Photogrammetric Brief

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Another Multi-Band Camera for Archaeology

The construction of a 35-mm multi-band motorized and radio-controlled camera system is described.

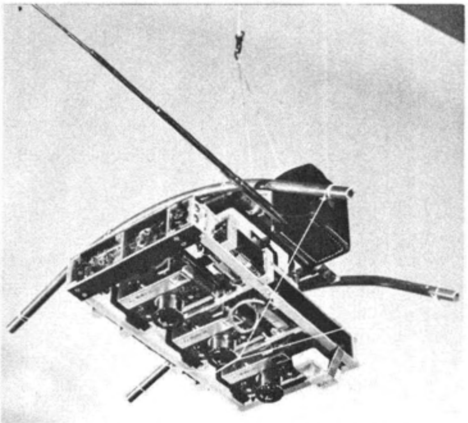

FIG. 1. The 35-mm multi-band camera and gimbal system.

THE SUCCESS of our first aerial multi-band camera (Whittlesey, 1972) has led to the design and construction of an entirely new one, in this case for 35-mm rather than 6-cm film. Both formats are needed in field work. Motorized film advance and remote radio control are obvious requirements where the camera platform is an unmanned tethered balloon or airfoil high in the sky, or a floating tripod on the water at some distance from the operator. These features are also a great convenience even when the platform is a bipod raising the camera 10 meters over a sensitive archaeological excavation (see Whittlesey, 1966).

No 6-cm format multi-band camera having been on the market in 1972, we designed and made our own as had NASA, Grumman Ecosystems, the Defense Mapping Agency, and perhaps others. Likewise, today there is no 35-mm automated, radio-controlled, multi-band camera on the market. The Hasselblad EL 500, already automated, gave us a head start on our first multi-band camera. There was no such head start for the 35-mm version if it were to meet the foremost requirement, namely, a material saving in weight. One statement in the Photogrammetric Brief (Whittlesey, 1972) proved wrong. The 23-pound camera system therein illustrated, along with gimbal, resulted in an unfavorably low Lift-over-Drag (L/D) ratio when flown by a tethered balloon manageable by a two-man ground crew. A good L/D ratio is very precious to the balloonist. Motorized radio-controlled stock 35-mm cameras on the market saved little weight over the Hasselblad EL 500 with Zeiss Distagon lens. They were not a point of departure in this case. Therefore, we had no choice but to design a system that would accept three standard hand-held 35-mm cameras and serve to operate them as a motorized unity. The very compact lightweight Rollei 35 was chosen. It is equipped with a Zeiss Tessar 40 mm focal length lens affording an angle comparable to that of the Zeiss Distagon 50 mm focal length lens on the larger format.

Another reason for turning to 35-mm film was the convenience to the archaeologist in his lectures, as opposed to the larger format requiring big projectors or the inconvenience of providing reductions for the more usual smaller classroom projectors. Resolution of 35-mm film will satisfy most archaeological missions, but the 6-cm format remains far preferable for photogrammetric plotting. The smaller film will be practical also for spectral analysis in most, though not all, cases. Each format has its place in our work, which includes search missions, mapping, photo interpretation, and general recording. A capacity of three cameras such as for color, B & W and IR, or for various filter combinations, suffices for most any mission. Two cameras in unison will do for many missions, and one will satisfy some.

The 35-mm multi-band system — motorized, radio-controlled, and carrying three cameras — is now completed (Figure 1), rigorously tested, and ready for the next field season in the air. It weighs in at one-third the Hasselblad version above referred to, which came to 23 pounds. Measuring but 7 by 13 by 1½ inches, it may be flown from the same gimbal and below the same balloon employed for the single Hasselblad EL 500, which has been our most reliable mono-camera on scores of aerial missions in many countries. The design, redesign, construction, and reconstruction of the prototypes leading up to the final successful result has taken many months. In the course of the work we set up our own precision shop under the guidance of Mr. P. W. Winter, who has built a variety of systems from our designs in the past. Work on the new system started in his shop in New York City and was completed in ours.

As-built drawings and specifications have yet to catch up with the final work, but will be available eventually. Meanwhile, the following description along with photos and wiring diagram may satisfy those who are interested in further detail at this time, The first design decision was that the Rollei 35 be left intact as taken from the shelf. We had learned some time ago not to build our own cameras or to modify stock cameras except in minor respects. But two minor exceptions to this decision were made, namely that the film-advancing levers were inverted and shutter-release button maintained in the depressed position.

Each camera is very precisely mounted in the sturdy structural aluminum-channel frame. A strobe light is also mounted as in the former multi-band. Its distant flash from the sky assures the operator on the ground that the radio signal has been received and obeyed. A single 12-volt-D.C., geared electric motor advances and releases the cameras simultaneously. The motor was built by Wertronix Corporation to our performance specifications following torque tests of the cameras. Shutters release within a quarter second of the radio signal or, if hand-held, of the manual signal. Film advance and recocking follow automatically upon the shutter release, the cycle taking seven seconds, less if the voltage be increased. A blue light burns during the film advance, a red one during the return of the film advance lever. These lights are helpful signals as the multi-band is prepared for flight, and are well to watch during the initial ascent when some low-level coverage may be taken.

The mechanical design became simple after a variety of relatively complex shutter-release systems was discarded. These had developed "hang-ups" not to be risked in field work. One such can spoil the day of perfect flying weather. The solution for sure and timely release was to maintain the shutter-release button depressed so that the release takes place of itself just as the film advance is completed. Accordingly, each cycle of the operation stops a quarter-second short of having completed the film advance. Once the signal is given the advance finishes, releasing shutters within the quarter second. The return and next advance follow within seven seconds to await the next signal for exposure.

A common drive shaft operates a pair of reduction gears at each camera to swing forward and to return the film-advance lever. Ten miniature ball bearings seat the drive shaft and gears to tolerances within 0.001 inch. Camera mountings are equally precise, although they do not qualify this multi-band as a metric camera, as is the earlier Hasselblad system. The film frames do not carry fiducial marks.

The drive shaft turns a commutator on which five points are precisely located. Two of these govern polarity of the current for forward or reverse motor action. Two provide mechanical stops to protect the cameras against over-run of either the advance or return action. The fifth operates a limit switch, closing each cycle. Adjustment in the gearing is tooth-by-tooth to assure perfect coordination among cameras.

The heart of the electrical system (Figure 2) is a double-pole magnetic-latch relay. This affords great versatility in the sequencing of the four circuits at its disposal. Only two circuits, however, are utilized: one is for the motor and the "on" latch; the other is for the "off" latch magnetic-relay receiving its signal from the limit switch on a separate circuit. The "off" latch not only shuts off all current but by its own action renders itself dead. We call it the suicide relay. This precaution in the circuitry is vital to reassure resumption of the action should any cycle close, leaving the limit switch engaged. The "on" latch, receiving its signal from the radio or manual start, then will take precedence over the "off" latch relay whose separate circuit had been left open. We arrived at this circuitry only after a number of others had proven unreliable and been dismantled. Manual and radio signals are wired in parallel so that the multi-band may be operated hand-held as shown in Figure 3. Cameras are mounted with the view finders unobstructed.

The electrical controls are recessed in the channel at one end of the frame. They are protected by a transparent dust cover permitting observation of the commutator, double-

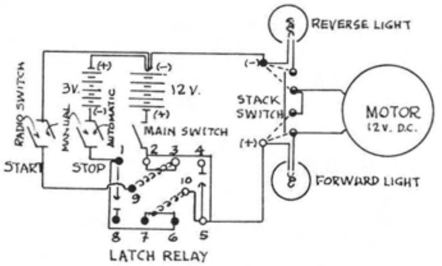

FIG. 2. Circuitry for the 35-mm multi-band camera.

pole-stack reversing switch, magnetic-latch relay, wiring, and the miniature circuit lights associated. The larger colored circuit lights before mentioned are mounted in more evident positions within the frame. One-and-one-half volt pen-light batteries are recessed in the side channels and are protected by covers. While other re-chargeable batteries are equally practical, these batteries are chosen as easily replaceable even in very remote towns and villages in far countries. One set of eight alkalide 1.5-volt batteries suffices for over 100 cycles. An extra pair reinforces the current to the very critical "off" latch-relay as may be required when the motor is drawing upon the main batteries. One interesting difference between this multi-band and the earlier Hasselblad version is that one may have the pleasure of watching the action as it works, not to mention having ready access to any point in it.

Cameras may be readily removed for reloading or use as hand-held single cameras. The gimbal above the multi-band may also be readily removed so the multi-band may be hand-held itself. The gimbal is made of tubular magnesium, and its axes are set in ball bearings. The gimbal may be set for oblique as well as for vertical coverage. The radio system is a variation upon that originally recommended by Hasselblad, which required major alteration to avoid interference on the ever-more-crowded radio channels around the world.

Design of the multi-band is by the author. Construction was supported by the Whittlesey Foundation. Our work in aerial archaeology and related techniques in field archaeology has called for a variety of new

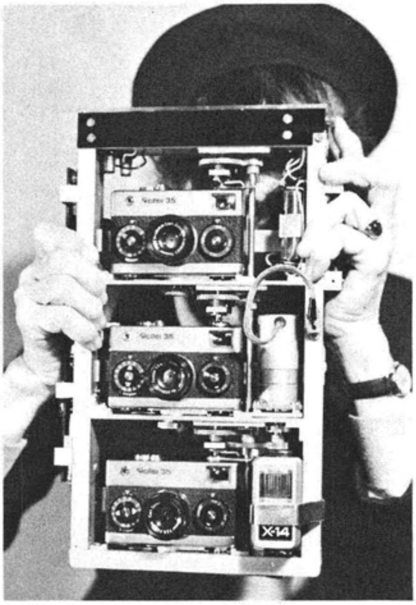

FIG. 3. The 35-mm multi-band camera shown being hand held.

camera-support systems for aerial, terrestrial, and underwater recording. The Foundation has undertaken many missions for field archaeologists in Mediterranean and Middle East countries, as well as in England and the USA (Whittlesey, 1970). Production of more multi-band cameras is now called for to fulfill missions on a wider scale. The next system, already on the drawing board and to carry the same cameras, will be shaped more compactly and occupy 40 per cent less volume than the one here illustrated — thus a coat pocket model. Structure will be entirely of magnesium. Electronics will be unchanged but the drive system radically different.

REFERENCES

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