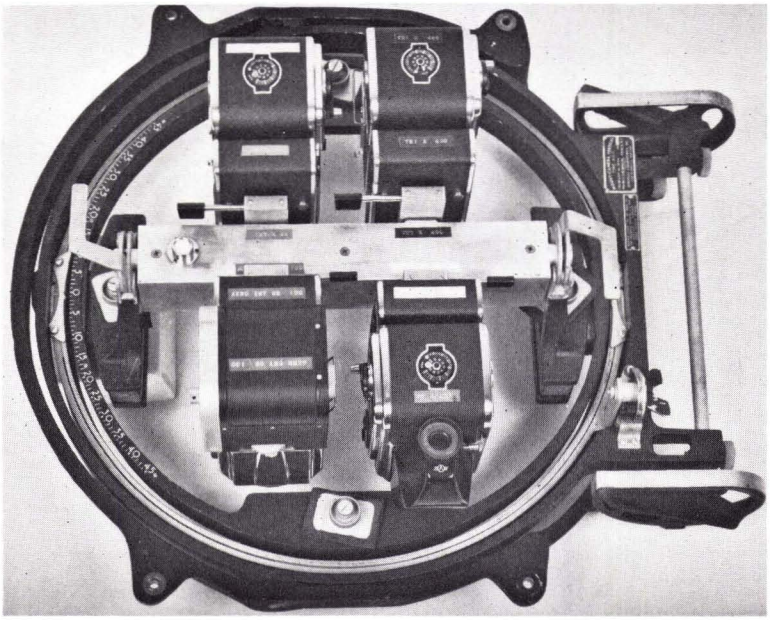

FRONTISPIECE. The Hasselblad assembly as mounted in an A11A aerial camera mount. With this arrangement only two of the cameras can be aligned with the flight path so that the direction of film advance is correct for stereo viewing. The other two cameras advance the film in the opposite direction and their films cannot be viewed in stereo without cutting and transposing the frames.

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A Small Four-Camera System for Multi-Emulsion Studies

The relatively inexpensive aerial 70-mm combination is a versatile device for testing films and filters.

(*Abstract on next page*)

THE SIMULTANEOUS EXPOSURE of different emulsions and film/filter combinations has proved useful to many applications in photo interpretation. It can however be an expensive operation and beyond the budget of many who have an interest in such matters. The Photographic Interpretation Research Division of the U. S. Army Cold Regions Research and Engineering Laboratory (USA CRREL) has long had a need for multi-emulsion photography and has conducted a

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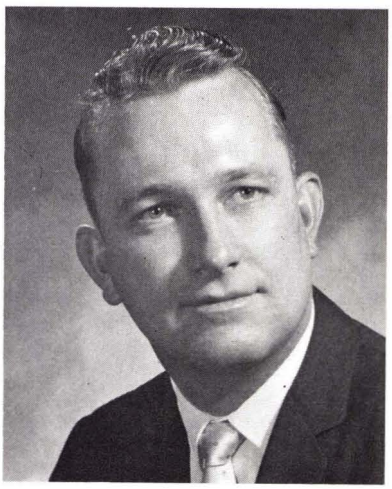
variety of such experiments in arctic, temperate, desert and tropical regions. Although simultaneous exposure of several emulsions was desired on these projects it was not obtained; it could only be approximated by using repetitive passes (changing film and filters) with anywhere from minutes to days between the passes.

This was quite unsatisfactory and we decided to find out what could be assembled from commercially available items to provide a simple and economical system that would simultaneously expose four different emulsions.

ABSTRACT. *Aerial photography, with simultaneous exposure of different film/filter combinations, has proven to be very useful in photo interpretation. However, such photography is often expensive and beyond the facilities and budgets of many laboratories. For some of our work in environmental analysis, it was necessary to assemble a relatively inexpensive, small, four-camera airphoto system. The set has been successfully used on projects in arctic and temperate regions. It is light-weight, motor-driven, and has a self-contained power supply. It has a wide range of readily available accessories and features rapid interchangeability of film magazines, lenses, filters, and viewfinders. The set is not only suitable for aerial photography (vertical and oblique) but is also easy to disassemble to provide hand-held cameras for ground control photography.*

THE REQUIREMENTS that we wanted the system to meet were: (1) a film size in which the standard aerial emulsions were available and which was compatible with the processing and analyzing equipment already in use at the laboratory; (2) cameras that could be operated manually or automatically and be independent of aircraft power; (3) a size and weight such that it could be used from light aircraft (on either external or internal mounts) and for oblique as well as vertical photography; (4) ability to simultaneously expose four different emulsions or film/filter combinations; and (5) the cameras making up the system were to be easily detached so that they could be used for ground photography.

A review of the literature pertaining to commercial films showed that the 70-mm width provided the greatest diversity of film types. Not only are the standard aerial emulsions made in this size, but other specialized films are available that are not made in the $9\frac{1}{2}$-inch width. Although the 9×9-inch format is preferable for interpretation and analysis procedures, it is not necessary for the experimental testing and evaluation of various emulsions and film/filter combinations. A



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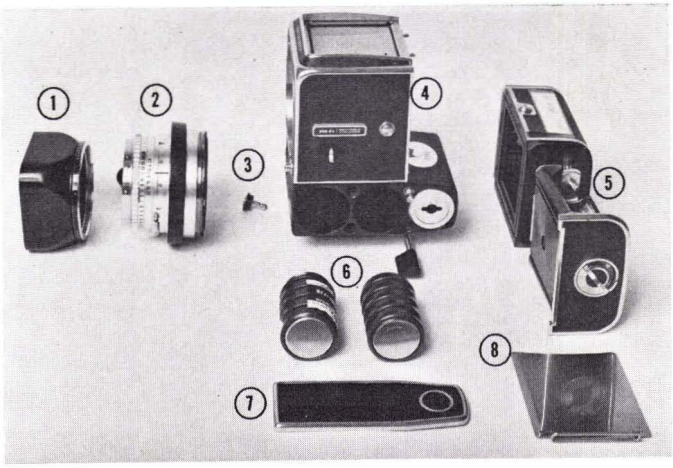

FIG. 1. Major components of the Hasselblad 500 EL camera are: (1) lens hood; (2) 80-mm lens; (3) release button; (4) camera body containing a motor and film drive mechanism; (5) film magazine; 120-size in this illustration; (6) batteries; (7) battery case cover; and (8) dark slide.

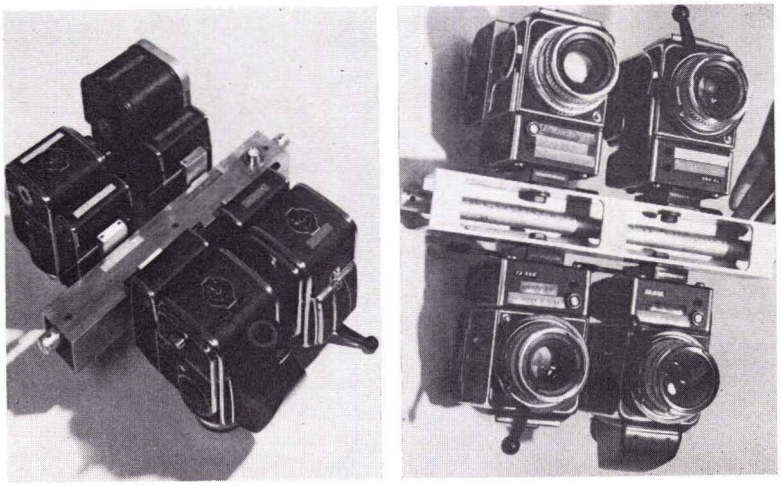

FIG. 2. Two views of the four-camera assembly. The rapid tripod-mount shoe used to secure the cameras to the bar shows in both of these views of the set. The cameras are offset vertically so that one of them does not block the dark slide of the other. The upper magazine (left photo) is a 70-mm Cine Mechanic (NASA Model) which was used pending the arrival of the Hasselblad backs. The other magazines are for 120 film. The eye-level prism finder (lower camera, left photo) with suitably inscribed reticles, serves as a viewer, drift sight, and for indicating exposure overlap during manual operation.

smaller format would be acceptable for such purposes and have the added feature of being less expensive.

FROM THE AVAILABLE camera equipment, we selected the Hasselblad 500 EL* as best meeting our needs and a system was designed around a mount of four of these cameras arranged to fit in our AllA aerial camera mount. The 500 EL camera body (see Figure 1) contains a power supply (two easily replaced nickel cadmium 6.25 V batteries, suitable for 2000 exposures at full charge), motor unit, mirror, exposure mode selector, shutter release, viewfinder, tripod mounting shoe and external power or charging receptacle.

A variety of lenses are available ranging in focal length from 40 mm to 500 mm and each

* Citation of commercial products is for information only and does not constitute official approval or endorsement.

TABLE I. OPERATIONAL CHARACTERISTICS OF THE HASSELBLAD 500 EL

Mode of operation	Circuit completion
Controls required to operate	Intervalometer or manual switch (film cannot be advanced manually)
Film size	Type 120 or 220 roll film, 70 mm perforated
Picture sizes	2-1/4″×2-1/4″, 1-3/4″×2-1/4″, 1-5/8″×1-5/8″
Cycle time	Approximately 1-1/2 seconds
Lenses available	40 mm, 50 mm, 80 mm, 120 mm, 150 mm, 250 mm, 500 mm
Focus	Variable
Shutter	Between-the-lens
Shutter speeds	1 second to 1/500 second
Diaphragm control facilities	Manual
Power requirements	6.25 volts DC, self contained
Footage counter	Frames used

containing its own between-the-lens shutter. All the lenses have helical focusing and are attached to the camera by a bayonet mount. The magazines presently available for the 500 EL provide the following format on 120 film: 2-1/4×2-1/4 inch, 1-3/4×2-1/4 inch, 1-5/8×1-5/8 inch, and 2-1/4×2-1/4 inch on 70-mm film. The 70-mm magazine utilizes a special Kodak 448 cartridge of 70 exposures per loading and closed cassettes give maximum film protection. The magazines are easily changed with one hand. A dark slide interlock prevents accidental removal of this magazine with the dark slide out or operation of the camera with the dark slide in place. Available accessories include interchangeable viewfinders, radio controls, power cords, charging units, close-up attachment, microscope adapters, special cases for underwater photography, and a rapid tripod-mount shoe which was used to mount the cameras in this system. The operational characteristics of this camera are shown in Table I.

The Frontispiece shows the cameras installed in the A11A mount and Figure 2 shows them attached to the mounting bar.

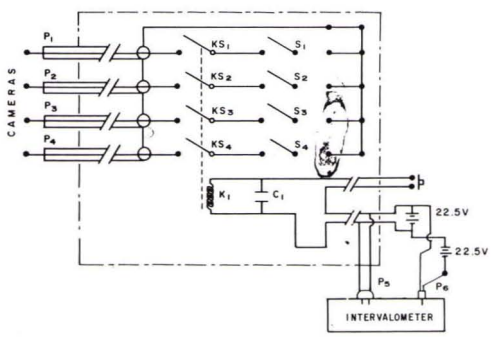

FIG. 3. Schematic diagram of the control system.

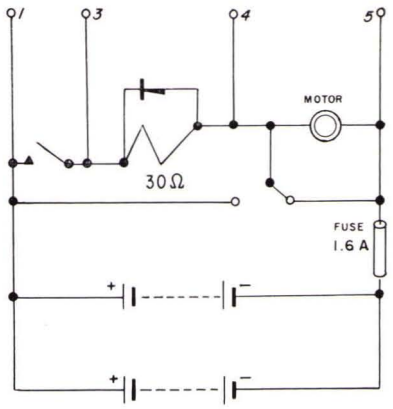

FIG. 4. Schematic diagram of the electrical system of the camera.

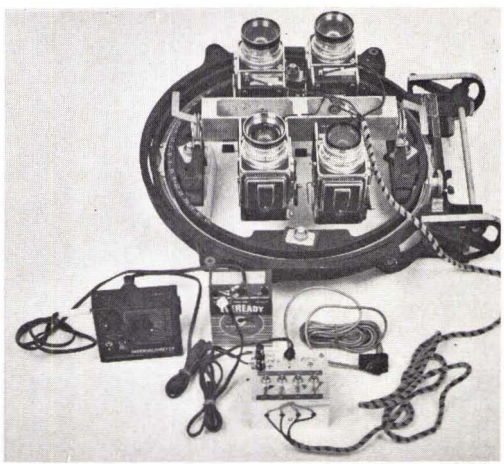

FIG. 5. The assembled system of cameras, mount, and controls. The unit below the cameras and to the left is the Nikon Intervalometer. To the right of it is the battery and next to it is the manual trip cable. Below them is the control box.

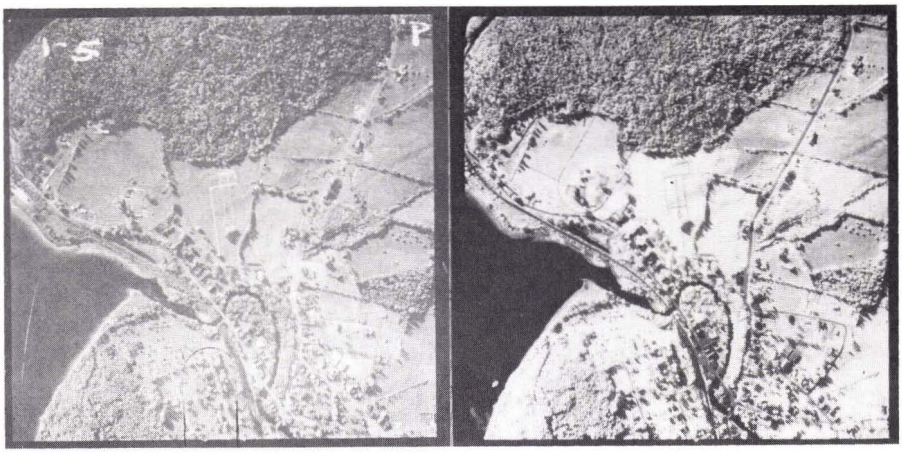

FIG. 6. Photographs of an area in New Hampshire (October 1966) taken on Tri-X film (left) and Gevaert I. R. film (right) with an 80-mm lens (approximate scale, 1:28,000).

THE CONTROL SYSTEM shown in the schematic in Figure 3 is simple, self-powered and may be used at some distance from the camera. The intervalometer selected was the Nikon Model NC-1, which is a standard stock item. The time interval available ranges from $1\frac{1}{2}$ seconds (cycle time of 500 EL camera) to approximately 8 minutes. A larger battery may be used to supply the power to the intervalometer and the relay box for longer operation between battery changes.

The control box contains a relay and four line switches, one for each camera. The cameras may be operated singly or in any

FIG. 7. A section of a 9×9-inch enlargement made from the Tri-X negative used for Figure 6.

TABLE II. WEIGHTS OF THE COMPONENTS OF THE SYSTEM

1. Camera body & 80 mm lens & 2 batteries	4	lbs
2. Camera body & 80 mm lens & loaded 70 mm magazine	6	lbs
3. Adapter to fit AllA mount	2-1/2	lbs
4. Intervalometer	1	lb
5. Control box and battery	2	lbs
6. Complete system (excluding AllA mount)	28-1/2	lbs

combination by the intervalometer or with a hand switch. The camera cycle switch is built into the camera and meters the film advancement (see schematic in Figure 4). Care must be taken not to interconnect the camera trip circuits as this will cause uncontrolled cycling of the camera. Figure 5 shows the assembled system with the cameras inverted so that the plug in points of the controls are visible. Table II shows the weights of the parts which, excluding the AllA mount, total to less than 30 pounds.

THIS IS THE BASIC system as used at USA CRREL: four Hasselblad 500 EL cameras; 1 spare body in case of camera failure; 14 (70-mm) magazines; 7 (120-size) magazines; 4 (80-mm) lenses; 4 (50-mm) lenses; mount; intervalometer; and control box. Spare power and connecting cords, batteries, filters, and various other accessories may be added as desired. All items are available as off-the-shelf products and are readily obtained from numerous suppliers. Table III shows the breakdown of costs.

TABLE III. COST BREAKDOWN OF THE SYSTEM AS USED AT THE U. S. ARMY COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

5	Camera bodies, @ $479.00 ea.	$2,395.00
4	(80mm) lenses, @ $286.00 ea.	1,144.00
4	(50mm) lenses, @ $460.00 ea.	1,840.00
14	(70mm) magazines, @ $200.00 ea.	2,800.00
1	Eye level prism finder	172.00
4	Quick-coupling tripod adapters @ $15.00 ea.	60.00
8	Batteries @ $18.00 ea.	144.00
	Misc. (cords, filter adapters, filters)	300.00
1	Nikon intervalometer	299.00
1	Control box	20.00
1	AllA mount (acquired from surplus)	50.00
		$9,224.00

Figures 6 and 7 are examples of photography obtained with this system.