STATINTL

[redacted]

PANORAMIC STEREO EXPERIMENT

FINAL REPORT

June 15, 1962

STATINTL

[redacted]

INTRODUCTION Photo reconnaissance from medium and high altitudes imposes stringent requirements on the interpretation system if small target objects are to be recognized and functionally understood. One of these requirements is high magnification, which implies higher resolution in the original negative than has been available from conventional cameras and films. Another is stereoscopy. As all photo interpreters know, targets which are fairly large, simple in structure, and familiar in appearance can be recognized by monocular viewing; but their relative heights, details of structure and arrangement, and (if they are unfamiliar) their probable functions cannot be deduced with any certainty without making use of stereo viewing. The intelligence interpreter faced with the problem of understanding an unknown structure or other target needs every additional bit of information made available by improved stereo techniques.

Aschenbrenner[1] and others have shown that in medium- and high-altitude photography the stereoscopic effect obtained with conventional verticals having 60 per cent overlap is at best barely adequate for the interpretation of small, complicated, and unfamiliar objects; convergent stereo pairs with a base/height ratio of three times the "normal" are decidedly superior. In the experimental program just concluded, [redacted] have combined convergent stereoscopy with the unique advantages of the [redacted] panoramic camera and the efficiency of projection stereo viewing. The [redacted] has a focal length of twelve inches and can

[1] Aschenbrenner, Claus M., "High altitude stereo techniques," Photogrammetric Eng., Vol. 16, no. 5, December 1950, pp. 712-719.

thus be taken to quite high altitudes without sacrificing the resolution obtainable with modern film emulsions. Moreover, with an appropriate viewing device, useful stereoscopic fusion can be maintained over a surprisingly wide portion of the panoramic scan.

The combination of panoramic configuration with converging camera axes poses serious problems of geometry. The projection device or the interpreter's eyes, or both, must accommodate two kinds of distortion: the increasing obliquity (and decreasing scale) toward the edges of the panoramic strip, perpendicular to the flight line; and the obliquity in the direction of flight produced by the forward tilt of the camera axis (Figure 1). The experimental projection viewer used simple mechanical means of rectifying these distortions.

Two areas were chosen for test flights: the Central Valley of California and the west shore of San Francisco Bay. The flat surface of the Central Valley gave a useful indication of the horizontal plane in the projected stereo model, and the rectangular road pattern served as a check on the rectification of tilt in both x- and y-directions. In this area there is a variety of rural and semirural structures, orchards and field crops, highway overpasses and bridges, whose images in the stereo model effectively demonstrated the possibility of perceiving and measuring heights. The San Francisco Bay shore includes a wide range of natural and cultural landscapes: rolling and rugged topography, shoreline and water features, large urban areas with many industrial and military installations, open and dense vegetation.

The convergent coverage was obtained with a single camera, mounted with a fifteen-degree forward tilt, by repeating each pass in the reverse direction. This amount of convergence provided a base-height ratio which gave satisfactory stereo exaggeration in the projected model: target objects could be clearly discerned and understood, and with a suitable measuring device their heights could have been determined. All flights were made at 20,000 feet, which with a 12-inch focal length gave a contact scale of approximately 1:20,000 at the center of format. At 20X magnification both viewing scale (1:1,000) and sharpness were excellent for study of small targets.

The following paragraphs summarize the work performed by [redacted] for the Panoramic Stereo Experiment.

EQUIPMENT MODIFICATION The [redacted] panoramic camera was suitable in all respects for use in this program except that the film transport and the scan rate were too slow. The film transport rate was speeded up to five seconds. The scan rate was increased to 0.5 second for three flights; for the April 26 flight, on which a slow film was used, the scan rate was slowed to about 1.5 seconds so as to permit a longer exposure time.

A new camera mount, combining stability with an unusual degree of rotational freedom, was designed and fabricated. The mount provided not only the required forward tilt of 15 degrees, but also 10 degrees of lateral tilt correction and a full 360-degree rotation about the vertical axis. The mount was installed in a Cessna 180 aircraft.

Since the road pattern in the Central Valley is very regular, it was convenient to position exposures by visual observation. The flights over the Valley were therefore planned for manual exposures. Photographs were taken one-half mile apart, with identical ground areas covered on the return pass. An A-2 view finder was purchased and modified to fit the space limits of the aircraft and camera mount. In addition, two pairs of auxiliary cross-hairs were etched on the glass viewing plate, so that at the instant of exposure the aerial photographer could identify the center of format, not only of the photo being taken, but also the previous photo and the photo to be taken next. This addition greatly facilitated the process of manual exposure.

The photographs of the Bay Area were taken with intervalometer setting, timed so that the stereo mates overlapped instead of covering identical areas.

TEST FLIGHTS On April 13 a test flight was made over the Central Valley. In spite of extensive ground testing of the camera before the flight, the film transport system proved faulty and satisfactory coverage could not be obtained. A new cam was installed and the flight was repeated the next day. Photographs were taken over a five-mile pass from a point just south of Modesto. It had been planned to fly additional photography over the Bay Area on the same day, but this could not be done because of coudy weather near the coast.

On April 26 the third flight was made. Forty exposures were made in each direction over an east-west strip twenty miles long in the Central Valley. The film used was Eastman Kodak SO-132, which has the rather slow ASA speed of 1.6 but the very high resolving power of 400 lines per millimeter. Exposure time was accordingly lengthened and the scan rate proportionally slowed. One pass was also made over the Bay shore, southeast to northwest. Before the return pass could be made, however, a second malfunction appeared in the film transport system.

The camera was immediately repaired and retested, but continuously poor weather conditions precluded reflying the Bay Area convergent coverage until June 12. The flight covered a strip approximately thirty-five miles long from San Jose to San Francisco International Airport; 44 exposures were made on the first pass, southeast to northwest, and 49 on the return pass. For this flight the co-pilot's seat and view finder were reversed so that the aerial photographer could sit comfortably, facing aft, instead of kneeling on the floor as on the earlier flights. This adjustment materially improved the precision of ground coverage during long passes.

STEREO PANORAMIC VIEWER Two projection viewers devel-

STATINTL

opted by [redacted] were modified for stereoscopic projection using crossed polarization. The modified viewer (Figures 2 through 6) displays the 70-millimeter panoramic negatives placed vertically in 18-inch plastic carriers, on which guide lines are scribed for orientation. Thus the flight line in the projected stereo model is always horizontal. The horizon in the direction being viewed is kept at the top of the model simply by reversing the film carrier. To help the interpreter's eyes accommodate, the top and bottom of the 45-inch square viewing screen were masked off, making the image area 15 inches high by 45 inches wide (Figure 3).

With the modified experimental viewer, registration of conjugate images is done manually by the projectionist. First the two photo centers are superimposed on the screen. Then any part of the panoramic image can be brought onto the screen by means of a coupled drive mechanism which moves the two film carriers vertically before the projection lenses (Figure 4). Errors in registration in the direction of flight (y-parallax) are corrected by a cam arrangement which rotates one or both film carriers about the theoretical convergence point (Figures 5 and 6). The precision of this correction depends mainly on the correspondence of ground area covered by the stereo mates; if the ground area corresponds, then the amount of rotation required to correct errors in y-parallax should be exactly equal for the two images. In this experiment, in fact, only very slight differential corrections were required. The experiment showed that satisfactory registration in the direction of flight could be maintained throughout the image area. Although perfect registration is possible only at one point, the maximum misregistration at the edge of the 45-inch screen was only about one-half inch, an error which the eyes aided by polaroid glasses can easily accommodate. Even when deliberate errors of up to two inches were made, the interpreters could fuse the images without discomfort.

Errors in registration in the direction of scan (x-parallax) proved more troublesome. The rectification mechanism was a simple cable arrangement which tilted the viewing screen, compensating the obliquity produced by the panoramic scan. This method of compensation proved adequate up to about fifteen degrees either side of the flight line. Beyond this angle the distortion of target objects was too great for comfortable stereoscope fusion, and displacement of the horizontal plane became clearly apparent (Figure 7).

Approved For Release 2001/07/16 : CIA-RDP78B04747A000600140007-4

On May 15 representatives of the contracting agency visited [redacted] to inspect the stereo panoramic viewer, view sample stereo pairs, and discuss possible uses of convergent panoramic instrumentation in intelligence interpretation systems.

<u>CONCLUSION</u> The Panoramic Stereo Experiment was not undertaken to provide image quality consistently satisfactory for operational use,or a final viewer design; but rather to demonstrate that it is feasible to construct a projection stereo viewer incorporating rectification for convergent panoramic photography, and to suggest directions that further design work may take. [redacted] believes that this purpose has been achieved . The adaptation of existing equipment in the present experiment was of course attended by severe limitations, of which the most troublesome was the screen tilt resorted to for correction of x-parallax. It is, however, entirely practicable to design a stereo projection viewer[1] having more refined and reliable means of rectification; all corrections would occur at the projector, in no way distorting images or displacing the horizontal plane in the stereo model. With such a projection viewer, stereo mates could be registered with a negligible error in x-parallax (that is, no error that could not be comfortably accommodated by the eyes) and no error in y-parallax out to 20 to 22 degrees either side of nadir. The viewer could be operated by one man, and would permit either continuous stereo interpretation within the

---

[1] Similar in design principle to [redacted] EN-71 printer, which automatically produces enlarged rectified panoramic prints.

angular limits just stated; or, with greater operator comfort and probably greater efficiency, monocular scanning with provision for switching in the conjugate frame at any point where detailed stereo interpretation is deemed necessary. The necessary controls could be built into a panel about 8 by 10 inches in size (Figure 8).

The feasibility experiment just concluded has been based on the most difficult geometry likely to be encountered in photo intelligence work, and has pointed up the problems connected with further development of the convergent panoramic idea. [redacted] belief that these problems can be solved is based not only on this experiment, but also on extensive experience with the geometry of panoramic photography.[1] Projection equipment which will make it possible to combine scanning and stereoscopic study, at scales suitable for the understanding of small targets, is needed to exploit the full information potential of panoramic reconnaissance photography.

---

[1] See, for example, [redacted] Laboratories, "Panoramic progress," Photogrammetric Eng., Vol. 27, no. 5, December 1961, pp. 747-754, and Vol. 28, no. 1, March 1962, pp. 99-107.

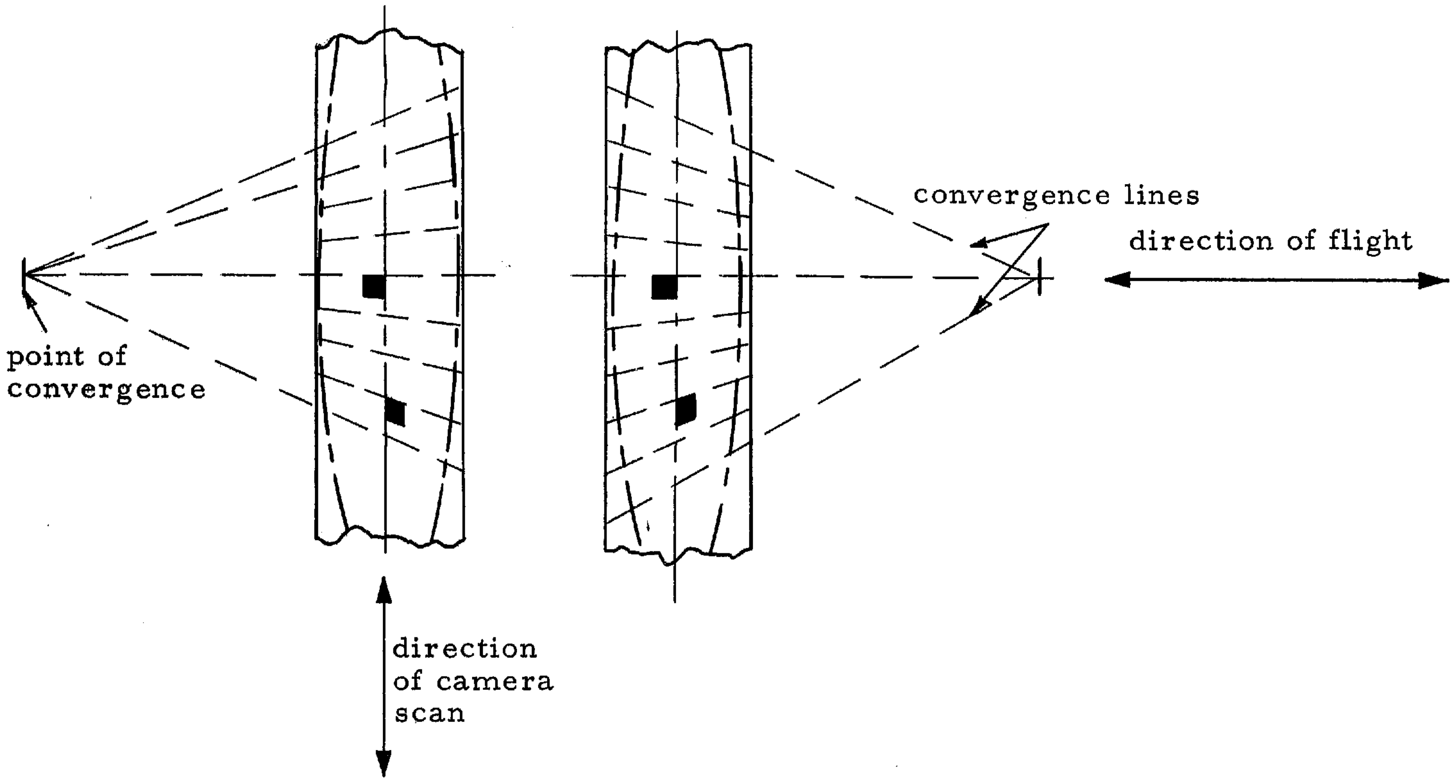


Figure 1. Distortion effects in stereo pair of panoramic photographs with convergent tilt of 15 degrees.

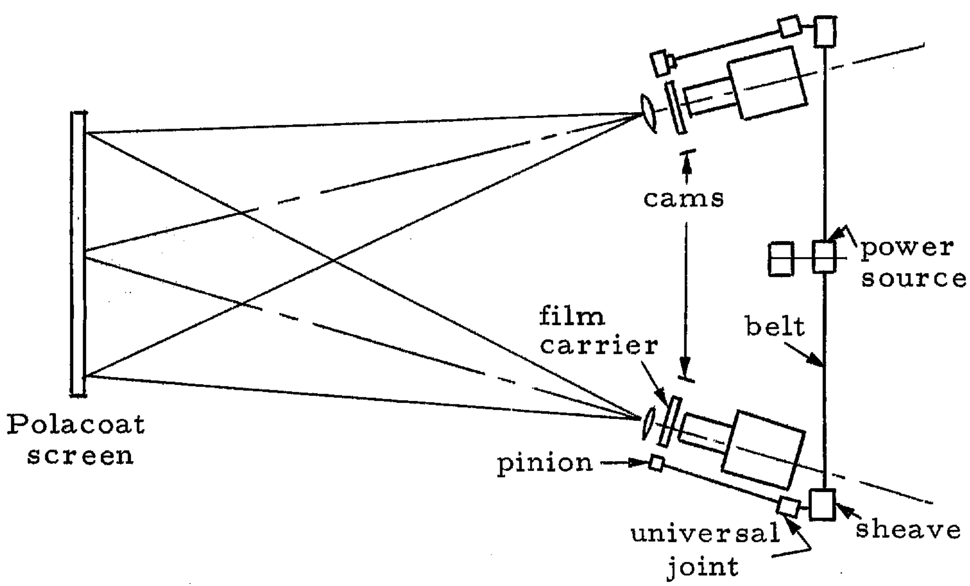
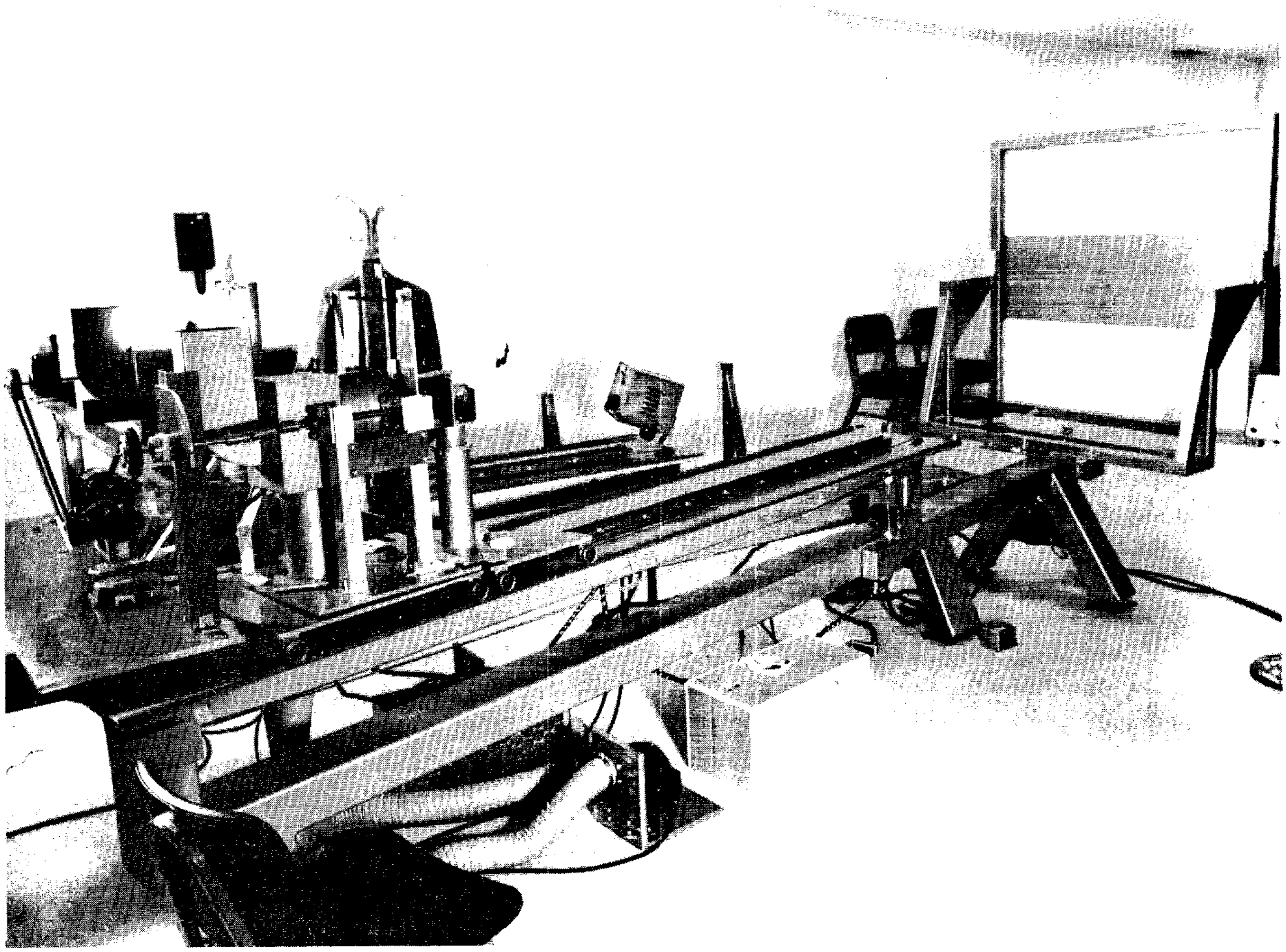
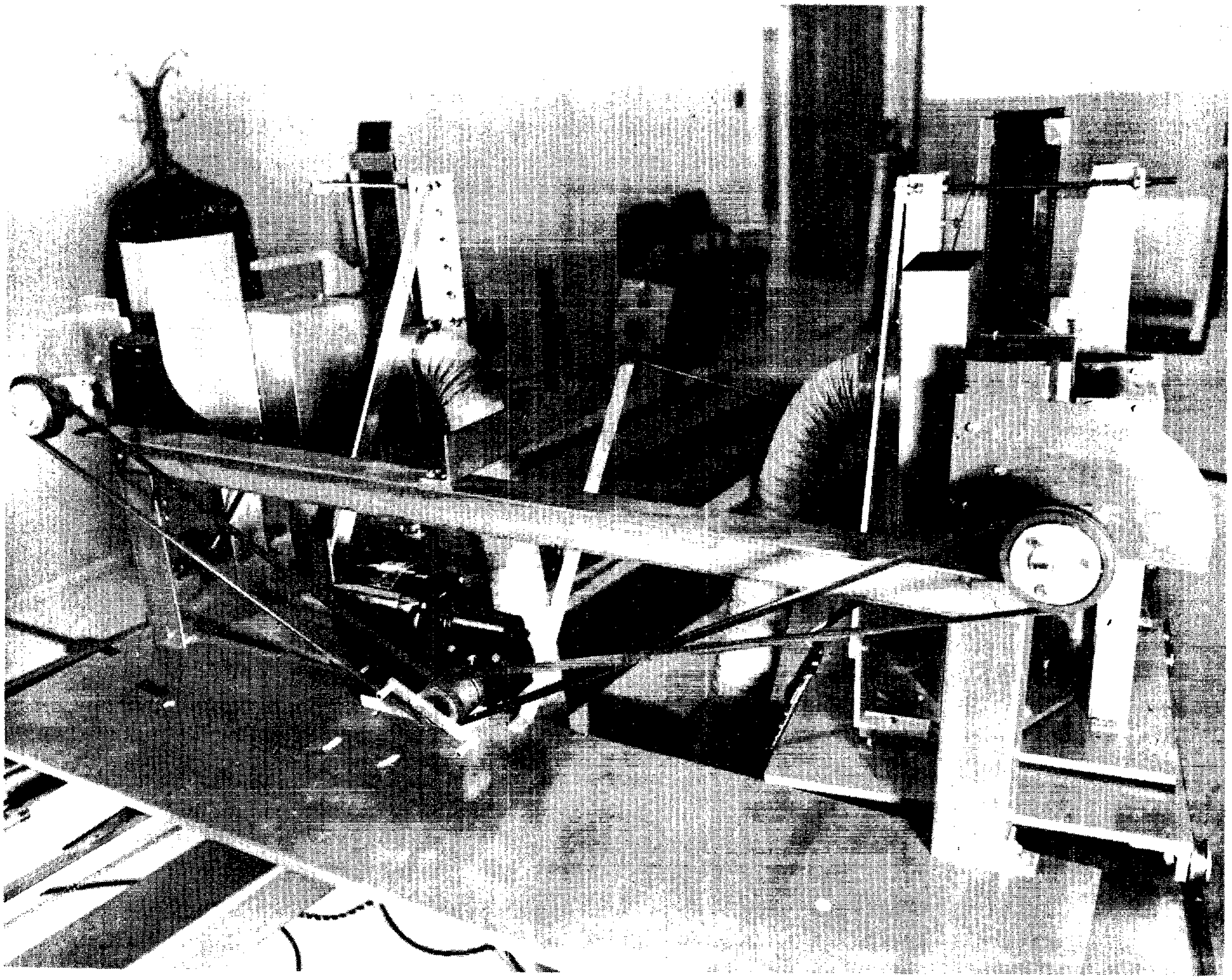


Figure 2. Plan view of stereo panoramic viewer.



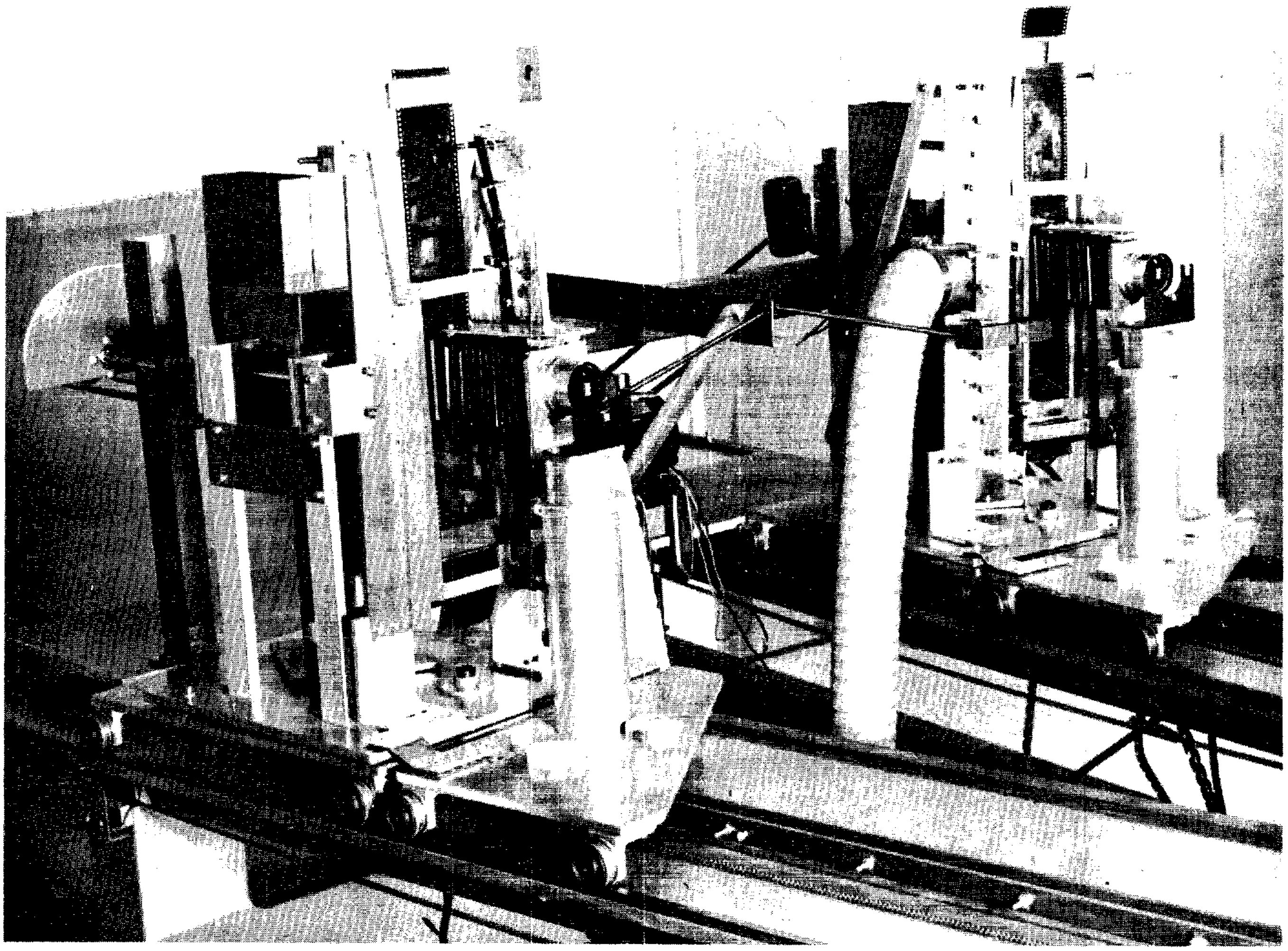
S-102

Figure 3. Photograph of experimental stereo panoramic viewer. Projector heads are seen at left, masked Polacoat screen with cable tilting mechanism at right.



S-103

Figure 4. Rear view of stereo projectors, showing coupled film drive belt.



S-104

Figure 5. Close-up of stereo projectors, showing conjugate photographs held in film carrier and cams which rotate photographs about their theoretical convergence point. See Figure 6 for geometry of y-parallax correction.

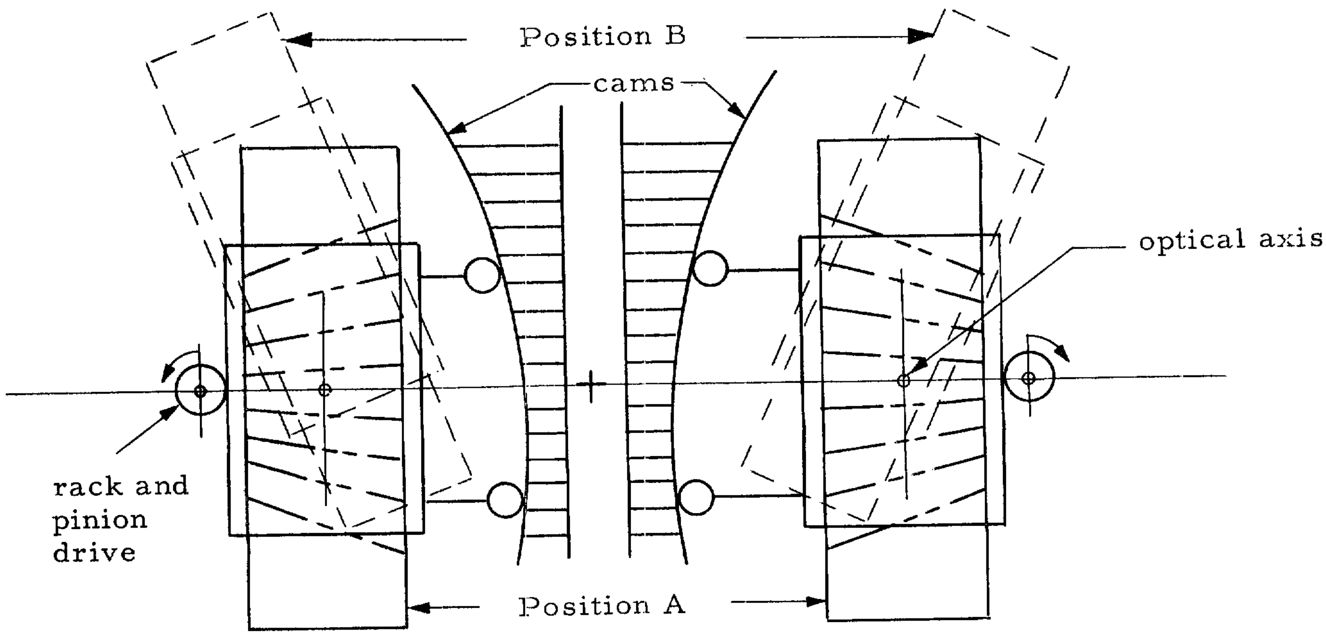


Figure 6. Rotation of film carriers about convergence point corrects errors in y-parallax. Film carriers are viewed looking toward screen from light source. Counter-rotation of pinion raises or lowers frame so that convergence lines are horizontal when crossing the optical axis.

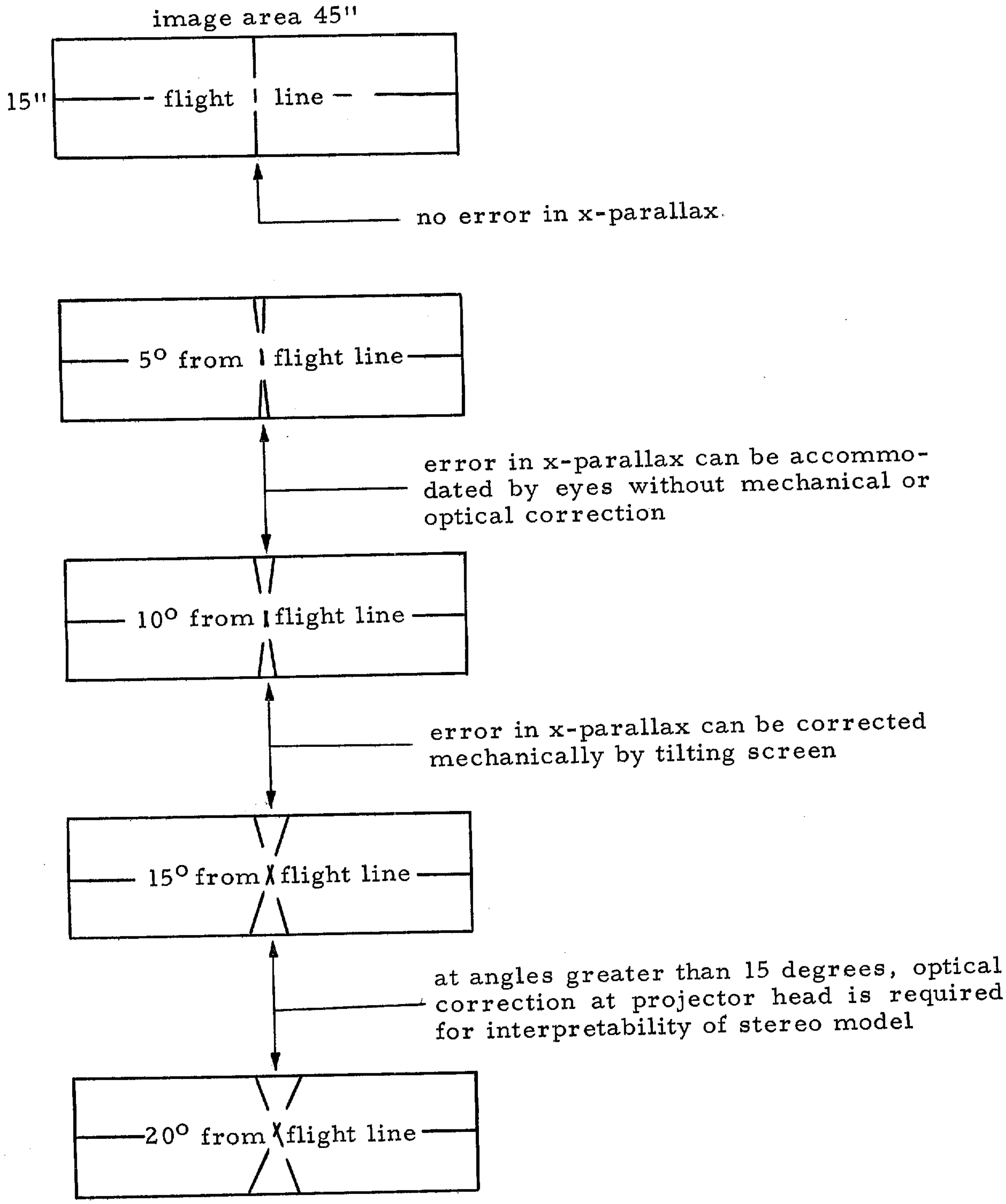
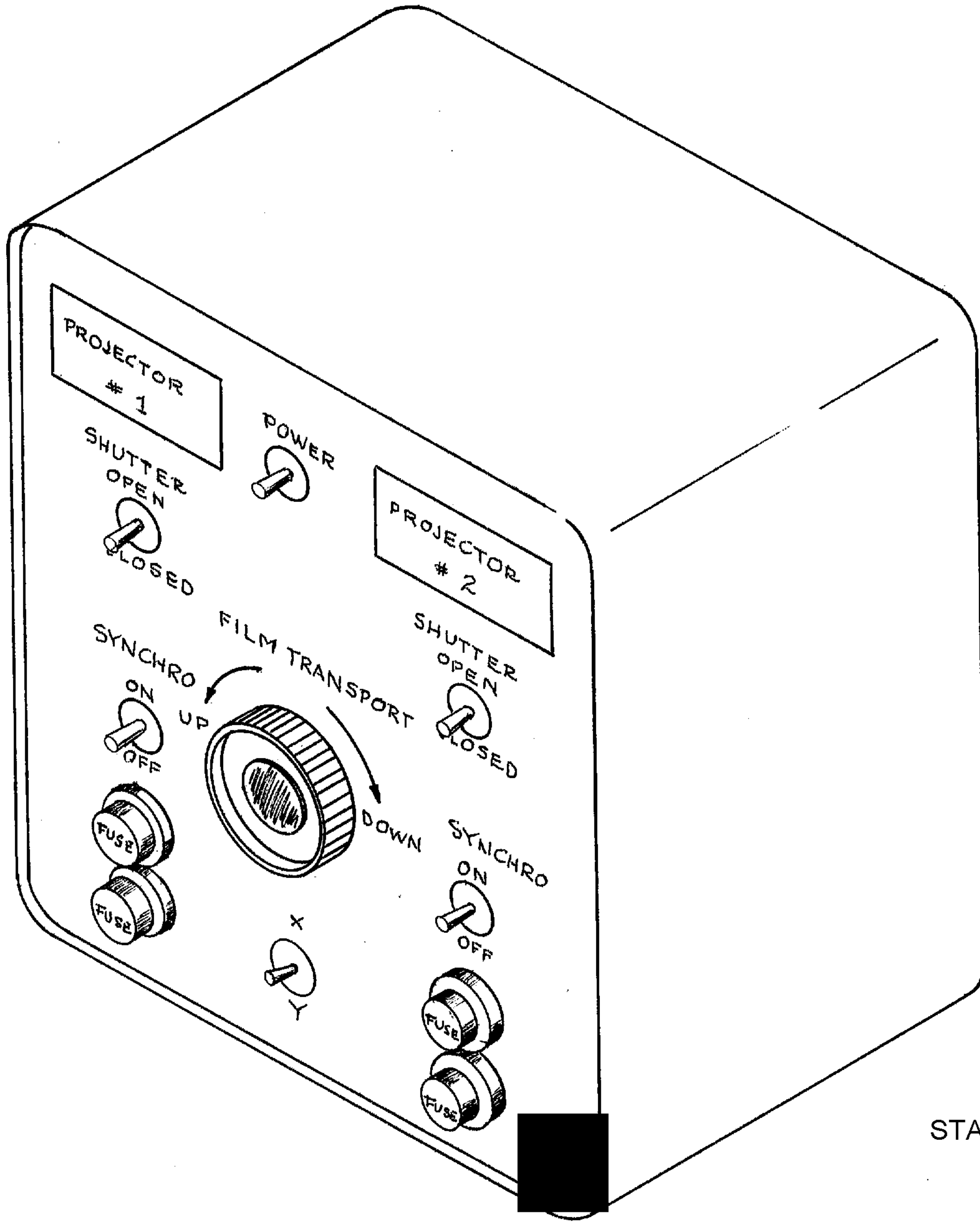


Figure 7. Increasing error in x-parallax with increasing distance from flight line.



[redacted]

STATINTL

Figure 8. Control Panel for Stereo Projection.