

In this paper no reference has been made to the various government agencies which have carried out this work in Canada. The original mapping with horizontal photographs was under Dr. Deville's direction in the Department of the Interior. In conjunction with the International Boundary Commission, the Geological Survey of the Department of Mines, and the Topographical Division of the Department of Lands and Forests of British Columbia, they mapped approximately 50,000 sq. miles in the years prior to 1925. The Topographical Division of the Department of Lands and Forests of British Columbia pioneered in the use of horizontal photos with verticals. Later the Topographical Survey of the Dominion Government followed suit, adapting trimetrogon photography for four mile to 1 inch in mapping as well. The experiments in bridging vertical control with multiplex and the operational use of horizontal photographs in conjunction with multiplex are being carried out at the Army Survey Establishment.

PRESIDENT SANDERS: Thank you, Major Thompson. We trust that you will take back with you our sincere appreciation to the Canadian Institute of Surveyors, for which you are the delegate.

We have just heard from our good neighbor to the north. We have another neighbor, not close in the sense of miles, but which is very close to us in the sense of language and cultural background. We have been trying to have this gentleman with us for a long time, and it is fortunate that we succeeded at the time of our annual meeting in having with us Mr. F. L. Wills, the founder and director of the first air photographic company in England. He is now Managing Director of the Hunting Aerosurveys, Ltd., of London.

Mr. Wills, Member of the British Empire, is a Fellow of the Royal Photographic Society. He is a member of the Royal Society of Arts, and is also a member of the British Institute of Photographers. But most important of all, to us at least, he is a member of the American Society of Photogrammetry.

I have great pleasure indeed in presenting Mr. Wills who will speak on the subject of "Equipment and Methods Employed by the Hunting Group of Air Surveys Companies."

MR. F. L. WILLS, M.B.E.: Mr. Sanders, Members of the Society, Friends and Distinguished Guests: I am very glad that your President mentioned that I was a member of the Society, because I wear a red badge, which is a guest badge. This I think is due to the hospitality of the committee because of the fact that I was permitted to come here by the goodness of the British Treasury who hand out their dollars in sufferance.

I appreciate the honour of submitting a brief paper to this Society which has done so much towards the advancement of Photogrammetry throughout America and the rest of the World. I must first explain that I am not a technician but a business administrator and therefore I am not able to give you a learned exposition on the Science of Photogrammetry. Perhaps the brief outline of the activities of my Associated Companies within the British Empire will provide you a little diversion, at this stage of the Conference.

The Hunting Air Survey group consists of a number of associated companies established in Africa, Canada, Australia, New Zealand, South America and the United Kingdom. The Group takes its name from the Chairman of my London Company, Mr. P. L. Hunting, who co-ordinates the various interests of the companies. He comes of an old Scottish family, which from 1860 was associated with ships of the sea and to-day is, in addition, associated with ships of the air.

Varying types of available civil aircraft, modified for air survey are used within our Group of Companies. There is the "Bristol Freighter," with 1350

h.p. Hercules engines, providing an operational ceiling of 23,000-ft., range 1,000 miles, duration about 6 to 8 hours at 160 m.p.h. capable of carrying a load of about $3\frac{3}{4}$ tons which can be used if needed for work in undeveloped countries where aerodromes and communications are few and climatic conditions extreme. Other types included are Anson V, Lockheed XIV, Hudson III, Stinson, Oxford, Rapide and Bell Helicopter. One of the smallest types employed is the "Percival Proctor" with 210 h.p. Gipsy engine, ceiling 13,000-ft., duration $5\frac{1}{2}$ hours at 135 m.p.h., for photographing small areas sometimes called for in the United Kingdom.

Flying and navigational equipment includes magnetic compass and directional gyro combined with distance reading compass, blind flying panel and other necessary instruments. Since the war the only auto-pilot available to us commercially in the United Kingdom has been the Sperry A3 but we expect this will soon be replaced by an auto-pilot working on three axes. During the past year, we in London have carried out a number of trials employing the Decca Navigator equipment, both as a means of straight-track navigation on a pre-determined course, and also in order to test the accuracy of fixation of the aircraft within a radius of 100 miles from the Master Station. So far the results have been encouraging and further experimental trials are proceeding.

A new Percival twin-engine aircraft, the Prince, specially adaptable to air survey is under production to our order, which we plan to equip with the latest navigation, radio and radar instruments.

Our standard air-borne photographic equipment includes the Williamson Cameras—Eagle IX and O.S.C. types with 6", 12", 20" and 25" optical units. The O.S.C. camera is in a heated spherical closure; has a focal plane register glass, accommodates 500 film exposures. The 6" Ross lens has a sector shutter which is removable without disturbing the setting of the optical elements. Air-borne accessories include 35 mm. statoscope and instrument recording cameras.

Ground equipment used includes continuous film processing machines, Williamson and Wild diapositive reduction printers with glass correction or compensating plates for each respective camera lens, and Williamson and Wild rectifying enlargers.

Our standard mapping and contouring equipment is the Wild A5 and A6 for large scale and medium scale maps and plans, also the Williamson-Ross S.P.3, the counterpart of the multiplex, for medium and small scale topographical maps. Other general apparatus includes epidiscopes, anharmonic rectifiers, arundel traversing equipment and various types of stereoscopes.

The operational methods of our Companies vary according to the nature and requirements of the countries in which they are working.

For instance in Africa, which although sparsely populated is fast developing, the Aircraft Operating Co. (Pty.) Ltd. has chiefly employed the simple forms of air survey for reconnaissance and topographical mapping with form lines. There is now a radical change indicated towards precision surveys. Activities in connection with geology, forestry and economic surveys have been extended to the Gold Coast, Nigeria, the Rhodesias and many other parts of Africa.

In Canada over 100,000 sq. miles have been photographed by the Photographic Survey Co. Ltd. in the last 2 years and a large part of it mapped, covering areas in Ontario, Newfoundland, British Columbia and Nova Scotia for forest inventory and other purposes. Experienced technicians in forestry, entomology and geology are employed.

Some 21,000 sq. miles have been photographed in South America since the war by Aerophotos Limitada for petroleum and mining surveys.

Australia is concerned with the development of agriculture, minerals and communications and a recent survey in operation by Adastra Airways (Pty.) Ltd. is being carried out for the Province of Victoria covering some 62,000 sq. miles.

New Zealand Aerial Mapping Ltd. is photographing most of the Dominion for the Government and has covered 4% prewar, 40% during the war and 20% postwar, a total of 64% of the whole island to date. Average photo scale is 1/15,840. They have been very successful with forward overlapping obliques for erosion and drainage schemes.

The United Kingdom company, Hunting Aerosurveys Ltd., has been and is actively engaged in the Middle East on air surveying in connection with geological exploration and development of the oil fields. Work has also been carried out in connection with major irrigation and flood control schemes. In the British Isles large scale surveys are carried out for reconstruction and town planning, road and rail improvements. We are also engaged in revising for Municipal Councils the Ordnance Survey 1/2,500 maps where they are badly out of date.

In these Countries our Associate Companies are coping with the increasing demand for precision surveys where contoured maps and plans are urgently required for towns and growing industrial centres. Photographic mosaics are also produced in quantities for our clients' projects.

Our London Company has recently completed a test survey on behalf of the Southern Railway Company in England, covering a few miles of railway tracks and sidings, and including the main line station at Bournemouth and its adjacent buildings and workshops. What is of interest is that the scale of this survey was 1 to 480 (40-ft. to the inch) with contours at 5 foot intervals and it was carried out on an experimental basis with a view to meeting the rigid specifications of the Railway Company for this type of survey. The photographs were taken with a Wild glass-plate camera from a height of 1,600 ft. to a negative scale of 1/3,500 (lens 165 mm.)—thus entailing an eight times enlargement between negative and plotting table. Preliminary checks have been made and we have every reason to believe the accuracy of the completed plan will be to the order of 6 to 9 inches. The work from the date of photography to the completion of the finished plan, took three months, including the time taken to establish control points and levels on the ground. Obviously time plays a large part in normal ground survey of busy railway junctions, stations and sidings, and air survey has a decided advantage in work of this type, but it is recognized that the production of surveys at such a scale is not generally possible from air photographs. However, it is significant that where the ground is not screened by vegetation or densely built-up areas, it is both possible and practicable to produce plans at engineering scales by photogrammetric means within the tolerable accuracy.

I believe I am correct in saying we were the first organization in the British Commonwealth to employ the precise 3-dimensional plotting instruments developed between the two wars in Switzerland and Germany. In 1938 we introduced the first Wild Autograph A5 into England which immediately opened up an entirely new field in the application of air survey to plotting at scales up to 1/1,000 with contours at intervals as close as 5 ft.

Whilst the theorists and the sceptics in my Country maintained in the past that such instruments were not economic, and could never give the accuracy obtained on the ground, we remained convinced that the future of photogrammetry lay not only in the production of topographical maps to small and medium scales by graphical and semi-graphical methods, but could also make possible the plotting of engineering and cadastral plans at a speed hitherto im-

possible by ground methods, and at a cost no greater than the outlay to be expected of similar surveys made on the ground.

The war saw the partial destruction of our English laboratories at Wembley, and the turnover of our personnel and organisation "en bloc" to the Royal Air Force. The original A5 Autograph luckily survived the blitz, and it may be of interest that after six moves during the war it was returned to us, and is in operation to-day, with others, in as good condition as it was ten years ago when first exhibited at the International Convention of Photogrammetry in Rome.

As you know the requirements for photogrammetric mapping impose the most rigid specifications on every phase of the production, beginning with the initial conditions of exposure, and extending to the control supplied on the ground, and the final plotting of the map. The successful integration of these operations necessitates not only a very close liaison between the separate parties concerned, but it is also imperative that the pilot, navigator, air photographer, ground surveyor and photogrammetrist should be thoroughly conversant with the difficulties and nature of each others' specialist activities. We believe that the strength of our Organisation lies in its ability to undertake the whole work of an air survey operation, of whatever nature, from start to finish. Only by combining the experience of all personnel engaged in the different fields of the work, can the best results be achieved at a maximum economy. To this end, we endeavour to encourage the closest relationship between the various departments of our organisation by stimulating the close contact between all our technical personnel, and by the institution of inter-departmental lectures on the different aspects of air survey. In London our air crews, when not engaged on flying duties, are able to get experience in the photographic and photogrammetric departments. Our ground surveyors, in addition to their experience in field survey, receive as full an education as possible in the theory and practice of photogrammetry including that of operating three-dimensional plotting machines. The fact that our air crews are employed full time on flying survey duties, induces a very high standard in both the accuracy and quality of the flying.

In conclusion, I would like to suggest that there exist as yet many people, on both sides of the Atlantic, who are unaware of the advantages of air survey and its varied applications. Not only have we to build up a wider appreciation of the use of air survey, but we must also take care at the same time to maintain a high standard of technical skill and operating efficiency in any work we undertake. Extravagant claims and inferior work must inevitably reflect not only on those firms and government departments individually responsible, but will almost certainly prejudice the confidence of others less well-informed. We in the commercial field are particularly susceptible to this type of criticism and it is, therefore, all the more important that we should spare no amount of research and energy to maintain the best traditions of our profession. On this assumption, and this assumption only, can we be assured of the confidence of our clients and the general public and thereby make use of the fullest application of the science of photogrammetry and air survey to the future development of the world's resources, and to the mutual benefit of all concerned.

PRESIDENT SANDERS: We thank you, Mr. Wills, for an excellent presentation of your subject. The commercial companies could scarcely have done better than our Program Committee in selecting as spokesman this commercial photogrammetrist from England.

We now move to a military phase of photogrammetry, and for that subject we have a dual speaker arrangement. The Army Map Service is a stronghold in photogrammetry. It is fitting that it should be called upon to provide speakers to cover this phase.

Like all good executives, the commanding officer, Colonel W. H. Mills, has surrounded himself with capable men. He has brought with him to help carry the ball today one of the men we know well, a photogrammetrically minded assistant, Major Albert L. Nowicki. We know him particularly for his writings on the subject of stereoscopy.

I take great pleasure now in presenting to you Colonel Mills who will, in turn, introduce Major Nowicki. Colonel Mills.

COL. W. H. MILLS: Mr. President, Members of the Society, Ladies and Gentlemen: I have neither the ingenuity nor the intention of discussing the technical aspects of photogrammetry. That subject has been, and will be, much discussed here by more capable men. My experience with bridging, for example, has been over rivers or at the card table. So my status in this conference is that of an interested spectator. For I am intensely and officially interested in photogrammetry's application to military cartography. And I am cursed with a profound and *unofficial* curiosity.

Fighting men, even in peaceful years, have need of extremely accurate and detailed knowledge of all strategic areas. The practice of training an Army with wooden guns and obsolete maps belongs to history, we hope, along with chain mail and Roman cartograms. There are indications that the future satisfaction of such mapping needs rests largely with photogrammetric processes. The remark that the aerial camera was the Mata Hari of World War II is probably a colorful exaggeration. But there is no denying its important role in furnishing up-to-the-minute intelligence for both combat and construction planning. Nor is there cause to discount its importance in the postwar task of providing the maps this country so woefully needs.

Tremendous technical difficulties had to be overcome to permit the accurate plotting of maps from stereoscopic surveys. The solution to some of these problems is still a responsibility of the future. Sporadic battles are still waged among the experts about the relative value of favorite methods and equipment, but photogrammetric compilation, like radio and frozen foods, is probably here to stay. Technicians, who comprise societies such as this, can guarantee that the aerial photograph will be a continually improved instrument of communication for terrain intelligence. They can encourage the discovery of more rapid, more precise and more economical procedures. They can assure the United States of up-to-date, low-cost, large-scale topographic maps.

Various military authorities have remarked upon the relative ignorance in map language among the public, as evidenced by inductees during the past war. This lack of knowledge is not confined to an understanding of cartographic expression. It extends to an almost general ignorance of map purposes and map procurement. Government agencies have tried since the war, to correct this condition by establishing map information offices and by issuing notices of items generally available. Associations like yours can do much along similar lines to educate the layman who needs a good map and just doesn't know how or where to ask for it. There is a tendency in scientific societies to confine discussion of their interests almost exclusively to their membership. This is a commendable practice when it pertains to the aspects of the membership's specialized activities. But it seems to me some informal and informative campaign could be devised which would serve two purposes—blow the air of mystery from cartographic procedures—and enlighten the public on the types of maps being published in this country, their purpose and the channels for their distribution.

Military cartographers are continually trying to extend the application of aerial photography beyond its customary and accepted uses in topographic