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AERONAUTICS

TECHNICAL REPORT

OF THE

AERONAUTICAL RESEARCH COMMITTEE

FOR THE YEAR 1920-21.

(With APPENDICES).

VOL. I.

General questions, Airships and model Aeroplane research.

LONDON:

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1924.

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MEMBERS OF THE COMMITTEE, MARCH, 1921.

Professor Sir Richard Glazebrook, K.C.B., F.R.S. (Chairman).
Sir Joseph E. Petavel, K.B.E., D.Sc., F.R.S. (Vice-Chairman)
Professor L. Bairstow, C.B.E., F.R.S.
Wing-Commander W. D. Beatty, C.B.E., A.F.C.
Air Commodore H. R. M. Brooke-Popham, C.B., C.M.G.
Wing-Commander T. R. Cave-Brown-Cave, C.B.E.
Professor J. D. Cormack, C.M.G., C.B.E., D.Sc., M.Inst.C.E.
Professor W. E. Dalby, M.A., B.Sc., F.R.S.
Lieut.-Colonel E. Gold, D.S.O., F.R.S.
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Mr. A. Ogilvie, C.B.E., M.I.Mech.E.†
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Mr. H. White Smith, C.B.E.*
Mr. G. I. Taylor, M.A., F.R.S.
Mr. H. T. Tizard, M.A.

Secretary, Mr. J. L. Nayler,
National Physical Laboratory,
Teddington.

Assistant Secretary, Mr. J. G. Gibson,†
Mr. H. B. Irving.

* Representing the Society of British Aircraft Constructors.
† Mr. Irving replaced Mr. Gibson in December, 1920, on his appointment to other work.
‡ Representing the Royal Aeronautical Society.
Report for the Year 1920-21.

May, 1921.

To Captain the Right Honourable F. E. Guest, C.B.E.,
D.S.O., M.P., Secretary of State for Air.

Sir,

The Aeronautical Research Committee begs to submit its report for the year 1920-21.

In the month of March, 1920, the Air Ministry took the necessary steps to reconstitute the late Advisory Committee for Aeronautics, and nominated the members of the present Committee.

The Air Council, in their letter of appointment to individual members, stated they wished the Aeronautical Research Committee to assist them in carrying out their responsibility in regard to research in aeronautics, and to devote itself generally to the advance of aeronautical science. The terms of reference of the Committee include the following duties:—

(1) To advise on scientific and technical problems relating to the construction and navigation of aircraft;

(2) to undertake or supervise such research or experimental work as is proposed to the Committee by the Air Ministry, and to initiate any research work which the Committee considers to be advisable; to carry out such work itself or to recommend by whom the work should be carried out;

(3) to take over complete responsibility for the Air Inventions Committee and for the Accidents Committee;

(4) to promote education in aeronautics by co-operating with the Governors of the Imperial College;

(5) to assist the aeronautical industry of the country by scientific advice and research, and to co-operate with any Research Association that may be established;

(6) to prepare for the approval of the Air Council a scheme of work and estimate of expenditure for the year, and to administer the funds placed at its disposal by the Air Council;

(7) to make reports from time to time to the Air Council.
The Council has appointed in all some sixteen members constituted as follows:

(a) Four Air Ministry representatives. (Official.)
(b) Two representatives of the Aircraft Industry. (Independent.)
(c) One representative of the Royal Aeronautical Society. (Independent.)
(d) Two representatives of the Imperial College of Science of whom one will be the Chairman of the Committee, Professor Sir R. T. Glazebrook, K.C.B., F.R.S.
(e) Two representatives of the Department of Scientific and Industrial Research. (Official.)
(f) Five representatives of Science. (Independent.)

The Committee met for the first time on Tuesday, 11th May, and made the necessary arrangements for carrying out the wishes of the Air Council. At that meeting it was explained that the six official members should serve on the Committee while holding their appointments, and the nine non-official independent members were placed on a rota of service for periods up to three years, the first three being appointed only for one year, the second for two years, and the third for three years: all non-official members are eligible for re-appointment on the completion of their term of service.

The work of the Committee has been largely carried on through Sub-Committees* which include the following:

1. Aerodynamics Sub-Committee.
2. Engine Sub-Committee.
3. Materials and Chemistry Sub-Committee.
5. Accidents Investigation Sub-Committee.
6. Fire Prevention Sub-Committee.
7. Load Factors Sub-Committee.
8. Air Inventions Sub-Committee.

* At the commencement of the year the membership of these Sub-Committees was composed as follows:


Aerodynamics Sub-Committee.—Sir J. E. Petavel, K.B.E., F.R.S. (Chairman); Professor L. Bairstow, C.B.E., F.R.S.; Professor B. M. Jones, M.A.; Professor H. Lamb, M.A., D.Sc., F.R.S.; Mr. Alec Ogilvie, C.B.E., M.I.Mech.E.; Mr. G. I. Taylor, M.A., F.R.S.; Mr. H. White Smith, C.B.E.; Wing Commander T. R. Cave-Browne-Cave, C.B.E.; J. D. Coales, D.Sc., and Mr. R. J. Goodman Crouch, of the Air Ministry; Mr. C. I. Campbell, of the Royal Airship Works; Mr. R. V. Southwell, M.A., and Mr. E. F. Relf, A.R.C.Sc., of the National Physical Laboratory;
These Sub-Committees have dealt with the detailed consideration of almost all the technical questions which have arisen during the past year, and have reported monthly to the Main Committee.

The Aerodynamics Sub-Committee have discussed all matters relating to full-scale and model work on aircraft, and the application of the results obtained by experiments on models to the full-scale craft. They have included in their purview aeroplanes, airships, flying boats and questions connected with kite balloons and parachutes; also matters relating to the design of aeroplanes as regards structural strength. For the consideration of special papers, four panels, on airships, control and stability, airscrews and design, have been appointed.

The Engine Sub-Committee have carried on the work previously dealt with by the Engine Committee of the Advisory Committee for Aeronautics, and have considered questions relating to aircraft engines, from the point of view of the power plant, the ignition, the installation and the fuels employed.

Squadron Leader R. M. Hill and Mr. R. McK. Wood, of the Royal Aircraft Establishment; Major F. H. Bramwell; Captain W. S. Farren, M.B.E.; Lieut.-Colonel Mervyn O'Gorman, C.B.; Squadron Leader A. J. Miley, O.B.E., of the Air Ministry (vice Major Linton-Hope, M.I.N.A., F.R.Ae.S., deceased); Captain F. S. Barnwell and Mr. J. D. North, representing the Society of British Aircraft Constructors; Dr. H. C. Watts, A.M.I.C.E.; with the Chairman of the Aeronautical Research Committee (ex officio).

Engine Sub-Committee.—Professor W. E. Dalby, M.A., B.Sc., F.R.S. (Chairman); Mr. Alec Ogilvie, C.B.E., M.I.Mech.E.; Sir J. E. Petavel, K.B.E., F.R.S.; Mr. J. D. Siddeley, C.B.E.; Mr. H. T. Tizard, M.A.; Professor H. L. Callendar, F.R.S.; Professor A. H. Gibson, D.Sc.; Lieut.-Colonel Mervyn O'Gorman, C.B.; Mr. H. R. Ricardo; Wing-Commander T. R. Cave-Browne-Cave, C.B.E.; J. D. Coales, D.Sc., Squadron Leader B. C. Carter, and Lieut.-Colonel L. F. K. Fell, D.S.O., O.B.E., of the Air Ministry; Squadron Leader R. G. Parry, of the Royal Airship Works, Cardington; Major H. E. Wimperis, O.B.E., of the Air Ministry Laboratory; Dr. T. E. Stanton, of the National Physical Laboratory; Squadron Leader G. H. Norman, of the Royal Aircraft Establishment; Brigadier-General R. K. Bagnall-Wild, C.B.E., C.M.G., of the Aeronautical Inspection Directorate; Mr. T. B. Barrington and Mr. A. J. Rowledge, representing the Society of British Aircraft Constructors; with the Chairman of the Aeronautical Research Committee (ex officio).

Materials and Chemistry Sub-Committee.—Professor C. F. Jenkin, C.B.E., M.A., M.Inst.C.E. (Chairman); Professor L. Bairstow, C.B.E., F.R.S.; Professor W. E. Dalby, M.A., B.Sc., F.R.S.; Sir J. E. Petavel, K.B.E., F.R.S.; Mr. H. White Smith, C.B.E.; Mr. J. D. Siddeley, C.B.E.; Mr. G. I. Taylor, M.A., F.R.S.; Mr. H. T. Tizard, M.A.; Dr. L. Aitchison; Professor F. C. Lea; Dr. A. J. Sutton Pippard, M.B.E., A.M.I.C.E.; Sir Robert Robertson, F.R.S.; Mr. J. W. W. Dyer and Mr. S. Payne, of the Royal Airship Works, Cardington; Mr. A. Young, of the Air Ministry; Dr. G. Barr, B.A., Dr. G. W. C. Kaye, B.A., Dr. W. Rosenhain, F.R.S., Mr. R. V. Southwell, M.A., and Dr. T. E. Stanton, F.R.S., of the National Physical Laboratory; Mr. W. D. Douglas and Dr. J. E. Ramsbottom, of the Royal Aircraft Establishment; Brigadier-General R. K. Bagnall-Wild, C.B.E., C.M.G., of the Aeronautical Inspection Directorate; Mr. J. D. North and Mr. A. J. Rowledge, representing the Society of British Aircraft Constructors; with the Chairman of the Aeronautical Research Committee (ex officio).
One of the main questions with which they have been concerned is that of reliability, and a small panel appointed for this purpose has discussed from time to time detailed questions.

Materials of construction are discussed by another Sub-Committee, who include in their terms of reference the questions relating to mechanical tests on all types of materials (metal, timber, fabrics, &c.) and have, in addition, dealt with several chemical questions.

The Meteorology Sub-Committee of the Advisory Committee for Aeronautics was reconstituted to carry on the work of that Committee and of the Special Committee for the Electrification of Balloons. The Sub-Committee has in addition dealt with several important questions relating to the navigation of aircraft.

The Accidents Sub-Committee have continued the work of the previous Committee, carrying out at the request of the Ministry enquiries into the specific causes and prevention of such accidents.

Meteorology Sub-Committee.—Sir Napier Shaw, F.R.S. (Chairman); Professor B. M. Jones, M.A.; Professor H. Lamb, M.A., D.Sc., F.R.S.; Mr. G. I. Taylor, M.A., F.R.S.; Squadron Leader G. H. Cooke, D.S.C., A.F.C.; Mr. G. M. B. Dobson; Mr. W. H. Dines, F.R.S.; Professor F. A. Lindemann; Mr. F. E. Smith, O.B.E., F.R.S.; Mr. C. T. R. Wilson, F.R.S.; Wing Commander T. R. Cave-Browne-Cave, C.B.E.; Lieut.-Colonel E. Gold, D.S.O., F.R.S.; Dr. G. C. Simpson, Colonel L. F. Blandy, D.S.O., Flight-Lieut. R. S. Capon, of the Air Ministry; Major H. E. Wimperis, O.B.E., of the Air Ministry Laboratory; Dr. T. E. Stanton, F.R.S., of the National Physical Laboratory; Mr. G. L. Smith, of the Royal Aircraft Establishment; with the Chairman of the Aeronautical Research Committee (ex officio).

Accidents Investigation Sub-Committee.—Lieut.-Colonel Mervyn O'Gorman, C.B. (Chairman); Professor L. Bairstow, C.B.E., F.R.S.; Sir J. E. Petavel, K.B.E., F.R.S.; Mr. G. B. Cockburn, O.B.E.; Dr. A. J. Sutton Pippard, M.B.E., A.M.I.C.E.; Lieut.-Colonel E. Gold, D.S.O., F.R.S.; Mr. M. A. Doyle and Squadron Leader Pritchard, of the Air Ministry; Squadron Leader R. M. Hill, of the Royal Aircraft Establishment; with the Chairman of the Aeronautical Research Committee (ex officio).

Fire Prevention Sub-Committee.—Lieut.-Colonel Mervyn O'Gorman, C.B. (Chairman); Sir J. E. Petavel, K.B.E., F.R.S.; Mr. G. B. Cockburn, O.B.E.; Wing Commander T. R. Cave-Browne-Cave, C.B.E., and Lieut.-Colonel L. F. R. Fell, D.S.O., O.B.E., of the Air Ministry; Squadron Leader G. H. Norman and Dr. J. E. Ramsbottom, of the Royal Aircraft Establishment; Mr. F. M. Green and Mr. R. K. Pierson, representing the Society of British Aircraft Constructors; with the Chairman of the Aeronautical Research Committee (ex officio).

Load Factor Sub-Committee.—Sir R. T. Glazebrook, K.C.B., F.R.S. (Chairman); Professor C. F. Jenkin, C.B.E., M.A., M.Inst.C.E.; Sir J. E. Petavel, K.B.E., F.R.S., Dr. T. E. Stanton, F.R.S., and Mr. R. V. Southwell, M.A., representing the Aeronautical Research Committee; Lieut.-Colonel Mervyn O'Gorman, C.B., and Capt. G. de Havilland, O.B.E., A.F.C., representing the Royal Aeronautical Society; Mr. F. Handley Page, Captain F. S. Barnwell, Mr. J. D. North, and Mr. O. Short, representing the Society of British Aircraft Constructors; Wing Commander W. P. Beatty, C.B.E., and Mr. R. J. Goodman Crouch, representing the Air Ministry.
to aircraft as appeared to require special technical investigation. In particular, enquiry has been made into the cases of accidents to the F type flying boats, the Tarrant Tabor and the Airship R.36.

The causes and prevention of fire on aeroplanes both in the air and on crash has occupied the attention of the Fire Prevention Sub-Committee, who will report shortly on the many possible causes of fire on crash, their probable frequency and the means by which the fire can, in certain cases, be prevented. Their preliminary recommendations have been adopted, and action has been taken in accordance with them.

The Load Factors Sub-Committee has only recently been reconvened to deal with various questions brought to the attention of the Air Council by the Society of British Aircraft Constructors.

The Air Inventions Sub-Committee have not met during the past year as matters which necessitated reference to this Sub-Committee for a decision on technical detail have not come before the Air Inventions Department.

Publication of reports presented to the Main Committee and to its Sub-Committees.—The Committee have each month approved for issue a selection of the reports which have been discussed at their meeting, following in this respect the practice of the Advisory Committee for Aeronautics. Arrangements have been made with H.M. Stationery Office for the publication and issue of all approved matter, and the office issue each month a statement of the Reports and Memoranda placed on sale during this period. There is some small risk in this rapid publication, for it is inevitable that it should sometimes be necessary to revise the views reached and even the experimental results obtained in the light of later work. Every effort is, however, made to secure the necessary accuracy in all technical information that is communicated to the public, and the Committee believe early publication to be of real value to the industry.

Liaison work.—The Committee are in correspondence with the various aeronautical laboratories in allied countries, and have instituted a series of preliminary tests on a number of models which are to be tested in these laboratories in order that strict comparison may be made between the experimental results at the various institutions. In addition, close touch is maintained with the Associate Air Research Committee in Canada. To the latter a copy of the Scheme of Research for the year 1920-21 has been forwarded, and information as to Canadian researches has been supplied in return. Mention should also be made of the exchange of information with the American National Advisory Committee for Aeronautics through Mr. William Knight, their technical assistant, stationed at Paris. The work dealing with the above matters has been considerable, but it has been found
possible to cope with it and to keep in close touch with all the aeronautical bodies concerned.

**Equipment for experimental work at the N.P.L. and Royal Aircraft Establishment.**—The facilities for carrying out experimental work at these two establishments have been considerably increased during the last few years. Both institutions have completed a number of investigations for the Engine, Materials and Fire Prevention Sub-Committees. The N.P.L. is equipped for experiments on models and for such other work as can suitably be carried out in a central research laboratory.

This equipment at the N.P.L. comprises in the Aerodynamics Department a duplex channel measuring 14 ft. by 7 ft., three 7 ft. channels, two 4 ft. channels and one 3 ft. channel. Excepting the duplex, which has only just been completed, all the channels have been in full working order during the past three years. The duplex channel at the time of writing has recently been calibrated and found very satisfactory as regards uniformity of flow and steadiness of air current. In this channel it is hoped to make experiments in directions in which the scale effect between model aeroplane work and full-scale is more pronounced. Amongst such items is included the determination of the centre of pressure on wing sections at low lift coefficients. In the Engineering and Metallurgy Departments facilities exist for the various researches on aeronautical matters detailed elsewhere in this report, and in the William Froude National Tank tests are made on various forms of hulls for flying boats.

The R.A.E. has devoted attention to full-scale work on aeroplanes, engines, propellers, &c., and also to researches on instruments, but in addition the staff has carried out a large number of tests on model aeroplanes and their parts. The equipment for these purposes includes two 7 ft. wind channels and one 4 ft., a complete installation capable of making tests on aircraft engines of all sizes up to 1,200 h.p.; a whirling arm for full-scale propeller tests; foundry and factory facilities for the production of experimental aeroplanes and engines, and well-equipped chemical, physical and engineering laboratories for the study of special problems. In addition plant for tests under high altitude conditions for engines up to 1,000 h.p. is being provided.

**Aerodynamics.**—The work on special problems of aerodynamics has been under the direction of the Aerodynamics Sub-Committee, who have arranged a series of fundamental researches involving lengthy investigations. Among these should be mentioned an investigation now in hand at the N.P.L. on the stability of certain complete rigged models. A preliminary report on the longitudinal stability of these machines has been issued, and the characteristics of their lateral stability are now being carefully examined. The programme was initiated at the commencement as a result of an arrangement that a complete
model of any new type of aeroplane should be submitted to the N.P.L. for a thorough investigation of its stability, and the Committee are of opinion that, by carrying to a conclusion experiments on this subject, it will shortly be possible to define the conditions requisite to secure stability in any new type of machine. During the summer of 1921 it is hoped to devote two channels entirely to stability experiments.

Up to the present the Accidents Investigation Sub-Committee have not been in a position in the case of certain accidents to distinguish between the defective stability of the aircraft and certain other causes of trouble. The above experiments on the series of complete models should elucidate many points that have arisen in this connection and, in particular, a few discrepancies now existing between stability characteristics predicted from the model and their realisation on the larger types of aeroplane should be cleared up.

A research on ailerons commenced in the previous year has been continued, and a number of reports relating to model experiments on different types of ailerons have been issued. The experiments consisted in the measurement of rolling and hinge moments for various settings of the ailerons, and in one case pressure plotting measurements were completed over the wing with the aileron set at zero incidence relative to the wing. From the results of the model tests, coupled with flying experience, it is now established that the horn type of balance possesses some undesirable features which may become prominent or even dangerous in large machines. A more satisfactory type is that in which balance of the aileron is obtained by placing the hinge some distance behind the leading edge.

Mention should here be made of a large amount of full-scale work carried out at the R.A.E. for direct comparison between model work and the full-scale trial. In many cases the comparative model work has been carried out at the R.A.E. in their own wind channels. Two reports have been issued giving the existing scale effects for the R.A.F. 15 and 18 wing sections; these are of the same order of magnitude as those given in the report of the Scale Effect Sub-Committee in 1916 on the B.E. aeroplane.

Aeroplane Carrier Ships.—At the request of the Director of Naval Construction, further experiments have been made on aeroplane carrier ships to investigate the flow of air over the deck. During the summer, full-scale trials on H.M.S. Eagle were made, and these have now been analysed at the N.P.L. The analysis shows that the difference as regards velocity and direction of wind on the model and the actual ship are within the error of experiment, so that model work promises well as an aid to future design.
**Airscrews.**—The Aerodynamics Sub-Committee appointed a panel to discuss what were the most urgent requirements for airscrew design. Following on their recommendations the N.P.L. have commenced a series of tests on a family of airscrews of various pitch diameter ratios, the airscrew being mounted in the wind channel in front of, or behind, a standard stream-line body. In the experiments now in hand, this body has a diameter of about one-third that of the airscrew, but the experiments are to be extended so as to include both the case when the aeroplane body shall have a diameter approximating to that of the airscrew itself, and the case when the airscrew is placed eccentrically to correspond to the conditions obtaining in a flying boat. The former will prepare the way for the installation of larger bodies on aeroplanes whenever it becomes possible to house in the body more portions of the structure than can be made in the aeroplane of to-day.

A most important research having a bearing on general airscrew theory is an investigation which has just been completed on the distribution of pressure over the entire surface of an airscrew blade. The model work has been carried out in a 7 ft. channel at the N.P.L., and an analysis of the experimental data has been made with a view to the advancement of airscrew theory. It follows from these experiments that the theoretical prediction of the thrust of an airscrew is accurate to within 2 per cent., but, if frictional effects be neglected, there is a difference of 15 per cent. between the observed and calculated values of the torque.

Various other problems have been attacked, including (1) the effect of the proximity of a plane surface on the performance of an airscrew—this has an application to the fitting of airscrews near the hull of an airship, and (2) the comparative performance of various airscrews for the S.E.5A aeroplane with a Wolseley Viper engine in which the comparison has been made both in the full-scale and model experiments. These last show that small airscrews running at high speeds can in certain cases be made as efficient as others of larger diameter running at slower speeds.

Mention may here be made of an investigation of the sounds given out by aeroplanes. It was considered probable from the experimental results that the sound first heard from a distant aeroplane comes partly from the engine and partly from the airscrew; for the noise from the former, as heard from close quarters, could be greatly reduced by the use of exhaust silencers, but no corresponding reduction was observed in the maximum range of audibility. This result has an important bearing on the possibility of locating hostile aircraft by sound.

**Seaplanes.**—Seaplane researches have been continued at the N.P.L. by the staff of the William Froude National Tank, who have investigated, on a model, the effect of loading up a float of given beam, and have measured the pressure on the full-scale hull of
a flying boat when landing on the water. In this investigation, the pressure on the different portions of the hull was measured under a variety of flying conditions on an F type boat, and these are to be repeated in the near future on the P type boat which has a less rigid form of construction.

_Airships._—The Committee have learnt with great regret of the decision to stop or greatly to reduce all work connected with airships, and have addressed a letter to the Ministry pointing out the importance of full scale research, not only for airship progress, but as an essential part of general aerodynamic theory upon which the design of all types of aircraft depends.

Considerable progress has been made with the collection of aerodynamic data connected with airships. Full scale trials have been made in R.26, R.29 and R.32. In these trials, deceleration tests to determine the ship's resistance were made and the turning circles at various speeds were determined.

Some experiments on the stability of R.29 are of great interest. The turning circle and other characteristics of the ship's performance were observed with the ship in its original condition and with successive portions of the fabric removed from the top stabilising fin. When the whole of this fabric was removed the airship was definitely unstable. Corresponding wind tunnel tests on models have been made in order to connect the model with the full scale work. The agreement of the observations made on the full scale with those which might have been predicted from the model tests is very good.

An accurate knowledge of the pressure distribution over the fins of an airship is specially important by reason of the severe restrictions on the weight of the structure of the planes imposed by the comparatively small buoyancy of that part of the ship. Some failures have actually occurred in flight, and the problem is therefore under very careful investigation. In addition to model work pressure plotting records on the fins of R.32 have been made, and similar observations will shortly be made on R.38.

The distribution of pressure over the hull is also important as affecting the necessary structural strength and the arrangement of hatches for the ventilation and cooling of the interior of the hull.

The full scale work that has been possible up to the present forms, when compared with the corresponding model tests, a very valuable contribution to the general theory relating to model and full scale work on all aircraft. Its importance is therefore not limited merely to the application to airship design.

_Stability and Control._—Mention has already been made of a number of experiments contemplated or in hand on the stability of aeroplanes. In addition the problem of control, especially at low speeds, has been receiving earnest consideration. The present
day aeroplanes cannot be landed at speeds slightly below that of stalling as the lateral control becomes inoperative. Experiments have been initiated on various methods of overcoming this difficulty; one of the most promising suggestions is the use of interplane ailerons in place of those normally fixed on the wings. The amount of yawing moment caused by this type of aileron is relatively small, but unfortunately the performance of the aeroplane will probably be adversely affected to a considerable degree in consequence of their extra resistance. Full scale experiments are to be undertaken and they should show what are exactly the advantages to be gained by improvement in the lateral control at low speeds. Should these advantages prove to be large it is possible that they may outweigh any reduction in performance which is entailed. The study of this problem is most important for safety in flying. Not only must an engine of an aeroplane be reliable in flight, but the machine must also be able to land safely in the restricted area of the aerodrome. If greater control can be obtained at low speeds, then it will be possible to increase the maximum speed of the aeroplane while retaining the same virtual stalling speed.

As an alternative the employment of high lift wings, such as the Handley Page or of a wing of variable camber, has been proposed, but here also the same problem is important, namely, how to improve the inadequate control when the aeroplane is flying at speeds approaching that of stalling.

*Engines.*—The most important question in connection with aeroplane engines is that of reliability. To this special attention has been paid, and the Air Ministry are making an analysis of engine failures covering a long period of service. In the main, failure of the power plant occurs not in the engine itself, but in one of the many auxiliaries. The sparking plug has also been a cause of trouble.

The development of an engine with high compression ratio is under consideration and various devices to increase its efficiency have been discussed. It is hoped to proceed with research on this problem by introducing modifications into existing designs of engine.

Fuels of a high flashpoint have been examined. Flight experiments on these fuels are in progress at the R.A.E., and it has been found that although some difficulties are experienced in starting engines with these fuels, they can be overcome. The use of a high flash-point fuel involves a slight increase in consumption and a decrease in the power developed.

One of the difficulties associated with the use of heavier fuels is detonation, and a lengthy research on the whole question on lines suggested by Sir Dugald Clerk is in progress at the N.P.L. The early difficulties arising in the commencement of a research of this nature have now been surmounted.
In connection with these questions reference should be made to the paper by Mr. Ricardo on "Some Possible Lines of Development in Aircraft Engines," read before the Royal Aeronautical Society, which has been the subject of careful discussion by the Committee. It is hoped to carry out further researches of the kind described in the paper. Matters relating to ignition, particularly as regards the fireproofness of magnetos, have received attention, and continuous research on this subject has been carried on at the R.A.E., who have at the same time kept in touch with the requirements of the industry.

The internal combustion turbine has been discussed in considerable detail, and a report summarising the present position has been issued. In this report attention is drawn to the low efficiency attainable at the present time with this type of prime mover.

_Fire Prevention on Aircraft._—A preliminary report on fire prevention in aircraft and an account of various experiments bearing on such questions was issued early last year. Since that date the Fire Prevention Sub-Committee have confined their attention principally to the causes of fire in crash, as the frequency of the occurrence of fires in the air is much less. The latter are possibly in the main caused by backfiring, by the collection of petrol or vapour which may have access to leaks from inlet or exhaust pipes, or to occasional sparks. Attention is directed to the joints of the inlet and exhaust pipes, which should be constructed and jointed so as to withstand a pressure of 20 lbs./sq. in., and be located to discharge in a safe place.

The possible causes of ignition of an aeroplane on crash are, on the other hand, very numerous, and mention is made of these in the supplement to this report. They can be divided roughly into those from the hot parts of the engine, from the ignition system and from incidental causes. The Sub-Committee propose to issue a report dealing in detail with the cause and prevention of fire when an aeroplane crashes.

_Meteorology._—As affecting aviation, fog and the possibilities of its dispersion is an important question, and on this subject the Meteorology Sub-Committee are shortly issuing a report. Three methods for dispersing fog have been considered, viz., the mechanical, thermal and electrical. Each is suitable for clearing small volumes of air of the small fog or mist particles contained in it, but their application to large volumes such as that of the slowly drifting air over an aerodrome is not a feasible proposition. Other means will have to be found to assist aviation in the difficulties of navigation in fog, and amongst these may be mentioned the choice of suitable aerodromes normally free from fog, or of alternate sites, one of which may be expected to be free from fog on any given day, and the development of mechanical means for the safe landing of an aeroplane in the fog. In connection with this last the Air Ministry are experimenting with
kite balloons to be flown at such a height that they mark the position from which a given type of aeroplane can be glided safely into an aerodrome. Other methods involving the mechanical movement of the controls independent of the pilot’s action are also under consideration.

In connection with navigation, careful attention has been paid to recording and other instruments for use during flight. The accuracy of altimeters can be considerably improved, and a recommendation to this effect has been made to the Air Ministry. Various methods of calibration of altimeters have been considered and, for ease of co-operation with allied powers, it has been arranged by the Air Ministry to adopt Toussaint’s formula to express the relation between height temperature and pressure. Other formulae give greater accuracy for height determinations and the comparison of height records, but the differences between the readings of these and on the Toussaint basis are small.

The R.A.E. and other types of sextant have been tried out in various navigation flights, including one of 1,000 miles on a Handley Page aeroplane and another on a rigid airship. The determination of position by dead reckoning on the latter is equally as effective as that obtainable at sea, but on the aeroplane the accuracy is much less, being at present not greater than 10 per cent. for flights of two or three hundred miles. The use of flares over the sea or inland water was found of great value, and gave results of the same order of accuracy as sights taken from an easily determinate point on land.

To increase our knowledge of the structure of the atmosphere at different altitudes a scheme for using unmanned kite balloons carrying recording instruments has been proposed. It is hoped that the scheme will be shortly developed by the Air Ministry.

General questions bearing on the theory of the formation of cyclones have also been carefully discussed.

**Materials of Construction.**—An extensive programme to investigate the properties of materials used in aeronautical constructional work has been commenced under the direction of the Materials Sub-Committee. This includes the continuation of the study of light alloys, an enquiry into the fatigue properties of metals and a number of experiments on fabrics and dopes at the N.P.L. and the R.A.E. Investigations of the strength of aeroplane structures have continued at the R.A.E., where the staff has also paid attention to certain metallurgical and chemical problems. In connection with work at Universities and other technical institutions a special programme has been drafted for which definite funds have been allocated by the Department of Scientific and Industrial Research. This programme includes, in cooperation with the N.P.L., a continuation of the work carried
out under the direction of the late Light Alloys Sub-Committee
and experiments on certain definite properties of a number of
metals: in particular further information is needed to assess
the value of a new theory on the strength of materials as
developed by Mr. A. A. Griffiths, of the R.A.E., in a recent paper
to the Royal Society.

A number of matters have been reported upon during the
past year. Static tensile tests have been made on duralumin
and suggest that the elastic limit of this material is not high.
Experiment has shown that very soft rivets composed of nearly
pure aluminium are not necessary for airship work since perfectly
satisfactory joints can be made using either cold drawn and
annealed wire of 3/20 alloy or duralumin wire. Details and working
instructions for the preparations of cuprammonium solutions of
cellulose and the determinations of the viscosity of such solutions
are reported. A general comparison of various metals for
aeroplane construction has been made showing that for flanges
of members subject to bending and for beams of a given flexi-
bility there is little to choose between 45-ton steel and duralumin
but that for strut members, weight for weight, duralumin is
as strong as steel, having a modulus of elasticity of 13,200
tons/sq. in. Thus for small aeroplanes duralumin is preferable,
but for large machines steel should prove the better material.

Signed on behalf of the Committee,

R. T. GLAZEBROOK,

Chairman.