AERIAL SURVEYING BY RAPID METHODS

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by

BENNETT MELVILL JONES, A.F.C., M.A.

FRANCIS MOND PROFESSOR OF AERONAUTICAL ENGINEERING, AND FELLOW OF EMMANUEL COLLEGE, IN THE UNIVERSITY OF CAMBRIDGE

and

MAJOR J. C. GRIFFITHS, B.Eng., Hon. B.Sc.

CAMBRIDGE

AT THE UNIVERSITY PRESS

1925

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107511514

First published 1925
First paperback edition 2015

A catalogue record for this publication is available from the British Library

ISBN 978-1-107-51151-4 Paperback

AUTHORS' FOREWORD

THE way in which the series of experiments described and analysed in this book originated is explained in the preface by Captain H. Hamshaw Thomas, M.B.E.; it remains to explain the somewhat peculiar circumstances under which the experiments were made and the book written.

The experimental investigations on this subject, which began in Cambridge in the autumn of 1920, were the result of co-operation between many departments and individuals. Major J. C. Griffiths, who was at the time a research student in the University, carried out the bulk of the experiments, supported, meanwhile, by a financial grant from the Department of Scientific and Industrial Research. The Royal Air Force provided the aeroplanes and pilots together with cameras and other instruments, whilst the Royal Aircraft Establishment lent certain experimental apparatus which were not at the time standard in the Air Force. The direction of the experiments and the responsibility for the utilisation of the apparatus and facilities provided by these departments lay in my hands, but the original inspiration concerning the need for the experiments and the type of information required came from Captain Thomas, as the result of his experience in Palestine during the campaign of 1917–8. We have been in close touch with Captain Thomas throughout the course of the experiments and his advice and criticism have been invaluable.

During the whole of the work valuable assistance has been received, both from private individuals and from members of the staffs of the services and departments mentioned. In particular the Air Survey Committee, a joint committee of the three fighting services, has co-operated wholeheartedly. By the kindness of the Chairman, Colonel H. StJ. L. Winterbotham, C.M.G., D.S.O., I was invited to attend the meetings of this Committee and was kept informed of its activities, so that, together, it was possible to arrange a combined scheme of work which would cover, without undue repetition, the whole of the ground over which it appeared that experiments were required. The assistance rendered by the members of this Committee, both collectively and individually, has been very great, and it was mainly through their support that we were able to borrow the costly and delicate apparatus that we required.

The investigations could not have taken place at all without the material assistance rendered by the Royal Air Force. The Chief of the

Air Staff, Sir Hugh M. Trenchard, G.C.B., D.S.O., provided a number of aeroplanes for our use, detailing pilots to fly them and mechanics to keep them in working order. The small experimental flight so formed operated at the service aerodrome of Duxford, near Cambridge; it was placed absolutely at our disposal "except in so far as the exigencies of the service permitted." For administrative and disciplinary purposes this flight was under the control of the Officer Commanding the station, and our sincere thanks are due to Group Captain W. R. Freeman, D.S.O., M.C., and to Wing Commander Sidney Smith, D.S.O., A.F.C., for the sympathetic manner in which they interpreted this arrangement whilst they were in command of this station. Experimental work in the air, in the uncertain weather that prevails in this country, is at all times difficult to carry through successfully. The necessity of seizing every spell of fine weather, regardless of times and seasons, makes such work particularly difficult to fit in with the ordered routine of service life; it is not too much to say that no appreciable progress could have been made had not the Commanding Officers taken a personal interest in the work and done all in their power to push it forward.

The piloting throughout the experiments was in the hands of three officers: Flight Lieutenant F. H. Coleman and Flying Officer C. E. H. Allan, D.F.C., working together for the greater part of the time, and Flight Lieutenant D. L. Blackford working alone in the later stages. The work of these officers will appear in the text, but what cannot be indicated there is the enthusiasm with which they carried out their instructions, which often involved long and very arduous flights at times when they would normally be off duty. I wish also to take this opportunity of thanking Flying Officer D. F. Drudge, who was for some time in charge of the photographic section at Duxford, for the enthusiastic way in which he co-operated and the interest that he took in the work, and I feel that special mention must be made of two air mechanics, Smallman and Bollen, whose enthusiastic work as engine man and rigger respectively contributed materially to the success of the experiments.

The more elaborate and expensive instruments necessary for the experiments were received on loan from the Royal Air Force and the Royal Aircraft Establishment, and in connection with these loans I have to thank particularly Squadron Leader F. C. V. Laws, C.B., O.B.E., in charge of the Photographic Department of the R.A.F., Mr W. Sydney Smith, C.B., O.B.E., Superintendent of the R.A.E., Mr G. L. Smith the head of the Instrument Section of the R.A.E. and Major H. E. Wimperis head of the Navigation Department of the Air Ministry.

Finally help and advice has been received from many private individuals, amongst whom I would like to tender special thanks

to Dr G. T. Bennett, F.R.S., for assistance on the geometrical side, Mr F. Debenham, O.B.E., for help on the surveying side, and my wife for help in connection with the reduction of data and the typing of the manuscript.

In the spring of 1923 the experiments had reached a stage when we judged that they could conveniently be collected and published in the form of a short book, and an agreement was concluded with the Cambridge University Press for the publication of a book, under the joint authorship of Major Griffiths and myself. Certain experimental work, connected with the scheme of Navigational Control combined with oblique photographs, remained to be completed, but we judged that this would not take very long, and the experiments already completed indicated clearly the nature of the results to be expected. At this juncture Major Griffiths received the offer of a very responsible post with a firm of Aircraft Constructors. We considered that this offer was too good to be missed, particularly as the firm had agreed to extend to him facilities for the completion of his experiments, and to release him for part time in the winter to allow the results to be analysed, and to enable him to take his part in the writing of the book. In the meantime, during the summer of 1923, I was to take his place as observer at Duxford and carry out what experiments I could. We realised, however, that I should be able to devote a part of my time only to this work, and that therefore there was little hope of my getting much done: we relied principally upon Griffiths being able to finish off the work, either in his new situation, or whilst on leave.

The book was to have gone to press about Christmas 1923, but in October of that year Griffiths was accidentally killed whilst flying, and thus all our plans were dislocated.

After Griffiths' death the final analysis of much of the experimental data and the writing of the book itself fell entirely on my shoulders, and as I could only give a portion of my time to the work, its completion was much delayed, so that publication is likely to occur nearly a year later than was originally intended. The situation so created placed me in considerable difficulty. I was anxious that Griffiths' name should remain as joint author, because many of the ideas and most of the experiments were his, but it was clear that I should have to write it myself and even draw some of the final conclusions without Griffiths' assistance or approval. I therefore felt, and still feel, some diffidence in expressing, under his name, conclusions with which conceivably he might not have agreed; I could not have adopted this course at all had not the main conclusions and the general form of the book been agreed upon between us before his accident.

I think I am right in saying that the first five chapters contain only matter which had been discussed between us so thoroughly that there is no danger of my having inserted anything in relation to which we were not in complete agreement; but, in regard to the last four chapters, this cannot be said with the same degree of certainty. The ideas involved in chapter VI, dealing with Navigational Control and the use of oblique photographs, had been extensively discussed between us, but much of the data had either not been obtained, or had not been analysed, at the time of our last discussion. Although, therefore, the general outlines of this chapter had been agreed between us, I must take the responsibility for the detailed conclusions reached.

Chapter VII, on detailed routine, was to have been written, in rather longer form, by Griffiths himself, but he had apparently not been able to start upon it up to the time of his accident, and I have had to do my best with it from my own experience and memory of our previous discussions. In general it may be said to be in conformity with ideas that we held in common.

For some reason we had omitted to discuss the necessity for the inclusion of a chapter on the training of personnel. Some reference to this question was clearly necessary to complete the work, and I therefore wrote chapter VIII, as nearly as I could in conformity with our common views; here again much of the data upon which the detailed conclusions are founded had not been analysed at the time of his death, although the general trend of the results was sufficiently evident.

For the final chapter, which summarises the work and draws conclusions from it, I must take entire responsibility, although I have no doubt that Griffiths would have been in agreement with the general outlines.

I feel I cannot close this foreword without some reference to Griffiths himself. A man of immense courage and enthusiasm, he was exactly suited to the work upon which he was engaged for the last few years of his life. He had that rare temperament which fits a man for active and dangerous work out of doors, and yet does not prevent him from excelling in the laboratory and office. It is certain that the aeronautical world in general, and aerial surveying in particular, has suffered a great loss by his death. His accident re-opens the old controversy concerning the extent to which scientists of exceptional promise should be allowed and encouraged to take part in dangerous occupations. The problem is really one of degree, and all that can be said about the case in question is that there must, at all times, be some individuals filling the difficult rôle of intermediary between the theoretical and laboratory world, and the world of practical aeronautics, and that rôle was one for which Griffiths was

particularly fitted. This he realised and faced the risk joyfully, as an integral part of his life. Of all men who have aspired to fill this rôle I have known none who stood a better chance of coming safely through the risks involved, but the nature of accidents is that they cannot, in general, be foreseen and may happen to anyone, no matter how skilful he may be.

Young though he was, Griffiths had already contributed greatly to our knowledge of a subject in which experiment is by no means an easy matter; by his energy and application to work he had achieved results which will, I believe, be found to have a permanent value. To the natural sympathy which we all feel, in such circumstances, for those who have lost the society of a delightful and stimulating personality, is added our deep regret for the loss of that much greater volume of pioneer work which he would undoubtedly have carried through had his life been longer.

B. M. J.

PREFACE

By CAPTAIN H. HAMSHAW THOMAS

ONE of the characters of the modern world is its dependence on maps. Scarcely a day passes without the appearance in the press of a map illustrating the site of some current event, while the millions of travellers, hurrying to and fro on the earth in trains, boats or motor vehicles, are for the most part intelligent map-readers. At the same time, in every part of the world, schemes are on foot for the more effective utilisation of the earth's surface, and the first step towards the carrying out of such schemes is the preparation of a map or plan.

Those who live in a small country like England, which has been accurately mapped in great detail, can scarcely realise the difficulties and drawbacks of life in a country whose maps are of an imperfect description. Travel becomes a matter of difficulty and uncertainty, the development of agricultural land and the utilisation of forests are retarded, the exploitation of minerals may have to be long postponed. In some places many small surveys are made from time to time, but they are generally the outcome of private effort and seldom benefit the community as a whole.

As time goes on the demand for a complete topographical survey, such as exists for the countries of Western Europe, will probably become irresistible in other settled parts of the world, and with the march of civilisation it cannot be ultimately avoided. But in the vast territories of Africa, Australia and America a topographical survey of the ground in any detail is a colossal undertaking and would involve an enormous expenditure of time and money. Moreover in some places forests, mountains or other difficulties render the task of surveying ground-detail almost impossible. The expense of keeping survey parties in the field long enough to secure the desired results would be so great that the production of the desired maps may be indefinitely postponed. But at the same time we find that trigonometrical surveys are now being made in many places. The geographical position of many isolated points is being determined and a foundation is being laid for the topographical surveys.

It would seem that we need some new survey method which has the power of depicting very rapidly the surface features of the country in considerable detail, which can be operated over a wide tract of country, far from bases or settlements, and which is unhampered by forests, mountains or broken country.

During the war topographical maps were required of many places which had not been surveyed in any great detail, and on the Palestine Front the writer was intimately concerned with the construction of maps of inaccessible country by the aid of aeroplane photography. A wide area—over 2000 square miles—had to be covered, the country was very broken, and the greatest possible detail was required. A certain number of points had been fixed by previous surveyors but these were generally many miles apart. By the joint efforts of officers belonging to the Royal Air Force and to the Royal Engineers with the most valuable help of some members of the Survey of Egypt, a system was evolved by which a series of maps was produced which were found to be of considerable utility and of fair accuracy. The conditions of the work, the needs of the situation and the methods employed, differed considerably from those which were evolved independently on the Western Front.

This system, which had been elaborated empirically to meet the needs of the situation, seemed to possess some of those features indicated above as desirable in a new method of survey. It appeared to have the advantages of speed, range of action and wealth of detail, but it was not definitely known to what extent such a survey would be sufficiently accurate and economical for civil use.

An accurate map should show correctly the exact geographical position as well as the correct shape of all ground features, but in most topographical maps made by the ordinary methods there is some departure from the theoretical accuracy. When they are compared with corrected air-photographs or with maps made by other photographic processes, it is found that the surveyor on the ground has often to make generalisations and to be content with approximate shapes and positions. To the map user, accuracy of shape and correct relative position may at times be more important than correctness of geographical position with generalisation of shape.

While the Palestine methods of topographical survey by aerial photography seemed to have possibilities of great utility, it was based on the assumption that aeroplanes could be flown for a certain distance at a uniform height and with their wings level. It was also inapplicable to mountainous country, and was more especially designed for territory in which a complete knowledge of all the surface features in detail was desired.

Before attempting to apply this method for civil uses, it was necessary to investigate whether the underlying assumptions were correct, to determine the limits of its accuracy and to consider whether it could be used as the foundation of methods applicable to mountainous or desert countries. At this juncture the late Major Griffiths arrived at Cambridge, having taken his degree in Engineering at Liverpool University and possessing

considerable flying experience. He was full of enthusiasm and was anxious to investigate the possibilities of aerial photographic survey and the chances of using it for the exploration and development of distant unmapped lands overseas. To his work this volume owes its origin. Undeterred by laborious and often fruitless labour, anxious to establish firm foundations, patient under the difficulties of working with inadequate materials and machines designed for totally different purposes, he carried out with Prof. Melvill Jones a series of researches which are of fundamental and lasting importance. It is a matter of great regret that he did not live to complete his work and to see his results utilised. The fatal accident at Coventry on October 20, 1923 has deprived the world of one of its most talented investigators in the sphere of aeronautics.

The researches, described in the following pages, come at a very opportune moment. The last five years have seen the formation of aeroplane units in various parts of the world which are in need of extended topographical surveys. In the British Empire the Dominion of Canada, the Commonwealth of Australia and the Union of South Africa each has its Air Force, and all of these organisations have shown an interest in aerial photographic surveying. In Canada, where pioneer work had been done in photo surveying on the ground, several surveys have already been made from the air. The Canadian Air Board reported in 1923 that experimental work was being carried out and that "Important progress has already been made and a successful conclusion may mean much to those branches of the Government service engaged in the mapping of Canada."*

In Canada it has been found that aerial photographic survey, while of great value for mapping the boundaries of forests and the waterways running through them, is also of great utility for the location of the more valuable timber trees. Thus in a forest survey two distinct services are performed at the same time. This illustrates the fact that such a survey depicts not only the surface features of the ground but also the different types of vegetation growing upon it, or the beds of rock which may be exposed on the surface. The vegetation has often a most important economic significance in the development and colonisation of a new country, as it gives indications of the presence of springs and of water supply, apart from its own intrinsic value in wooded countries. Likewise the location of rock outcrops may be of great value to the geological surveyor and in the investigation of mineral resources.

The reports of the Canadian Air Board show how aerial photo surveying may have still other useful practical results, in addition to map production, and emphasise the potentialities of the method. A series of

* *Report of the Air Board for* 1922, Ottawa, 1923, p. 50.

air photos has a permanent value, and after it has been used for purely topographical purposes it may be kept for reference and used from time to time as required, in connection with land settlement or irrigation schemes, in road and rail construction, for vegetation or geological surveys and so on. While there seems to be very little scope for aerial survey in England, it may be a means of facilitating the progress of civilisation in many lands overseas.

It has always seemed to me that the future of aerial survey lay in its ability to do work which could not be readily accomplished by the usual methods on the ground, work in which the nature of the terrain, the wide area to be covered, or its inaccessibility were limiting factors. I therefore suggested to Prof. Melvill Jones and Major Griffiths that it would be useful to investigate the relations existing between aerial methods and ground control. It is always necessary to have some points in the area whose position has been fixed by trigonometrical survey, but the profitable employment of aerial photography will be greatly limited if a large number of such points are required. If, for example, it is necessary to have three fixed points on every photograph, we shall be able to do little in some forest lands. I also pointed out that where a wide area has to be dealt with, it is necessary to reduce as far as possible the labour of compiling a map from the photographs; therefore it might be well to avoid methods which necessitated the accurate measurement of a large number of distances and angles on the prints or negatives.

In acting on these suggestions the investigators have travelled along lines which are very different from those of most of the other workers on the subject, and in so doing they have contributed results of great importance. They have not, of course, arrived at any final and complete scheme, but they have laid foundations, and have gone far towards producing methods which have great possibilities. They dealt with flat country, but some of their work may be developed for use in hilly country. They have not investigated the application of stereoscopic methods, but their results on the investigation of the path of a machine through the air indicate that success may be expected in the survey of mountains and the measurement of heights by the use of oblique stereoscopic photography.

It is certain that the investigations described in this volume constitute an important step in the evolution of the methods of aerial survey, and will eventually result in great additions to our knowledge of the surface of the earth.

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