

AERONAUTICS.

REPORT

OF THE

ADVISORY COMMITTEE FOR AERONAUTICS

FOR THE YEAR 1909-10.

Presented to both Houses of Parliament by Command of His Majesty.



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MEMBERS OF THE COMMITTEE.

The Right Honourable Lord Rayleigh, O.M., F.R.S. (President)
Dr. R. T. Glazebrook, F.R.S. (Chairman).
Rear-Admiral R. H. Bacon, C.V.O., R.N.
Mr. Horace Darwin, F.R.S.
Sir G. Greenhill, F.R.S.
Major-General Sir C. F. Hadden, K.C.B.
Mr. F. W. Lanchester.
Mr. H. R. A. Mallock, F.R.S.
Mr. Mervyn O'Gorman.
Professor J. E. Petavel, F.R.S.
Dr. W. N. Shaw, F.R.S.
Capt. Murray F. Sueter, R.N.

Secretary, Mr. F. J. Selby,
Bushy House, Teddington, Middlesex.

REPORT FOR THE YEAR 1909-10.

To the Right Honourable H. H. Asquith, M.P., First Lord of the Treasury.

SIR :—

The Advisory Committee for Aeronautics, appointed on April 30th, 1909, have since that date held ten meetings, of which one was at the Balloon Factory, Aldershot, one at the works of Messrs. Vickers, Sons & Maxim at Barrow, two at the National Physical Laboratory, and the remainder at the War Office.

The work for which the Committee was appointed was defined in the announcement made by the Prime Minister in the House of Commons on May 5th, 1909, which was as follows :—

“ The Government is taking steps towards placing its organization for aerial navigation on a more satisfactory footing. As the result of a report made by the Committee of Imperial Defence, the work of devising and constructing dirigible airships and aeroplanes has been apportioned between the Navy and the Army. The Admiralty is building certain dirigibles, while certain others of a different type will be constructed at the War Office Balloon Factory at Aldershot, which is about to be reorganized for the purpose. The investigation and provision of aeroplanes are also assigned to the War Office. With a view to securing that the highest scientific talent shall be brought to bear on the problems which will have to be solved in the course of the work of the two departments, the National Physical Laboratory has been requested to organize at its establishment at Teddington a special department for continuous investigation—experimental and otherwise—of questions which must from time to time be solved in order to obtain adequate guidance in construction.

“ For the superintendence of the investigations at the National Physical Laboratory and for general advice on the scientific problems arising in connection with the work of the Admiralty and War Office in aerial construction and navigation, I have appointed a special Committee, which includes the following names :—President : The Right Hon. Lord Rayleigh, O.M., F.R.S. : Chairman : Dr. R. T. Glazebrook, F.R.S. (Director, National Physical Laboratory) : Members : Major-General Sir Charles Hadden, K.C.B. (representing the Army), Captain R. H. S. Bacon, R.N., C.V.O., D.S.O. (representing the Navy), Sir G. Greenhill, F.R.S.,

Capt. Murray F. Sueter, R.N., has now been appointed by the Admiralty as representative. Rear-Admiral Bacon remains on the Committee as an ordinary member. Mr. Mervyn O'Gorman, Superintendent of the Balloon Factory, is also now a member of the Committee.

Dr. W. N. Shaw, F.R.S. (Director of the Meteorological Office), Mr. Horace Darwin, F.R.S., Mr. H. R. A. Mallock, F.R.S., Professor J. E. Petavel, F.R.S., and Mr. F. W. Lanchester."

On May 20th, the following further statement was made, in reply to a question from Mr. Balfour :—

"It is no part of the general duty of the Advisory Committee for Aeronautics either to construct or to invent. Its function is not to initiate, but to consider what is initiated elsewhere, and is referred to it by the executive officers of the Navy and Army construction departments. The problems which are likely to arise in this way for solution are numerous, and it will be the work of the Committee to advise on these problems, and to seek their solution by the application of both theoretical and experimental methods of research."

The work desired thus falls into three sections :

1. The scientific study of the problems of flight, with a view to their practical solution.
2. Research and experiment into these subjects in a properly equipped laboratory, with a trained staff.
3. The construction and use of dirigibles and aeroplanes, having regard mainly to their employment in war.

The Advisory Committee are to deal with the first section, and also to determine the problems which the experimental branch should attack, and discuss their solutions and their application to practical questions. The second section represents the work referred to the Laboratory, while the duties connected with the third section remain with the Admiralty and the War Office.

An Interim Report was presented in July last, and in this was given the following preliminary programme of experimental work which it was considered desirable to carry out.

(I.) GENERAL QUESTIONS IN AERODYNAMICS.

- (1.) Determination of the vertical and horizontal components of the forces on inclined planes in a horizontal current of air, especially for small angles of inclination to the current.
- (2.) Determination of surface friction on plates exposed to a current of air.
- (3.) Centre of pressure for inclined planes.
- (4.) Distribution of pressure on inclined planes.
- (5.) Pressure components, distribution of pressure and centre of pressure for curved surfaces of various forms.
- (6.) Resistance to motion of bodies of different shapes; long and short cylinders, &c.
- (7.) Combinations of planes: effect on pressure components of various arrangements of two or more planes.

(II.) QUESTIONS ESPECIALLY RELATING TO AEROPLANES.

- (8.) Resistance components for aeroplane models.
- (9.) Resistance of struts and connections.
- (10.) Resistance of different stabilising planes, both horizontal and vertical.
- (11.) Problems connected with stability :—
 - (i.) Mathematical investigation of stability.
 - (ii.) The stability of aero curves of different section and of different plan (Turnbull's experiments).
 - (iii.) Effect of stabilising planes, and investigation of questions as to their size and position.
 - (iv.) Effect of rudder action.

- (v.) Effect of gusts of wind.
- (vi.) Investigations as to stability of models for different dispositions of weight, &c.
- (12.) Materials for aeroplane construction.
- (13.) Consideration of different forms of aeroplane, monoplane, biplane, &c.
- (14.) Other forms of heavier than air machines, helicopters, &c.

(III.) PROPELLER EXPERIMENTS.

- (15.) Efficiency, and the effect on the efficiency of variations in blade area, pitch and slip.
- (16.) Positions relative to the machine.

(IV.) MOTORS.

- (17.) Efficiency.
- (18.) Reliability and steadiness.
- (19.) Materials of construction.
- (20.) Design.

(V.) QUESTIONS ESPECIALLY RELATING TO AIRSHIPS.

- (21.) Materials of construction, strength, &c.
 - (i.) Alloys, wood, bamboo, &c.
 - (ii.) Balloon fabrics.
 - (iii.) Wires, cords.
- (22.) Production of hydrogen.
- (23.) Gastightness of fabrics.
- (24.) Detection of leakage.
- (25.) Air resistance to ships of different form ; experiments on models.
 - (i.) Effect of shape of ends.
 - (ii.) Effect of length.
 - (iii.) Variation with speed.
 - (iv.) Distribution of pressure as affecting stability, strength in construction, position of propellers, fins, &c.
 - (v.) Total resistance of models rigged to represent different balloons.
- (26.) Questions as to stability of airships in different positions.
- (27.) Stabilising and steering appliances, fins, rudders, &c. ; form and position.
- (28.) General design.
- (29.) Navigation of airships, mooring, &c.
- (30.) Efficiency and position of propellers for airships.
- (31.) Motors for airship work.

(VI.) METEOROLOGY.

- (32.) General information relating to variations of wind velocity and phenomena connected with gusts of wind.
- (33.) Relative variation in speed and direction of the wind at different heights above the earth's surface.
- (34.) Vertical movements in the air
- (35.) Rotary movements in the air.
- (36.) Electrical phenomena.
- (37.) Formation of clouds, snow, hail, &c.

Equipment for the Experimental Work.—The arrangements which it was proposed to make at the National Physical Laboratory for dealing with this work were also outlined in the Interim Report. Good progress has been made during the year with the construction and erection of the apparatus required. The following particulars of the equipment at present provided may be of interest: a full description, with scale drawings, of the wind channel, whirling table, motor testing plant and wind towers is given in the Appendix to this Report (p. 14).

Wind Channel.—For the experiments included under “General Questions in Aerodynamics,” and for investigations of the resistance of models, the efficiency of rudders, and similar problems, a wind channel has been constructed 4 feet square in section and 20 feet long. The wind channel proper is entirely enclosed in an outer chamber, 8 feet square in section, and the air drawn through the channel by a centrifugal fan, 6 feet in diameter, is returned again outside the channel to the point of entry. As was anticipated from the experience of others, difficulty was at first found in maintaining a steady flow, but this has now been overcome, and for a velocity of 30 feet per second the current can be kept satisfactorily uniform. Provision is being made for attaining higher velocities.

The measuring apparatus for determining the forces due to the air resistance has been so constructed that the components perpendicular to and in the direction of the air current (“lift” and “drift”) can both be measured in succession for one setting of the model, while the adjustment of the model to any desired angle with the current can be made without the necessity of stopping the flow. Apparatus has also been set up for the determination of the centre of pressure in certain cases.

In addition to the wind channel, a water channel has been available, which had been previously used by Dr. Stanton for determination of the resistance of small ship models. It was found that with this apparatus useful work could be done, giving results closely comparable with those obtained in an air channel.

With this equipment several series of experiments have been carried out at the request of the Government Departments to whom constructive work has been assigned, and the results obtained have been of considerable value in dealing with important features of design. Systematic investigation of the questions connected with air resistance is in progress, and now that the initial difficulties connected with the obtaining of satisfactory conditions in the air channel have been surmounted it is hoped that the collection of the information and data necessary to designers can proceed rapidly. Particulars as to some of the work already done are given in the Appendix to this Report.

Whirling Table.—For this a special building, 80 feet square, has been erected. The construction of the whirling table or arm itself, which has been done in the Laboratory, is now completed. The apparatus for testing model propellers has also been erected, and preliminary trials have been made. The whirling arm is of 30 feet radius, giving a clearance of 10 feet from the walls of the building, which is held to be sufficient to prevent any disturbance from the walls, and from the observations made the performance of the apparatus appears to be satisfactory.

A number of applications have been received from private firms and individuals for tests on propellers of special design. It is hoped that it may be possible for the National Physical Laboratory to carry out such tests on propellers, under conditions similar to those which apply in general to the test work there undertaken. The details as to the conditions for these tests will be arranged as soon as possible.

In conjunction with the Admiralty and War Office Departments, a comparison will be made between the results obtained on this whirling table for model propellers and those given by tests on full-sized propellers. These will, it is hoped, afford the necessary information as to the relation subsisting between full scale and model experiments.

The special tests above indicated will no doubt occupy a considerable part of the time of the staff in charge of the whirling table. It is hoped, however, to undertake a systematic study of the air propeller problem, in order to develop, if possible, a method of design similar to that used for water propellers.

Wind Towers.—Two steel towers, 60 feet high and 110 yards apart, have been erected, by permission of H.M. the King, in Bushy Park, on the western boundary of the Laboratory grounds. From this point there is open ground, free from trees and other obstructions, for about 600 yards in the direction from which the most prevalent winds blow. These towers will be employed for experiments in the natural wind on large scale models, thus supplementing the work on small models in the artificial wind obtained in the wind channel. On the top of each tower is a rotating platform 20 feet long by 3 feet wide, so that it will be possible to gain access to plates and models of large area.

These towers, in conjunction with others of lighter construction which will be erected, will also be employed in a study of wind structure, and the variations in wind velocity and resistance, over an area extending probably to 400 feet by 50 feet. Some of the apparatus for this work has already been set up, and observations have been for some time in progress.

Motor Testing Plant.—An electric dynamometer has been installed for tests on the efficiency and endurance of petrol motors. This apparatus, which is for small motors up to 10 h.p., has been tested and found satisfactory, and a similar apparatus for tests up to 50 h.p. is now being set up. This will include special arrangements for an air blast, to reproduce working conditions for air-cooled motors; and provision is being made also for tests on machines when tilted and under certain other conditions which obtain in practice.

This apparatus will be employed in carrying out the trials for the Alexander Motor Prize Competition, to which reference is made below.

Tests on Balloon and Aeroplane Fabrics.—The testing of fabrics, especially for balloons and airships, constitutes an important branch of the work which is being undertaken at the Laboratory for the Committee. The most essential qualities are lightness, strength, impermeability to hydrogen, and durability, while moisture absorption, water proofness and, of course, cheapness are also important.

For the strength determinations, in addition to the ordinary tensile test, a bursting test on cylinders of the fabric has been employed and has furnished valuable information. A careful comparison of the results afforded by this test and of those obtained by tensile tests on specimens of different dimensions is in progress,

and it is hoped, as the outcome of this investigation, that thoroughly useful strength tests may be devised. In addition, the resistance of the fabrics to tearing is being examined. Some account of the results already obtained in these strength tests is given in the Appendix (p. 81).

For the permeability tests a special apparatus has been designed and constructed at the Laboratory, and has been in use for several months. A description of this is given in the Appendix (p. 86). Various questions have presented themselves as requiring careful investigation, especially the effect of variation of temperature, of increased gas pressure, and of tensile stress on the fabric, and information with regard to these questions will be accumulated as rapidly as possible.

A number of tests on the strength and permeability of fabrics have been carried out for the constructing departments as well as for private firms. Assistance has also been rendered to the Committee by manufacturers who have furnished particulars as to their own methods of test and results obtained, and who have supplied and made up material for the bursting and other tests.

Durability tests have been arranged. These will necessarily extend over a considerable period of time. They will include exposure in the open to the sun and weather, while experiments are also being made with a view to producing in the Laboratory conditions which shall imitate the injurious effect of exposure in the open and enable a more rapid durability test to be devised. As is well known, this question is one of great importance, in view of the comparatively rapid deterioration of fabrics in ordinary use.

Other tests of fabrics are being arranged and as soon as possible a complete account of the procedure followed will be prepared. The methods of manufacture are also being examined into by the Committee, while experiments as to the employment of various oils and varnishes will be undertaken.

Detection of Hydrogen Leakage.—Means for the ready detection of the presence of hydrogen in dangerous quantity and for the determination of the places where leakage is occurring are necessary for the safety of men at work in balloon sheds, and for other purposes. This question is also being investigated at the Laboratory. Various forms of indicator have been under consideration, and the matter will have further attention.

Light Alloys, and other Materials of Construction.—Researches on alloys of aluminium have been carried out at the Laboratory and results of value in regard to alloys which may be of use in aeronautical construction have been obtained. Further light alloys are being investigated, and a considerable amount of information has been before the Committee in regard to other materials of construction. Strength tests on materials and joints have been made at the Laboratory for the Constructive Departments.

Stability.—The problems to be dealt with under this head are of the greatest importance for the dirigible balloon as well as for the aeroplane. In the former case the question of stability is intimately related to those of the speed attainable and of economy of power: for the aeroplane stability is plainly one of the first

considerations. The Committee have taken steps to obtain particulars as to existing knowledge on the subject, and some of the information which has been before them is given in the Reports and Abstracts to be found in the Appendix to this Report. This question will continue to engage their attention, and it is hoped that the experiments to be made in the air channel will lead to useful results.

Meteorological Work.—The importance of collecting data with regard to air currents is clearly recognized by the Committee. A valuable report as to present knowledge on the subject of wind structure, and on vertical motion and rotary motion in the air has been presented by the Director of the Meteorological Office, and is included among the Reports in the Appendix. Arrangements have also been made for experimental research into questions of special importance to the aeronaut, and it will no doubt be necessary to extend this work as experience in conducting the experiments is gained.

The programme of experiments which it is proposed to undertake at once includes the investigation of vertical air currents, and also of rotary movements in the air, together with the designing of suitable apparatus for recording the observations. This work will be carried out at Pyrton Hill under the superintendence of the Director of the Meteorological Office, and with the advice and guidance of Mr. W. H. Dines, F.R.S.

With regard to wind structure, as has been already stated, it is hoped that valuable information may be obtained from the experiments which are proceeding at the National Physical Laboratory, with the aid of the wind towers already erected.

By the courtesy of the Director of the Meteorological Office it has been arranged that a selection of anemographic records and other curves of interest to aeronauts shall be available for inspection at the Meteorological Office, daily, between the hours of 10 a.m. and 4 p.m. (Saturdays to 1 p.m.).

Electrostatic Charges on Balloons.—The accumulation of electrostatic charges on balloons, whether due to the rapid variation of electric potential with altitude, or to air friction, or other causes, has long been suspected as involving serious danger under certain conditions, and in the absence of special precautions and protective measures. The matter is of considerable and immediate importance in view of its bearing on the type of construction to be employed, and the use of conducting or non-conducting materials for the envelope. A large amount of information on this question has been before the Committee, including the reports which have been made to the Permanent International Aeronautical Commission, and some experiments have also been made. Diverse opinions are, however, held as to the best means of construction to avoid the dangers involved, and the question is one which must be kept carefully in view, in order that the most efficient safeguards against accident may be provided.

Reports and Memoranda.—A number of reports either as to existing knowledge on general questions of importance or relating to special points under consideration by the Committee have been presented by members of the Committee and others, and some of

these, which it is thought may be of general interest, are printed in the Appendix to this Report. The following are thus included :—

Report on the Experimental Equipment of the Aeronautical Department of the National Physical Laboratory.—By T. E. Stanton, D.Sc. M.Inst. C.E.

General questions in Aerodynamics, Stability, &c.—

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Report from the National Physical Laboratory on the determination of the rate of leakage or diffusion of hydrogen through balloon fabrics.—By W. Rosenhain, B.A., D.Sc., and Guy Barr, B.A.

(b) Light Alloys, &c. :

Report on Light Alloys.—By W. Rosenhain, D.Sc.

Meteorology—

Report on—I. Details of Wind Structure ; II. Vertical Motion in the Atmosphere ; III. Rotary Motion in the Atmosphere ; IV. The Beaufort Scale of Wind Force and the formulæ used in Anemometry.—By Dr. W. N. Shaw, F.R.S.

Electrification of Balloons—

Report as to existing knowledge on the subject of the accumulation of electrostatic charges on balloons, and the precautions to be adopted to avoid the dangers arising therefrom.—By the Secretary.

Report on experiments made at Eskdalemuir Observatory with regard to electrification of bodies in the air.—By G. W. Walker, M.A.

Note relating to experiments carried out at Glossop Observatory.—By W. Makower, M.A., D.Sc.

General—

Translated Extracts from the Annual published by the German Society for the Study of Airships. Being a detailed account of the programmes they drew up, and the methods and instruments they proposed to use. Published March, 1907. Also a summary of the work of the above Society up to March, 1908, as published in their second Annual, in the summer, 1908. Presented by Rear-Admiral R. H. Bacon, C.V.O., R.N.

Memorandum on Flying Fish and Flying Machines.—By A. Mallock, F.R.S.

Notes on Anemometers.—By A. Mallock, F.R.S.

Abstract of Paper "Contribution to the Theory of the Robinson Cup Anemometer."—By C. Chree, Sc.D., F.R.S.

A Report by Sir G. Greenhill on the Theory of a stream-line past a plane barrier, and of the discontinuity arising at the edge, with an application of the theory to an aeroplane, will be issued separately.

Abstracts of Technical Papers on Aeronautics.—The Committee have arranged for the preparation of abstracts of papers and memoirs dealing with aeronautical questions. These are issued periodically and have been furnished to societies and institutions to whom they might be of interest. The numbers already issued are included in the Appendix to this Report.

Communications with the Aeronautical Society, the Royal Aero Club and the Aerial League.—As explained in the Interim Report the Committee put themselves in communication at an early date with the bodies who have given attention to the science and practice of aeronautics in this country, with a view to rendering such assistance as might be possible in their work.

Alexander Motor Prize Competition.—In November last Mr. Patrick Y. Alexander made an offer, through the Aerial League, of a prize of £1,000 for the best motor for aeronautical purposes which should satisfy certain conditions, the most important of these being that it should pass a satisfactory endurance test. The Aerial League applied to the Committee for their assistance, and the Committee undertook to help in drawing up the regulations for the competition and carrying out the tests on the machines submitted. A sub-committee was formed and regulations were drawn up for the competition, and the trials will be made at the National Physical Laboratory under the sole control of the Advisory Committee, who will report the results to the Aerial League. It is hoped that the tests may afford information of considerable value in this important branch of the work of the Committee.

Designs submitted by Inventors.—The position of the Committee with regard to inventions and ideas submitted to them was stated in the Interim Report. A number of designs have been laid before them under the conditions there set forth, and the Committee have also advised the Admiralty and War Office Departments as to ideas presented. In some cases experiments will be made at the National Physical Laboratory to test special features where these are held likely to be of value.

Other Communications to the Committee.—The Committee is indebted to various other individuals and firms who have forwarded information of value to them in their work.

Laboratory Buildings.—As has been already stated, it was necessary to provide a special building at the Laboratory for the accommodation of the whirling table. An additional story was also added to the office block of the Engineering Building to provide drawing offices, &c. for the Aeronautics Division. It was found further that the space available in the Engineering Department of the Laboratory was insufficient for the housing of the wind channel, the motor testing apparatus, and other machines and equipment, and an application was accordingly made to the Lords Commissioners of H.M. Treasury for the necessary funds for an extension of the Engineering Building. Their Lordships have intimated that the sum required will be placed on the estimates for the year 1910-11, and the building has accordingly been proceeded with. Special arrangements have been made in this extension for the motor testing equipment.

The work on permeability is at present temporarily carried on in the building occupied by the Electrotechnics Division of the Laboratory. Experience has shown that in order to carry out the tests with sufficient rapidity the apparatus must be extended. Accommodation for this and for the other chemical and metallurgical work required is already somewhat urgently needed.

Visits to Farnborough and to Barrow.—In July the Committee visited the Balloon Factory at Farnborough, where they were received by Col. Capper, and had the opportunity of examining into the details of the various sections of the work there in progress. In November the Committee paid a visit to the works of Messrs. Vickers, Sons & Maxim at Barrow, where they were very kindly entertained by Sir A. Trevor Dawson, and were shown the constructional and experimental work proceeding on behalf of the Admiralty.

Imperial College Research Scholars.—In view of the growing importance of the subject, arrangements have been made at the Imperial College of Science and Technology for lectures in Aeronautics, for advanced engineering students, and two research scholarships in Aeronautics have been founded. It has been arranged that the scholars appointed for the year 1910 shall carry out research at the National Physical Laboratory.

Signed on behalf of the Committee,

RAYLEIGH,
President.