

The pencil outline of a drawing on the top of ink in another of Hogarth's note-books is also in typical graphite. The lines in the drawings of a later volume of Stowe MSS. (993), about 1747, show fine interrupted striæ, such as are frequently noticeable in the marks made by pure graphite. In "Heraldic Collections" (Stowe MS. 661) of 1763-64 the pigment in the drawings of the coats-of-arms is also in graphite, and shows the fibres of the paper lit up by adherent particles. An interesting example of graphite markings is to be seen in a letter from Prof. Herrmann (1780) from Strasbourg (Add. MS. 22,935, fol. 140b). This contains a pencil drawing of a fish, in which the pigment has formed branching striations along the lines of the paper fibres.

Flaxman was in the habit of making drawings on the backs of the envelopes of letters received by him at Buckingham Street, Fitzroy Square, and a series of these, dating from about 1800 to 1814, is preserved in the British Museum. In every instance the pigment in these drawings is typical of pure graphite, and even interrupted striations are only of exceptional occurrence.

In view of the fact that Conté's composite clay process was invented in 1795 in Paris, it is interesting to note that a card sent to Flaxman by the painter Fleury Epinat, of Lyons, between

1805 and 1814 was written with a pencil producing the characteristic fine regular beaded striations of the modern type of pencil. This is the first instance noted of the occurrence of writing in a composition pigment in the MSS. in the Museum.

Of the other manuscripts and drawings of the early nineteenth century, mention may be made of a letter of Byron (about 1809) which is written in a particularly brilliant graphite, and of the pencil corrections made by Keats (about 1820) in his manuscript of "Hyperion," which are also in pure graphite. The same characteristics of rich pigment deposit, showing only scanty, irregular, broken striations, may also be seen in a letter of Lord Wellesley written about 1828.

The manufacture of graphite pencils by the original method of cutting from the block was continued until about 1869, overlapping the modern process; but, as the old pencils must have been widely distributed, it is not surprising that the characteristics of pure graphite are frequently to be found in writing, and especially in drawings, for several years after that date. Hence it is quite in accordance with the development of the industry that the note-book of James Thomson, the author of "The City of Dreadful Night," for the year 1869 should be written with a pencil which produced no silvery striations.

### The Relationship of Education to Research in Aeronautics.

THE relation of education to research is a simple one in most fields of scientific work, in that the universities provide both one and the other. This simplicity cannot, however, extend to the subject of aeronautics, because the cost of experimentation is so great and the organisation required so complex. In the future the universities may perhaps be equipped even for this extension of their activities, but at the present time, and for many years to come, the experimental work will in general be beyond their means. The Government, however, for its own sake, needs to continue to carry on aeronautical research, and the question naturally arises: What are to be the relations between the Government research establishments and the university teaching establishments? The Committee appointed in October, 1918, by Lord Weir to advise on this matter has now reported, and its recommendation is to merge the staffs undertaking these two classes of work. At the present time it is scarcely practicable or wise to found more than one school of aeronautics, and the Committee selects the Imperial College of Science as its home, suggesting that the staff of the school should for the most part be composed of those members of the Government research establishments who are best qualified for the work, and can be permitted to spend part of their time at the Imperial College.

The Committee also provides that the Advisory Committee for Aeronautics should come to an end, and that its former powers should—with certain additions—be made over to a new body, the Aero-

autical Research Committee. The Advisory Committee has had a very distinguished history. Its composition was mainly non-official, and it became a watchful and highly independent body able and ready to intervene in any matter where it thought such intervention was required. With the many reorganisations of Air Service matters during the war, whether relating to the R.N.A.S., the R.F.C., the Air Board, the Air Ministry, or the R.A.F., it became the one continuously operating body, and rendered services to the State of a value which can be realised only by those who kept in touch with its wide activities. The Education and Research Committee endeavours to pay tribute to the Advisory Committee, and it must have had some difficulty in finding words appropriate to the occasion.

It seems that the Government took definite decisions some six months ago that an Aeronautical Research Committee should be created to replace the existing Advisory Committee; that, in addition, research work should be undertaken by a Research Association to be formed by the Department of Scientific and Industrial Research, on the usual terms, if the industry should so desire; and that the Imperial College should be the educational centre (although applications from provincial universities for grants would be considered). The Committee, taking note of these decisions, suggests that the new Aeronautical Research Committee (A.R.C.) should supervise both research and education. Any plan for the supervision of research needs to take into account

the nature of the establishments where it is at present undertaken. These places are the Royal Aircraft Establishment (Farnborough); the National Physical Laboratory (controlled by the D.S.I.R.); Martlesham Heath, Biggin Hill, Pulham, Grain, Felixstowe, and possibly other Government aerodromes. All of these, except the R.A.E. and the N.P.L., are controlled by the Director of Research at the Air Ministry on behalf of the Air Council, which is responsible for these centres and pays for them. The Committee does not attempt to pursue the allocation of responsibilities further, but such allocation need not be expected to lead to difficulty, since much of the work from these centres found its way in the past to the old Advisory Committee, and will doubtless in the future find its way to its successor.

As regards the educational side, the Committee mentions an estimate that before the war the total yearly number of honours graduates in engineering, including civil, mechanical, and electrical, and in naval architecture, etc., from all the universities in the United Kingdom averaged only about two hundred, and that of these it rightly considers only a fraction of the future number are likely to devote themselves entirely to aeronautics. It certainly seems probable that the number will be quite small; the Government has its own Air Service establishments, and these will naturally take a proportion of the possible entrants each year. Moreover, the most promising career for aeronautical engineering work at present is the Government service, since it is the Government which controls nearly all the research and no small proportion of the full-scale design, to say nothing of the ordinary Service work and its attraction to the adventurous. The only factor which would seem capable under present conditions of adding materially to the numbers of students taking an aeronautical engineering course at the Imperial College or elsewhere would be if the Government used this means for the training of its own future technical staff.

The course, once formed, is to consist of twelve months' specialised teaching, coming after the usual degree or diploma course in engineering already provided at the universities and great technical schools. The subjects selected for this course are: Aerodynamics; aero-engines; general design; instruments, meteorology, and navigation. The proposed staff includes a general director, who would be the Zaharoff professor of aviation, two other professors, and a number of lecturers. This staff should, the Committee suggests, act as a clearing-house for the study of the results of experimental work, whether full-scale or in the laboratory, and for the dissemination of conclusions based thereon as forming the right foundation for further design. As the Committee naturally adds, no school for providing this education can be successful unless the students are brought into direct touch with practical problems during their tuition, and unless those engaged in teaching are also occupied in, or directing, scientific research or experimental design.

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Some extracts from the Committee's report are subjoined.

#### INTRODUCTION.<sup>1</sup>

The Government has now decided how provision is to be made for research in aeronautics. We desire at the outset to emphasise the necessity for that research. The Department of Scientific and Industrial Research is to continue the provision for fundamental research at the National Physical Laboratory, and to assist the aeronautical industry in the same manner as other industries by taking part, when desired, in the formation of a research association. In our view, at the start of a new industry something more is required. At the present moment the industry is passing through a crisis; Government support is necessary if it is to emerge satisfactorily. The time is critical and the development of civil aviation is beset by numerous difficulties, and calls for the fullest consideration. It is urgently necessary that the policy adopted should command the support of all who desire to maintain the superiority in the air gained during the past eventful years, and that ample funds should be provided for carrying it into effect.

A difficulty which arises in the case of a new industry of this kind lies in the fact that the scope of the work is inadequate to maintain automatically a sufficient number of experts in design and production. A research organisation may elucidate problems and provide general information and specific facts, but before these can bear fruit of industrial value they must be interpreted and applied by a suitable technical staff, closely associated with the works organisation. At the end of the war most of the works had collected a team of technical experts of marked ability; many of these teams have now been disbanded, and further disintegration is in progress. We see no possibility of achieving the desired result except by such Government action as will secure the retention of adequate technical staffs.

During the war this country obtained the lead in aeronautical research; it would be lamentable to see the fruits of the work pass from a paralysed industry to better-supported foreign competitors. In the later sections of our report we recommend the establishment of an organisation for aeronautical research to assist the Air Council, and, in our view, it is important that the work of that organisation should be available in great measure for the assistance of the industry and for the advance of civil aviation, as well as for the Services. Should an industrial research association be formed, it should be linked up with the organisation we recommend.

Education and research are clearly very closely inter-related. The education with which we have chiefly concerned ourselves is that suitable for aeronautical engineers and constructors—that is to say, post-graduate work for which the students will be fitted by a previous undergraduate course of either mechanical or general engineering training at one of the universities or technical colleges. We have not dealt with the training of pilots or of mechanics. The course we contemplate will comprise a special study of the following matters:—Aerodynamics, the laws of motion of bodies moving in the air, illustrated by experiments and researches in wind-channels; the principles of design and construction; engines and the methods of propulsion of aircraft; and the inves-

<sup>1</sup> Abridged from the Report of the Committee on Education and Research in Aeronautics (Cmd. 554, price 2d. net) to Mr. Winston S. Churchill, Secretary of State for Air. The members of the Committee were: Sir R. T. Glazebrook, K.C.B. (Chairman), Sir Alfred Keogh, G.C.B., Sir H. Frank Heath, K.C.B., Sir Francis G. Ogilvie, Mr. F. Handley Page, Mr. G. Holt Thomas, Prof. J. E. Petavel, and Lt.-Col. H. T. Tizard.

tigation of instruments used in flight, with problems in meteorology and navigation. The engineer must also gain the practical knowledge acquired only in the workshop, and must have experience of the full-scale researches necessary to test and verify his theoretical conclusions. Such a course might eventually involve one or more centres of theoretical instruction with experimental aerodromes and laboratories where the full-scale problems may be worked out, but as the number of persons likely to require this higher post-graduate education will not be great we consider that it will be wise for the present to concentrate the work in one central institution with which the experimental aerodromes should be closely connected. Such a central institution we find in the Imperial College of Science and Technology, at which the professorship lately founded by Sir Basil Zaharoff is to be held.

To turn now to research. This is the means by which advance in aeronautics is possible, and it is required by all interested in the progress of the subject: by the State, whether for the purposes of defence or to enable it to lay down the rules necessary for the safety of aircraft when used for civil purposes; by the professor, whose aim is to increase knowledge; and by the industry, in order that it may maintain the superiority which British aircraft has already achieved. Research is difficult, its requirements are costly, and the men who can undertake it are few. To establish separate research laboratories and aerodromes for each of these special interests is, for the moment, out of the question; here, again combination is called for—combination, too, with the agencies concerned in education. At the same time we recognise fully that special problems may be dealt with at other research centres, and we trust that every encouragement may be given to these for such work.

Since the commencement of practical aeronautics, research has been directed by the Advisory Committee for Aeronautics, a body, under the presidency of the late Lord Rayleigh, appointed by the Prime Minister in the year 1909 "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."

Full-scale research has been carried out at Farnborough, in part at the initiation of the Advisory Committee, in part at that of the military authorities; the Committee, however, has no control over the work there, and occupies only an advisory position with regard to it. During the war other centres of full-scale research were established—*e.g.* the Isle of Grain and Felixstowe for seaplanes, Kingsnorth and Pulham for airships—and the Advisory Committee has been kept in close touch with the work in progress at all of these. Its activities have been of the greatest value. In our view, a central co-ordinating body of this kind is essential, and it is now proposed to establish an Aeronautical Research Committee, to which the duties of the Advisory Committee would be transferred, and certain other duties and responsibilities added with regard both to the central research aerodromes and to education. The proposed Committee should be in a position to supervise effectively such work as comes within its purview.

The work in aeronautics conducted at the National Physical Laboratory would also, usually, be undertaken on the initiation of the Committee, the expenditure for such work forming part of the budget of the Department of Scientific and Industrial Research.

In order to connect the Committee with the educational work and to render the opportunities of research at Farnborough and elsewhere available both to teachers and to students, we suggest that arrange-

ments should be made between the Committee and the Imperial College for dealing with matters with which they are jointly concerned. In this connection, moreover, we suggest that it would be possible in a number of cases for members of the research staff to act as professors or lecturers at the college.

#### CONSTITUTION OF THE AERONAUTICAL RESEARCH COMMITTEE.

The Aeronautical Research Committee should include representation of (a) the Department or Departments responsible for (i) naval and military aeronautics, (ii) the regulation of civil aerial transport; (b) the Department of Scientific and Industrial Research, including direct representation of the National Physical Laboratory; (c) the aircraft industry; (d) the Imperial College; as well as (e) other members of scientific attainments. The chairman of the Committee should be an eminent man of science, and in a position independent of the Government Departments represented on the Committee. He and the other non-official members of the Committee should receive suitable remuneration.

#### FUNCTIONS OF THE AERONAUTICAL RESEARCH COMMITTEE.

It should be the duty of the Aeronautical Research Committee to devote itself to the advance of aeronautical science, and, with this object, in particular (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; and (7) to make reports from time to time to the Air Council.

#### CO-ORDINATION OF THE RESEARCH AND EDUCATIONAL ORGANISATION.

We have referred to the need for close association between the research and experimental work and the strictly academic portion of the higher education. No school for providing this education can be successful unless the students are brought into direct touch with practical problems during their tuition, and unless those engaged in teaching are also engaged in or directing scientific research or experimental design.

The arrangements whereby the student will divide his period of post-graduate instruction between work on books and at lectures and practical work at research stations should apply also in regard to the duties of the teaching staff. These should be such as to enable a professor or lecturer to spend part of his time in giving instruction at the Imperial College, while giving the rest to investigations at one of the research centres.

The School of Aeronautics should provide advanced instruction as regards aeroplanes, seaplanes, airships, and kite-balloons in (1) aerodynamics; (2) aero-engines and methods of propulsion; (3) design,

including structure and materials; and (4) instruments, meteorology, and navigation. It would follow, therefore, that certain of the professors or lecturers in each of these subjects will discharge double responsibilities (a) as members of the staff of the Imperial College and (b) as officers of the research organisation directed by the Aeronautical Research Committee.

The Interim and Final Reports of Special Committee No. 5 of the Civil Aerial Transport Committee contain much valuable information as to the organisation of teaching and research. One factor of importance which they emphasise is the need for a trained staff to act as a clearing-house for the co-ordination and dissemination of aeronautical knowledge in all its aspects. The Central School of Aeronautics should, in our view, serve this purpose.

The functions of the teaching staff of the School may be stated under four distinct, though closely related, purposes:—(a) To study, co-ordinate, summarise, apply, and extend the knowledge derived from the experimental work carried out by the individual workers at various experimental stations in this country and abroad. (b) To stimulate research by indicating what information is most urgently required and what line of attack is likely to prove most profitable. (c) To guide and encourage research by constructive criticism based on a careful study of past and current work in this country and abroad. (d) To impart this knowledge by personal teaching to a limited number of post-graduate students.

A similar clearing-house for current knowledge would be of value in any science, but for aeronautics it is, for the present, essential; for whereas in older sciences—physics, for instance—the bulk of the experimental data has, throughout the course of generations, crystallised into well-defined laws which form a framework ready to receive any new facts and a criterion by which their accuracy can be estimated, in aeronautics the facts are the result of the work of the last five or ten years, and the framework uniting them exists only in the minds of the few men who have been personally connected with the process of development.

Before the war the total available knowledge was small, and it was possible for the members of the Advisory Committee to keep all the facts in mind while devoting most of their time to other duties. They then provided the necessary co-ordinating factor. This is no longer possible, and the function could best be discharged by the staff of the School working under their director with the view of co-ordinating and making available all the knowledge in each branch of the work as existing at the moment.

For these reasons it is essential that the permanent staff of the Central School should be adequate both in numbers and in range of experience to the duties outlined above.

The subject of meteorology, including with it training in navigation and the use of instruments employed in flight, is one of great importance. The position, however, of the teacher of this subject must depend on the action taken with regard to research and inquiry into meteorological science generally. We have made provision in the estimates for a teacher in meteorological subjects closely connected with aeronautics who should combine this work with research at one of the experimental stations. His work would be brought into connection with the central meteorological establishment. We would add that, quite apart from the other interests concerned, we feel it our duty to press for the establishment of a properly equipped centre of teaching in this subject, the need for which has been felt for some years and is now acute.

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## Notes.

By a majority of seventy-five in a House of close on eight hundred Oxford has decided, for good or ill, that the Greek language shall no longer be a compulsory study for any of her *alumni*. In favour of the statute embodying this policy, which came before a full meeting of Convocation on March 2, speeches were delivered by Mr. C. Bailey, of Balliol College, Dr. Farnell, Rector of Exeter College, and Dr. David, Headmaster of Rugby. The opposition was undertaken by Mr. R. W. Livingstone, of Corpus, Mr. R. Carter, Headmaster of Bedford Grammar School, and Mr. John Murray, M.P., of Christ Church. The issue before Convocation was, perhaps, not quite so clear as it might have been; for it is probable that many voters thought that the rejection of the statute would have meant the perpetuation of the old form of Responsions, an examination which is allowed on all hands to be in need of radical reform. There is no doubt that in any case, whether the statute passed or was rejected, no attempt would have been made by the advocates of Greek in Responsions to make that language compulsory for passmen or for honours candidates in science or mathematics. But the feeling against compulsory Greek in any circumstances prevailed with the majority of voters, and Oxford has distinctly and definitely decided that, so far as she is concerned, the Greek language, however desirable as a study for specialists, is no longer to be considered a necessary element in a general education. The present vote may be taken as the final settlement of a keenly debated and long-protracted controversy.

THE council of the Royal Society has decided to recommend for election into the fellowship of the society the following fifteen from the list of candidates:—Dr. Edward Frankland Armstrong, Sir Jagadis Chunder Bose, Dr. Robert Broom, Prof. Edward Provan Cathcart, Mr. Alfred Chaston Chapman, Dr. Arthur Price Chattock, Mr. Arthur William Hill, Dr. Cargill Gilston Knott, Prof. Frederick Alexander Lindemann, Dr. Francis Hugh Adam Marshall, Dr. Thomas Ralph Merton, Dr. Robert Cyril Layton Perkins, Prof. Henry Crozier Plummer, Prof. Robert Robinson, and Prof. John William Watson Stephens.

THE KING has been pleased to approve the appointment of the Right Hon. Sir Auckland C. Geddes, K.C.B., President of the Board of Trade, as his Majesty's Ambassador Extraordinary and Plenipotentiary in Washington. Sir Auckland Geddes was formerly demonstrator and assistant professor of anatomy in the University of Edinburgh; professor of anatomy, Royal College of Surgeons, Dublin; and late professor of anatomy, McGill University, Montreal. A year ago he was appointed to succeed the late Sir William Peterson as principal of McGill University, and he has now cabled his resignation of this post.

DURING the war little was heard of wireless telegraphy except that its use by unauthorised persons was entirely prohibited, but a great deal of pioneering research in the development of new methods and the