Arctic Air Photography

Part II

R.C.A.F. Photo Equipment and Techniques

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SYNOPSIS

The normal problems of maintaining air survey equipment in accurate working condition and of obtaining consistently good photo results are accentuated when working in the North. Distance and climate make reflying of poor photo work an expensive operation.

The Fairchild Cartographic and Williamson Ordnance Survey cameras have been modified to meet the requirements of Arctic tri-camera and vertical photography respectively.

Exposure is standardized and film processing is centralized in one place, with close sensitometric control.

INTRODUCTION

There are no very special problems or techniques required for the photography of Arctic terrain, which are not also common to ordinary good air photography elsewhere. The main problems always seem to be:

(a) To provide equipment which can be handled in the field in a manner which will not disturb its accurate calibration; and

(b) To properly expose and process the film to the best possible standards.

These factors, however, assume overwhelming importance in the conduct of expensive Arctic operations, where great distances, climate and weather make it very difficult to refly poor photo work.

I shall confine myself to a description of the photo equipment we use, and what we have done to make it serve its function in the far north; also, to tell how we attempt to standardize exposure and processing.

As you have heard, the two types of northern air photography carried out by the RCAF are the tri-camera, and the vertical.

The ancestry of the tri-camera photography now practised by the RCAF, may be traced to the original survey of the Rocky Mountains begun by Dr. E. Deville, Surveyor General of Canada in 1886 with glass photo plates. Photographs used in this process were essentially the same type of oblique mapping air photos which were later made by the RCAF from 1921 to 1939. It is not stretching the facts too far to state that American Tri-Metrogon photography grew out of and represented a major advance on the Canadian Oblique method. We feel that our present tri-camera method is a further refinement of this system. It was developed by necessity to chart the large northern areas in a way which would be most economical in manpower, flying and time devoted to final compilation.

TRI-CAMERA PHOTOGRAPHY

Fairchild F224. The camera used in the tri-camera fan is the Fairchild F224, also known as the Cartographic. It has the 6-inch Bausch and Lomb Metrogon wide-angle lens. Several modifications had to be developed to fit this camera for the particular function we had in mind. A most important factor was the employment of the fan far away from a source of recalibration. The chief of these modifications were:

(a) Fitting heavy brass trunnions to the camera body to permit precise calibration in the tri-camera mount over long periods of time.

(b) Securely pinning the inner cone, which holds the lens, to the camera body shell.

(c) Fitting a lens hood with baffles externally, and placing a number of baffle plates inside the camera to substantially reduce non-image forming veiling glare. It is understood the newer models of this camera now incorporate this latter practice.

Tri-camera Mount. In the Canadian method of tri-camera photography, a heavy cast aluminum mount is used to maintain the three cameras in a rigid relationship to each other. The two outboard cameras are depressed 30 degrees from the horizontal. Each camera fits into brass trunnion plates on the mount, and the whole system is then calibrated. Each camera is held in position relative to each other camera to an accuracy of plus or minus two minutes in all planes, including that of rotation. Tolerance in the trunnion mounting system is so close that cameras may be interchanged, or even replaced by previous calibrated spares, without significantly disturbing the all-over accuracy of the system. It should be made plain that each camera is calibrated separately to normal survey standards before fitment into the tri-camera fan.

The modifications to the optical system were necessary because the sunlight reflected off the thousands of lakes, snow or ice in northern latitudes often caused objectional glare and ghost images, particularly in the oblique photographs of the tri-camera fan. Valuable detail was obscured or made difficult to print, and theoretical loss in resolving power because of flare amounted to as much as 20 per cent in some cases.

Mounting. The tri-camera mount is placed on a sponge rubber pad in the aircraft, to insulate it from the range of vibration frequencies which are most harmful to air photography. The pad consists of a two inch thickness of medium soft Dunlopillo, and is loaded at one lb. per sq. inch. The all-up weight of the mount, cameras and magazines totals 340 lbs.

Heating. In addition to the standard 60,000 BTU glycol hot-air heater, a 100,000 BTU janitrol is used to heat the section of the fuselage where the camera equipment is mounted and stored. An average temperature between 60 and 70 degrees F is maintained in any temperature range encountered in the North.

F224 Magazines. Stowage is provided in this section of the fuselage for eighteen 250 exposure magazines for the tri-camera fan.

VERTICAL PHOTOGRAPHY

OSC. Vertical photography has been done with the 9×9 inch Williamson Ordnance Survey Camera since 1947. This English camera is fitted with the Ross *f*/5.5 wide-angle lens which gives a half stop larger than our other survey cameras. It has a 500 exposure magazine. The main modifications made to this camera have been:

(a) Anti-reflection coating of all elements of the lens.
(b) Depositing a carefully graduated density of chromel metal on the optical glass filter, to counteract the vignetting effect common to wide angle lenses. Incidentally, the F224 filter is treated in the same manner.
(c) The RC 1 time interval control has been extensively modified to incorporate the reliable mechanical escapement movement of the type 35 military control.
(d) The instrument panel in the camera has been modified to include the following:
    (i) Temperature in camera.
    (ii) Outside air temperature.
    (iii) Sensitive altimeter.
    (iv) Data card.
    (v) One-fifth second chronometer watch.
    (vi) Exposure counter.

    The last two items were added and some of the others re-arranged.
(e) Very extensive mechanical and electrical modifications were developed to ensure trouble-free operation in the field.

Magazines. Three magazines are carried in the aircraft for this camera.

As the Ordnance Survey Camera may not be very familiar to American Air Survey Operators a further brief description may be in order. The camera is almost completely electrical in operation. The magazine contains its own electric motor for film transport. The pressure plate is cork faced, and by means of a powerful spring forces the film down on the glass register plate on the camera body. The spring is relieved by an electrical solenoid during film transport.

The shutter is driven by a cam and segment arrangement, which engages with the rim of a flywheel which is constantly driven during camera operation by its own small motor. Shutter speed is varied by a rheostat which controls the motor speed. The whole shutter mechanism can be withdrawn from between the lens elements, and can be completely replaced in flight without disturbing calibration, which is very desirable in northern operations. Positive indication of shutter operation is given by a flashing light.

Mounting. The entire camera is housed in a spherical shell, the upper part of which is transparent plastic. The lower part of the shell has been modified by fitting a number of electrical strip heaters of the Calrod type, which are controlled by a thermostat. This helps to maintain local temperature, since this camera is set down close to the skin and aft of the heater duct openings.

As in the case of the tri-camera mount, the Ordnance Survey Camera has been modified to be mounted on sponge rubber, also loaded at 1 lb. per sq. inch.

Operating Failures. The percentage of camera operation failure is extremely low, and the amount of reflying necessary because of camera failure has almost been nil during the last few years, on both the tri-camera and vertical operations. This is a condition we naturally have been striving for, because of the high cost of reflying lines in northern areas.

EXPOSURE & PROCESSING

Exposure calculation is based on a light table derived from the RAF exposure tables. Experienced camera operators are permitted to vary this should permanent snow cover make such advisable.

Sun Angle. In country with any relief, photography is not started until the sun is about 24 degrees above the horizon. At a latitude of 80 degrees, the photo day is about one hour long in mid-May and again in mid-August. In the interim it approaches eleven hours in June. In the Arctic flat lands, such as the Boothia Peninsula and the Western Islands, an angle of 17 or 18 degrees was found acceptable, and this served to add from 30 minutes to two hours to the photo day.

Super XX Topographic Film, with a filter equivalent to a Wratten minus blue is used for all our air survey photography, without exception.

An interesting sidelight is the difficulty often encountered in the North in storing survey films under sufficiently cool conditions. Ground temperatures of 80 degrees are encountered and film storage pits are sometimes dug in the ground to form a sort of cool cellar.

Processing. No film is processed in the field since this would yield such a wide variety of unpredictable results. All survey film is air expressed from the field to the RCAF Photographic Establishment, near Ottawa, where it is handled in two specially designed continuous processing machines.

CP Machines. These machines resemble in principle the RAF CP equipment made familiar during the last war. However, in this case all tanks are surrounded by a stainless steel temperature controlled water jacket. D19b developer is used and the film is processed to a gamma of 1.30, 0.15. The film passes through the darkroom wall into the final fixing and washing stages. Knife blade air squeegees strip all surplus moisture from both surfaces before the film enters the dryer. The dryer is a much modified USAF A-10. Air at a temperature not greater than 110 degrees F. is used for drying. The machines process at the rate of $2\frac{1}{2}$ ft. per minute.

Sensitometric Control. Close sensitometric control is exercised by printing a step wedge on the trailing edge of the survey film, the last 10 exposures having been left blank for this purpose. A section of fresh control film, also imprinted with wedges, is spliced into the roll being developed. Comparison between the two sets of wedges gives a complete picture of the conditions of processing, and serves as a check on the storage and handling which the survey film roll has undergone in the field.

Film Report to Squadron. The processed films are immediately checked for correct overlap, exposure, camera troubles and so forth. Any irregularities are reported to the Squadron directly by signal so that deficiencies may be overcome while it is still operating in the area. As will be realized, this is a most important phase in making the system workable where film development takes place at such a distance from the actual operations.

The Human Element. Of course, none of this air survey organization or equipment works, as W/C Thomas has pointed out, without trained personnel. We are proud of the interest and ingenuity which our camera operators display in the field, working under makeshift conditions and with the many unusual problems which only seem to occur when you are a thousand miles from base. From the successful results of the past, we think our training methods for air photographers are sound.

Another most important element has been the energetic help given by Dr. Howlett and his colleagues in the National Research Council of Canada. A joint RCAF-NRC programme has been operating for many years to define the most practical approach to current problems of survey camera optics, exposure and processing.

Summary. In summary then, we have found the chief ingredients to successful photography in the north to be:

(a) Modification of equipment to permit its accurate use over long periods of time under extremely rugged conditions, and
(b) Centralized processing of film which has been exposed to predetermined standards.

The Future. Survey photography in Canada is shifting rapidly to the completely vertical phase of the operation, as the tri-camera coverage is nearly complete. The RCAF is withdrawing steadily from large participation in survey, and civilian companies are assuming an increasingly larger share. It is encouraging to report that the companies concerned are most interested in developing techniques and equipment to meet the requirements to higher precision and economical operation. One concern is experimenting with air conditioned camera magazines. We feel that this is indicative of the general trend in all the companies concerned.

Arctic Air Photography

Arctic Mapping

Lt. Col. Paul E. Gremmler, Aircraft and Guided Missile Branch, Strategic Air Division, U. S. Air Force

The United States Air Force became interested in the Arctic and Sub-Arctic in 1941, when it was realized that aeronautical charts far more accurate than those in existence were needed in maintaining a flow of Lend Lease equipment to our allies.

Of first concern were the natural avenues over which the air traffic would flow.

Armed with the best charts available, the First Photo Mapping Group sent a Squadron to Alaska to complete this task as quickly as possible. Each year during the periods of best weather, a Squadron was sent to Alaska until the charting was completed in 1943. Ground survey parties were also working their way through the areas at the same time.

There were many problems to solve and the task became one of trial and error. For example, it was found early in the project that the oil used in lubricating the cameras congealed at the low temperatures encountered and had to be removed. There was much to learn about the operation of the planes and aerial photography in this area. Equipment failure hampered progress on many a mission and on some occasions kept a plane grounded for as long as a month.

By far the most interesting problem for the units in those days was personnel. Colonel Eldon D. Sewell of WADC, Dayton, Ohio, in his presentation at the 1952 Annual Meeting of the American Society of Photogrammetry, touched on several points of improvement methods for Aerial Mapping Photography. One concerns the flying or operational phase of mapping. Col. Sewell stated, "Photogrammetric flying requires more than a careful conscientious pilot." He couldn't be more correct. I should like to go a step further and say that the crew member should be a person who understands the need for the end result—"the maps." He must be burning with the desire to do his job as economically as possible, and to keep to the minimum the number of reflights due to his errors.

Col. Sewell also stated "the pilot must be trained for this type of flying and he must be provided with proper flying instruments."

The first crews sent to the Arctic had many navigational problems to solve because with unreliable magnetic compasses and poor charts, they relied on a system of pilotage, directional gyro, astro compass and drift correction to fly a fairly straight line. It is amazing, with the little amount of training they had, that so much was accomplished. In spite of the fact that F-2 and F-10 aircraft were used during the initial years for this project, the aeronautical charting photography of Alaska was for all practical purposes completed in 1943. Mapping photography was usually limited to small missions of certain small specific areas.

With the conclusion of World War II, the Arctic was considered in a new and more important light. Accurate maps were required with the result that organizations were stationed at Ladd AF Base, Alaska to do the job. Improved equipment in the