AERONAUTICAL RESEARCH
COMMITTEE

TECHNICAL REPORT
FOR THE YEAR
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AERONAUTICAL RESEARCH COMMITTEE

Report for the Year 1938

February, 1939.

The Right Hon. Sir Kingsley Wood, M.P.,
Secretary of State for Air.

Sir,

We, the Aeronautical Research Committee, beg leave to submit our Report for the year 1938.

We add to our Report as usual reports from our Sub-Committees which give a general survey of the work undertaken during the year. We take the opportunity in our Main Report of drawing attention to some problems of special importance. Increase in performance by reduction of drag and the attainment of a higher degree of safety through improvement of stability and control come in the forefront.

1. *Drag Reduction.*—One of the ways in which an increase in efficiency can be obtained is through a reduction in area of those parts of the surface of the aeroplane which do not contribute to life, and, as the wing surface in this way becomes a larger proportion of the total surface exposed to the wind, reduction of wing drag must be of ever increasing importance. In our Report for 1937, we described the two types of air-flow which are found very near the surfaces of good stream-line shapes such as wings—the smooth type, free from eddies, near the leading edge of the wing changing at the transition point to the eddying or turbulent type some way back. The position on the surface of a wing of the transition point where eddies start to form is affected by size and speed, and by the shape and the condition of the wing surface. The importance of the exact position of the transition point lies in the observation that the drag on the forward part of the wing where the flow is smooth is very much less than on the back part where it is turbulent. Thus experimental work is being directed towards finding the conditions in which there will be a maximum proportion of the wing area in smooth flow, in other words, a far back position of the transition point.

Unfortunately it is difficult to obtain accurate information on wings from wind tunnel experiments because the air in all existing tunnels is too turbulent. Thus, the bulk of the experimental work has to be carried out in actual flight, where the difficulties of measurement are greater than in the laboratory.

It is believed that increase of size and speed tends to move the transition point forward, and it is possible that at very high speeds there is no way in which the air can be made to flow over any substantial part of the wing surface without breaking up into the eddying, high-resistance type of flow. Experiments are being made to provide information on this vital point, but the technique is difficult. It has been found that, however smooth the wing surface, the disturbed slipstream behind the airscrew greatly reduces the extent of any smooth flow over the wing behind it ; since so great a proportion of the wing surface of modern aeroplanes, particularly multi-engine types, is in the slipstream, it would seem that there may be an appreciable loss of performance as compared with what might be achieved by using pusher airscrews instead of the almost universal tractor type. While a change of design of this kind involves many difficulties, we hope, during the coming year, to be able to provide information as to how much it might improve performance.

As regards the wing surface itself, experiments have been successfully carried out which throw light on the effect of roughness of the surface, and breaks in the surface consequent on the retraction of the undercarriage within the wings, the fitting of essential armament and inspection doors, etc.

Taking roughness first, it appears that extremely small departures from a perfect surface, roughnesses less than one-thousandth of an inch in height, are sufficient to increase measurably the drag of a high performance aeroplane ; while we realise the extreme difficulty not only of producing, but also of maintaining, wing and body surfaces really free from roughness, we are glad to observe the steady improvement in surface which new types of aeroplane attain. The losses arising from breaks in the wing surface may be reduced by sealing the joints against air-flow, and the great importance of this sealing is referred to later during the description of the work in connection with the reduction of cooling drag. The degree of waviness of the surface which can be tolerated is not yet known, but it is undoubtedly bound up with the position of the transition point, which may move forward if the waviness is appreciable.

A further question of fundamental importance to the designer is the best thickness for the wings. This problem is one of great complexity, on account of the number of factors involved, and experimental work, which will help to provide answers to the many questions involved, is now in progress.

2. *Stability and Control.*—It is probably in this field that the designer stands in greatest need of help. For well over twenty years a considerable body of information and experience has been steadily accumulated for his guidance in predicting both the stability and control characteristics of aircraft. But until recent years nearly all this information had direct application to the biplane type, and a lack of similar knowledge relating to the modern type of monoplane has been a most potent cause of delay in developing new types to a condition fit for issue to the Service, or for civil uses. Defective longitudinal stability in particular has entailed serious modifications, expensive in both cost and time, in certain designs, and such modifications can only be started after the first test flight.

Much work has been done during the past year to provide designers with information which will help them to achieve a more satisfactory degree of stability at the first attempt. In particular, we are glad to learn that the Air Ministry is working in close co-operation with the aircraft firms in the consolidation of the knowledge gained in the last few years of design both from full-scale stability and control tests, and from laboratory tests on models...This is one of the most useful ways of providing that link which is essential for the successful prediction of the flying characteristics of a new design from an examination of its model tests.

Although it may be difficult of attainment, we believe that the right policy is to make aeroplanes stable under all conditions of flight. Modern development continually extends the range of these conditions. The aeroplane should be stable over an ever widening range of speed, and also on the climb ; it should be stable with the crew and equipment in various positions, and with the high lift flaps up and with them down for landing. Whereas stability on the glide is not usually difficult to provide, it has been found that the slipstream from the powerful engines now fitted often exerts a severe destabilising influence, and during the year a lengthy investigation of slipstream effect has been made, resulting in basic information of value to designers.

Lateral stability at slow speeds and near the stall has been the subject of a large amount of full-scale experimental work, and we are glad to be able to report that in certain cases defective lateral stability has been greatly improved by modifications to the cross-section of the wing towards the wing tips. Aircraft designers are already making use of some of the preliminary results which have been obtained.

All the work which has been done, both on stability and control, would be of greater use to the designer if we had a more fundamental understanding of many parts of the subject, a better framework into which our knowledge could be fitted ; and we are of the opinion that advance in the subject must be founded on a real quantitative basis, built up by measurements made in flight. We feel that, just as accurate measurements of performance and resistance have been of immense value in the achievement of the great increases of aeroplane speeds in recent years, so measurements of control and stability will in like manner help to guide the designer through what is to-day probably the most anxious part of his task.

Steps are now being taken to provide and improve measuring apparatus which will enable quantitative experiments, particularly on control, to be carried out in flight ; an " Anson " has been allotted for this work, and preparations for altering its stability and control characteristics are now well advanced.

3. *Engines.*—For all types of aircraft engines the development of improved superchargers is of the greatest importance. The Engine Sub-Committee has reviewed and advised on the progress of experimental work at the Royal Aircraft Establishment and elsewhere, and is in close touch with work on new designs which is being actively pressed forward.

Promising results have been obtained from the experimental work on the compression ignition engine which, during the past year, has made good progress, with single-cylinder units working on both the two-stroke and four-stroke cycles. We are of the opinion that the two-stroke engine offers greater scope for future development for aircraft purposes, and we think that the time has come for constructing a complete two-stroke compression ignition engine on the lines indicated by the single cylinder experimental work.

As mentioned previously, wing drag is being reduced, and its reduction brings into greater prominence the importance of the drag associated with the cooling of the engines. While the power required to force enough air over the cylinders or through the radiator to secure adequate cooling is quite small, being only of the order of 2 per cent. of the engine horse-power, the losses on actual engine installations are commonly very much greater, and may amount to 25 per cent. of the horse-power, or even more, while losses of this kind increase rapidly as the speeds of aircraft rise. A number of engine installations have now been tested at the R.A.E., and investigations have been made to show where and how the losses arise. It has been found that all the cooling air must enter and leave at carefully chosen points, and that all leaks in the ducting system must be effectively sealed, if minimum resistance is to be attained. While a further investigation of the losses arising from cooling the oil is needed, the results already obtained show how cooling duct losses, which are now common, may largely be avoided, and a valuable report summarising the practical effects of the work done has been issued to designers.

4. *Materials.*—The improvement of alloys used for aircraft construction is of the utmost importance, but the work is on the whole concerned with matters of detail on which we feel we cannot be of very much assistance. So far as the Air Ministry is concerned, most of this work is done at the N.P.L. or the R.A.E., but in addition

a great volume of well-directed work is in progress at industrial firms. We feel that the value of the Alloys Sub-Committee rests much more in the opportunity it gives for the different workers on aircraft alloys to meet and to exchange views than on any scientific advice that can be given by its independent members. We have therefore arranged that in future there shall be two set meetings of the Alloys Sub-Committee each year, one at the R.A.E. and one at the N.P.L., when reviews of the progress of the work can be made.

Besides the work on alloys, investigations are being made of materials of the reinforced synthetic resin variety, and we have had discussions upon the research work now in progress and its future application ; further reference to this is made in the Elasticity and Fatigue Supplement.

In addition to the development work described, there is in progress at various Universities much scientific work of interest on the properties and structure of materials. All branches of engineering will, of course, benefit by the fundamental knowledge gained, and we are in close touch with the laboratories concerned.

5. *Wind Tunnels and Whirling Arm.*—We have recommended substantial expenditure on new wind tunnels ; in particular on the construction at the R.A.E. of a wind tunnel of 10 feet × 7 feet section to investigate problems of high speed up to 600 miles per hour. It is expected that this tunnel will be in operation about the end of 1940, but in the meantime a 1-foot tunnel, running up to about the same speed, has been in operation for over a year at the N.P.L. and has provided information on the increase of drag of models at air speeds approaching that of sound. Another similar tunnel of somewhat larger size, intended mainly for high-speed flow photography, is being constructed there.

Four new tunnels are under construction at the N.P.L. The largest is 13 feet × 9 feet in section, so designed that the degree of turbulence should be very low in comparison with that in most existing tunnels. Two of the other tunnels will have closed working sections 9 feet × 7 feet in size to meet increased demands by Government Departments other than the Air Ministry for tests of an aerodynamic nature. The fourth tunnel, the plans for which are now complete, will be 7 feet in diameter and the air flow will be as free from turbulence as possible. One of the immediate uses to which this tunnel will be put will be an investigation of the effect of turbulence on the properties of aerofoils. At the R.A.E. one 7-foot tunnel has now been modernised by converting it to a single return flow tunnel with rectangular cross section $11\frac{1}{2}$ feet × 8 feet in size.

At the N.P.L. a new whirling arm is being built sufficiently stiff and strong for testing the stability of models with airscrews running.

6. *Meteorology.*—Some promising results were obtained last winter in a single experiment on the dispersal of fog by heat. Apparatus modified in the light of experience gained has been installed at Farnborough Aerodrome for a continuation of the experiments, and another set of apparatus has been installed at Brough with the co-operation of Messrs. Blackburn Aircraft Limited ; we have the close co-operation of the Director of the Meteorological Office in these experiments.

During the measurement of atmospheric gusts which has been in progress during the past year, no record has been obtained of any gust which comes near that envisaged by the airworthiness requirements for civil aircraft, even at their highest speeds. The gust measurements were made at the top of the Blackpool Tower, and these have been completed during the past year ; the Committee's thanks are due to the Blackpool Tower Company, Ltd., for the facilities which they have so kindly and so readily given. While it was the intention at one time to carry on this work on the Eiffel Tower, with its greater height and inland position, we are now considering other methods of measuring gusts at still greater heights.

In our last Report we referred to the insufficient provision for the study of meteorology at Universities. We now learn with pleasure that the Staff of the Meteorological Department at the Imperial College is to be strengthened, and that there are possibilities of further developments with the support of London University and of the Government.

7. *Noise.*—We welcome the appointment of the Committee under Lord Gorell and have already given his Committee the results of experiments which have been carried out over a number of years on the reduction of noise caused by the engine exhaust and by the airscrew. We are interested to learn that Professor Cave-Browne-Cave is co-operating with the Air Ministry in an endeavour to reduce the annoyance caused to the general public by the noise from the engine exhaust of training aircraft. An arrangement of exhaust pipe which has been found to make an appreciable improvement in one installation is being tried on several types, and we are assisting in these trials.

8. *Organisation.*—There have been some changes in the organisation of the Committee during the past year. The Accidents Sub-Committee has been for long a standing sub-committee, and although it has never had any general responsibility for the investigation of accidents to aircraft, it has had the duty of investigating in detail any accidents or series of accidents that may be referred to us by the Air Ministry. As it has not met for two years, we have thought it wise to abolish the standing committee ; in future we shall set up a suitable *ad hoc* committee to undertake any proposed enquiry.

The Noise Sub-Committee has also been abolished because we feel that, from the aspect of research, the ground has been substantially covered.

9. *Aircraft Industry.*—We have continued to keep in touch with representatives of the aircraft industry both by informal meetings and by meetings with representatives of the Society of British Aircraft Constructors.

In connection with the design of very large types of aeroplane, we have discussed with the Society the possibility of the use of "flying models" large enough to contain a pilot. This method of experiment has already been found to be of great value in the design of the "Empire" flying boats and we think it could be adopted more generally with advantage.

The Society have also consulted us about the design of wind tunnels for use in the industry. We have advised that although very expensive tunnels are required to get the highest practicable accuracy from model tests, a great deal of information of value to designers can be obtained by experiment in wind tunnels of moderate size, say 7 feet square in the working section.

It will not be out of place for us to record here our great sorrow at the death of Captain F. S. Barnwell in a flying accident. By his early work in connection with the Bristol "Scout" and the Bristol "Fighter" he is known to many; but this was only the beginning of many years of service to aviation which culminated in the design of the Bristol "Blenheim". Captain Barnwell's advice, co-operation, and friendship have always been greatly valued by us.

(Signed) H. T. TIZARD,
Chairman.