Some Commercial Aspects of Air Surveying.

Paper read by Major H. Hemming, A.F.C., F.R.G.S., A.F.R.Ae.S. (Managing Director of the Aircraft Operating Co., Ltd.), before the Institution in the Lecture Theatre of the Royal Society of Arts, John Street, Adelphi, W.C.2, on 12th May, 1927. Sir William H. Clark, K.C.S.I., C.M.G. (Controller of the Department of Overseas Trade), in the Chair.

I HAVE attempted in the following paper to deal with the commercial aspect of air surveying from my own personal experience. The technical side of the work I will not attempt to go into fully, as there are others who are better able to deal with that aspect than I am. As air surveying has been developed in this country entirely by private enterprise unassisted by subsidies, it may be of interest briefly to review its development to date.

Early Work.

One of the few benefits that we derived from the War was the development of aerial photography to a stage where it could be of great value for exploration and mapping work in the Empire. The authorities responsible to the Government for the development of civil aviation in this country and the Empire failed to realise this, and it was left to private enterprise to develop that side of civil aviation, the Authorities concentrating their efforts on the development of air transport.

As far as Governments in the Empire are concerned, the Canadian Government was the first to realise that the aeroplane and the air camera could assist in the opening up of the unmapped and little explored areas of their Dominion. They concentrated on the development of air surveying and forest fire fighting, leaving the development of air transport to other countries. They soon found that their policy was justified, and since then many thousands of square miles have been mapped from the air. Successful private air surveys companies have sprung up in Canada as the result of the Government's policy, and the Canadian Government undoubtedly have the finest Air Survey Department in the world, while the aeroplane and seaplane have saved Canada many millions of dollars from the forest fire menace.

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All those interested in civil aviation owe a debt of gratitude to Canada for having shown such foresight. Not only did the Government adopt a wise policy, but they also soundly administered it. They bore the expense of the early pioneer work, and as soon as they saw they had developed air surveying to a stage where it could be commercially self-supporting, they encouraged the formation of private air surveying companies to whom they let out contracts. They were therefore able to assist commercial aviation without having to pay a subsidy, thus avoiding Government supervision, which is a deterrent to private enterprise and initiative.

Although Canada has taught us a lot, we, in this country, have had to pay for that education, as the official support given in Canada, coupled with the development of air surveying in the United States, resulted in the quick development of new and improved aerial cameras and air survey aeroplanes on that side of the Atlantic. The aircraft trade, with one exception, and the instrument trade in this this country, failed to grasp Canada's requirements. The result is that to-day we find an American camera used as the standard camera by the Royal Canadian Air Force and by most of the Canadian Companies, and that camera has undoubtedly given excellent service. True, the Eagle camera has now been produced in this country, and we think this is a great improvement on the American camera, but the fact remains that owing to this country's failure to grasp the situation in time, the Americans got in first. One British aircraft firm showed great enterprise by establishing a Canadian branch—I refer to Messrs. Vickers. As the result, they have produced special seaplanes for air survey work, built to the specification of the Canadian authorities ; otherwise I believe, apart from British aeroplanes of the war period, most other aircraft being used on air survey work in Canada are American.

While this useful development work was proceeding in Canada, the Government of this country concentrated their attention on the development of air transport. A Government department of considerable magnitude was formed to assist and administer the development of civil flying. Private enterprise came forward and four different companies were formed to run air lines from England to the Continent, each Company receiving a subsidy from the Government. Apparently it was felt that subsidised competition would be the best way to develop air transport, on the assumption that there was nothing like competition to stimulate commercial initiative. Thanks to the enterprise and ability shown by all those concerned with the running of these air lines, and to the operation of the " Geddes axe " in the various departments of the Government, this unsound policy was changed. The Civil Aviation Department was cut down to reasonable proportions, and a saner policy was adopted for the development of air transport. To-day we see Imperial Airways, the successor to the four companies referred to, forging ahead with the extension of Empire air routes, and building up a sound reputation for British commercial aviation.

While this State-aided development was taking place in this country, air survey was left to carry out Mr. Churchill's famous dictum that " civil aviation must fly by itself." It proceeded to do this. Shortly after the War a British Company sent out an air survey expedition, under the command of my friend, Major Cochran Patrick, to the Orinoco Delta in Venezuela and to British Guiana, where

certain useful air survey work was carried out. A great deal of private money was lost, through no fault of the Company, and much valuable experience gained. While no financial assistance was given by the Air Ministry, various members of the Air Ministry went out of their way to help the Company who were engaged in sending out the first British air survey expedition abroad. I would specially mention the name of Wing Commander Laws, who has always been a tower of strength to those engaged in air surveying.

During the time this work was going on Professor Melvill Jones and the late Major Griffiths were carrying out valuable practical research work in air surveying at Cambridge, with the aid of R.A.F. machines and pilots. The work that they carried out has proved to be a very helpful and important contribution to the development of air surveying. It was as the result of this work and of the work referred to in Venezuela and British Guiana that the Irrawaddy air survey contract was secured. A complete success was made of that contract and several successful contracts followed on. To-day I am glad to say both the British companies engaged on air surveying have plenty of work to do.

Present Position.

Chancellors of the Exchequer have a way of being ruthless, but I believe we shall be thankful to Mr. Winston Churchill for his dictum previously referred to in this paper, as we have had a hardy education. The early days of air surveying were difficult ones. No official support was received, but plenty of valuable advice from individuals holding official positions ; the ground surveyor was against us, due I imagine to too much optimism by the airman ; while the business-man, so long as he was not asked to pay for anything, treated us politely but not seriously.

To-day, happily, the situation has changed. The airman and the ground surveyor are working in close co-operation, and we have to thank the Air Survey Committee for this satisfactory state of affairs. This Committee sits at the War Office, under the Chairmanship of Colonel Winterbotham, an authority of world repute on air survey matters ; it is made up of representatives from the Admiralty, the War Office, and the Air Ministry. Wing Commander Laws, who has addressed your Institution, was a member of the Committee before he went to command the School of Photography at Farnborough. Captain Tymms, who recently read a paper before you, was a member, and Captain McCaw, who has contributed to a recent discussion before your Institution, is the Secretary.

The Air Survey Committee were not formed to assist civil aviation, but to study air surveying for military purposes. Nevertheless, the Committee has become a kind of fairy godmother to the Companies interested in air surveying. They help us with valuable advice, and give us useful information, while their official support and wise discernment has once and for all overcome the difference of opinion which previously existed between the ground surveyor and the airman.

The civil aviation section of the Air Ministry have also been of great assistance, and their records of flying conditions in different parts of the World are always at our disposal. Their Chief, Air Vice-Marshal Sir Sefton Brancker, civil aviation's finest and most energetic propagandist, has spread the gospel of air survey abroad,

while the personal interest that Sir Samuel Hoare showed in air survey, by placing a room at the disposal of the two Companies engaged on air surveying, so that they could demonstrate their work to the delegates of the Imperial Economic Conference, has already provided fruitful results. So much for the official attitude.

Those of us interested in air surveying owe a very real debt of gratitude to the Press. We have always had a good and sympathetic Press, without which air surveying could not have progressed. It is one thing to have a service which you know can be of benefit to other people, but it is a different thing to sell that service, especially with a new service like air surveying. When business men and Governments read in the Press of definite achievements in air surveying, and of work in progress, they listen far more intelligently to our proposals.

As I have referred to the part played by certain official and private people in the assistance of the development of air surveying, I should be failing in my duty if I did not refer to the very important and essential part that the British Aviation Insurance Group have played in the development of air surveying. They have always, in our experience, shown a wish to help us in every way. I would not admit for one moment that their rates are low—quite the contrary—but the fact that they have been able to quote at all, says a great deal for their enterprise and trust, as they frequently have to cover risks in air surveying in parts of the World of which they have had no knowledge or experience, and where they have no agent to look after their interests.

Aviation insurance is really very important, as its rates will finally reflect the value of the safety factor of commercial flying.

Apparatus and Instruments.

As I said previously, I do not propose to go into technical details, but a reveiw of the situation of apparatus and instruments in connection with air surveying may be of interest, as seen from the commercial point of view.

Up to the time when the Ordnance Survey revision contract was carried out, All British air survey contracts, with the exception of those carried out in Canada, were, I believe, carried out with the old War type L.B. plate camera, which is still, I understand, doing yeoman work.

The introduction of the film camera specially designed for air survey work has enabled us to reduce costs, and the suitability of the film camera for such work was fully demonstrated on the Ordnance Survey Revision contract. That contract was actually carried out by the F.8 camera, loaned to my Company by the Air Ministry. Since then the commercial edition, known as the Eagle camera, similar in all respects to the F.8, has become available, and is in fact at present being used by us on the Northern Rhodesian air survey.

The camera has many improvements on the old type, as it automatically photographs certain valuable data on each negative, thus saving a great deal of the laborious and difficult work of record-writing by hand on each negative, or alternatively keeping a filing system ; while the fact that film is used, simplifies and reduces the dark-room work.

A great deal of skill and ingenuity has been put into the design and manufacture of special instruments for enabling accurate navigation of the aeroplane to be carried out. We believe that most of the problems that these instruments are intended to solve will be overcome by the construction of special aircraft for air surveying.

I am convinced that the practical and commercial requirements of air surveying show that air surveying must be reduced to a simple operation. It should not be necessary for the pilot to steer through optical sights, although these at present are of great value for partially overcoming the bad view which is inherent in the tractor aeroplane when used for air surveying. Captain Tymms fully dealt with this problem in his paper before your Institution on " Flying for Air Survey," so I need not say more on the subject. We hope shortly to build a special air survey machine, and I believe that the improved view, higher ceiling, and increased safety from liability to forced-land, will very materially reduce our costs and increase output.

It is, I think, safe to say that we have solved the problem of straight and accurate flying, although if Flight-Lieut. Reid can give us an instrument which will enable us to ensure that the optical axis of the camera is truly vertical at the moment of exposure, as he says he expects to be able to do, that will help us enormously. There are some very important problems to be solved in connection with the ground side of air survey work, and one of the biggest problems facing those engaged on the commercial side of air surveying is the separating of the practical and the theoretical methods of mapping from air photographs.

German scientists have paid particular attention to contouring and producing instruments which enable the operator to plot detail by means of a pantograph from pairs of overlapping photographs examined stereoscopically. While these instruments are marvels of mechanical and optical skill, and have proved a very valuable contribution to air surveying, we have yet to be persuaded that they are the instruments for which we are looking. Similar instruments and methods have been produced in Italy, and, I believe, in France, and I am informed that a considerable measure of success has been achieved with such instruments.

In the course of our reasearches into commercial methods for air surveying we have, I think, investigated practically all these methods, while I know that the Air Survey Committee has been into the whole subject very thoroughly indeed. The successful experiment recently carried out at Arundel by Lieutenant Hotine for the Air Survey Committee, has shown that contoured maps on a large scale can be made from vertical overlapping air photographs, with the aid of the stereoscope and a certain number of spot heights established on the ground. I also understand that a very promising instrument for contouring is being built in this country, so that I think we are wise in waiting, as there is still an enormous amount of air surveying to be carried out in the British Empire, which can be safely undertaken with the present tried out systems at our disposal. The temptation to try and run before we can walk in air surveying is very great indeed. I am sure that simplicity will be the key to success as far as instrumental methods of air surveying are concerned. I can assure you that in having to consider these many problems and the many inventions which claim their solution, the business man engaged in doing his

share to put air survey on a sound commercial baisis, daily travels a similar path to that travelled by Pilgrim during his negotiation of the Valley of the Shadow of Death.

The Commercial Side of Air Surveying.

Air Surveying is to-day commercially self-supporting, and has achieved this position without the assistance of a subsidy. Its greatest claim to rank as a commercial service is that in most unmapped parts of the globe, air mapping can be undertaken by air survey companies far more quickly and more cheaply than it can be carried out by the ground method. Even in this country which has the finest survey in the world, we are regularly undertaking contracts for air surveys for official or commercial concerns, and the results have proved highly satisfactory.

Air Surveying has passed the speculative stage. To-day the Government or business man interested in having maps made, or forest surveys carried out, can obtain a definite tender for the work, and have the work executed on a contract basis in the same way as engineering projects are daily carried out by contract.

Independent evidence of the value and achievement of air surveying is available from work carried out in this country, in Canada, and in Burma, when Mr. Kemp successfully organised the Irrawaddy Survey, as the following examples show :—

Extract from Report on Civil Aviation for 1925 *issued by The Department of National Defence, Dominion of Canada, when referring to mapping from oblique aerial photographs* :

" It is not too much to say that its introduction has brought within the sphere of possibility the production, within a comparatively few years, of maps of the whole Dominion far more complete and as correct in scale as those made by the present ground methods. With three or four photographic aircraft only, in the past three years, 100,000 square miles have been photographed and the resulting maps are now being published."

Extract from Burma Forest Bulletin No. 11, *dealing with the Irrawaddy Air Survey* :

" 1. *Cost.* The cost, including ground work and mapping, has worked out at about Rs. 293.7 per square mile. A ground survey on the same scale would have cost in the neighbourhood of Rs. 500, without giving any indication of the types of forest growth.

" 2. *Rapidity.* The actual survey was completed in five months and the whole period taken from the commencement of the fixing of the ground control to the completion of maps and stock maps should not greatly exceed one year. Ground survey would have taken three to four years.

" 3. *Accuracy.* This is far in excess of anything that could have been obtained by ground survey in this type of country, except at a further increase in cost and time.

" 4. *Details available.* The areas and distribution of the different types of forests are not only obtainable at no increase of cost, but with an accuracy that it would have taken years and a considerable expenditure to have equalled."

Letter from Borough Surveyor, Doncaster, to Aerofilms, Ltd., Aerial House, Hendon. 7th October, 1926 :

" I have now received the whole of the prints of the aerial survey of about 15 square miles of our district comprising the villages of Askern, Armthorpe, Edlington, Warmsworth, Bawtry, Rossington, Cantley, Barby Dun-cum-Sandall and about 29½ miles of railway.

" The results have come up to our expectations and I am transferring the survey on to the 1/2500 Ordnance maps. The accuracy of the resulting plan is nearly as great as could be obtained by a chain survey, and much greater than I have got by plane tabling. There has also been a great saving of time and expense."

The foregoing are just three examples of many that can be produced.

The air surveyor is in a trusted position similar to that occupied by a solicitor or banker. In executing surveys and advising on air survey work, the air surveyor is frequently entrusted with information of a very confidential character, so that not only must the successful air survey company prove that they can do the work, but they must build up a reputation for reliability and for being able to keep " trade secrets." The importance of this can at once be seen when the nature of the work with which the air surveyor has to deal is considered.

Quotations for Air Surveying.

The costs, frequently quoted, of air surveys are liable to be deceptive unless details are given on which the costs are based. Some costs simply cover the flying and photographic work, while others also include the laying down of the control, and the drawing, compilation and printing of the final maps.

It is impossible to lay down a standard cost for air surveying, as so many important factors contribute to the making up of these costs, and these factors vary according to the nature of the work. For example, if the air survey is to consist of a small scale survey in some Colony, the ground control will probably be supplied by the local survey department, who may also wish to prepare the maps from the photographs. The accuracy required, the control available, the nature of the country, the purpose for which the survey is required and the weather conditions, etc., all have an effect on cost. Every problem has therefore to be treated on its particular merits, and frequently many discussions have to take place before a contract is finally entered into. Frequently this entails sending away for several months an expert whose time is of great value, and as some of the areas to be mapped are very big, it sometimes takes a considerable time to negotiate a contract.

The size of the area has an important bearing on cost, the bigger the area the smaller the cost per square mile. For example, it has been stated earlier in this paper that the total cost of mapping the 1,350 square miles of the Irrawaddy Delta by the air method was about £19 10s. 0d. per square mile, the scale of the map being 1/20,000. The cost of the aircraft was not taken into consideration in this figure, as they were machines proved by the Government of India. Since then, however, air survey costs have considerably fallen.

Now let us take an imaginary case of an air survey of 60,000 square miles in jungle country intersected by rivers, on a scale, say, of 1/20,000 ; the company carrying out the work to be responsible for supplying, aircraft, hangars, all material, and for taking the photographs ; the ground Survey Department to provide the control and make the maps from the photographs ; the air work to be carried out in two seasons. I estimate the Company would want £3 17s. 0d. to £4 per square mile for their part of the work.

Let us consider another case where a Government require a large area to be mapped, the Company to do everything, including the printing of the maps and the control. Suppose the area is 400,000 square miles, for which an astronomical control must be laid down, and maps made to a scale of 1/50,000 with 25 metre contours. Let us assume that the area consists of rolling country, mountainous in places. It is estimated that such work would cost from £3 10s. 0d. to £4, per square mile, including the printed maps, and would take four years to complete.

In this country costs of making photographic mosaic maps vary from £7 to £15 per square mile, according to the nature and size of the work, and the scale of the map required. Aerial photography can be applied with great advantage to the mapping of towns and cities, where town planning schemes are in contemplation, together with many other kinds of engineering work. For this reason we are likely to see it largely applied for these purposes in the future.

The Future.

The future of air surveying looks very promising, and there is every indication that there will be a big demand for this work. As work proceeds the Companies engaged on air survey work will themsleves gradually take on more of the work which at present is frequently undertaken by the employers. To date most contracts have called for certain work to be undertaken by the Survey Company, while the Government or Company for which the work is to be carried out have to provide aerodromes, ground control, etc. This state of affairs is changing. Finally, the Survey Company will be able to arrange all the local contracting work for the preparation of landing grounds, the building of hangars and quarters, and the laying down of the control, as well as arranging for the printing of the maps.

My Company are sending out their own ground surveyor in order to fix the control on which air maps in Northern Rhodesia are to be made. For this purpose a special wireless receiving set has been designed, and the control points will be fixed by astronomical observations and wireless time signals. This, I think, is the first time that an air survey company has sent out its own surveyor to carry out this class of work.

It is very encouraging to see the way in which the authorities are now giving more careful attention to air survey work. Air surveying will play a very important part in the development of the British Empire, and the air surveyor should create a demand for air transport operations, as newly mapped areas will require to be linked up with civilisation.

Take for instance the air survey that my Company are carrying out for Messrs. Rhodesian Congo Border Concessions, Ltd. Already the Concession Company

has constructed a main aerodrome with hangar and workshop and 39 emergency landing grounds in the heart of the African bush. This is a colossal undertaking, especially when it is considered that a further 96 landing grounds have been planned, but as we expect to use the special air survey aeroplane later, the work on the balance of the landing grounds has been held up.

I will now show you some slides illustrating some air survey work that has been carried out; these photographs also include some sent by Major Cochran Patrick, who is in charge of our air survey expedition in Northern Rhodesia. He has, as you know, been associated with most of the successful air surveys carried out by British Companies.

LIST OF SLIDES SHOWN AT THE LECTURE.

1. Eagle camera installed in D.H.37 for Ordnance Survey revision.
2. & 3. Diagrammatic photographs showing method of taking vertical overlapping air photographs.
4. The result of a single flight—a rough mosaic to check the area.
5. Example of a single photograph taken with the Eagle camera, showing certain data photographed in the margin.
6, 7, 8, & 9. The use of the aerial camera in exploration work in British Guiana.
10. The grid system of mapping from obliques.
11. The Rhodesian air survey.
12-28. Photographs of the Rhodesian air survey expedition at work.
29. Photographic mosaic map of a private estate, mounted on the Ordnance map.
30. Mosaic made up of unscaled and unrectified photographs taken during the Ordnance Survey revision experiment.
31. An example of air photographic mosaic work under arctic conditions. "The Daily Mail" pulp mills at Grand Falls, Newfoundland in mid-winter.
32. Photographic mosaic map of Central London.
33. The Heart of the Empire.

DISCUSSION.

The CHAIRMAN : I feel a certain diffidence in opening the discussion on this very important and interesting paper, because my personal experience of photography is based on a few attempts with a Kodak twenty-five years ago, and so far as aviation is concerned, I have only made one flight.

Major Hemming calls his paper " Some Commercial Aspects of Air Surveying," and I should like to say a few words on the commercial side of the question.

Many of the older industrial countries like ours are bound to experience as time goes on, that the younger countries increasingly start manufacturing for themselves. This is particularly true as the result of the war. We therefore lose trade so far as our older industries are concerned, and to compensate for that we must get the very best out of the newer possibilities that science and invention give us. Looking back, it may well seem hardly possible that there should be again developments such as steam gave us during the Victorian era, but there is no need to despair of a century which has seen inventions such as the internal combustion engine, and with it the conquest of the air, and the great progress in electrical engineering, notably wireless. I do feel we should take our hats off to those people who have moved with the times and made things like air surveying a commercial success without any financial assistance from the Government, for it is a very big achievement.

Major Hemming says that the Eagle camera is the best in the world. I was lately reading an article in an American journal on aeronautical photography, and you will not be surprised to hear that the writer thought the American camera was the best in the world. You will be the less surprised when I tell you that the writer was also the maker of the camera ! I have no doubt that it is a fine one, but it is gratifying to think that we are now making an even better camera in this country. In the same article there was a photograph of Dayton, the native city of flying, taken at 6½ miles, a very wonderful achievement.

My first point, therefore, is, that in this new development you have a new industry that is going to expand and sell its services, and lead to a demand for the manufacture of new and highly complex products.

Secondly, so far as our older staple industries are concerned, clearly their best prospects of expanding markets lie in the development of the undeveloped areas of the world. There are many such areas, and fortunately a great many of them are in the British Empire, and more especially in Africa. In a country like Nigeria, when you get an extension of railways, you at once get an increase of exports and an increase of imports from this country for which the exports pay. Development therefore, is of the greatest importance to our trade, and it is obvious that there is no way in which it can more quickly be brought about than through the medium of Air Survey.

I am sure we feel very grateful to those whose enterprise is helping us to achieve these two ends.

LORD THOMSON OF CARDINGTON: I feel very privileged at being the first member of the audience to thank Major Hemming for what has been a most intensely interesting and instructive lecture.

A commercial flying enterprise which is self-supporting is like a spring of water in the wilderness. I think that this is the first enterprise of the kind that I have come across, except, perhaps, skywriting. I remember that the man who managed that used to claim when I was at the Air Ministry, that it was unique, but apparently it is not. I do not think I have ever listened to a paper which more fully proved its case, than the one we have heard to-night. Those photographs of the country surveyed clinched the matter for me.

I remember some twenty years ago I was on a boundary commission in West Africa. We were working near the source of the Niger, in very similar sort of country. There had been a question in dispute between ourselves and the French, who had a commission there, while the Germans also had a commission whose task it was to arbitrate between us. Our work would have been much more expeditiously carried out if we had had the use of aeroplanes.

What impressed me most in Major Hemming's lecture was the price that he quoted—£4 a square mile. I am afraid my mess bill came to £4 a square mile, but perhaps mess bills are not included in Major Hemming's estimate.

I am bound to say that I think this lecture will linger in many of our minds. Hitherto I have taken a casual sort of interest in this question; I remember going down to Cambridge University and being shown some photographs of the Eastern counties. They certainly had produced extremely good results, but I did not get the same vivid impression of the possibilities of aerial survey as I have done this evening, and I again wish to express my thanks and admiration for Major Hemming's paper.

SIR GRAEME-THOMSON (Governor of Nigeria): I think it would be difficult to find anybody with less expert knowledge of flying than I have. All I can say is that I have gone a little further than the Chairman, because I have been in an aeroplane twice instead of once.

I am rather surprised that Major Hemming should expect me to speak, because I think he must regard me as a fraud. When I was Governor of British Guiana I induced him to come out there, but shortly afterwards we became so short of funds that I had to tell him there was nothing doing. About a year ago I induced him to come out to Nigeria (of which I was by that time Governor), and Major Cochran Patrick came out and undertook a very interesting investigation of the possibilities of surveying the Niger Delta by air, which is a region that I think it would be almost impossible to survey by any other means at a reasonable cost This time I have promised that, if finance permits, we will do something. I was greatly interested by all the photographs Major Cochran Patrick brought out,

showing the enormous developments that have been made in air surveying, which I am sure is going to be of the utmost importance in the development of our Colonies in the very near future.

SIR GORDON GUGGISBERG (Governor of the Gold Coast): I have heard two lectures on aeronautics in my life. One was forty years ago when I joined as a young subaltern in the Royal Engineers, and there were one or two quite respectable fellows at Chatham who were pointed out to be as being cranks. They were, as it turned out, our ballooning experts, for the Royal Engineers (who usually are the first to take on awkward and uncomfortable jobs) were starting scientific military ballooning in England. Forty years later I come back and find equally respectable and equally keen " cranks "—this time talking about surveying scientifically the ground from the air.

As I spent about fourteen years in surveying the Gold Coast and Nigeria I think I can probably criticise Major Hemming's proposals and his lecture to-night from the survey point of view, as well as even my old friend, Colonel Crosthwait here, could. I am convinced that there is a very great future for air survey. As to whether the, Government of a Colony like the Gold Coast could afford to maintain an air survey, that depends on the amount of work it can offer a Company. Unfortunately, we have nearly completed our survey from the ground, and for the moment we have no need to employ an Air Survey Company, but I feel sure that in a few years' time when we have to carry out a revision of our surveys, then it will probably be most thoroughly and economically carried out by aeroplanes which we might borrow or arrange for with Sir Graeme Thomson.

Sir Graeme was talking about the Niger Delta. We tried to survey it from the ground between 1910 and 1914, and we did not get very far. I quite agree with him that the quickest way to make a good survey of the Niger Delta is from the air, and I certainly hope that Major Hemming will get the contract.

With regard to developing the country by railways and roads, I think that an air survey would be of the greatest use as a preliminary to the design and construction of the railway and roads system. Up to the present our Tropical Colonies have had to make shift; when we have had to make roads we have made them, whether a contoured map existed or not; the same thing applied to railways. The other day we spent one-and-a-half millions in straightening out the railway between the coast and Coomassie, which had been constructed before a map was made. If you get can a photographic map first, you are going to save yourself literally hundreds of thousands of pounds in road and railway construction, but if you are going to conduct that survey by working through forests, it is going to take a long time; on the other hand, if your Air Survey Company can get a decent photographic contoured map of the country, it will be a good and quickly made guide and greatly help the Colonial Government of a tropical country in its work of developing railways and roads.

AIR VICE MARSHAL SIR W. SEFTON BRANCKER (Director of Civil Aviation): I contragulate the Institution on their commonsense in arranging this most inter-

esting and valuable lecture at a date when the Governors and representatives of our Colonies are all present in London

Major Hemming has made some flattering remarks regarding my propaganda of air survey I have certainly been trying to " sell " air survey for the last five or six years, but my trouble has always been that I could not say how much it would cost and it is very difficult to sell any article without knowing its price I have been trying to extract definite figures from Major Hemming for a long time, and to-night I am delighted to hear him give some quite clear and understandable figures I look upon these figures as most valuable, and they represent a real mile stone in progress in Air Survey

I plead guilty regarding the failure to provide subsidies for Air Survey, but would point out that Air Survey can live and flourish without subsidies I am quite sure that the new industry of Air Survey has benefitted by its avoidance of artificial support from the Government, and that in the future it will be duly grateful It is quite clear that to-day Air *Transport* cannot pay its way, and, as we must be up-to-date in our Imperial communications, it is necessary to subsidise Air Transport until such time as it does pay

If any Canadians are present, I hope they will express to their people at home the admiration and gratitude we owe to Canada for the manner in which she has developed Air Survey She is certainly leading the world in this important activity

Major Hemming has spoken with regret of the fact that Canada has employed American aircraft and American cameras for this enterprise The reasons are two-fold First, America is very close to Canada, and can thus quickly realise what is required, and, secondly, two of the great qualities of the American race are "ginger" and "service" The Americans seize on innovations and push them, while the British are inclined to hang back and avoid making use of them until they are forced to The American attitude might perhaps be described as trying to run before you can walk, but in this case their policy has given them the market We have an excellent camera now, and I hope it will assert itself and prove its superiority

I suggest to the Colonies that are contemplating Air Survey, that they should make up their minds quickly I am convinced there is a rush of work in the way of Aerial Survey coming in the near future, and that those who do not take advantage of it in the early stages will find it impossible to get the work done later on

One of Air Survey's handicaps in the past has been that it is necessary to have a big job in order to work economically There are plenty of demands for Air Survey all over the world which are not big enough to ensure commercial success For instance, it is impossible, from a commercial point of view, to order an aeroplane and send an expedition thousands of miles across the sea to carry out work which could be accomplished in a couple of days The price would be out of all proportion, because the whole of the overheads would fall on this small amount of work On the other hand, when we get into big areas, such as 50,000 square miles, costs fall rapidly, and could really in many cases be brought down considerably below that of survey by ordinary methods I have been rather horrified to hear that Major Hemming's scheme in Northern Rhodesia includes the construction of

96 aerodromes. The right place for an aeroplane is in the air, not on the ground. We have surely reached a state of reliability which does not necessitate such an enormous expenditure on the ground to prevent pilots crashing through forced landing.

Major Hemming has indicated regret that I was not able to visit Rhodesia whilst in Central Africa. If only an aeroplane had been at my disposal this would have been perfectly easy, but, with the means of transport as they exist to-day in Central Africa during the break of the rains, it was absolutely impossible for me to reach Northern Rhodesia in the time at my disposal. In fact, wherever I went in Central Africa, I was impressed by the absolute necessity of Air Transport for the future development of the country.

MAJOR D. A. HUTCHISON, R.E.: I have been very interested in this lecture. As an ex-surveyor the point that struck me most is the fact that it has taken Civil Aviations firms to show Governments and other big concerns that the first thing you want in any development scheme is a map.

With regard to the actual survey work Major Hemming has referred to the work of the Aircraft Operating Company has been doing for the Ordnance Survey. The Ordnance Survey has been investigating the revision of 25-inch to 1 mile plans of Great Britain with the aid of aerial photographs, and so far the work is still in the experimental stage. On an Ordnance Survey plan of that scale an accuracy of somewhere about two feet is required and this entails very accurate plotting. The photographs used were taken by the Aircraft Operating Company on a scale of 1/5,000, or twice that of the plan, the alterations were plotted from them on to the field documents which were afterwards checked on the ground. The experiment shewed that though it entailed greatly increased office work, such a saving of time was made in field that further trials are being arranged to see how the costs can be still further reduced.

The reality is that the aerial camera is now a recognised survey instrument, just as the theodolite or plane table, and its value has certainly been established for preliminary reconnaissance work. Henceforth it is for the complete surveyor to judge how and when to use it.

COLONEL G. H. D. RYDER (a Director of the Air Survey Co.): I speak from a different angle of vision from previous speakers. I have been a ground surveyor myself for thirty-six years, and in my old age I have taken to directing the making of maps by aerial photography, in the future of which I am a firm believer. I do not for one moment say that it is going to replace the work of the ground surveyor in every case. The ground surveyor will always be necessary in certain classes of country, in ground control and the drawing of the resultant maps. There are, however, certain large areas in our Colonies that it would be practically impossible to survey by any other means than by air photography. Anyone who knows our tropical dependencies will be of the same opinion.

I was in Canada last year, and they have made an absolute success of air surveying out there.

There is one point which has not been mentioned to-night, that is the qusetion of fever. We have carried out an air survey of the Irrawaddy Delta, and if it had been a ground survey, half our people would have been dead or stricken with fever. Moreover, the survey would have taken three or four years. Carried out by air it took five months, no one had fever, and it was a complete success.

We had air photos taken at my request of an area that had just been surveyed by the settlement surveyors. Every time a settlement survey is carried out, the ground surveyors settle on the villages like a swarm of locusts. They take bribes from the villagers by threatening to drag their chains across fields such as tobacco. The owner can only save his tobacco by giving a suitable bribe. When however, an area is photographed, none of the villagers know that a map is being made; they cannot even get hold of the airman to bribe him. We have practically proved our case, and large areas will be open to air instead of ground survey.

Regarding the question of cost; Sir Sefton Brancker was very pleased to hear a definite figure quoted, but in case anyone should think that any area can be surveyed for £4, a square mile, let me say that it cannot be done except with a very large area. If any Colonial Government can give us a large area we can get it done in a quarter of the time that it would take a ground surveyor and at smaller cost.

I think Major Hemming is to be very much congratulated on his interesting lecture, and I hope that what he has said will bear fruit, and that his company, or mine, will get some good contracts from some of the Colonial Governments.

COLONEL CROSTHWAIT (a Director of the Aircraft Operating Co.): I am in the unfortunate position of finding myself with something to say which has already been said by others.

Major Hutchison referred to the question of having to persuade the authorities in the Colonies of the necessity for making maps before development instead of afterwards. To do the reverse is like putting the cart before the horse. The remarks just made by Sir Gordon Guggisberg is a good example of what I mean, where a very large sum of money is being expended on the re-alignment of a railway which would not have been necessary had maps been available when it was originally constructed. By the old ground methods of survey this was not always possible on account of the time involved before maps were available. But air methods have altered all this, and the time required to produce maps can now be reckoned almost by months where years were required in the case of ground surveys.

I was rather interested in what Sir Graeme Thomson said about the difficulty of finding money for air surveys. I heard a story the other day which, perhaps, might lead Governments to acquire some extra money for survey purposes. It is told of a man in America. He was the owner of a certain estate, and was much annoyed at the assessment which the authorities had put on his property. He went to interview the tax collector, and, relying on the fact that there were no maps, represented that his estate was very badly situated. There was no water

near him and he was far from communications, etc. In fact, he tried to make the better appear the worse. The revenue authorities apparently anticipating trouble with this gentleman had had his estate photographed from the air, without his knowledge. The tax collector then showed him the photographs, and asked if it was his property. He had to admit that it was. " But," said the official, " what is the meaning of this stream running right through it ? And there is a road not far away. You don't seem to be badly off after all." This end of it was the owner had to admit that he had been guilty of terminological inexactitudes, with the result that his assessment was suitably increased to the advantage of the government concerned. I think other governments might bear in mind what can be done in the matter of replenishing the treasury if proper surveys are made and a complete knowledge of the ground is available. This not only applies to taxation, but to economy in the construction of public works where maps have preceded, and not followed, development schemes.

MAJOR HEMMING'S REPLY TO THE DISCUSSION.

I rise with a great load off my mind, because I expected to be " shot at," instead of which I seem to have been fully supported in my claims for what air surveying can achieve. It is indeed good to know that both the Chairman and Lord Thomson are in full support of this new science.

I wish to express my appreciation of the remarks of the Governors of Nigeria, and the Gold Coast. I have worried Sir Graeme Thomson considerably both in British Guiana and over here. I wanted to worry him again the other day when I heard that he had arrived in this country. The Colonial Office, rightly wishing to protect their Colonial Governors from people like myself, would not give me Sir Graeme's address, but offered to forward my letter. As soon as Sir Graeme received my letter he rang me up and himself gave me his address, so that shows he is keen on air surveying. It is because a man of Sir Graeme's standing and ability believes in air surveying that I am an enthusiast myself.

It is a great pleasure to hear a man of Sir Gordon Guggisberg's knowledge and wide experience of survey supporting air surveying. After hearing his remarks I feel we can look to the future with the confidence which we already have in air surveying, considerably strengthened.

Referring to the question of cost, while the area for the proposed air survey in Nigeria is big enough for an economic figure to be quoted, costs could be reduced, for example, in the other Colonies on the West Coast of Africa if the Colonies concerned would get together and form a common policy. The same remarks apply to the Colonies in Central and East Africa, for, as Colonel Ryder has said, by contracting for large areas, the operating Company can reduce the air survey costs.

It is always a great pleasure to hear Sir Sefton Brancker, and I personally always imagine I feel money trickling into my pocket when he talks. I should like to say that we do indirectly benefit from the subsidies that are granted to Imperial

Airways, because they order machines and instruments for commercial work, and as many of our requirements are identical with theirs, the introduction of improved aircraft and instruments is a help to us.

With regard to the question of aerodromes, I am very glad that Sir Sefton Brancker raised this point. Obviously for our work in Northern Rhodesia, we should be using a special multi-engined air survey aeroplane, but that aeroplane at present only exists on paper. We refuse to let our valuable personnel fly over jungle, out of gliding distance of a safe landing, if single-engined aircraft are used. Our friends, The Rhodesian Congo Border Concession, Ltd., required the survey to be carried out quickly, so they solved the problem by making a number of forced landing grounds in the bush with native labour.

We can carry out the air survey of the Niger Delta with only one base, using the special air survey aeroplane, and operating from the river. It is possible to-day to build an aeroplane which will fly 150 miles from its base, over jungle country, with a pilot, photographer and camera, etc., without the same risk of having to effect a forced landing, which is inherent of the single-engined aeroplane. This is due to the enormous reserve of horse-power. We do not mind, whthin reason, what we pay in capital and running costs for such an aeroplane, because it gives us great height and great reliability ; it enables us to increase the area covered per flight, and saves our having several operating bases. Therefore, I can assure Sir Sefton Brancker, that the point he raises is fully realised, and we are now meeting it.

With regard to the accuracy of air maps, we can provide maps of a very useful order of accuracy, and also show contours. The recent experiments carried out by Mr. Hotine for the Air Survey Committee show that by the aid of the setereoscope and a number of spot heights, contours can be put in.

Major Hutchison will, I think, be interested to know that we could considerably reduce our costs if we could undertake the air photography for the whole of the Ordnance Survey revision. The revision contract that we carried out for the Ordnance Survey was only over an area of some 50 square miles.

I will not take up any more of your time, as it is getting late. I will conclude by expressing my great appreciation to Sir William Clark for his kindness in presiding at this meeting.

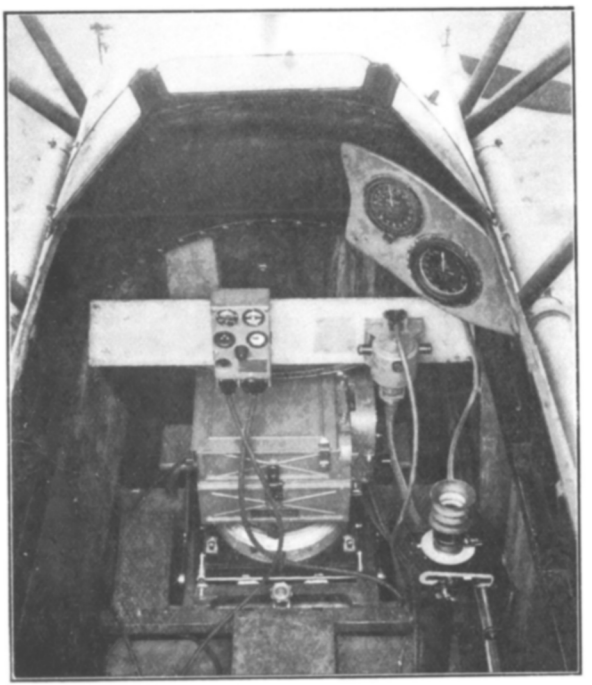
The CHAIRMAN : It is now my pleasant duty to thank Major Hemming on your behalf for all the trouble he has taken in preparing his lecture, and for the fascinating pictures we have seen.

Mr. NORMAN J. HULBERT : I propose a very hearty vote of thanks to Sir William Clark for kindly coming here to-night. He has conducted the proceedings with very great charm, tact and ability, and we are very much indebted to him.

As you know, Sir William is Controller of the Department of Overseas Trade, which the Chancellor of the Exchequer has decided shall cease to exist. I cannot pay any higher compliment to Sir William Clark than to suggest to him that in that event he should devote his whole attention to aviation.

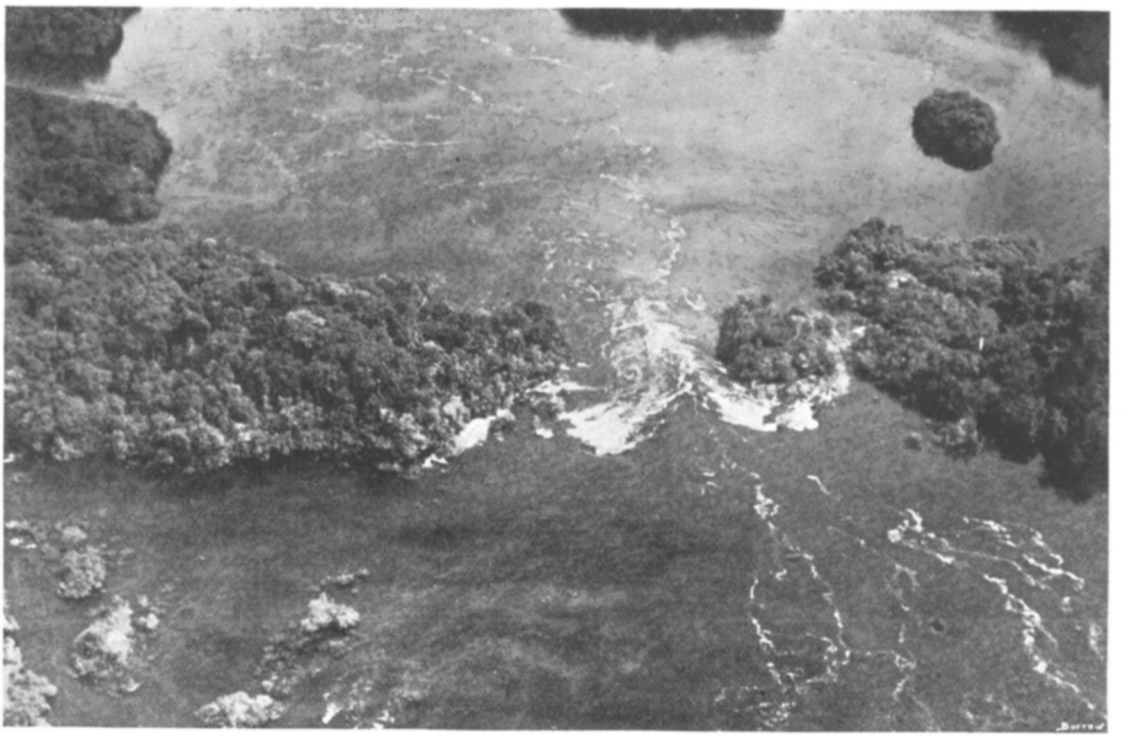
The votes of thanks were carried with acclamation, and the meeting closed.

Photograph of the Lecturer.

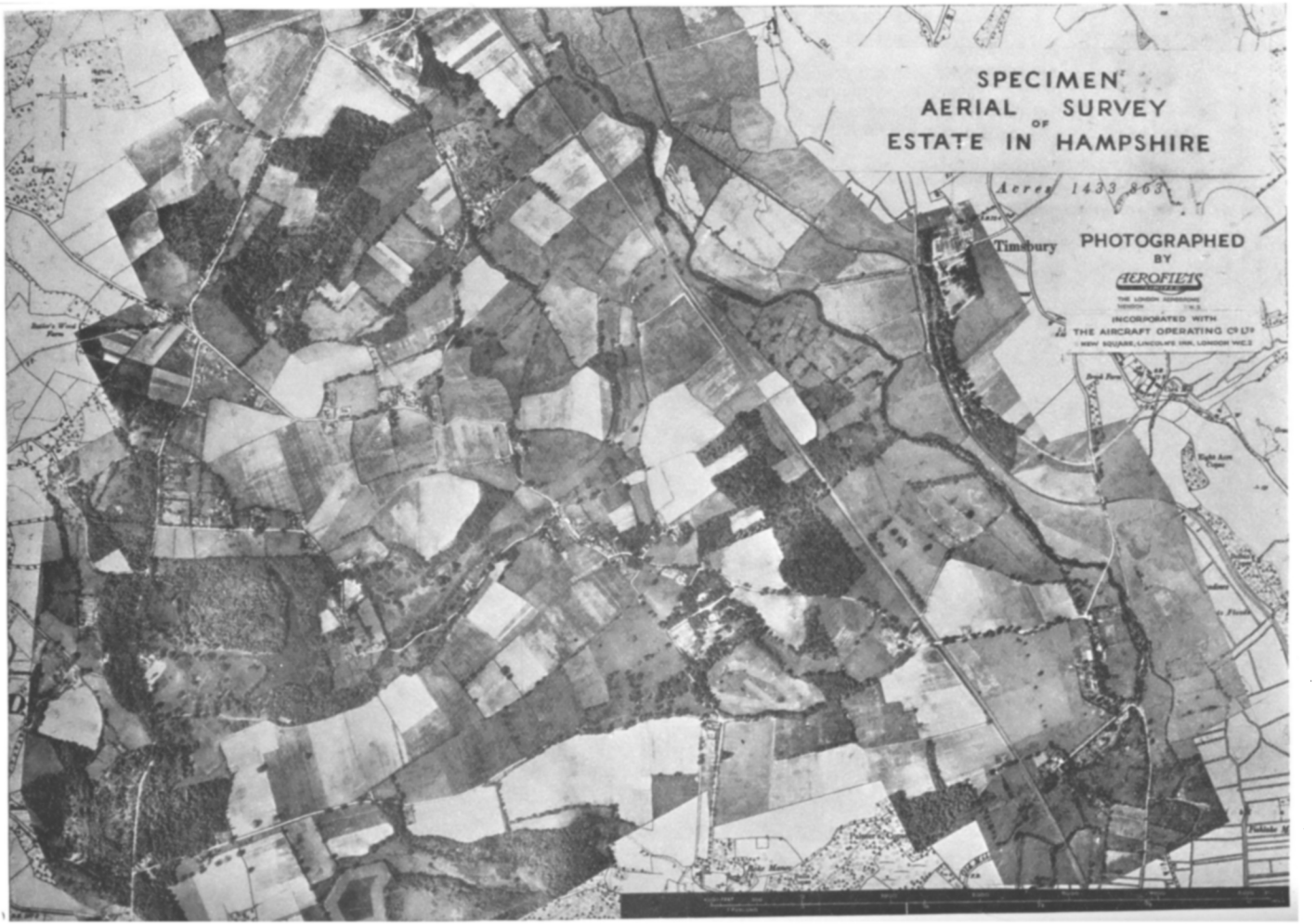


Photographer's cockpit, showing the installation of the Eagle air survey camera and Aldis aiming sight, as used on the Ordnance Survey Revision Contract.

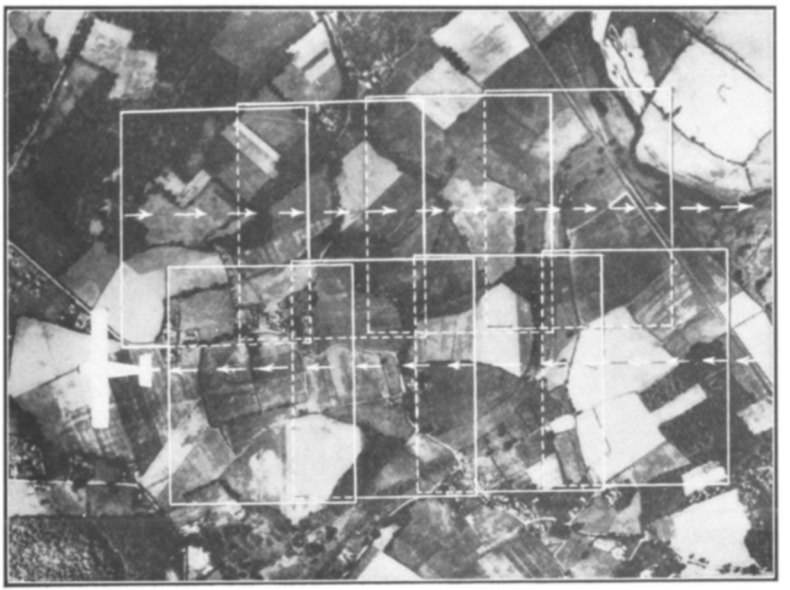
Negotiating a dangerous rapid during an air route reconnaissance up the Mazaruni River, British Guiana. It took the lecturer ten days to go 250 miles by this means. For comparative air view see opposite page.



The Same rapid photographed by Major Cochran Patrick during an exploratory flight up the Mazaruni River, British Guiana. A journey similar to the lecturer's was undertaken, the 250 miles being covered in some three hours, as against ten days by the older method.

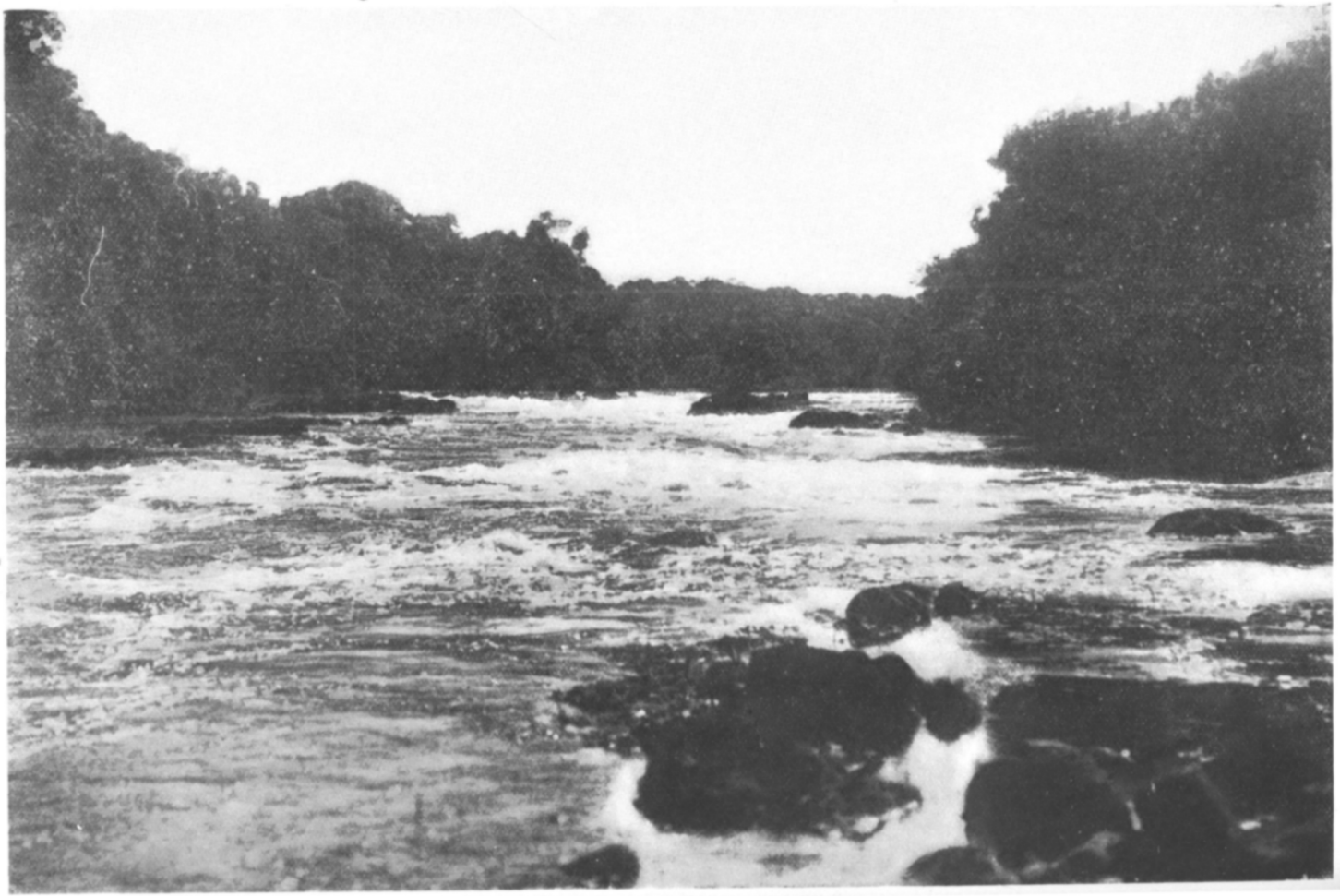


A mosaic map of a private estate, superimposed on the Ordnance Survey map. The mosaic is made up of some 30 or 40 photographs, and very considerably reduced in scale from the original.



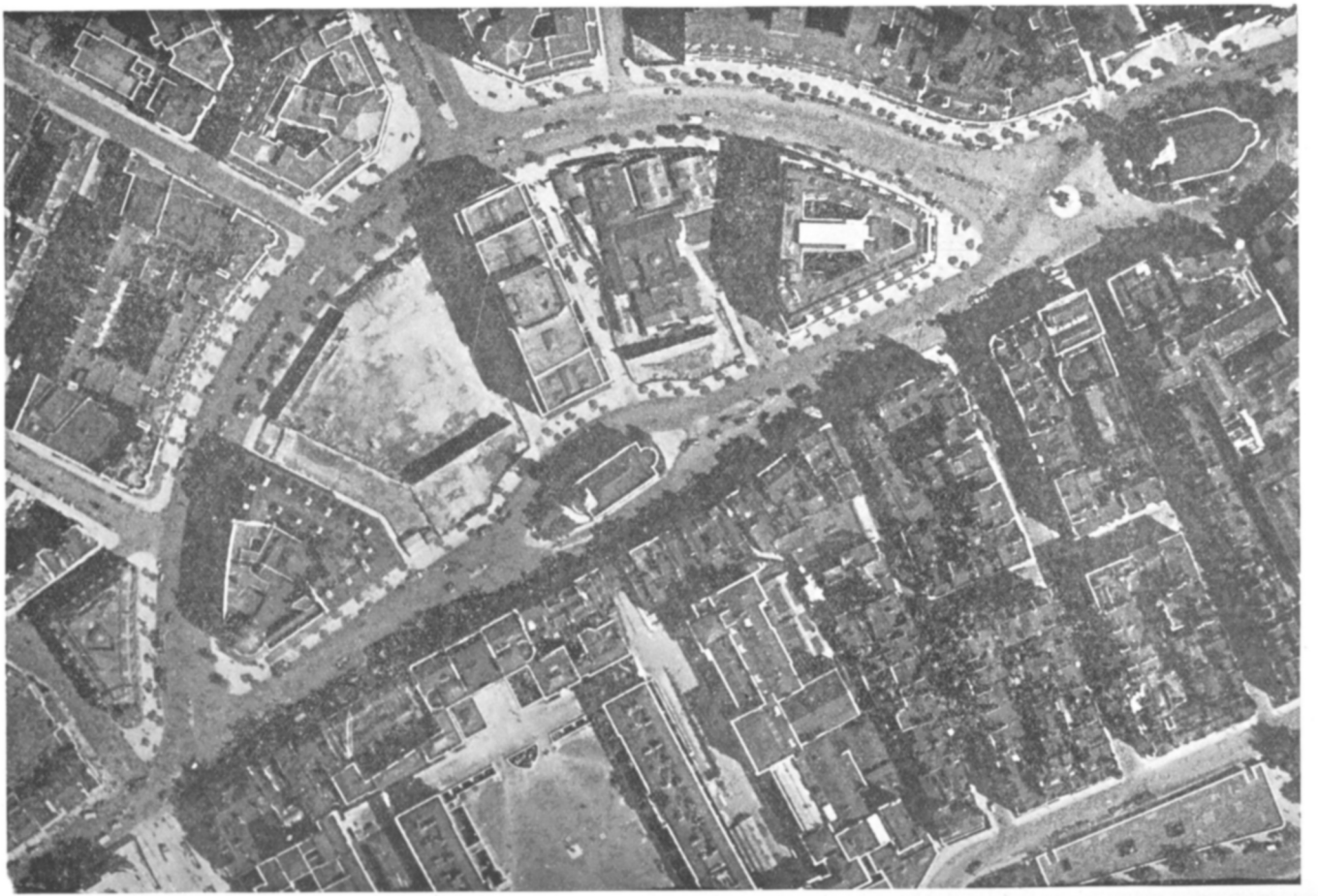
Having photographed a strip of the country, the aeroplane returns on a parallel line of flight, taking another strip of photographs overlapping the first.

Immediately after a flight the photographs are developed, prints made and roughly pieced together, as



The negotiation of the Itamine Fall, Essequibo River, British Guiana, by river boat. Note how the jungle, rising some 100—150-ft. completely obscures the view. Note carefully the features on the river, and see opposite page for comparative air view.

Aerial photograph taken 500-ft. above the area shown on the opposite page. The area covered by the ground photograph is seen in the foreground at the point marked " X." Note how in this single photograph a range of mountains is seen, with two valleys, the river splits up into three channels, and the plain of the Essequibo is seen stretching away to the left. This photograph contains information of great value to



Section of aerial photographic map of Central London, a subsidiary Company of the Aircraft Operating Co., Ltd., by Aerofilms, Ltd.