THE

NATIONAL PHYSICAL LABORATORY.

Report of the Advisory Committee for the William Froude National Tank, for Year ending December 31st, 1925.

by W. E. SMITH

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REPORT OF THE ADVISORY COMMITTEE FOR THE WILLIAM FROUDE NATIONAL TANK FOR THE YEAR ENDING DECEMBER 31st, 1925.

One change in the membership of the Committee has taken place since the last Report was issued. Sir Thomas Fisher, who had represented the Liverpool Steam Ship Owners' Association since 1920, died suddenly in February, 1925. He had shown a very keen appreciation of the work of the tank, and was always willing to give assistance to the Committee and to the staff. The Committee wish to record their regret at his untimely death.

Sir Aubrey Brocklebank, Bart., has been appointed a member of the Committee in succession to Sir Thomas Fisher.

The very marked depression in the shipbuilding world which has existed for the past two or three years, has this year only affected the number of tests carried out for firms to a small extent. Even a small drop is, however, a matter for regret if it is to be regarded as symptomatic of a tendency to economise at the expense of the scientific design of ship form and propeller. The time spent on tests for mercantile firms, including both normal tests and those of special character, has been 34 per cent. of the total time of the staff. This figure is derived from the monthly time returns.

Research work has made considerable progress in a number of directions. The Report prepared by the Skin Friction Committee of the Institution of Naval Architects has been considered, and action has been taken in two different ways. A letter has been sent to the Institution of Naval Architects by the Director of the Laboratory, on behalf of the Tank Advisory Committee, to say that the Committee consider the proposed towing experiments in the sea to be of the greatest importance, and that should it prove feasible to arrange for such experiments, they would be ready to give all the assistance within their power, and to provide staff and equipment for carrying out the experiments as part of their research programme. Secondly, it has been arranged that further experiments in the tank shall be undertaken, in accordance with the opinion expressed by the Skin Friction Committee. Apart from the above a considerable amount of work on skin friction has been carried out during the year, dealing mainly with the effect of an edge upon plank resistance.

The work in hand at the end of last year along one line of research has been completed, viz., that relating to the effect of movement of helm and yawing of ship upon rudder forces at different angles of helm. This forms part of a large programme dealing with rudder forces and steering. During the discussion of the paper detailing the results of this research an offer was made by Mr. S. Freeman, on behalf of Messrs. Alfred Holt & Co., to provide facilities to check the model results against those obtained in the ship. This offer was gladly accepted, and the trials were made in July on the motorship *Dolius*.

The comparison of estimates made from model results with those obtained on the ship is receiving continuous and increasing attention. In the comparison of actual ship resistance with that estimated from the model, the need for exact data relative to the frictional resistance of long surfaces was at once felt, and this ultimately led to consideration of the matter by the Skin Friction Committee of the Institution of Naval Architects. Comparisons have now been made of the propulsive coefficient on ship and model, and of the actual thrust of a screw propeller behind ship and model. Much more remains to be done and it is proposed to continue this work as opportunity occurs. In order to carry further the comparison of the behaviour of model and ship in rough water, Mr. Kent and Mr. Taylor will shortly make a voyage in a ship of finer form than those on which data have previously been taken. It is hoped that this work will show the manner in which energy is lost in rough weather, and the hull characteristics that are concerned in this wastage.

Advance in the same direction has been made with flying boats. A brief summary of the comparisons made between a flying boat and its model is given in this Report, under

the heading *Aeronautical Work.* This represents the second attempt at checking predictions made from such models, the comparison now covering resistance, seaworthiness and trim.

A brief and non-technical summary of the information obtained in the various experiments and researches in progress will be prepared annually for distribution amongst those interested in the work. It is hoped that this summary will make clear to the many people commercially and financially interested in shipping the service which the tank can and does render to the industry, and the need for the maintenance of a steady flow of research.

The appeal made by the Institution of Naval Architects for contributions to the research fund of the tank resulted in a sum of £760 10s. being collected up to March 31st, 1925, and a further sum of £185 during the present financial year. This, together with the sum of £1,000 received from the Chamber of Shipping, was almost sufficient to meet the requirements of the tank for the year. The appeal is being renewed to cover the work of the present year. It is hoped that in the near future the funds for research will be obtained in a more stable way than at present, and that some means will be found of distributing the cost over the industry, so relieving the Tank Committee of financial embarrassment.

Through the kindness of Sir Archibald Denny and Mr. F. W. Bridges a free site and stand at the Shipping, Engineering and Machinery Exhibition, held in London at the end of November, were given to the Tank, and an exhibit of models, results attained, etc., was maintained during the exhibition.

In the Annual Report for 1920 the Committee foreshadowed the possibility that the growth of tank work might make the provision of further facilities necessary. For many years the testing of seaplanes and flying boats for the Air Ministry has been carried out at the Froude tank. This work was initiated under Sir Richard Glazebrook as Director of the Laboratory, and the technique has been so far developed by the staff, and its reliability assured, that all new types are now tested, and modifications are made as found necessary from the results of the tests. These tests alone have involved a steady growth of high speed work, and at the same time there has been a steady and increasing demand for research work in connection with seaplanes and flying boats. The great increase in such work, together with the fact that the advance of flying is bound to continue, have led to a proposal that a new tank shall be built to allow of full development in this direction. The matter is now under consideration by the Government Departments interested.

Building and Apparatus.—At the request of the Laboratory, the tank walls were thoroughly examined recently by the engineers of H.M. Office of Works. This step was taken as a precautionary measure, as the walls have now stood for 14 years. It is satisfactory to know that they are still in good condition. No overhauling of the travelling carriage has been done this year nor has the level of the tank rails been checked. The carriage speeds remain quite steady, and during the past year steady runs at 23 feet per second were made with a model, and reasonably good resistance records obtained. It was found necessary completely to overhaul the model cutting machine. The levels were found to be satisfactory, but the motors showed considerable corrosion of the flexible leads and resistances. They have now been overhauled and the resistances and motor fields have been rewound by the respective makers.

The method of taking photographs of water motion has been again revised. It was found that, whatever the time exposure, even though this was reasonably short, the record did not properly discriminate between splash and solid water. A method of taking the photographs by flashlight, evolved by Mr. Stockwell of the Optics Division, has therefore been used during the past year, with much greater success.

A new gear for measuring the twisting moment on propeller shafts has been made. This is constructed on precisely the same lines as the two existing gears, but extends the range of torque covered, and certain minor improvements have been embodied in it. A new strickling gear is now in hand, which, when complete, will enable screws of larger diameter to be made. At present the limit to the diameter of a model screw is 10 inches. The new apparatus for recording thrust and torque on a self-propelled model is practically complete.

Tests for Firms.—The number of models tested during the year for shape of hull is 36, representing 23 different designs, two of which were partially dealt with last year. Of these, nine have been tested for appendage resistance, and fourteen have been tried with propellers. The forms tested have included cross-channel steamers, large Atlantic liners, intermediate and cargo steamers, shallow draught vessels, and large oil tankers. The percentage of these forms tried with screw propellers is higher than in any previous year. Of the designs submitted two were improved so that the total reduction of power at service speed was over 14 per cent., this reduction being effected without change of the principal dimensions and without loss of displacement. Five other designs were improved by over 7 per cent., in four out of the five cases without change of the principal dimensions. Four other designs were obviously of bad form, and in order to save time they were modified before testing. In these four cases the percentage reduction in power required for propulsion was large, but cannot be definitely stated.

In addition to the above, a number of special investigations have been carried out. Certain tests with a high-speed motor boat have been made for the Treasury Solicitor. In connection with these tests it was possible to compare two similar models, one 3 feet and one 5 feet in length. Both models were in wood with shellac varnish surface. The resistance results of the two models, when corrected to full size by means of the Tank friction curve, agreed at 30 knots, the smaller model showing 3 to 4 per cent. less resistance at 15 knots and 4 per cent. more at 45 knots. A fairly complete research has been made during the year on the steering value of the rudder of a vessel and on the forces acting on the rudder. In this connection some special rolling experiments on one form have been carried out. Three sets of steam trial data and service running data have been analysed for firms, and as a result new propellers have been proposed. Two of these have now been tried, and an increase in speed of about three-quarters of a knot has been obtained in each case. No data are yet available relative to the third case.

In addition a number of enquiries and queries relating to ship data and propulsion problems have been answered. Such enquiries with regard to the propulsion and working of ships are welcomed, and the Superintendent of the Tank is always ready to give the information desired so far as the necessary data are available.

An investigation on somewhat novel lines was undertaken during the year for the Royal National Lifeboat Institution. These experiments had for their object the determination of the paths followed by the two extremities of a motor lifeboat's keel during and immediately after launching. A model of a modern motor lifeboat was made, and a slip to scale was erected in the small Tank. Apparatus for recording the position of the model instant by instant was designed and made, and a small wavemaker was also erected. Launching experiments on slips of different declivities were carried out at different initial velocities, both in still water and in waves, the experiments in waves being so arranged that the model bow first encountered a wave crest as it entered the water, while in a repeat experiment it encountered a wave trough, all the other initial conditions remaining identical. A report on the work has been made to the Institution.

Aeronautical Work.—The arrangement made last year by the Aeronautical Research Committee, under which a sum of £1,000 was provided for seaplane research in the Tank, was continued this year.

The investigation into the effect of different longitudinal distribution of planing surface of a flying boat and variation of position of maximum beam has been completed, and a report submitted to the Seaplane Panel. A comparison has been made of the general behaviour and seaworthiness of a large flying boat and the behaviour and disturbance created by a model 1/16th full size, of length four feet. The full scale tests were carried out by the staff of the Marine and Armament Experimental Establishment at Felixstowe on the Atalanta N.4 flying boat. This boat has a total displacement of about 32,000 lb. and a minimum flying speed of 45 knots. Measurements were made on the machine of the longitudinal and transverse or lateral angles at a series of moderate speeds (when the splash and water

disturbance are always most troublesome), and cinematograph records were taken of the bow disturbance. The model was trimmed to various lateral angles, longitudinal angle being measured and bow disturbance photographed. The running angles were in good agreement, the maximum difference being one degree at 26 knots. The speeds for maximum bow disturbance were approximately the same, and the disturbance was of the same general character. These results should be taken in conjunction with the earlier comparison work carried out with the smaller C.E.1 machine, in which case satisfactory agreement was found between the predicted and actual resistance, longitudinal running angle, speed of planing, and longitudinal stability at high speeds. A report on this work has been submitted to the Seaplane Sub-Committee. A further comparison between full scale and model work is now in hand to determine with what accuracy predictions can be made as to the tendency of a hull to porpoise. The full scale work is being carried out at Felixstowe on the Seagull hull.

Tests have also been commenced for the Air Ministry to obtain the increase in weight of planking, etc., due to water absorption. The timber is tested both uncoated and coated with paint, varnish, etc. This work is being confined to the timbers normally used in seaplane construction, and to specimens that satisfy the Air Ministry specifications for the particular timber.

Strength Calculations.—With reference to the strength calculations made in 1924 for a flexible type of seaplane hull, the Mechanical Test Department at the R.A.E., Farnborough, has carried out a breakage test of a hull of this type, and a comparison of the calculated and actual results has been made by the Tank staff.

The comparison confirms the theoretical work, to the order of accuracy of the experiments, in so far as the ultimate breakage was due to buckling under hoop compression, exactly as predicted. The results have been described in a note submitted to the Seaplane Panel of the Aeronautical Research Committee.

Further experiments have been suggested with a view to determining the relative importance, in respect to strength, of different portions of the structure, and preparations for these are being made by the R.A.E.

The number of type models of flying boat hulls and seaplane floats tested for the Air Ministry and private firms during the year is 61, covering 13 designs ; 57 of those models are for the Air Ministry and 4 for private firms. Three of the designs were for a high speed seaplane, and experiments with a reasonably large model were able to cover only a small portion of the speed range. Another test was of a special design which necessitated allowing the model to roll as well as to rise and trim, and which involved a new method of experimenting, with modification of the apparatus. In nearly all cases of type tests photographs are now taken at characteristic speeds, in order that the water disturbance can be more readily studied and recorded for comparison with the machine when built. Of the 13 designs above mentioned, three were tested for record purposes only ; three were considerably improved in resistance, the reduction in one case reaching 30 per cent., and three were improved in respect of longitudinal stability and reduction of disturbance. Three of the designs were of very high speed which involved, according to the scale law, such abnormally small models that considerable doubt was felt about using the results obtained to predict the behaviour of the machine For this reason no modifications were suggested.

Research Work Completed and in Progress.—Influence of Waves on Resistance, Propulsion and Pitching of Ship.—The completed work on this research has included an investigation of the effect of longitudinal inertia, vertical distribution of hull displacement and other changes in shape, period of encounter of hull with waves, and height of waves. Several voyages have been made by Mr. Kent to check this work and to ensure a useful line of investigation for future work. Reports on this research have already been published.

The second series of model experiments on this subject has now been completed, and a paper on the results obtained has been offered to the Institution of Naval Architects for publication at their Spring Meetings in 1926. Five models have been made, with block

coefficients varying from 0·6 to 0·8, and experiments have been carried out with each model at load and at ballast draughts. Each model has been tried at different speeds in smooth water and also in waves of constant height but of varied length. Continuous records of the resistances, speeds, pitching angles and heaving of the models have been obtained, together with the position of the wave crests from instant to instant relative to the ship. The results give useful data for purposes of design as in determining the maximum fullness desirable for economic running under voyage conditions, and they throw further light on the causes of vessels shipping seas in bad weather.

Apparatus for the study of the effect of pitching on the efficiency of a single screw propeller is nearing completion. This apparatus will enable thrust and torque to be measured on a self-propelled model, and when completed will be used for trials of models in waves.

With a view to contrasting the behaviour of full and relatively fine vessels under stormy sea conditions, members of the Tank staff will, early next year, undertake a return voyage across the Atlantic on a fine form passenger liner. The thanks of the Committee are due to Mr. Lee Wood, of the Pacific Steam Navigation Co., for arranging this voyage, and to the Company for the offer of facilities on the voyage. In addition to the records of weather and power obtained on previous vessels, it is proposed to record the propeller thrust under all weather conditions.

Manœuvring of Ships.—This research has so far covered the determination of the forces on, and the manœuvring value of, an unbalanced rudder behind single and twin screw ships of one fullness, viz. 0·78 prismatic coefficient. It has also included the manner in which these forces are influenced by slip stream, hull wake, etc., together with the scale effect in passing to rudders of large size. A model of the same fullness was used for experiments to determine the effect (*a*) of yawing motion of the hull on the rudder forces ; (*b*) of reversing the helm from full port to full starboard helm, the model being free to yaw ; (*c*) of head-on and overtaking waves. A paper entitled " Manœuvring of Ships—Model Experiments on the Rudder Forces under Service Conditions ", describing these tests and their results, was read before the Liverpool Engineering Society on January 7th. During the discussion of this paper Mr. Freeman, of Messrs. Alfred Holt and Co., and Mr. Bruce, of the White Star Line, kindly offered the Tank staff facilities for carrying out full scale experiments, so that a correlating factor might be obtained between model and ship. So far the Tank have availed themselves of Messrs. Alfred Holt's offer. Full scale measurements of the torque on the rudder stock, both when moving the rudder over under normal manœuvring conditions and with rapid reversals of helm from one side to another, have been made on their twin screw ship *Dolius*, in smooth, deep and shallow water. Further Tank experiments have been made to obtain corresponding data with a model of the *Dolius*, and this portion of the work is now complete. It is proposed to submit an account of this work to the Liverpool Engineering Society. It is hoped that it may be possible to take advantage of the offer of the White Star Line at a future date when the model work has made further progress. The Committee would like to record their thanks for the facilities so generously offered to the Tank.

The programme outlined last year of tests on rudders, for ships of different fullness, has been partially carried out. Rudder forces and manœuvring values have been obtained with five different unbalanced rudders behind a single screw vessel of fuller form than that previously used, with and without the screw working. Work on a finer form will shortly be commenced.

Screw Propeller Work.—Pressure of other work has prevented any real progress with research on this subject. During the year a start has been made with tests of propellers of varying sizes at varying immersion, and a few experiments have been made in connection with the study of the propeller conditions which exist at the after end of a ship. Neither of these pieces of work has proceeded sufficiently far for results to be stated.

Steam Trial Analysis.—The analysis of the trial data in hand at the end of last year in connection with the ship trials carried out under the supervision of the Marine Oil Engines

Trials Committee has been completed so far as the Tank is concerned. The broad results for the *Sycamore* and *Dolius* are given in the first two reports of the above Committee. A third report containing result for the *Pacific Trader* will be published by the Committee early in the new year. The trials of three other ships have been attended during the year, one for the information of the firm concerned, the others for general information. In addition the trial and service log data of two other ships have been analysed. As a result of these analyses, new propellers have been fitted to two of the ships, resulting in both cases in an increase in speed of three-quarters of a knot.

A paper giving the results of the analysis of the trial data accumulated during the last two years was read on November 26th before the North East Coast Institution of Engineers and Shipbuilders, under the title "Measured Mile Trials and Other Ship Propulsion Data". The analysis has aimed, in the main, at comparing the estimates formed from model data with the results obtained in the ship. The comparison has been made, when possible, with regard to three quantities, viz., the propulsive coefficient, the thrust value of the propellers, and the resistance of the ship. In cases where the values of the indicated or shaft horsepower for the ship have been above reproach, the propulsive coefficients obtained have been very much the same on ship and model. The thrusts measured on the single screw ships have been within a few per cent. of the model propeller thrusts when both have been plotted as ordinates of thrust/(velocity)^2 to a base of (revs.$\times$pitch)/velocity. For the two twin screw ships on which thrust has been measured there are appreciable discrepancies between model and ship. The model of one of these ships was tried with the propeller behind the naked hull, *i.e.*, without any shaft bossings, and the thrust values obtained on the ship come reasonably close to these figures. When the propeller was tried behind the model hull with bossings, higher thrusts were obtained at the same revolutions, and the ship results at least suggest that the increase in thrust obtained on the model is greater than that on the ship. Other (resistance) results have been obtained which go to show that small appendages are liable to have an exaggerated effect on the model, and it is possible that not only the resistance, but also the wake, and therefore the propeller thrust is affected. Further trials are required to settle this point. The comparison of resistance of ship and model has necessarily dealt with the total resistances, *i.e.*, it has included the increase of resistance due to the interaction between the hull and propeller. In the single screw ships the resistance was always noticeably higher than the estimated value. It is not yet clear whether this is due to higher increase of resistance due to reaction between the propeller and the hull, or to error in the estimate of effective horse power. In the twin screw ships a similar but smaller discrepancy was found in one case, but in the other the differences were small.

Comparison of Results in Air and Water.—The object of this research is to obtain a direct comparison of the resistance of several forms in both air and water, using precisely the same apparatus in both fluids. The apparatus necessary for the work was constructed by the Aerodynamics Department of the Laboratory. Some preliminary experiments were made in December, 1924. The gear has since been partially reconstructed and it is understood that it will shortly be ready for further preliminary tests. No statement can at present be made as to the possibilities of these experiments.

Stream-Line Flow and Frictional Resistance Research.—Up to the end of 1924, a number of wax planks, roughly 16 feet in length and varying in depth from 1.1 foot to 3.3 feet, together with one wax plank 34 feet in length, had been tested for resistance. A metal plank, of length 28 feet, maximum beam 4 inches, and depth sufficient to give an immersion of 20.8 inches, has been made in the Metrology Department of the Laboratory. The plank was finished with a vertical stem and sternpost, both drawn out to a knife-edge finish and extending the full depth of the plank. The surface was carefully smoothed and given a final coat of Ryland's boat varnish over a very thin coat of enamel. This plank has been tested for resistance at a number of different immersions through a varying range of speeds. All these frictional resistance data are being gathered together by Mr. Perring and the Tank staff, and will be

presented in a paper to be submitted to the Institution of Naval Architects for their Spring Meetings in 1926.

It is interesting to record that, at any vl/ν value, the value of R/v^2 obtained with this 28 foot plank is in very close agreement with Herr Geber's Vienna results over the same experimental range, and some 7 per cent. below Froude's friction data. These results also show that in comparing plank resistances similarity of form is of relatively small importance, the finish of the ends, edge effect and, of course, the smoothness of the surface being the important matters to consider. Even with this narrow plank, at the full immersion of 20.8 inches, with a midship section area of 79 square inches and an angle of entrance (side to side) of 2.75 degrees, appreciable waves were formed in the Tank, and the resistance due to wave-making could not be neglected at speeds above 420 feet per minute. At the six-inch immersion, when the maximum beam was only 1.5 inches and the angle of entrance was correspondingly reduced, the results appeared to be free from wave effects at speeds up to 1385 ft. per min., the limit of the tests. Two series of models have also been run in this connection. In one of these series, the curve of sectional areas was maintained the same, but the ratio of beam to draught was varied. This work was keyed on to the similar experiments made by Mr. Kent in 1918. In the other series of models, there was constant distribution of cross-sectional area, but the shape of cross-section was varied over wide limits from rectangular to semi-circular, and the ratio of beam to draught varied from 3.1 to 1.0. The effect of cross-section shape on frictional resistance is very small, but with diminishing beam the resistance first drops slightly, and with further decrease rises again a little. The excess of the actual results over the calculated plank frictional resistance varied from 12 per cent., with the broad beam, downwards as the breadth decreased. The results of these tests were given in a paper read before the Institution of Naval Architects at the Spring Meetings this year (1925).

Calculation of the Wave Resistance of Three-dimensional Forms.—The calculation has been completed, by Prof. J. H. Michell's method, of the wave resistance of three forms defined by simple mathematical equations. One of these is the form suggested by Professor Michell himself in his paper in the *Philosophical Magazine* for 1898, Vol. 45, p. 106.

These three forms have been made as models which have been tested for resistance to the highest practicable speed. The residual resistance, obtained by subtraction from the practical result of the skin friction contribution as defined by Froude, has been compared with the results of the calculation. The general features of the calculated curves are reproduced in the actual resistance curves, though there are differences in detail which may be instructive.

In order to simplify the calculations, all the forms tested up to date have been symmetrical fore and aft.

A considerable amount of calculation has been done in order to decide what error is introduced into the work by the necessary assumption that the angle made by the tangent plane to the form and the fore-and-aft vertical plane is small; the method employed has been that suggested by Professor Havelock in the Proceedings of the Royal Society, 1923, Vol. 103, p. 571, which consists in comparing the results obtained by calculating the resistance of submerged spheroids, at different speeds and immersion, in two ways, firstly using Professor Havelock's integral (which is derived by integrations of a sink and source system, and is accurate for a spheroid of any shape, provided the depth of immersion is sufficient), and secondly by using the equation due to Professor Michell, which is accurate at any depth, but depends on the assumption under investigation.

The general conclusion is that the error due to this cause does not exceed 5 per cent. for reasonably ship-shape forms, that it always leads to an under-estimation of the resistance, and that it does not vary much with speed.

A paper giving the details of these calculations, etc., will be submitted to the Institution of Naval Architects, for the Spring Meetings, 1926.

Programme of Research.—Influence of Waves on the Resistance, Propulsion and Pitching of Ships.—This work will be pursued in two directions. Arrangements have already been

made for two members of the staff to take measurements on a fine-lined ship. These will to some extent check and extend the results already obtained, and will enable the tank work to proceed on right lines.

The apparatus for measuring torque and thrust on a single screw propeller shaft will be under trial. When this has passed its tests, it will be used for measuring propeller efficiency with models in waves, etc., with the object of determining to what extent pitching and wave motion affect efficiency. If this apparatus is found to be sufficiently sensitive for ordinary propeller tests, new gear for twin screws on the same general lines will be made, with a view to carrying out firms' tests with truly self-propelled models.

Manœuvring of Ships.—The analysis of the *Dolius* model and ship experiments remains to be completed. If an opportunity occurs to carry out similar tests on a different type of ship, it is proposed to proceed with the work.

Rudder forces and manœuvring values have been obtained with models having stern fullness coefficients of 0.8 and 0.75 and work with models having a finer coefficient (0.70) is in hand. This last is the finest of the single screw vessels that it is proposed to test. This form will also be tried with twin screw propellers and the experiments repeated as necessary. Work will also be done on a still finer form with twin screws, and on the determination of the comparative value of balanced and unbalanced rudders in a twin screw ship.

Screw Propeller Work.—The determination of the limits of thrust of propellers at several immersions, both in open water and behind ship models, will be continued as opportunity occurs. It is proposed that these tests shall cover the trial of propellers of three different sizes in order to discover to what extent size of propeller affects loss of thrust at the water surface. A few tests have been made in connection with the investigation of the wake conditions behind a ship model, and it is proposed to continue these during the year.

Wave Resistance of Three-dimensional Forms.—It is proposed to extend the calculations already completed to cover a non-symmetrical form somewhat like a destroyer. If this can be done successfully, the corresponding model will be made and run for comparison.

Frictional Resistance.—The data for smooth flat surfaces are to be extended to the extreme limit possible in the Tank. For this purpose a flat plank 70 ft. in length and 5 ft. in depth is to be constructed, which will be tested at the highest speeds which can be reached in the Tank.

Wind Resistance of Hull and Superstructures. A preliminary investigation will be made of the data available on this subject, and a programme of experiments will be framed, to be commenced as soon as an opportunity occurs.

W. E. Smith,
Chairman.

LIST OF MEMBERS OF THE ADVISORY COMMITTEE FOR THE WILLIAM FROUDE NATIONAL TANK. JANUARY, 1926.

To Serve until Dec. 31st,		
1931	Sir W. E. SMITH, C.B. (*Chairman*)	Representatives of the Institution of Naval Architects on the General Board of the Laboratory.
1927	Sir A. F. YARROW, Bart., F.R.S.	
1926	Sir R. T. GLAZEBROOK, K.C.B., F.R.S. ...	Representing the Executive Committee.
1927	Professor HORACE LAMB, F.R.S.	
1928	Dr. J. H. JEANS, *Secretary*, R.S.	
1929	Mr. W. J. LUKE, C.B.E.	
1926	Sir JOHN H. BILES, K.C.I.E.	Representing the Council of the Institution of Naval Architects.
1927	Sir WESTCOTT ABELL, K.B.E....	
1928	Mr. H. G. WILLIAMS, O.B.E.	
1929	Professor J. J. WELCH.	
1926	Sir KENNETH ANDERSON, K.C.M.G.	Representing the Chamber of Shipping of the United Kingdom.
1927	The Hon. Sir C. A. PARSONS, K.C.B., F.R.S.	Representing the North-East Coast Institution of Engineers and Shipbuilders.
1928	Sir AUBREY BROCKLEBANK, Bart. ...	Representing the Liverpool Steam Ship Owners' Association.
1929	Professor P. A. HILLHOUSE	Representing the Institution of Engineers and Shipbuilders in Scotland.

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