Progress of Aeronautical Research in Great Britain.¹

By H. E. WIMPERIS, Director of Scientific Research, Air Ministry.

IN all countries alike the two most disquieting aspects of aviation to-day are the frequency of accidents to service aircraft and the necessity for subsidising nearly all civil aviation enterprises; it is therefore natural that research should concentrate upon the problem of increasing the safety of aircraft in addition to striving towards improving what is known as 'performance.'

There are obvious reasons why any craft moving in a three-dimensional medium should be safer than the older two-dimensional form of transport; that this is not yet the case is largely because all conventional types of aeroplane depend for their sustenance upon a *horizontal* speed of some 50-60 miles an hour, relative to the surrounding air. If this necessary speed be lost, the loss of control which almost invariably follows is highly dangerous unless the height be sufficient for the aircraft to recover speed. If we can ensure that it will merely fall at a fairly steep gliding angle instead of starting to spin, then there is every prospect of a very considerable reduction in the number and serious nature of aircraft accidents.

In England the problem has been attacked with vigour and a form of control has been evolved which, even at very large angles of incidence, has neither of the long-recognised defects of the conventional ailerons in stalled flight, namely, rapid weakening of power to bank the aeroplane, and the introduction of a yawing moment, which, if not countered by adequate rudder control, causes the aircraft to enter into a spin. This result has been achieved by the use of a slot in front of the aileron. The slot opening, which for convenience of design may or may not be quite zero in normal flight, increases as the aileron is depressed. Full scale tests have been carried out on a number of types of wing section and aircraft, and there would seem no doubt that the principle of the method can be made generally applicable. In the last few months a further simplification of the use of such a slot has been made by Mr. Handley Page: this is now under test and shows great promise. At the same time, the influence of the rudder-power on the control in stalled flight has been investigated. Although there is no evidence that safety in stalled flight can be achieved merely by increasing the rudder-power, research has indicated that the size of this control has a large influence on the rapidity with which a spin following a stall can be stopped.

It is common knowledge that some types of aircraft, when stalled, go normally into a spin and are not easily brought out, whilst other types of aircraft are difficult to spin. On what features of design does this difference depend? Can we, by a manipulation of the form and arrangement of wings, by disposal of the centre of gravity with respect to the centre of pressure or by some ar-

range of the control surfaces, ensure that a civil aircraft will never spin, and that a service aircraft will only have such degree of ability to spin as may be necessary for its particular duty? We know, for example, that a forward position of the centre of gravity will lessen in some degree the danger of an involuntary spin; we know that when positive stagger is reduced, the spinning properties of a biplane are more dangerous, but the picture is far from complete; though it may be said that the mechanism of a spin in undisturbed air is now generally understood.

A somewhat extreme example of an aircraft designed primarily to affect control at and beyond the stall, is the Pterodactyl, a tailless aeroplane, designed and constructed by Capt. G. T. R. Hill, with the financial assistance of the Air Ministry. This aircraft provides adequate control at low speeds by virtue of the fact that the fairly large floating control surfaces at the wing tips are fully effective at all probable angles of incidence of the main planes. Successful full scale trials have been carried out with a lightly loaded tailless aeroplane, and it has been demonstrated that the aircraft has no tendency to autorotate. A tailless aircraft with higher wing loading is being built to the order of the Air Ministry.

It will be seen that much is being done to counteract the disadvantages arising from the natural limitation of the conventional fixed wing aircraft, namely, the dependence for sustenance upon a considerable forward speed. An alternative is the helicopter. We in Great Britain have from time to time looked not unhopefully along that road, but we have been compelled to turn away, always, indeed, with a little greater knowledge, but with a still greater respect for the magnitude of that attractive if elusive problem. But the task now seems not so hopeless as it once did. We have in England to-day a rotating wing aircraft having very attractive stability and controllability characteristics; I refer to the autogiro, the invention of Senor de la Cierva, belonging to the class we now call the 'Gyroplane.' This aircraft, by virtue of the hinging of the blades so that they can rise and fall as they rotate, escapes the instability which seemed at one time to be inevitably associated with rotating wing aircraft. Although not a helicopter, since it is not able to rise vertically from the ground, it is capable of almost vertical descent in a moderate wind. It cannot yet be said that it will compete with the more conventional types of aircraft at high speeds, but for some purposes it would be advantageous to sacrifice high speeds in order to achieve safe landing in confined spaces. Research is proceeding, a number of gyroplanes are being built, and the nature of the forces involved in the flapping motion of a rotating wing are being investigated theoretically and by experiments in a wind tunnel. Moreover,

¹ From a paper presented to the International Air Congress at Rome, October 1927.

the possession of a full scale rotating wing aircraft, the characteristics of which can be studied in actual flight, represents an exceedingly important advance towards the solution of the helicopter problem.

Of the other researches which are proceeding with the object of increasing the safety of aircraft, perhaps the work on wing flutter is of most general interest. It is well known that certain types of aircraft exhibit a dangerous wing flutter when diving at high speeds. We, in England, have not escaped this trouble, but happily we are within reach of an appreciation of the features of design which cause it. Theoretical investigations which have been carried out at the National Physical Laboratory, and recent wind tunnel experiments at that establishment, have shown that it is possible to reproduce on a specially constructed model the various types of flutter indicated by theory. Research is proceeding, but already it is clear that the mass distribution and aerodynamic loading of the ailerons is a factor of prime importance. Full scale experiments have also supplied very valuable data on the nature of wing flutter, and tribute must be paid to the skill and courage of the many pilots who willingly face the risk of diving aircraft at such speeds that flutter ensues; the knowledge so gained is of the utmost value, but it is better to substitute work on the model scale for such dangerous tests wherever possible.

On the subject of increasing aircraft 'performance,' one's thoughts turn naturally to the engine. One of the most amazing of modern engineering achievements is the production of a reliable power unit weighing little more than $1\frac{1}{2}$ lb. per horsepower at ground level. For special purposes, such as for the recent Schneider Trophy competition, engines have been constructed weighing considerably less than 1 lb. per horsepower, but of course these engines are not yet suitable for general purposes.

Engines with gear-driven and with exhaust-driven superchargers have been built and have shown satisfactory power outputs at altitude, but our knowledge of how far the advantage of increased power is outweighed by the increase of weight, head resistance, fuel consumption, and of fire risk with the exhaust-driven type, is still incomplete.

There is another direction, however, in which attempts are being made to meet the need for operating in an atmosphere of variable pressure. It is well known that engines running at ground level, on ordinary aviation spirit, exhibit a tendency to detonate if the compression ratio exceeds about 5:1. At altitude the decreased air density and temperature allow higher compression ratios to be used without detonation, and for this reason most engines are designed to have a compression ratio larger than 5:1, detonation at low altitude being avoided by throttling the engine. Conditions such as these have led to a search for a suitable fuel which will stand a higher compression ratio without detonation. Tests on variable compression engines have shown that by adding some 20 per cent. of benzol, the compression ratio can safely be increased to 5.8:1, with a resulting decrease of

the weight per horsepower and a decreased fuel consumption, but for many reasons this method is unsatisfactory.

It seems not unlikely that the best solution will be the addition to petrol of small quantities of 'dope,' the best known being a mixture of tetra-ethyl-lead and ethylene dibromide. Indeed, it is not too much to say that the discovery of a 'dope' entirely suitable in its supply, use, and storage, would mark a new era in engine design. The decreased weight-power ratio and fuel consumption consequent upon the use of high compression ratios would seem only to be limited by the skill with which the designer could deal with the higher explosion pressures without undue increase of weight. It is clear that there is no lack of incentive to work in this direction. In England intensive research has been carried out at the Air Ministry Laboratory, at the National Physical Laboratory, and at Oxford on the physical and chemical nature of the phenomenon of detonation and on the effect of using 'doped' fuels. Much progress has lately been made; according to Prof. Callendar, working at the first-named establishment, detonation is due to the formation of organic peroxides which become concentrated in the nuclear drops during compression and ignite the drops simultaneously when the detonation temperature of the peroxide is reached. Although much has been done, it still remains to discover a 'dope' which will be entirely satisfactory in an engine, be non-poisonous, and will not deteriorate in storage. For civil aviation purposes, such a 'dope' would be invaluable, since the need for power at ground level at present conflicts with the necessity for using engines having a low compression ratio.

Every decrease of the weight-power ratio of aero engines inevitably focusses attention on the problem of effecting economy in fuel consumption. The average aero engine consumes its own weight of fuel in four or five hours, and it may well be argued that efforts to reduce the fuel consumption have not kept pace with the reduction of the weight of the engine itself. For long-range civil aviation, this problem is of particular importance. If, by the use of 'dopes' it were possible to use as high a compression ratio as, for example, 10:1, a substantial reduction of fuel consumption would be achieved. There is, however, another avenue of progress—the heavy oil engine. If the prospect of using compression ignition engines on heavier-than-air machines is still distant, the advantages to be derived therefrom are so important that the ultimate displacement of the petrol engine by the heavy oil engine can scarcely be doubted.

With regard to the design of the aircraft itself, it would seem that any signal advance must await the discovery of a new alloy or some new treatment of an existing metal or a new aerodynamic principle. There is room, however, for progress along less spectacular lines. Fundamental aerodynamical investigations are proceeding, and the later R.A.F. wing sections have been successfully designed in

accordance with the Kutta-Joukowski aerofoil theory. Preliminary experiments have been made on the removal of the boundary layer from the upper surface of an aerofoil by suction from points well forward in the section; it has been found that the maximum lift is considerably increased thereby.

Similar results could no doubt be obtained by the emission of air under pressure; but it will be appreciated that this is in reality the principle of the Handley Page slot, which, moreover, has the advantage of being independent of any pumping plant.

News and Views.

THE Council of the Physical Society has awarded the Duddell medal for 1927 to Dr. F. E. Smith, Director of Scientific Research at the Admiralty. This medal is given annually for work in connexion with the development of scientific instruments or of materials used in their manufacture. Dr. Smith's work at the National Physical Laboratory on the development of electrical standards is too well known to require emphasis. He was trained at the Royal College of Science, 1895-1900, under the late Sir Arthur Rücker, entering the National Physical Laboratory in 1900. There he formed one of the band of pioneers who, under Sir Richard Glazebrook, did so much to raise the scientific work of the Institution to its present high level. His earliest work was concerned with modifications of the Wheatstone and Kelvin bridges for precise measurements of resistance, and the development of bridges for accurate platinum resistance thermometry. A classical piece of work followed on the current balance, by means of which it was found possible to evaluate a current of the nominal value of 1 ampere to within 1 part in 50,000. In the course of this work he developed the silver voltmeter which bears his name and is generally accepted as the most trustworthy form of voltmeter, in that there is no envelope between the anode and cathode. The successful development of the modern mercury-in-glass resistance standards is largely due to Dr. Smith's work. His specification for the Weston normal cadmium cell is the one generally followed. It is now no uncommon experience for a batch of twenty standard cells to be made commercially in which the E.M.F. given by the cells agrees to 1 part in 10,000. Dr. Smith was also responsible for the design of the Lorenz apparatus (the Viriamu Jones Memorial) installed at the National Physical Laboratory. He has also developed various magnetometers for the measurement of the magnetic intensity of the earth's field; one of his instruments now forms the standard for the measurement of the horizontal intensity at the Magnetic Observatory at Abinger. In 1920, Dr. Smith left the National Physical Laboratory to take up his present post at the Admiralty. He was president of the Physical Society for 1923-24. As one of the honorary secretaries of the British Association, his organising ability is being devoted in a striking manner to the advancement of science.

MR. ROBERT MOND has been appointed a member of the research council of Imperial Chemical Industries, Ltd., to which reference was made in our issue of Dec. 10, p. 850. Mr. Mond has carried out notable research in pure and applied chemistry and has given

particular attention to electrolytic problems. He was associated with his father, Dr. Ludwig Mond, in researches on the metallic carbonyls and the action of nitric oxide upon them. In other directions Mr. Mond has also contributed in a substantial way to scientific progress by his original work and personal influence, and he is as highly esteemed for his Egyptological explorations and studies as he is for his contributions to physical and chemical science. He is honorary secretary of the Davy-Faraday Laboratory of the Royal Institution and honorary treasurer of the Faraday Society; and many other societies and scientific organisations are indebted to him for generous support and encouragement.

It has long been known that the difference between good and poor pastures is not dependent alone upon the energy value of the herbage or the proximate food constituents, carbohydrate, protein and fat. The consequent investigations of mineral deficiencies, notably at the Rowett Research Institute, have already proved to be a well-directed inquiry. The discussions at the recent Imperial Agricultural Research Conference have made it abundantly clear that malnutrition consequent upon mineral deficiencies in pastures is widespread through the Empire. From South Africa one hears that 'styfsiekte' in cattle arises on certain veld soils, the vegetation of which contains less than the optimum requirements of phosphorus. The ruminant stock of the North Island of New Zealand have for some time been troubled with 'bush sickness,' a condition of anæmia and general emaciation which has now been shown by Aston to be correlated with iron deficiency. In the Bihar district of India low milk yield is consequential upon a low phosphorus content of soil and crops. The high mortality among sheep in the Falkland Islands has been found by Godden to be collateral with low lime and phosphorus percentages in the pastures. Similar evidence of malnutrition among Australian sheep is forthcoming. The pastoral industry of Australia contributes about 25 per cent. of the national income, a fact which makes the immediate investigation of mineral deficiency diseases imperative. These deficiency diseases are becoming more evident with the increasing population of the colonies, and the subdivision of the larger holdings. Stock migrated from one area to another in earlier days and so unconsciously secured adequate mineral supplies. The continuous maintenance of stock on the same area has now given rise to this new problem in nutrition, which is to receive full and immediate investigation largely through the co-operative efforts of the Empire Marketing Board, the