*The KC-2 Convergent Mapping Camera**

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ABSTRACT: *To fully utilize the advantages of the convergent system of photography, it is necessary to provide a camera and mount system capable of giving excellent photographs in spite of the operating environments imposed. Development of a single camera to accomplish the convergent photography is a logical and major step forward from the improvised and unwieldy system of utilizing two individual cameras in a single mount. The subject camera is specifically engineered to cope with the problems of camera operation at high temperatures and unlimited altitudes. Design problems of shutter synchronization, weight reduction, minimization of film transfer unbalance, heat conduction, vacuum system (self-contained) and pressurization are discussed herein. Close liaison in design has enabled an efficiently integrated camera and mount design of minimum weight and volume. The mounting provisions on the camera have been made versatile enough to permit installation on fixed mounts with an insulating blanket provided for this purpose. Details of the torquer stabilized mount design and its integration into the photographic system are covered in a separate paper.*

TO FULLY utilize the advantages of greater economy and efficiency obtainable in the convergent system of photography earlier discussed in Mr. Crouch's paper it is necessary to provide a camera and mount system specifically engineered for this purpose. The development of a single camera to accomplish the convergent photography is a logical and major step forward from the improvised and unwieldy system of utilizing two individual cameras in a single mount. Camera systems of the future must be smaller in size, lighter in weight, and in certain military applications be capable of operating in extremes of temperature and altitude. While these design objectives were rigidly adhered to in the KC-2 camera, nowhere in the design has precision been allowed to become secondary. Inherently, as we will see, the design formulated because of its lightness, compactness, rigidity and high degree of integration with the mount, gives the greatest capability of the ultimate in precision. It is anticipated that the potential of the entire system will be improved by the eventual integration of an improved 6″ f/5.6 wide-angle lens currently under development for the USAF. The details of this lens design and capability will be covered in a separate paper, as will the details of the torquer stabilized mount design and its integration in the system.

The KC-2 may be thought of as an advancement of the widely used KC-1, extending its capabilities to the convergent system with its inherent advantages. Additional features have been incorporated which increase its precision and flexibility. Briefly, the more salient characteristics or specifications of the camera are as follows:

1. Reduced size and weight
2. Matched Planigon lenses mounted in convergent inner cones which are held in a precise relationship to each other by a reinforced single body structure
3. Supplies its own capability of surviving in an environment of −100° to +300°F.
4. Pressurized to provide sufficient pressure differential at 100,000 ft. for operation of a self-contained vacuum supply for film flatness
5. Shutter speeds up to 1/800 are

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available, controlled remotely by electronic means with synchronization within 1 ms.
6. Equipped for both optical and binary data recording
7. Dual interchangeable magazines.

To date, convergent photography has been accomplished by mounting two KC-1 cameras at a fixed convergent angle to each other. The disadvantages of this system both from a size and weight and precision consideration are obvious. The total weight of the two KC-1's without film are 150 pounds. Combined into a single structure engineered for light weight construction, the weight is cut to 80 pounds. The camera envelope is 13"×17' ×27", whereas the combination as can be seen in Figure 1 would be substantially more. Future high

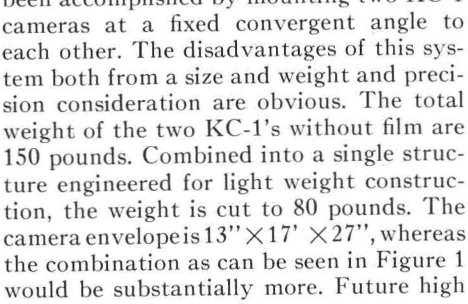

FIG. 1. Comparison KC-1 and KC-2 convergent installation.

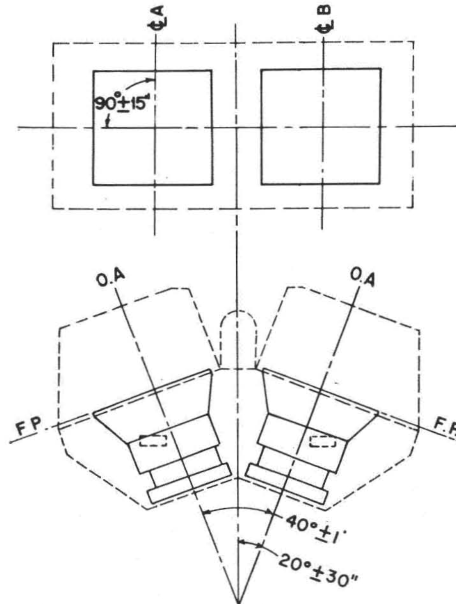

FIG. 2. KC-2 inner cone relationships.

performance vehicles must not only have the lightest possible photographic system, but since their cross-sections will probably be small, bulky cameras cannot be accommodated. Coupled with the compactness of the camera design is the vast reduction in the size of the mapping window.

Incorporating the two lenses into a single body structure lends itself to maintaining a precise angular relationship between the inner cones. The precision of the angular relationship is machined into the body casting. These cones, which establish the focal-plane positioning of the platen are fabricated of Al-Mag, an extremely stable aluminum alloy of rigid construction, and are protected from rough handling by an outer cover. Figure 2 shows the positioning of the cones and the manner in which the degree of precision is maintained. Platen flatness was considered of major importance; after investigation of various materials and configurations, a symmetrically ribbed Al-Mag platen was designed which was able to retain .0002" flatness throughout the operating temperature range of the camera. The camera magazines are completely interchangeable, a definite advantage for maintenance and spare parts storage. Travel of the 250 ft. film spools is arranged across the body structure in opposite directions so that transfer of the film during picture taking will not affect the center of gravity of the camera. The cycling rate is 4 seconds per cycle.

The heating effects of supersonic flight make it mandatory that the accessory equipment of the vehicle operate with as little drain as possible on the main cooling system. It must be emphasized, however, that the camera is designed for conventional use in a standard aircraft or with a thermal barrier in high performance vehicles. Accordingly, a comprehensive series of tests was conducted to determine the efficiency of a thermal barrier to be used in conjunction with the camera. Two conditions were considered; the camera used in a fixed mount necessitating a close fitting cover and the second, the camera in its stabilized mount requiring a thermal barrier box around the camera-mount combination with spot cooling for the components dissipating heat internally. The second condition being more closely related to the mount will be covered in a separate paper.

A camera mockup was constructed simulating the mass, volume, surface area and mounting provisions of the actual camera. Internal heat dissipation conditions were simulated by means of a loaded drive motor and heaters. The thermal jacket was fabricated of fiberglass, sandwiched between an outer and inner cover of silicone impregnated fiberglass and neoprene impregnated nylon, the selection of which was made after a series of thermal insulating materials was tested. The test mockup was subjected to an environment of 300°F. for two hours both at sea level and 70,000 ft. pressure altitude. Results of these tests summarized in Figure 3 indicated that the temperature in the critical areas such as the magazine, platen and lens were well within a tolerable heat range. The temperature slope was 0.04°/min. Not only does the thermal barrier solve the problem of the film surviving but also assists in protecting lens focus and prevents stresses caused by sharp temperature differentials. With the advent of higher resolution lenses and shorter mission time to photo target area, the presence of a disturbing thermal gradient will be more critical. It may therefore be necessary

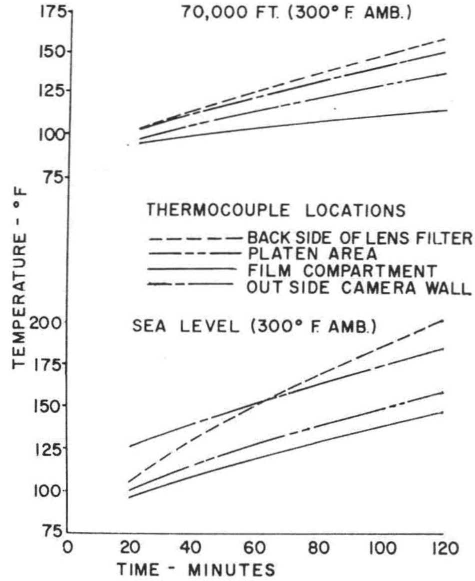

FIG. 3. KC-2 thermal barrier tests.

to use the thermal jacket even under what is considered normal conditions. This approach has completely eliminated the need for cooling provided by the vehicle. Heaters are also provided to facilitate low temperature operations.

Pressurization of the camera to maintain 3 in. of Hg, by means of suitable temperature resistant gasketing, not only assures good electrical operation, but provides sufficient pressure differential above 50,000 ft. for operation of a self-contained vacuum supply used for film flatness. Vacuum is achieved by means of a piston type pump located adjacent to the platens which are closely integrated into the camera structure. The design is such that no loads are transferred to the platens and vibrations non-existent when the exposure is made. Operation is synchronized with the cycling of the camera. The differential is minimized to reduce the pressure bow across the filter glass, and its deleterious effect upon the lens system. It is possible with minor modifications to by-pass the vacuum pump should an external source of vacuum be available.

Shutter speeds to 1/800 of a second are available on the Rapidyne shutter utilized. Synchronization of the shutters to within 1 ms. is made possible by means of an electronic timing circuit and trip magnets mounted directly on the shutter, thus eliminating inertia lags and machining discrepancies inherent in a mechanical system. The electrical pulses energizing the trip magnets are obtained by means of a thyratron controlled R-C delay circuit. Discharging of two capacitors in a controlled sequence furnishes the *A* and *B* blade trip pulses. Shutter speeds are controlled by varying the delay between these pulses. This is done by manually varying the resistance values in a control box external to the camera. Changing these values varies the firing time of the thyratron circuit in the timer through which the *B* pulse capacitor discharges. A system of this type has the flexibility of not only remote control but may be coupled to an automatic exposure control servo. Precise Shoran synchronization is also made possible by obtaining output pulses simultaneously with the transmission of the *A* pulse to the trip magnet coils. A manually operated diaphragm on the camera is also provided on the shutter assembly to provide more flexibility in exposure.

Provisions are made on the inner cone assemblies for recording essential items of photographic and navigational data such as camera serial number, exposure number, time, flight altitude, fiducial marks, calibrated focal length, lens serial number, vacuum indication and a datacard. Two systems of recording have been incorporated. The first is by optical means in which the dial faces of the recording instruments are photographed on the film. The other system, which is electronic, utilizes a miniature cathode ray tube which projects a series of coded dots (binary system); this is a record of information fed into it from instrumentation located elsewhere on the vehicle. This system, therefore, contains the capability of automatic data processing from the film record. Sufficient duplication of pertinent alpha numeric data is done on both formats to provide positive correlation of the exposures in both magazines.

It is believed that the KC-2 camera is not only the finest in precision, engineered to cover the specific requirements of the convergent system, but has the basic advantage of having been developed as part of an integrated system. This system's development approach has made it possible to achieve the greatest saving in over-all weight and volume and allowed the various elements of the system to be completely compatible without compromise. Greatly improved photographic quality is expected with simplified maintenance and ease of set-up and operation.

*Torquer Stabilized Mount for Convergent Mapping Camera**

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ABSTRACT: *With the advent of high speed, high altitude and relatively small vehicles has come the requirement for light weight and compact reconnaissance equipment capable of high performance in these vehicles despite the extreme environmental conditions encountered.*

This paper presents the general design features and performance characteristics of what is believed to be the first piece of photo-reconnaissance equipment capable of operating reliably without altitude limitations and in widespread ambient temperature ranges. The basic design combines in a single package, the necessary stabilization system for high resolution and verticality, a new twinplex camera design (covered in another paper) and a specially designed thermal protector. Close liaison and agreement on camera tolerances and mount configuration has allowed

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