Photogrammetry

The following is a Summary of Lectures given before the Discussion Group on Photogrammetry of the Melbourne Division.

DEVELOPMENT OF PHOTOGRAMMETRY IN AUSTRALIA. PERIOD UP TO JUNE, 1949.

Summary of paper read by Lt.-Col. D. MacDonald,
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Introduction :

Photogrammetry may be defined as the science of obtaining reliable measurements by means of photographs. Aerial photogrammetry uses photographs taken from aircraft and is the aspect of most interest to this Group.

The history of photogrammetry in Australia is intimately interwoven with the development of aerial photography, so that it is essential to first trace the history of aerial photography before discussing photogrammetry.

AERIAL PHOTOGRAPHY IN AUSTRALIA.

Period 1924-1929 :

After World War I, with the advent of the aeroplane, there are the first records of aerial photographs being taken in Australia, although only general purpose cameras were used and the photos taken with the camera held over the side of the aeroplane.

The first aerial photography of defined areas for mapping, using precise cameras, appears to have been taken by the Royal Australian Air Force in 1924. These photos were taken with a P18 plate camera that had a format of 4″ x 5″. The areas were not covered with regular overlapping runs but by a series of individual photos which overlapped each other to varying degrees.

By 1926 the value of aerial photographs for mapping purposes and other investigations had become apparent. The R.A.A.F. in that year arranged for two officers to attend a course in England to instruct pilots in the then new technique of photographing areas with straight parallel flights with correct lateral and side overlap of photos, and the camera maintained within a few degrees of vertical. It was on the return of these officers in 1927 that a start was made on the air photography of Australia as we now know it. The cameras used were the standard F8 which in 1921 had been converted from a plate camera to use film. The early models had an $8\frac{1}{4}$″ lens but later models were fitted with 7″ and 10″ lenses. The format of the photos was 7″ x $8\frac{1}{4}$″ of which $1\frac{1}{4}$″ was used to photograph an instrument panel showing photo number, aneroid barometer reading, clock face and level bubbles. Information concerning the date, focal length of lens and the area covered was also added to the marginal data. Each roll of film provided for 100 exposures.

The first areas flown were in N.S.W. Flight lines were flown North and South with East and West key strips. By the end of 1930, an approximate area of 19,000 square miles had been flown in the eastern portion of Australia.

Period 1930-1939 :

Steady progress continued with aerial photography in all States. The R.A.A.F. were the main photographing agency but during this period civilian firms began to contract to supply aerial photographs.

The main cameras used were the F8 or Eagle 3 with $8\frac{1}{4}''$ lens. In 1936, the R.A.A.F. introduced the Eagle 4 camera which had a picture format of 7″ x 9″ of which half an inch was taken up with photographic data.

In this period many areas in Northern Australia were photographed by the R.A.A.F. for the Aerial, Geographical and Geophysical Survey of Northern Australia. Photography only ceased with World War II.

Period 1939-1945 :

During the war years large areas of Australia were photographed for mapping projects, intelligence and other defence purposes.

The Eagle 4 camera was used extensively. In 1943 the R.A.A.F. introduced the K17 camera with a six inch wide angle lens. The photos had a picture format of 9″ x 9″ with an extra half an inch for photographic data.

Trimetrogon photography was first introduced in 1942.

This period marks another milestone in the history of photogrammetry in Australia because two States, Victoria and Tasmania, set up Aerial Survey Branches to provide and produce aerial photographs, photomaps and topographical maps. Photography carried out by civilian agencies commenced in both States in 1945.

Period 1946-1949 :

By 1946 procedures and techniques for obtaining photographs had become standardized. The demand for air photographs was steadily increasing. During this period large areas in all States of Australia were photographed.

The 9″ x 9″ format of photos was now considered a desirable feature. The R.A.A.F. continued to use K17 cameras but were making preparations to change to the O S C camera as the K17's became unserviceable. Most civilian agencies were using the E9 camera which can be fitted with 6″, $8\frac{1}{4}''$, 10″, 12″ and 14″ focal lenses.

In 1946 it was decided to discontinue the use of trimetrogon photography and substitute small scale vertical coverage in the areas where reconnaissance type photography is the main requirement.

The increased tempo in photography can be judged by the fact that in the year 1948 the R.A.A.F. photographed approximately 250,000 square miles.

DEVELOPMENT OF PHOTOGRAMMETRY IN AUSTRALIA.

The development of photogrammetry in Australia can most satisfactorily be reviewed under the two main headings of :—

(*a*) mapping, and

(*b*) other uses of air photographs.

Mapping :

Prior to World War II the main agency for topographical mapping in Australia was the Royal Australian Survey Corps. The methods of map compilation from aerial photographs followed very closely the standard British practice. The early photos of 1924–25 were used to supplement detail on plane table maps by straight out transference of detail using proportional compasses. Then the graphical methods described in the first paper of the Air Research Committee published in 1925 were used. In these methods similar figures are drawn on photos to those joining control points established on the ground and plotted on the compilation sheet. By joining diagonals, a series of control points are established and detail can be transferred by eye from the photos, or by the use of proportional compasses. This method still has its application as long as there is no great variation in height on the photo.

When details of the Arundel experimental work in England in 1925 became available, these methods were introduced here. The plane table sheet was still maintained but the principal points of the photos and the detail were plotted by radial line methods and transferred to these sheets.

In 1936, as an experiment, the SALE map in Gippsland was compiled entirely from air photographs by the Arundel method. Principal point traverses were plotted, transferred and adjusted to master control sheets and the detail plotted. The photographs were contoured by obtaining control heights in the field from trig heights, dumpy levelling and aneroid barometer heights. The field tests of the maps were entirely satisfactory and the method then became standard throughout the Corps.

The slotted template method of air photo control was first used in 1940 with improvised equipment. Later, improved equipment became available and the method was used extensively.

The war in 1939 brought to notice the critical requirement of adequate maps for the defence of Australia. Under the Emergency Mapping Programme, the Survey Corps, in conjunction with State mapping agencies, produced a large number of maps of Australia at various scales. Air photos were used for the compilation of the majority of the one mile maps using normal radial line methods.

With the introduction of trimetrogon photography in 1942, the technique of plotting from oblique photographs was introduced.

1945 saw the establishment of two State mapping organizations—Victoria and Tasmania. The Aerial Survey Branch of the Victorian Lands Department is equipped with Wild Plotting Machines, A5 and A6. These are used for the preparation of topographic maps. Slotted template equipment is also used for the preparation of planimetric maps.

Tasmania provides perhaps the most interesting contribution to the development of photogrammetry in Australia as original methods of plotting from air photos have been adopted.

Briefly the system is as follows :—

Field connections are made to the centre and end of each run ; two control levels for each photo are obtained ; photo control for each photo is derived by computation of aerial triangulation using the Cambridge Comparator for precise measurement ; components of tilt are computed using comparative tilt obtained from the comparator and absolute tilt computed from level control points ; rectified prints are made on glass positives corrected for lens distortion ; contours are drawn on the photos using a stereoscope with small adjustment for residual tilt ; planimetry is effected in a projector capable of enlarging three times ; glass positives are used, planimetry is drawn for each contour interval and the scale changed as the absolute height increases or decreases ; the system is very similar to the Brock process used in America, and excellent results are being obtained.

In 1946 the National Mapping Section of the Department of the Interior was formed. The map compilation method at present used by the Section is slotted template assembly and normal radial line plotting methods.

State Mapping organizations are being set up in New South Wales, Queensland, South Australia and Western Australia. Methods to be used have not been finalized in all cases, so it is a little premature to discuss plotting methods.

In addition to the authorities already quoted, the Main Roads Commission of Queensland as far back as 1933 compiled maps for road location from photos using the Arundel method. The Department of Main Roads in N.S.W. in 1936 used controlled mosaics for road location.

The latest entrant into the mapping field is Adastra Airways Pty. Ltd., which recently imported Multiplex plotting equipment and is now engaged on the preparation of topographical maps for the Public Works Department of N.S.W. in connection with the Snowy River Scheme for hydro-electric power.

Other Users of Air Photographs

One of the first into the field was the Water Board of Sydney which had the metropolitan area photographed about 1929. The photographs were used for house density surveys, contouring, sewer location and water supply. In 1931 the Melbourne Metropolitan Board of Works followed suit, and the metropolitan area of Melbourne was photographed for similar purposes. In addition mosaics were produced. These photographs must provide a unique historical record.

In 1932 the first photography for forestry investigations was carried out in Tasmania. It was about this time that the first use of photographs for geological interpretation was made in Central Australia and New South Wales by C. T. Madigan. Also about this time the Western Mining Corporation commenced operations for photography of the Eastern Gold Field in Western Australia.

In 1935, the City of Brisbane was photographed for a civic survey. It was also in this year that the Aerial Geographical and Geophysical Survey of Northern Australia commenced, and made use of photographs for

geological investigations. The Mines Department of N.S.W. commenced geological interpretation and the Irrigation Commission of New South Wales used photography for investigation purposes in this year.

In 1936 the Department of Main Roads, N.S.W., commenced using photographs for road location in rough country. They now have strip coverage of many of the main roads in N.S.W. It was in this year that the Victorian State Rivers and Water Supply Commission had the Acheron Breakaway photographed and a mosaic prepared. This photography is rather unique in that it was taken from an autogyro.

The remaining years before the war saw an increasing number of departments and public authorities making use of air photos for all manner of investigations.

In the war period, apart from map compilation, air photographs were used extensively for road and aerodrome location. The North-South Road for about 800 miles through the Northern Territory was located on air photos using the technique developed by the N.S.W. Department of Main Roads. Air photographs of parts of our Northern coastline often disclosed amazing differences between the only available charts and the actual ground formations.

In the post war period, Australia can truly be said to have become air photograph minded. In every State, for all developmental purposes, air photos have been in urgent demand. Soldier Settlement, the vast soil surveys being conducted by the C.S.I.R.O. in all States, but particularly in the Northern Territory, geological investigations by the Bureau of Mineral Resources and the Mines Departments of each State, Forestry, Water Supply and Irrigation, Hydro-electric schemes, and the preliminary investigations of the Snowy River Diversion Scheme were greatly assisted by air photos.

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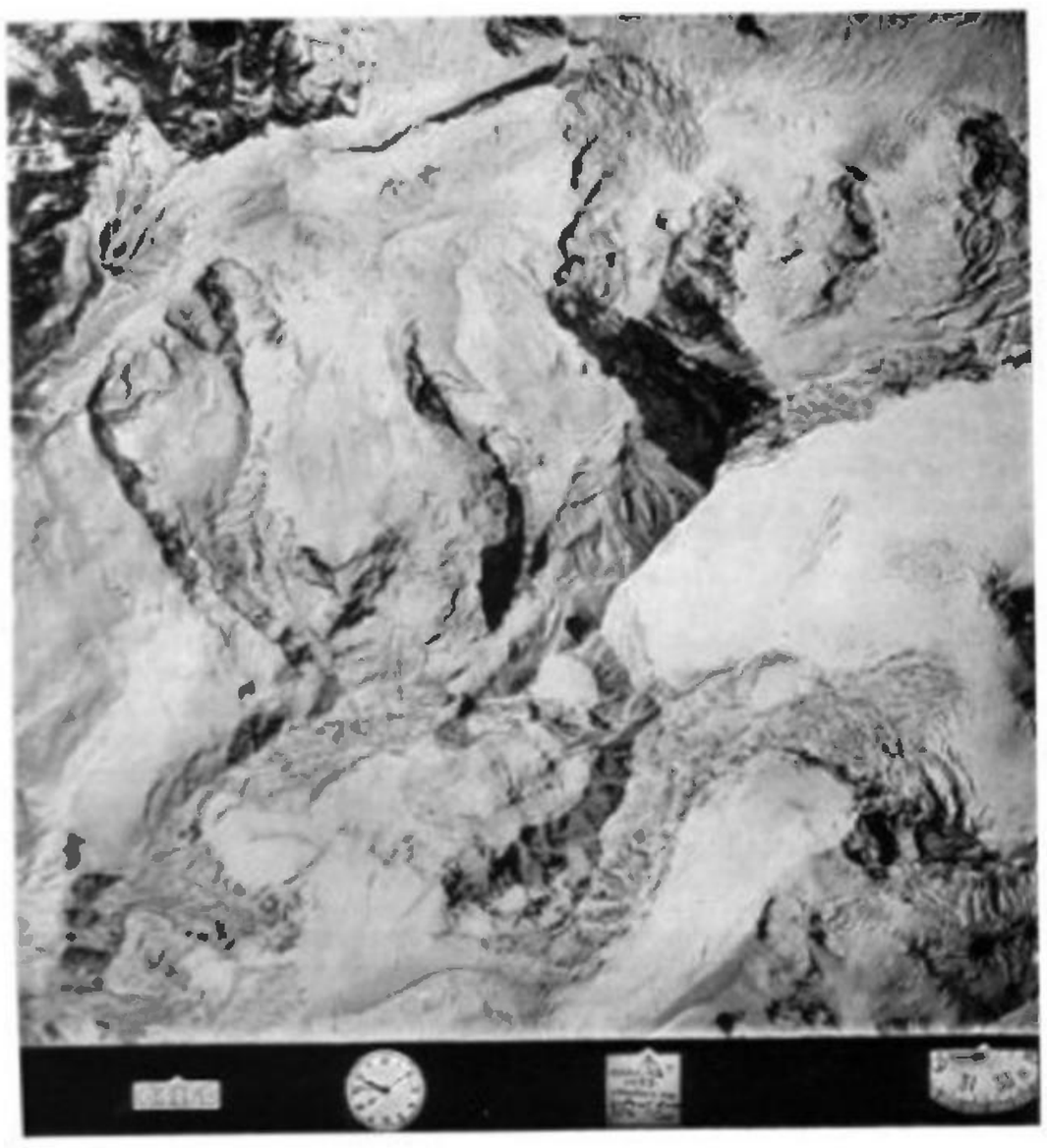
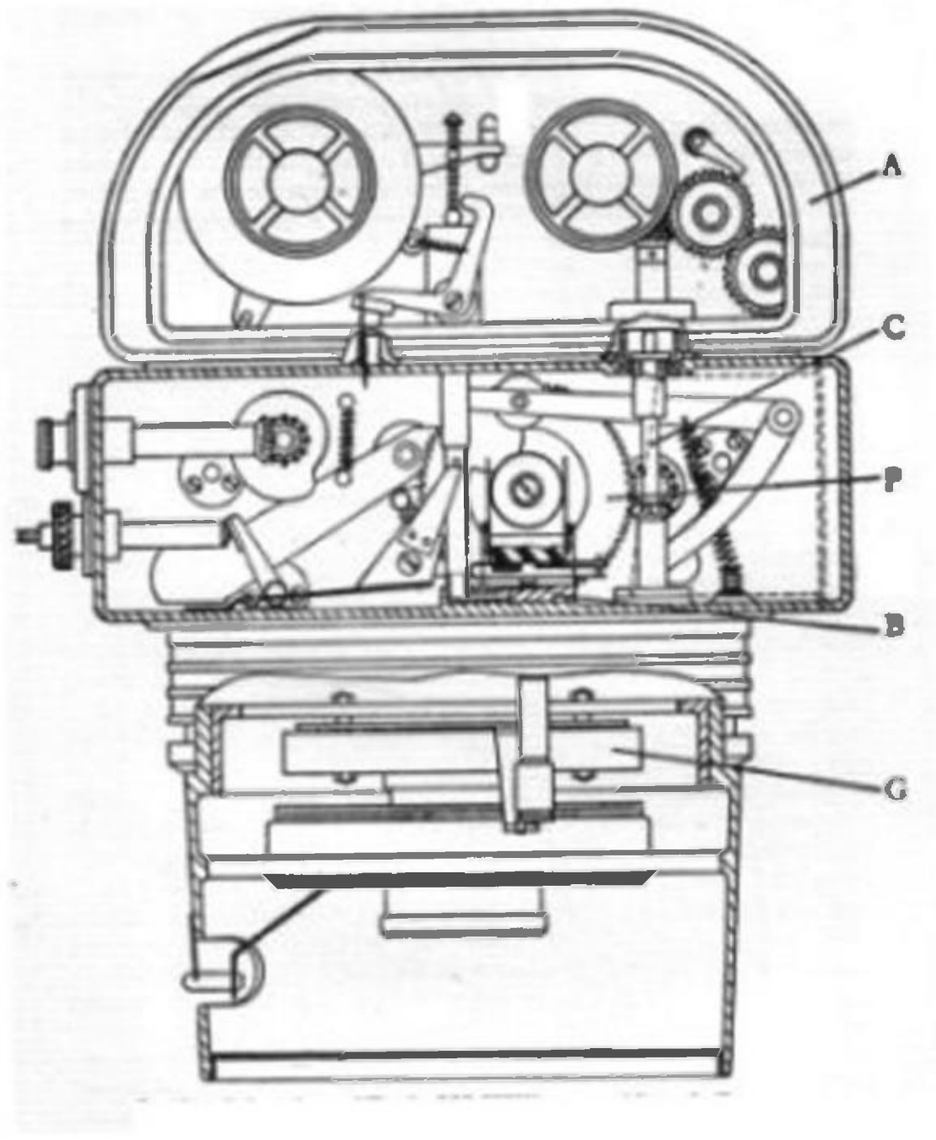
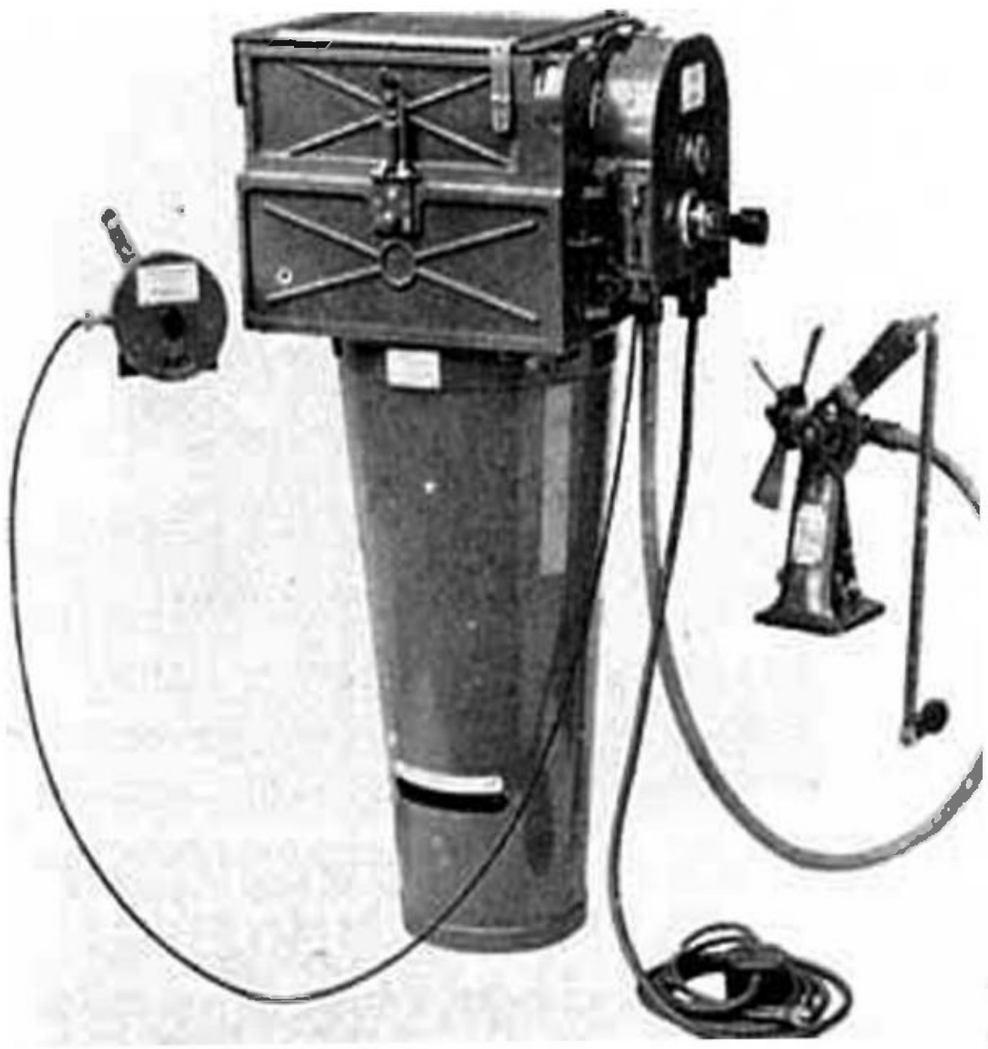
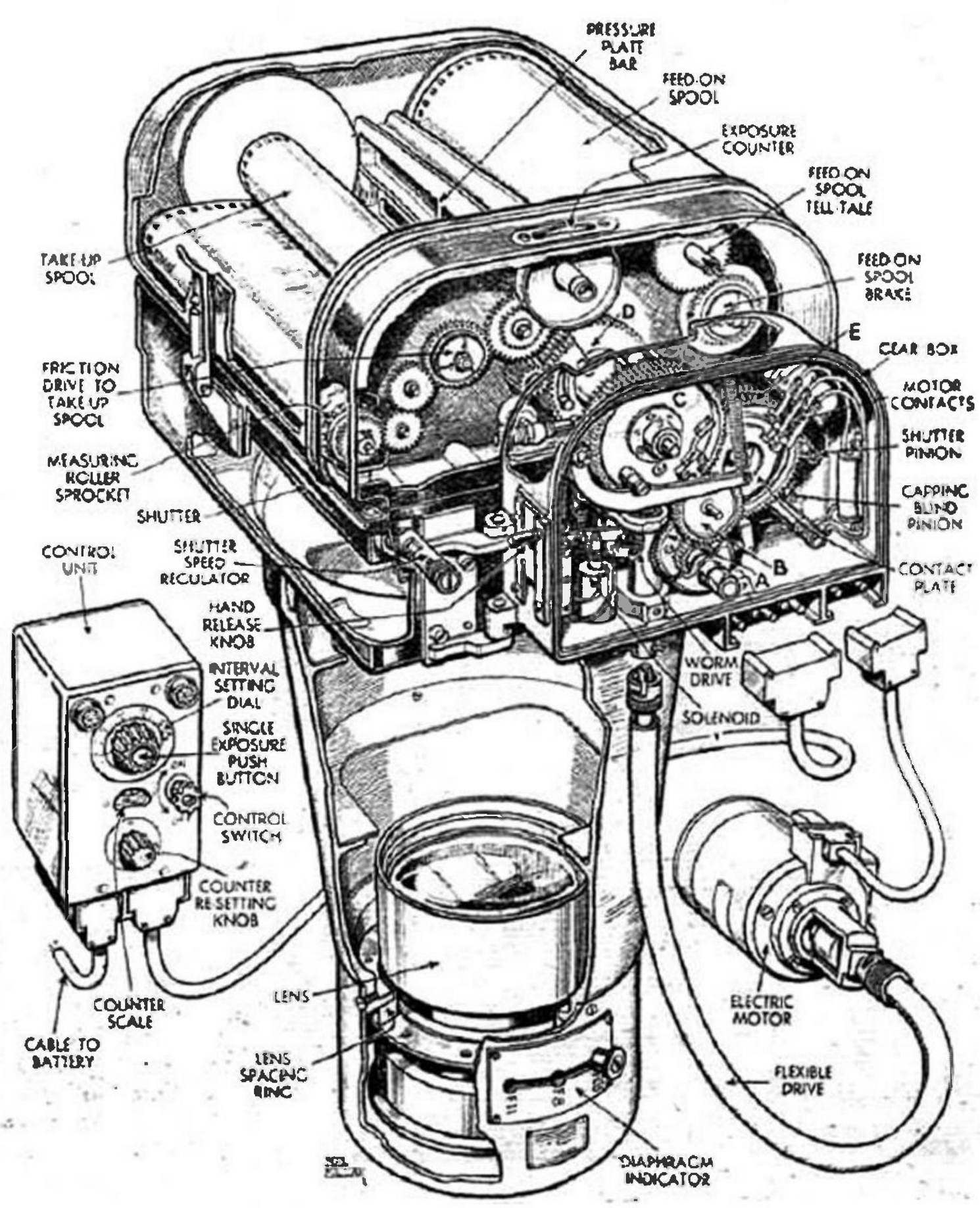


A vertical photograph taken with the Williamson Camera from 31,000 feet of the high spurs and glaciers near Everest.



Sectional drawing of the Eagle III Williamson Aircraft Camera



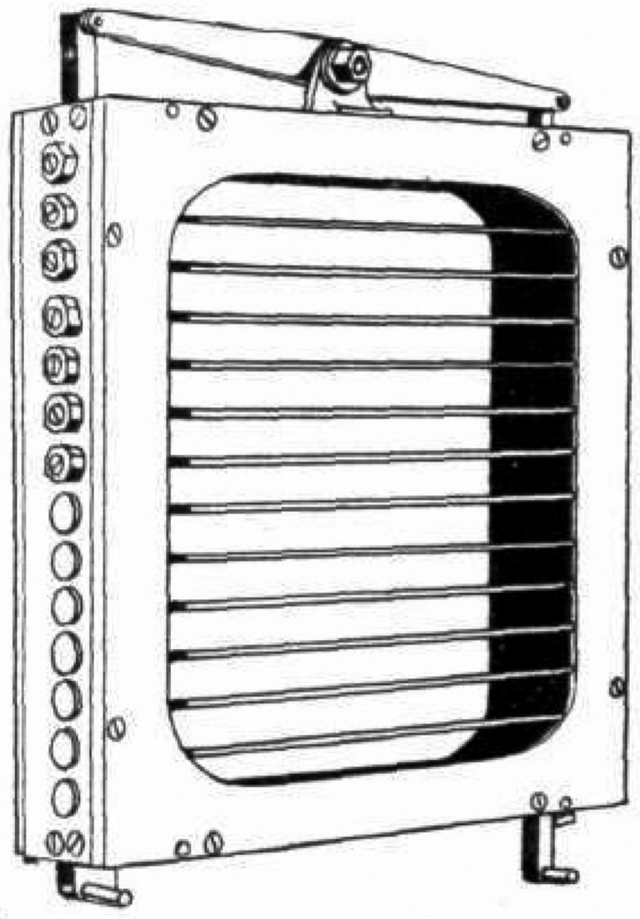


Williamson F8

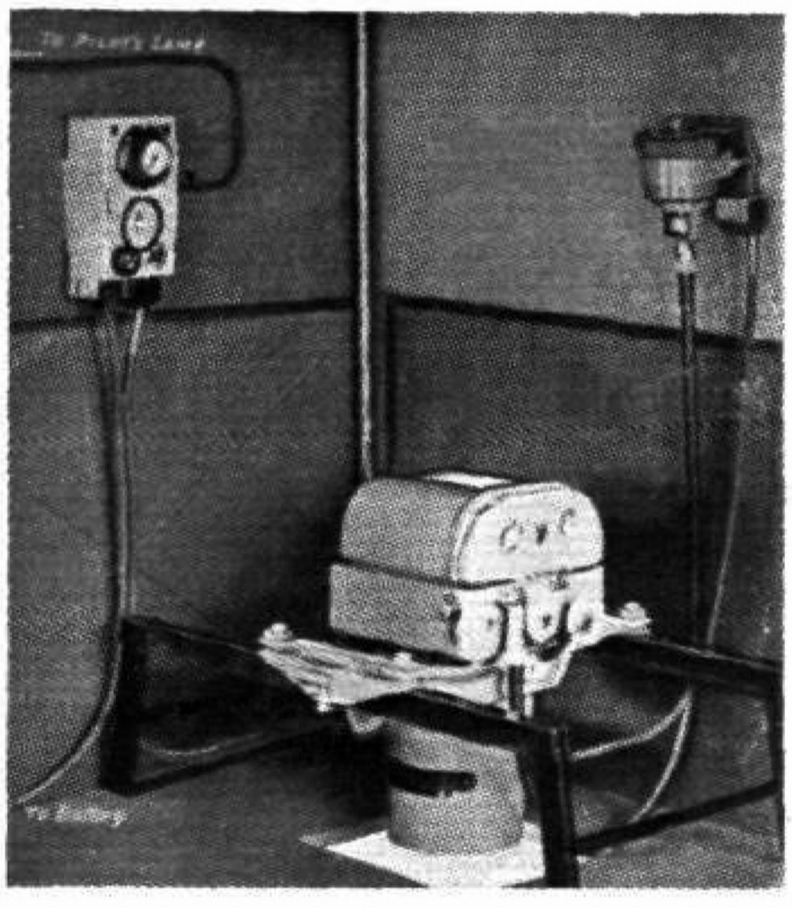
WILLIAMSON "EAGLE" III CAMERA

THE INCREASED confidence in the use of film for aerial photography has inspired the Williamson Manufacturing Co., Ltd., to produce another model of the well-known "Eagle" camera, classed as the "Eagle" III. A notable reduction in size and weight has been achieved by reducing the picture size to 5 in. by 5 in., resulting in a camera light and handy enough for use by hand for oblique photography while remaining adaptable to a vertical mounting for survey purposes, and operated semi-automatically by flexible drive and an air vane, or fully automatically by motor. The unit method of camera construction, which reduces the number and size of moving parts to a minimum, has not been sacrificed in the "Eagle" III, and, apart from the camera itself, all attachments and controls, such as the flexible power drive, electric connections, motor, etc., are identical and interchangeable with the older types. The one exception to this is the lever release which operates the camera by pushing instead of pulling.

Of very special interest in the "Eagle" III is the inclusion of the Williamson all-metal Louvre shutter, with which the Company have been experimenting for several years. Of the types of shutter previously developed the focal plane shutter gave the best results except with regard to distortion under certain conditions. The Louvre shutter consists of a number of thin steel metal strips fitting together like a Venetian blind, half of which rotate in a clockwise direction and the other half anti-clockwise, ensuring among other things even illumination over the whole negative, and no distortion of the image, as the whole area of the lens is simultaneously uncovered. Interposing these thin metal strips between the lens and the image might seem to interfere with the



The Williamson Louvre Shutter. This provides even illumination without any distortion of the image.



The "Eagle III" aircraft camera fitted for vertical photography in an aircraft.

light, but the actual light efficiency obtained is 80 per cent., which means that the interference is almost negligible.

Another special feature of the new camera is that the recording of instrument readings is optional. The instrument box is an entirely separate, optional and independent accessory. If fitted, the readings are recorded not on the pictures but in the margin of film between exposures, so that there is no wastage of film. Four instruments are contained in the box:—a counter mechanically operated from the main camera gearing, a watch with centre seconds hand, an Ivorine tablet for recording data or advertising matter, and a revolving dial aneroid recording up to 15,000 ft., or as required and ordered. Each instrument is arranged on a sliding fitting for ease of repair or replacement.

When the "Eagle" III is to be operated automatically or semi-automatically, the ordinary lid on the camera body is replaced by a similar lid carrying a worm reduction gear and connections for the flexible driving shaft, an arrangement which lightens the camera for hand work, and further allows for quick inspection of the gearing.

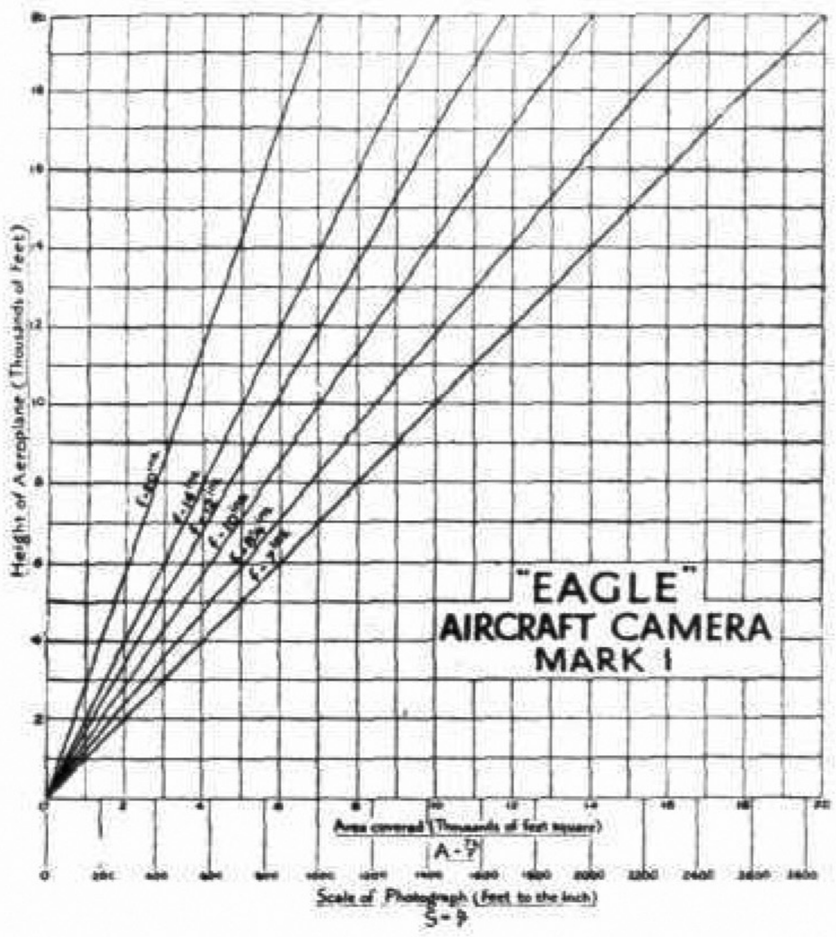
All gearing is totally enclosed, and the gear ratio is such that when the camera is driven by the standard 12-volt electric motor, photographs can be taken at intervals of 3½ seconds. Alternative operation by hand is obtained with a large knob.

For hand operating a hand mounting gear is provided. It consists of an aluminium ring machined and fitted to the camera body, with hand grips, trigger for firing the shutter, and a platform for securing a viewing sight.

When mounted on the camera the latter is conveniently balanced for oblique photography. The attachment takes but a few seconds and no adjustments or connections are necessary. The trigger attachment automatically falls into position in the camera body and locates the mounting centrally, while a single knurled screw secures it in position. For air reconnaissance or survey photography the accepted principle is to fix the camera in the aircraft with an optical axis as near as possible at right angles to the normal flying angle of the machine. It is then the business of the pilot to correct any deviation from this angle on receiving a warning that a view is about to be taken. The vertical mounting for the "Eagle" III has therefore been designed to allow for adjustments for correction of tilt in both planes and adjustment for drift. The supporting of the camera is as near the centre of gravity as is consistent with accessibility and method of control, and large spirit levels are conspicuously mounted for reading in flight. The bearers are interchangable on supports for the "Eagle" I and II.

Two sight patterns are available, tubular and open frame. Either can be screwed to the hand mounting already described. The tubular sight is fitted at each end with crossed wires which indicate the absolute centre of the picture, but the whole area to be photographed is not indicated. The open frame sight is so proportioned as to reveal the area covered by a 10-in. focus lens, and the adjacent country can be viewed at the same time through the sides of the frame.

The film capacity of "Eagle" III is 125 exposures, each 5 in. by 5 in. Last, but not least, we understand that the reduction in the size and weight of this new type carries with it a reduction in price. A London office in Bush House, Aldwych, W.C., has now been opened by the Williamson Manufacturing Co., Ltd., where the "Eagle" models will be on show.



AREA COVERED *and* SCALE of PHOTOGRAPH
with lenses of different foci
on a
7" x 7" PICTURE

This area will of course be different for the "Eagle" III using a 5" x 5" picture.

Williamson K17 camera and focal plane

Williamson Ordnance Survey Camera (OSC)

WILLIAMSON O.S.C.-1 AIR CAMERA

Heated "Bubble" Installation : Remote Control of Shutter Speeds Incorporated

THE science of photogrammetry should receive much stimulation following the announcement made at the annual general meeting of the Williamson Manufacturing Co., Ltd., by Mr. Colin Williamson, chairman of the company, that £5,000 had been voted to endow a Chair of Photogrammetry at the London University.

Air survey, in consequence, receives a dignity of which it is worthy, and a new field of scope and opportunity is open to our young technicians and scientists.

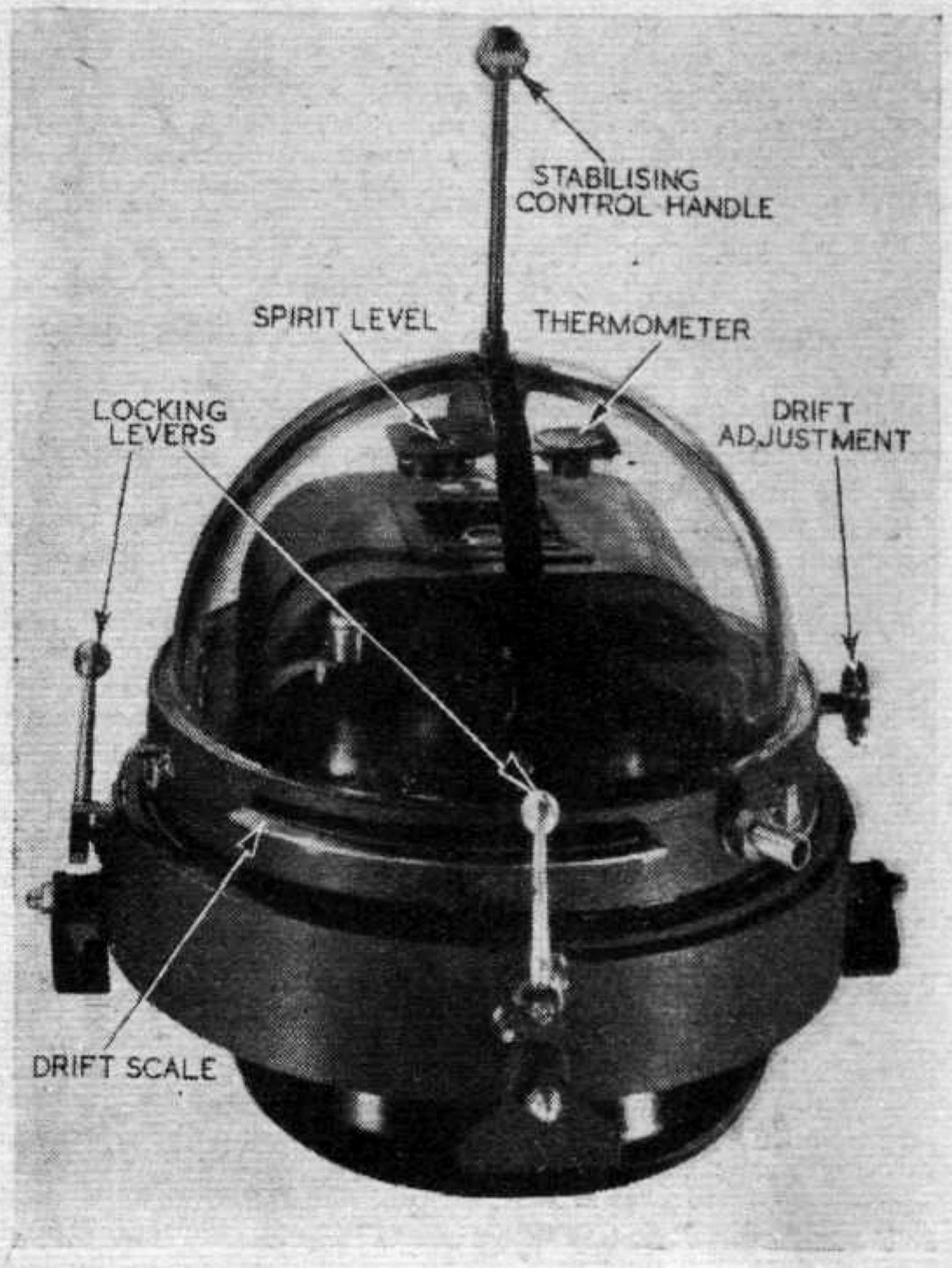
The result of much scientific research and mechanical engineering is exemplified in the Williamson O.S.C. Mk.I Photogrammetric Air Camera, which has been produced to meet the exacting demands of modern air survey.

In light of the long experience which the Williamson Company are in a position to apply to the problems concerned with air photography, developments can be seen in the design of the new camera. For instance, advantage has been taken of the high degree of reliability which has now been attained in electrical services. This has resulted in an all-electric operation of the camera which is arranged in such a manner that the independent functioning of each unit is provided. The shutter, film wind, pressure plate, and instrument exposing switch are each separately powered units, electrically interlocked to ensure a correct functioning sequence.

The camera body itself is of solid aluminium, providing the required degree of rigidity between the register glass and the lens, which in turn are seated on parallel machined faces accurately spaced and tested for flatness and parallelism.

Each camera unit is integral to its appropriate lens and cone, and in addition to containing the usual lens, shutter and shutter driving mechanism, it also contains the instrument recording equipment and electrical connections. Operated by a remote control giving accurate exposure intervals over a range of from 2 to 60 seconds. Remote control of the shutter speeds is also provided.

The efficient operation of the camera in view of the extremes in climatic conditions to which it may be subject in the course of normal routine is ensured by the installation of a hot air system which takes the form of an air-heated enclosure within which the camera operates. This innovation forms the subject of a patent taken out by Williamsons in 1937. Heat is obtained from the normal cabin heating supply. It ensures not only satisfactory protection in the interests of the camera's mechanical efficiency, but it also plays an important part in maintaining constancy on all optically calibrated points and serves to regulate the temperature variations which might otherwise create distortion effects. In effect, the camera operates within a bubble of warm air.



The O.S.C. Mk. I camera shown in its completely enclosed mounting, which provides a balanced temperature both inside and outside the camera. The tilt and drift adjustment and the control column used to enable the camera to be stabilised in verticality in conjunction with the spirit level is also shown

Heat Circulation

The hot air supply is not fed directly into the enclosure, but is led by a pipe into the camera body and thence to a nozzle which projects the heated air over the back of the lens filter glass to avoid any possibility of condensation. The air then freely circulates within the camera body, and finally passes out to the enclosure through holes on the opposite side. A thermometer is fitted under the transparent cover adjacent to the spirit level and the supply of hot air may be suitably regulated to maintain stable conditions within the enclosure. When adequate exhaust heat is available this is the most convenient and efficient method of heating the enclosure, but an electrical blower and heater unit has been designed for use with the O.S.C. Mk.I. A consumption of 800 watts for blower and heater will cover a temperature rise of 30 degrees, and 1,000 watts is required for 50 degrees. Petrol air heaters, now being employed for aircraft heating can also be used for that camera heating system. An innovation in camera instrument installation is the provision of a Kollsman self-correcting altimeter, and this introduces for the first time a means of recording accurately indications of relative altitude.

The complete camera enclosure is supported on two horizontal tilting axes disposed at right angles. Each of these tilt axes can be separately locked by conveniently arranged handles. Apart from functioning as locks, the requisite amount of friction may be applied by these handles to make operations by the stabilising control handle possible without excessive effort while ensuring at the same time the camera will not shift.

Messrs Williamsons have established an organization in Canada to deal with service and maintenance problems appertaining to their air survey equipment. This is a logical step in view of Canada's vast national development programme entailing the extensive application of photogrammetry.

F.24 CAMERAS

(250 EXPOSURE MAGAZINES)

Williamson F24 (above) and F49 (below)