this applies whether the drawings concerned are to English or American practice. It commences with drawing materials and their use, simple geometric construction and lettering.

The theory of projection is explained very fully and lucidly. Orthographic projection, isometric projection, perspective sectional views, multiview drawings, developments and pictorial drawings are dealt with. There are very useful chapters on conventional practice in orthographic drawing and free hand drawing and sketching, and useful advice concerning layout, choice of views, dimensioning notes, bills of material, etc.

Elementary reviews of engineering processes in the foundry, smith's shop, machine shop and die casting are included, as well as a chapter on graphs, charts, and diagrams.

The book is profusely illustrated and has a glossary of common shop terms and a bibliography of engineering drawing and allied subjects.

Records and Research in Engineering and Industrial Science.

(Second Edition Revised and Enlarged). By J. Edwin Holmstrom, B.Sc.(Eng'g), Ph.D.(Econ.), A.C.G.I., A.M.I.C.E. Chapman & Hall, Ltd. London. 1947. 366pp., 21s. net.

The aim of this book is to teach the remarkable and stimulating fact that the whole of knowledge, except what is purposely kept secret, is available for everyone to use.

Stocks of the first edition became exhausted early in the war but shortage of paper has prevented reprinting until now. The opportunity has been taken to carry out a fairly extensive revision which has lengthened the book by an aggregate of 64 pages of more recent references, in the hope that it will be useful for the period of post-war reconstruction. The sections relating to International, Imperial and Foreign Organisations for research have been expanded to form a short separate chapter which later it may be possible to amplify further.

The book contains the following chapters—The Nature and Methods of Technical Science; Phases in the Application of Science to Practice; British Experimental Organisations; British Collative Organisations; International, Imperial and Foreign Organisations; The Collection of Data from Technical Literature; The Sorting and Integrating of Facts and Ideas; The Expression and Transmission of Facts and Ideas; Foreign Languages and their Translation; The Technician as a Person.

Meter Engineering.

(Fourth Edition). By J. L. Ferns, B.Sc.(Hons.), A.M.I.E.E., A.M.C.T., A.M.I.I.A. Sir Isaac Pitman & Sons, Ltd. London. 1946. 350pp., 194 Figs., 12s. 6d. net.

Metering is generally looked upon as falling within the sphere of the specialist. Much of the mystery, however, disappears if the subject is approached from the right angle and dealt with on a logical basis.

One of the difficulties associated with a treatise on metering matters is how to deal with the numerous types of meter available without obscuring real issues. In this book the author has treated his subject of Meter Engineering in such a manner that the reader is taken through preliminary stages to more complex matters without being overburdened by confusing detail.

Sufficient theory and explanation of the "why and wherefore" is, however, included such as to satisfy those wishing to obtain a more fundamental grasp of the basic principles of meter design and operation.

Perhaps some of the earlier chapters tend to be elaborate and give the impression of duplication in the effort to cover as much ground as possible, while one could have wished for a more generous treatment of metering problems from the user's point of view.

On the whole this is a useful and practical book that deals with its subject in a comprehensive manner, of use both to student and practising engineer.

A Treatise on Compass Compensation.

A textbook for Academies and Colleges, and a reference manual for Navigating Officers. By Captain L. V. Kielhorn, U.S. Coast Guard. Formerly Instructor in Navigation and Surveying, United States Coast Guard Academy. D. Van Nostrand Company, Inc., N.Y. 1943. British Agents: Macmillan & Co. Ltd., London. 195pp., 45 Figs., 12s. 6d. net.

This work follows conventional methods of presentation, and assumes some mathematical knowledge on the part of the reader. In Chapter I is described the general magnetic characteristics of an iron ship with remarks about orientation during building. Having assumed the resultant ship's hard iron field to be split into three components, the author examines the effect on the compass needle of each of these components separately, thus reaching an explanation of semi-circular deviations. A somewhat obscure description of the Napier diagram follows, the chapter concluding with an account of the horizontal force instrument and of the heeling adjuster as applied to the "hard" iron portion of the ship's magnetism.

Chapter II deals with the effects of induction due to the earth's field in the ship's soft iron, and we find here our old friends the nine thin soft iron rods used in detail to illustrate the effect on the compass of the soft iron components. Thence the quadrantal deviation curve and the meaning of λ follow. In the middle of this chapter the apparently inevitable German capital letters symbolizing exact coefficients begin to obtrude themselves, but it is doubtful whether their introduction at this stage is so clear as if they emerged as substitutions for the parameters of the general deviation equation.

Chapter III is headed "Analysis" and gives useful information with practical examples as to the way of finding numerical values for A, B, C, D and E, first approximately and then by the method of least squares. Here we find stated (p. 83) the general expression for the deviation in terms of exact coefficients apparently taken from the mathematical appendix, equation (11). The chapter concludes with 14 pages of description of the Dygogram.

There follows in Chapter IV some quite interesting historical detail concerning Captain Flinders and the Scoresby-Airy controversy on comparative effect of the so-called subpermanent magnetism and that induced in soft iron.

Chapters V and VI are mainly practical and should be of value to the student.

The book concludes with a mathematical appendix in which the general deviation equations are derived from Poisson's equations in the conventional way—and various formulæ used in the text are obtained and classified. It is felt, on the whole, that a newcomer to the subject of compass adjusting will find this book difficult, not indeed on account of mathematical difficulty, since some mathematical equipment on the part of the reader is obviously assumed, but because of want of generality of treatment at the beginning.

De Ingenieur.

Special issue commemorating the centenary of the Koninklijk Instituut van Ingenieurs, The Hague. 1947. (With an abstract of all articles in English).

BEAMA-IOW British Electrode Classification—Covering Manual Arc Welding Electrodes for Welding Mild Steels.

Prepared and issued by the Arc Welding Electrode Section in collaboration with the Institute of Welding, London. BEAMA Publication No. 135. 1947. 24pp., 10 figs. Copies can be obtained, price 1s., from the British Electrical & Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2.

Engineering Organization and Methods.

By James E. Thompson, Consulting Industrial Engineer. Formerly Chief Engineer, Booth Manufacturing Corporation; Administrative Engineer, The Ryan Aeronautical Company; Member, Society of Applied Industrial Engineering. McGraw-Hill Book Company. Inc. New York and London. 1947. 337pp., profusely illus. 20s. net.

The title of this book is somewhat misleading since it does not cover the very wide field suggested. Those who expect to find a general treatise of "Engineering Organization" will be disappointed. Its chief interest will be for those concerned with the "Engineering Departments", as distinct from the "Production Departments" because it describes the functions and organization of those departments which normally come under the control of the Chief Engineer.

The first chapter deals adequately with the functional layout of the "Engineering Department" and shows the relations of the various functions one with the other. The author claims that the fundamental pattern is always the same regardless of the size of the organization, and it is upon this fact that he bases his claim that the methods described in the remaining chapters are applicable in large and small concerns alike.

Chapter 3 on "Cost Control", 4 on "Planning", and 13 and 14 on "Service" should be of interest to most readers, always bearing in mind that Chapters 3 and 4 only refer to Cost and Planning in relation to the Engineering Section and not in the general sense. Too many organizations commence work on new drawings and designs with no clear idea of the cost or how long they will take to produce. The author suggests the appointment of a Planning Clerk or Department, depending upon the size of the organization, to control new engineering projects in the design and drawing stage. This is a good idea and one which would be beneficial to most companies.

The author could not be expected to deal thoroughly with the subject of service in two chapters; he has, however, brought to the reader's notice the importance of both technical and general service.

In general the book is well written and illustrated if a little elementary in places; notwithstanding this fact the book is worth reading if only as a reminder of the many sides of engineering organization which one is apt to forget.

Britain at War: The Royal Navy and Allies—From October 1944 to September 1945.

By Commander Kenneth Edwards, R.N. Hutchinson & Co. (Publishers), Ltd. London. 1947. 280pp., 342 illus. 21s. net.

This book is a record in text and pictures of the work of the Royal and Allied Navies during the period October 1944 to September 1945. But for the omission of an index and descriptive headings at the beginning of each chapter it makes an excellent work of reference. One is left wondering too why in the fifth and last volume of a series, illustrations of events of an earlier period are included—e.g. Montague B. Black's impression of the brilliant action of H.M. Destroyer "Glowworm" ramming the German cruiser "Hipper" in 1940.

To those who are interested in the sea and naval warfare, this book will provide an easy study of the progress and achievements of the Navies during the Allied invasion of Europe and the final offensive against Japan. For the casual reader, the illustrations alone will develop a lively interest in the events depicted.

It is a book that is likely to continue in demand at every library.

Engineering Mathematics.

(Third Printing). By Harry Sohon, Assistant Professor of Electrical Engineering, Moore School of Electrical Engineering, University of Pennsylvania. D. Van Nostrand Company, Inc. 1946. British Agents: Macmillan & Co. Ltd. London. 278pp., illus. 20s. net.

This book was first published in 1944 and the present edition, dated February, 1946, is the third reprint.

The book is of the advanced type and is intended for students who have completed the study of the elementary calculus. The theory of determinants is dealt with in the second chapter and use is made of this theory in several other sections of the work. In the last two chapters (13 and 14) are given special applications of the Fourier series and the Gamma and Bessel's functions to problems of interest to physicists and electrical engineers.

The explanations given are clear and concise, and the book is well printed and indexed. Section references are given and freely used throughout the work.

Applied Thermodynamics.

By A. C. Walshaw, Ph.D., M.Sc., D.I.C., A.C.G.I., A.M.I.Mech.E. Blackie & Son, Ltd. London. 1947. 401pp., profusely illus. 30s. net.

This book is principally intended for students in the later stages of their primary degree. It is therefore unnecessary—though unfortunately not unusual—that the opening chapters cover elementary and fundamental aspects with which the student should be fully familiar from his earlier studies.

The scope is wide, embracing steam plant, internal combustion engines, compressors and refrigeration. Both atomic energy and combustion turbines are introduced, though neither case is adequately covered.

Much of the text deals with generalities, while many of the better illustrations are definitely specific and overburdened with unnecessary or irrelevant detail. The remaining simple illustrations are copious and resemble black-board sketches.

The only illustration of a boiler is that of a modern coal-fired land type of particular make. A description of steam reciprocating engines, in which the use of exhaust turbines is over-emphasised, is again accompanied by a specific illustration, this time of a marine engine with thrust block and other sundry details relevant only to marine practice. The basis of consideration for turbines reverts to land practices.

The power rather than the size of a ship determines the practical possibilities of its machinery installation, so that the statement "in large ships the turbine has no rival" leaves too much to the imagination of the reader, since an oil engine can readily develop up to 15,000 b.h.p., and in a modern 30,000 b.h.p. twin screw installation of this type the space occupied by the machinery is no greater than that occupied by turbines and boilers.

Frequent resort is made to the use of symbols throughout the book, and while these improve the neatness and compactness of the reasoning they can hardly be expected to ease the task of the struggling or non-mathematically minded student.

The worked examples will prove useful to both students and teachers, but the list of questions taken from examination papers—principally London B.Sc. and Institution of Mechanical Engineers—should certainly have the year appended or better still be replaced altogether by a bibliography.

Workshop Practice.

By F. Johnstone Taylor, The Technical Press Ltd., London, 1947. 741pp. 542 illustrations. 18s. net.

This book is a revised and enlarged edition of the well-known practical textbook E. Pull's "Modern Workshop Practice". While the scope of the original work has been maintained as far as possible the revised edition expresses recent progress on special machines for intensive production in the automobile trades, the important developments in alloy steels and cast irons, modern gear cutting machines and gear testing systems, automatic grinders, drop forging and machine forging, and welding.

The ground covered by the book includes: Measurements and Measuring Machines; Measuring Tools; Gauges and Gauge Systems; Common Workshop Tools; Bench Work; Materials: Cast Iron; Wrought Iron and Steel; Equipment of the Heat Treatment Shop Furnaces; Lathes; Tool Holders; Lathe Tools, Speeds, and Feeds; Lathe Accessories; Turning; Screws and Screw Cutting; Turret Lathes; Capstan and Turret Lathe Tools; Plain and Universal Milling; Gears and Gear Cutting; Gear-Hobbing and Planing Machines; Boring and Slotting Machines; Planing, Shaping and Drilling; Plain and Universal Grinding; Drop Forging and Stamping; Welding.

Thermodynamics.

By G. A. Hawkins. Professor of Thermodynamics at Purdue University. John Wiley & Sons, Inc. New York. 1946. British Representatives: Chapman & Hall, Ltd. London. 436pp., illus., charts. 27s. net.

The treatment of the subject matter of this book follows the orthodox lines of the usual good standard volumes of British authors, and is admirably suited for students who wish to study for a graduate course.

To ensure that readers may see clearly the limitations of the ideal gas laws, the subject is partly arranged in the form of a discussion dealing with real gas laws. The volume starting with Fundamental Concepts proceeds in the standard manner with Laws of Thermodynamics, with a useful chapter on the Equations of State for Real Gases.

Considerable space has been given to Gas and Vapour Mixtures, which greatly enhances the value of the book.

Entropy is treated at considerable length, with some useful diagrams of Temperature-Entropy, and Enthalpy-Entropy of Steam given in the appendix. A chapter is devoted to the Gas Turbine and Jet Propulsion, with a final chapter on Heat Transfer. This is followed by an appendix of Steam Tables and some useful charts of steam and a Pressure-Enthalpy diagram for Ammonia.

Throughout the work there are a number of worked examples and each chapter is followed by numerous useful problems, though the value of these to the reader studying for an examination is reduced by the absence of answers.

The letter symbols used throughout the text are in general those approved by the American Standards Association, but this on the whole is not detrimental to the value of the work since a table of symbols is given at the beginning.

The volume is well up to British standard works and creates a freshness of thought to students preparing for a degree and associate membership examinations of the various engineering institutions.

Fluid Mechanics.

By R. C. Binder, Ph.D., Professor of Mechanical Engineering, Purdue University, U.S.A. Prentice-Hall, Inc., New York. 1947. Constable & Company, Ltd. London. 307pp., 242 figs. 30s. net.

This is an excellent text-book for students of marine engineering and naval architecture who wish to obtain a general introduction to the problems of fluid motion.

The author has divided the work into three main parts—fluid statics, fluid dynamics and special problems such as lubrication, pumps, turbines, fluid-couplings, etc., and in each of these sections he deals with a wide range of subjects.

A knowledge of elementary differential and integral calculus is necessary to follow the mathematical parts of the text, but these are dealt with in a simple and direct fashion, and a number of worked out examples are given in each section.

In reading through the book, the student is presented with a series of new ideas in a natural and interesting manner—streamline flow patterns, viscosity, laminar and turbulent flow, the idea of a boundary layer, the principles of dynamical similarity and dimensional analysis, Reynolds' number and Froude's number, the lift and drag of aerofoils, vortex motion, and the flow of liquids in pipes and in open channels, are dealt with in a logical sequence, and special attention is paid to the fundamental physical ideas rather than to abstract mathematical conceptions. An introduction to the laws governing the flow of compressible viscous fluids is also included, and the final chapter outlines briefly some of the fundamental principles of theoretical hydrodynamics which are used in making mathematical analysis of fluid motion.

The keynote of the book is the wide range of applications which are dealt with by the author, ranging from steady flow in pipes to such subjects as ship resistance ballistics, fluid measuring devices, lubrication and pumps, turbines, etc., and the reader is thereby given a general picture of the problems involving fluid motion in many branches of engineering.

Sir Alfred Ewing—A Pioneer in Physics and Engineering.

By Professor L. F. Bates, Ph.D., D.Sc., F.Inst.P. Published for The British Council by Longmans Green & Co. London. 1946. 38pp., illus. 1s. 6d. net.

This booklet of only 38 pages is all too short to give more than a bare outline of the career of Sir Alfred Ewing, one of those pioneer scientists whose influence was such a great factor in placing Britain in a leading position in physics and engineering in the latter part of the nineteenth and the beginning of the present century.

The book is part biography and part textbook on a small scale. It gives succinct but lucid descriptions of some of the problems which came under Ewing's notice—and there was little that did not do so. He placed great emphasis on the value of research; the book shows the wide range of his own work in this direction, and he was far sighted enough to be able to include some significant words in 1931 on the misuse of atomic energy in an address to the British Association.

Altogether this is a very readable booklet which should arouse a desire to read the larger works mentioned in the Bibliography—"An Engineer's Outlook" and "The Man of Room 40"—for a fuller appreciation of the life work of a great man.

British Diesel Engine Catalogue.

First Edition. Compiled by the Editor of "The Oil Engine and Gas Turbine". Oil Engines of the Compression-ignition Type for Industrial (Stationary and Transportable), Railway Traction and Marine Duties, made by Member Concerns of the British Internal Combustion Engine Manufacturers' Association. Published for the British Internal Combustion Engine Manufacturers' Association, 6, Grafton Street, London, W.1, by Temple Press Limited, Bowling Green Lane, London, E.C.1. 1947. 247pp., profusely illus. Copies of this book are obtainable from Temple Press Ltd., price £2 2s. 0d., or £2 4s. 0d. by post to countries overseas.

Les Nouveautes Techniques Maritimes, 1946.

Edited and published by the Journal de la Marine Marchande, 190, Bd. Haussmann, Paris VIIIe. 216pp., profusely illustrated. Price 400 francs, post free.

This is the only French publication confined to shipbuilding. It is divided into three parts, dealing with the hull, propelling machinery and boilers, and auxiliaries, and a fourth part devoted to developments in cargo handling at ports. Each section is contributed by a highly qualified author on the particular subject, and records the latest practice resulting from experience gained during the war.

Intending purchasers should apply to the publishers at the above address for a permit to obtain the necessary cheque on a French bank.

Purchased.

The Characteristics of Pulverized Coal—Effect of Type of Mill and Kind of Coal.

Fuel Research Technical Paper No. 49. Department of Scientific and Industrial Research. H.M.S.O. 1947. 38pp., profusely illus., 1s. 3d. net.

Port Transport Industry.

Report of Inquiry held under Paragraph 5 of the Schedule to the Dock Workers (Regulation of Employment) Act, 1946. Ministry of Labour and National Service. H.M.S.O. London. 1947. 36pp., 9d. net.

British Merchant Vessels Lost or Damaged by Enemy Action during Second World War.

3rd September, 1939 to 2nd September, 1945. Admiralty, H.M.S.O. London. 1947. 103pp., 5s. net.

Reports of British Intelligence Objectives Sub-Committees on German and Japanese Industry.

Published by H.M. Stationery Office.

No. of report.	Title	Price, net.
B.I.O.S.		
651	German Docks and Harbours	9s. 0d.
1314	German Gear Cutting Machines and Tools for use therewith	2s. 6d.
1337	German Propellers for Aircraft and Marine Craft	1s. 0d.
1354	Aspects of German Foundry Practice	3s. 6d.
J.A.P.		
1295	Welding in Japanese Naval Construction	4s. 6d.
F.I.A.T.		
966	Recent Developments in the Design of Kaplan and Francis Turbines	5s. 0d.

Mechanics Applied to Engineering.

Vols. 1 and 2. By John Goodman, Wh.Sc., M.Inst.C.E. Longmans, Green & Co. London. 9th edition. 1946. Vol. 1, 853pp., 734 Figs., 21s. net.; Vol. 2, 472pp., 198 illus., 711 examples and notes, 18s. net.

MEMBERSHIP ELECTIONS

Date of Election 9th September, 1947.

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Andrew Wilkie.

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Robert Henry Taylor.
Montague Richard Ward, B.Sc
Middlemost Wawn, B.A.

Student.
Martin Joseph Lawlor.

Transfer from Associate Member to Member.
John Connal.

Transfer from Associate to Member.
Walter Bertram Abel.
Edward John Biles.
Ernest Northcott Cady.
Richard Francis Dillon.
Thomas Ismay.
Edward Thomas Middleditch.
John Lakin Rogers, M.B.E., Lt.-Com'r(E). R.I.N.
John Vernon Vincent.
George More.
Kenneth John Shone, M.A.
Ivan Limpright Wren.

Transfer from Associate to Associate Member.
William Walpole.
Arthur Wood.

Transfer from Student to Graduate.
John Adam.

PERSONAL

ENG. CAPT. W. J. WILLETT BRUCE, O.B.E., R.D., R.N.R. (Honorary Vice-President) has been a Member of the Liverpool Engineering Society for just over 50 years. As a tribute to his 50 years' membership and in appreciation of all that he has done for engineers and the profession of engineering during that period, the Council has unanimously elected him to Life Membership of the Society.

CAPT. W. E. DOMMETT (Member), having retired from the Ministry of Supply where he was in charge of the Inventions and Patents Branches, is now advising inventors and companies on claims to be presented to the Royal Commission on Awards, and also on the commercial exploitation of inventions.

T. S. HARKER, B.Sc. (Member), Principal of the School of Technology, Ipswich, has been appointed Principal of Wimbledon Technical College, where he takes up his duties in October.

JOHN McCANN (Associate) has been appointed to the staff of J. R. W. Murland, consulting engineer, Belfast, in the capacity of junior engineer and draughtsman.

HENRY MUSKER (Member) has resigned his appointment with J. S. Miller & Co. and has established himself in business at Leeds as an insulation engineer.

THOMAS O'DRISCOLL (Associate), whose service with the Admiralty has now terminated, has established himself in business as a principal of the firm of Griffiths, O'Driscoll & Co., Ltd., engineers, of London.

A. J. PASZYC, Ph.D., D.I.C. (Member) has been appointed technical director of Hughes & Lancaster, Ltd., Acrefair, Wrexham.

G. PYBOURNE (Associate) is now in Canada, where he has taken up residence and employment.

MAJ. R. J. RAINE, A.M.I.Mech.E. (Member), since his release from the Army, has been appointed superintendent engineer-in-charge, Deep Sea Fishing Station, Government of India, Bombay.

G. THORPE SMITH, M.B.E. (Member), assistant superintendent engineer of the Royal Mail Lines, has proceeded to Buenos Aires in the "Highland Monarch" which left London on the 3rd September, with a view to succeeding E. T. NICKSON (Member) as superintendent engineer at Buenos Aires upon the latter's retirement at the end of the year.

W. WALPOLE (Associate) was successful in the recent Ministry of Transport examination for the Extra-First Class Certificate.

THE LATE SIR S. GEORGE HIGGINS, C.B.E.
(Past-President)

Portrait by] *[Int. Rotogravure London*

OBITUARY

Sir S. George Higgins, C.B.E. (Past-President)

We record with deepest regret the death of Sir S. George Higgins, C.B.E. (Past President), which occurred at Fowey, Cornwall, on Saturday, August 30th, 1947.

Sydney George Higgins was born in 1867, the son of the late Warner Charles Higgins of Portland, Sunbury-on-Thames. In the early days of his career, Sir George was associated with Messrs. Fenwick, Stobart & Co., Ltd. which, with four other shipping companies, constituted Messrs. Wm. France Fenwick & Co., Ltd., formed in 1901. At first secretary of the new consolidating company, he was elected managing director in 1909, and in 1926, chairman, a position which he retained until the end of 1940, when he resigned. During the 1914-18 war he volunteered for service with the Ministry of Shipping, and during 1917-19 he was assistant accountant-general to that department. He was made a C.B.E. in 1918 and was knighted in the following year. In 1925 he was elected deputy chairman and treasurer of Lloyd's Register of Shipping, and held those offices until 1928 when he was appointed chairman. During his tenure of the chief office the Register attained its centenary and Sir George, a distinguished figure, presided with dignity over the gatherings held to celebrate the event. He resigned in 1943 after a breakdown in health.

Sir George had a distinguished public career and was formerly a Vice-Chairman of the Shipping Federation and a member of the Pilotage Committee of Trinity House as the shipowners' representative. He was also a member of the Council of the Chamber of Shipping and the Shipowners' Parliamentary Committee, and at one time represented shipowners on the Advisory Committee on Lighthouses. Sir George filled with success many other posts of importance and honour. On the formation of a Board of Referees, appointed under the Royal Mail Steam Packet re-organization scheme, he was appointed with Lord Plender and Lord Weir to decide on matters which might arise between owners and mortgagees interested in the scheme, and he was appointed by the Home Secretary and the Secretary of State for Scotland to the chairmanship of the Police Committee appointed to inquire into the pay of new entrants to the Police Force.

Sir George was elected President of the Institute in 1933, at a time when the marine engineering industry was experiencing one of the deepest depressions which had ever befallen it, and he carried out the duties of his office with that dignity, enthusiasm and success which he brought to all his interests.

Amongst other activities, he was a member of the committee of the London General Shipowners' Society and of the council of King George's Fund for Sailors. He was also a director of Denaby and Cadeby Main Collieries, Ltd. and of Messrs. France, Fenwick (Insurance) Ltd.

In 1890 Sir George married Ida Blanche, daughter of the late Mr. James Hollway, J.P. She died last year. There were one son and two daughters of the marriage.