# THE "MULTI" FAIRCHILD'S VERTICAL RECONNAISSANCE CAMERA TEST EQUIPMENT*

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ABSTRACT

The vertical reconnaissance camera test equipment described provides a means of determining with one photographic exposure the optical quality of a functioning reconnaissance camera when that camera is mounted vertically with its weight supported on its trunnions. The main features of this equipment are the high optical quality of the collimators, the vibration-isolation mount, the vertical-camera mounting, and its versatility which allows a high-production inspection schedule to be met while various research projects are concurrently being investigated. The equipment and its facility is described and some of the special projects are discussed.

## INTRODUCTION

DURING and following the Second World War, the large aerial cameras manufactured at Fairchild were tested for resolution and focus on a fixture called the Tri-Collimator. As the name implies this was a three collimator arrangement with adapters for mounting the camera to be tested.

Figure 1 is a picture of the Tri-Collimator. Each tube houses a complete colli-

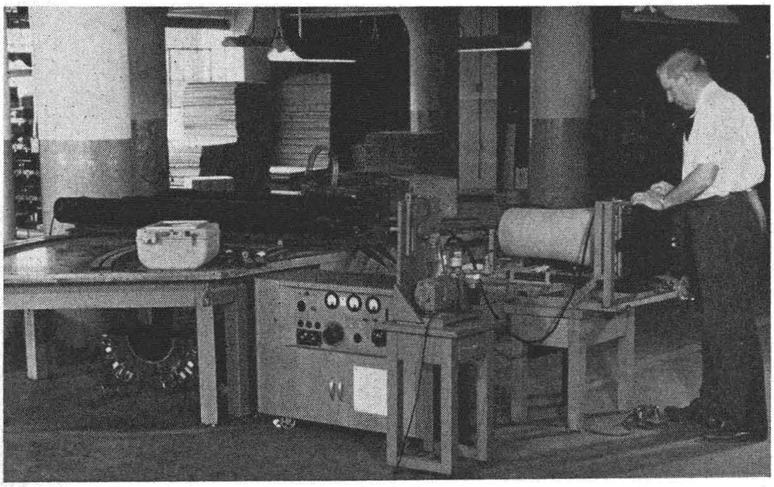

FIG. 1. The Tri-Collimator.

mator which comprises the 60 inch f/12 Tessar lens, the high contrast resolution target at the focus of the lens, the lamps which illuminate the target, and the necessary diffusing glass and filters. The center tube is fixed in a horizontal position in the center of a quadrant shaped table, while the other two tubes move on horizontal ways for angular adjustment with respect to the center. The camera tested on this equipment was mounted horizontally, facing the center collimator. When an exposure was made, three images of resolution targets were

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recorded—one at the center of the format and one at the center of each extreme edge.

Today at Fairchild's Syosset plant, an aerial camera is tested on new equipment, the most modern and versatile production equipment known to the author. An exposure made on it will record from five to ten images along any selected straight line through the center of the format.

This is a gain in information content of from 70 to 230 per cent. It is a direct and tangible gain, one of several advantages designed into the equipment. There were others,—bonuses they could be called—which resulted, not from planning, but because Fairchild in building this fixture, set the requirements at the highest attainable level of quality.

All of these advantages in no way reflect on the performance of the older equipment, the Tri-Collimator; this was, and still is, essentially reliable equipment. Its counterpart can be found in many industrial plants today. It served for many years as basic test equipment and is still in use at the Fairchild Jamica plant.

During the war years and those immediately following, the United States, Great Britain and Canada, were making significant progress in the field of optics and photography. The knowledge obtained from the many research projects sustained and guided by the Photo. Lab. at Wright Field and by Office of Scientific Research and Development, in addition to the work done by the National Bureau of Standards and by the Canadian Research Council, to mention a few eminent sources, was being diseminated throughout the optical industry.

The testing of lenses and cameras, as a result of this progress, was becoming critically defined. With the introduction and use of MIL-STD-150,[1] quality controls were instituted which for the first time brought a measure of uniformity into the field of lens and camera testing. It was then possible to compare the test data of one laboratory with that of another, on more than just a few select lenses. Correlation between the lens and camera manufacturer was imposed by Government specifications. Agreement became esential.

But correlation, or agreement within a limited area, is not always easy to obtain in photographic lens or camera testing and when results are evaluated with resolution criteria. In production testing, where values are further restricted to a definite flange distance setting at which agreement must be obtained, correlation can become evasive. When this happens, and with Fairchild it has happened several times, the critical eyes of the technical staffs of the non-correlating companies examine again the specifications of the Government. These specialists mentally dissect and analyze each of the other company's test equipment and processing techniques, and step by step go over every phase of work done by the inspecting personnel. Such problems, periodically encountered, made Quality Control at Fairchild aware of a need for camera test equipment which would give more quantitative and qualitative information of the optical performance characteristics of aerial cameras and lenses.

And this was not the full story. Side by side with the advance in quality control techniques was the engineering need for information on prototypes. By the year 1950 Robert Nelson, Director of Quality Control and responsible for the quality of the Fairchild products, was discussing with Irving Doyle[2] the requirements of new test equipment which would fulfill the joint needs of Quality Control and Engineering and which would also be recognized by both Government agencies and Industry for its optical quality and reliability.

[1] MIL-STD-150 is the Military Standard for Photographic Lenses.

[2] Then Chief Project Engineer in charge of the development of new cameras and now General Manager of the Fairchild Systems Division.

Mr. Robert Draghi, Vice-President in Charge of Manufacturing, following the Fairchild policy of keeping pace with the latest advances in the testing field, sponsored the project. Guided by Revere G. Sanders (former Vice-President of Sales) the project advanced rapidly from the stage of discussion to that of action.

Conferences with recognized authorities immediately followed the approval of the project. The first were held with personnel from the Photo. Lab. at Wright Field, the National Bureau of Standards and the Bureau of Aeronautics. Their sound advice and information made possible drawing up the general specification for the test equipment.

Dr. James G. Baker[3] was then consulted about the design of the collimators, and Jayburn Engineering Company drafted plans for mounting them on a huge, vibration-isolated base which would also hold the camera. The optics section of Quality Control at Fairchild set up detailed specifications, and with Engineers and Tool Designers reviewed all plans. Like a spider web, work proceeded in all directions at the same time, with authority and coordination vested in the Director of Quality Control.

The final product, which employed the efforts of many individuals and several firms, was formally named the Fairchild Vertical Reconnaissance Camera Test Equipment. Pictures and explanations of the development of this equipment follow. This formal name captures our interest and it is proper and descriptive. Any six word title, however, is almost surely destined to be shortened or changed and the men on the author's staff accomplished this in minimum time. The men who did the original testing and aligning of the optics and who keep the equipment in top working condition today, never used the full name. A little awed by the big iron and concrete structure, with the precious mirrors, they at first called it the "Multi-Collimator"; then with recognition as a dependable, precision equipment—a test that puts the final stamp of approval on a camera—they gave it a working man's name; it became the "MULTI." Inadequate as this name may be, it is obviously easy to remember and by association it has acquired meaning for those who use it.

## Description

In attempting to explain the development and working of the "Multi," it seems best to consult a picture of the complete equipment, discuss the general design, and then to show and discuss sectional views and sketches. Unfortunately, there is no point from which a full view of the eqiupment itself can be obtained. So a picture of the model (Figure 2) will be used.

In Figure 2, three walls of the square pit, in which the "MULTI" is housed, are shown. The wall which is swung out shows the ship's ladder which leads from the trap door entrance in the floor of the Final Inspection Area down to the base of the mount. This huge, steel reinforced mount (1) rises 15 feet above the floor or the pit. Twenty cast iron brackets, (2) extend out from the wall to support the ten collimating systems, i.e., 2 brackets to a system. Two steel channels (3) rise from the base of the mount, and 15 feet about it support the ends of six foot channel tie bars to the top of the wall (4). These shorter channels (5) in turn, support a one inch thick steel plate (6) which fits, with an inch space around it, into a cut in the floor at floor level.

The center of the steel plate is cut out to hold a window 26 inches in diameter; this window cannot be seen in this view. A large round annealed alumi-

[3] Dr. Baker was consulted initially about the design of the collimators, but his keen interest in the project, his advice on the mounting of the optics, their testing and alignment, the design of an astronomical telescope for testing the finished equipment and numerous details kept him in close contact with the program during its entire development and construction.

num donut (7) is amounted on the steel plate by means of three one-inch thick screws which act to support and level it. The center of the donut is a machined, ball-bearing ring which provides the means of holding the camera in a vertical position and rotating it 360 degrees around its vertical axis. At the base of the concrete mount can be seen the huge vibration isolators (8) of which five can be seen in this view; since the mount is symmetrical, there are five more on the other side of the wall. Each of the spring mountings which are incorporated in the base supports six (6) tons and has a static spring deflection of about 5-1/2 inches. This corresponds to a natural resonance of 80 cycles per minute and provides an isolation efficiency of 90% against all disturbing frequencies over 260 cycles per minute.

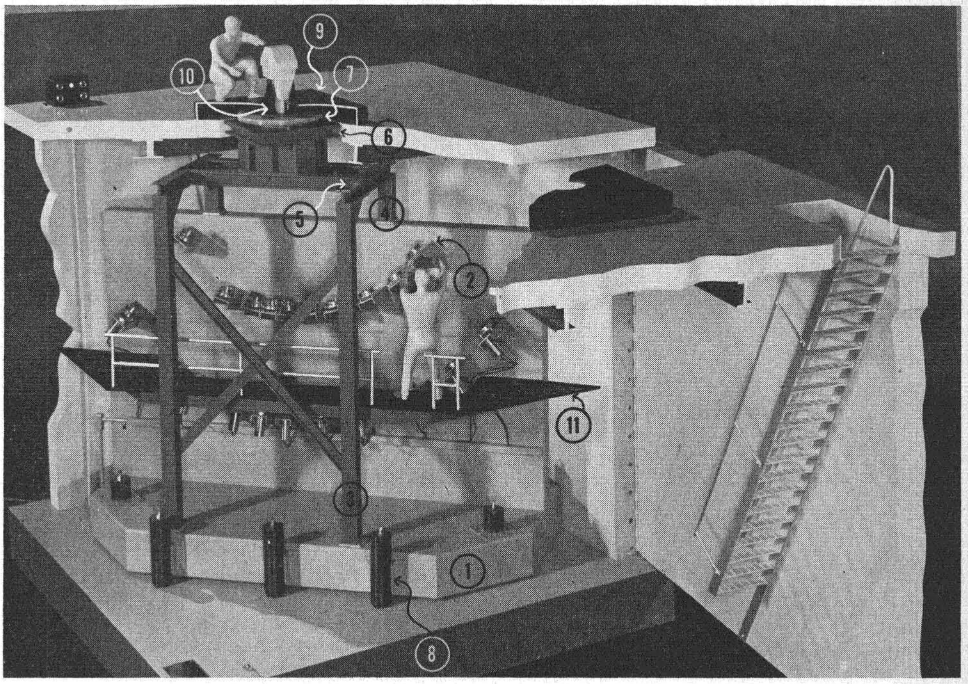


FIG. 2. The model.

A six foot square platform (9), with a twenty-seven inch circle cut from its center, rises six inches above the floor on which it rests. The inspector testing the camera is thus provided access to the camera mounting adapters (10) which project through this cut and is isolated from the equipment which he is operating while the camera becomes integral with the vibration-isolated base.

The grilled cat-walk (11) was added for safety and facility in maintenance and adjustment of the optics, when the "MULTI" was nearly completed.

Figure 3 shows another view of the model looking along the length of the wall. Taken in conjunction with Figure 2, it is possible to obtain from these two pictures of the model an understanding of the general structure of the "MULTI" itself. But at this point the usefulness of the model ends. To understand the quality, complexity, and facility of Vertical Reconnaissance Camera Test Equipment a study of the details of the equipment and a few explanatory sketches are needed.

The first step in constructing the big, vibration-isolated base is shown in Figure 4. Here can be seen the structural steel rods before they were embedded in the concrete of the inverted T-shaped foundation. Because of the size and weight (the complete system weighs approximately 62 tons) the foundation was built within the confines of the 20 foot deep pit. This photograph was taken from the floor of the inspection area, ten days before the cement had hardened, the I-beams and channels inverted, and a floor built over the pit area. Thereafter it was impossible to obtain pictures showing the complete equipment.

This iron and concrete structure provided the necessary mass for the vibration isolation and the vertical surface for mounting the brackets holding the optics.

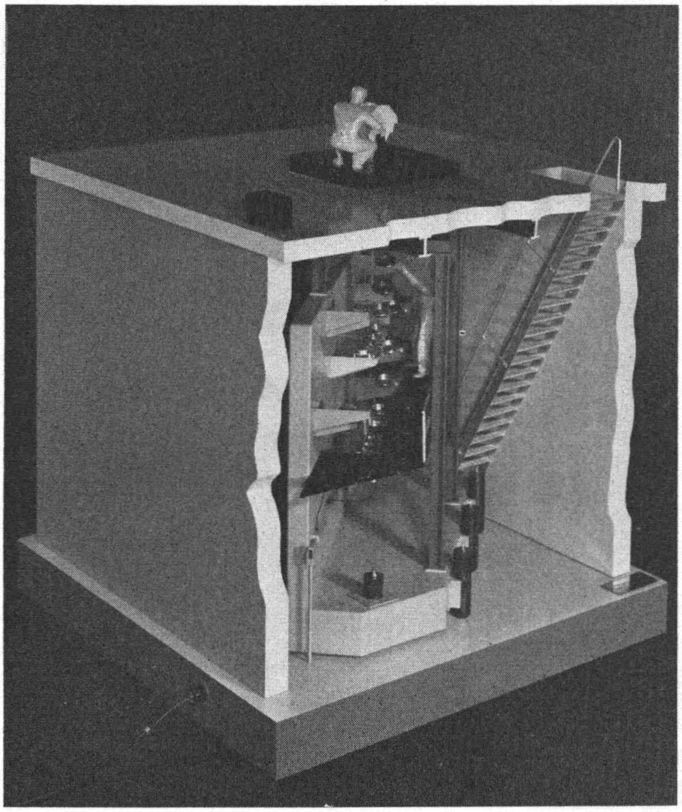

FIG. 3. Another view of the model.

Figure 5 shows the circular row of brackets mounted on the steel plates embedded in the vertical cement wall. On the top row the neutral density beam-splitters can be seen in their cast-iron cells. The lower row of brackets holds the paraboloidal mirrors and the reticle lamp housing assembly.

A sketch of the collimating system recommended by Dr. Baker is given in Figure 6. a Diffused light (a) is transmitted through the bars of the resolution patterns of the reticle (b), diverging toward the neutral density, plane parallel beam splitter (c). Half of the light incident on the lower face of the beam-splitter is transmitted and either absorbed by the painted dull black wall of the mount, or is redirected and lost for photographic purposes beneath the supporting cross channels which act as baffles. The incident light which is reflected is directed

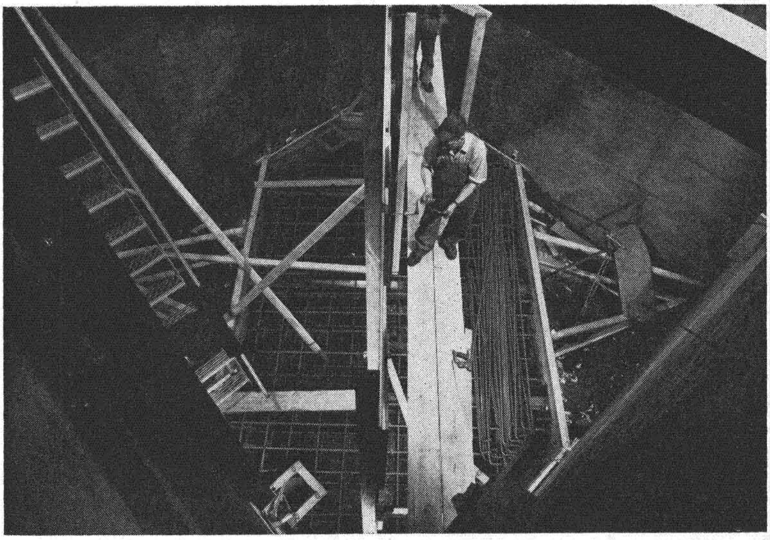

FIG. 4. First step in construction of big vibration-isolated base.

toward the paraboloidal surface of the mirror (d). Since the reticle lies at the focus of the parabola—that is to say, since the distance the light travels from the reticle by way of the beam-splitter to the mirror is equal to the focal length of the parabola—the light which is directed upward by the mirror is plane parallel light. When this light reaches the beam-splitter, half of it is transmitted through it to the window and through the window to the center of collimator where the under test is placed.

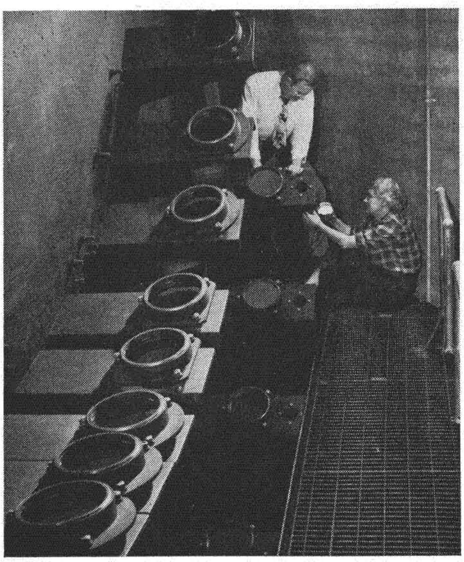

FIG. 5. Circular row of brackets.

The nominal focal length of the collimators is 120 inches and the diameter of the unvignetted beam at the center of collimators is 7 inches. There are no color aberrations in the system; optics themselves are of astronomical telescope quality, and the full field of each collimator is less than 45 minutes. It will therefore be possible to adequately test lenses (or cameras) up to 60 inches in focal length provided their entrace pupils do not exceed the 7 inch diameter of the unvignetted collimator beam.

It is an interesting fact, and one for which Fairchild is justifiably proud, that all of the mirrors and beam-splitters were individually processed by members of Harvard Observatory's Amateur Astronomer's Group. The author although accustomed to high precision production labor, will not forget the care spent by these men in correcting each optical element to the "Nth" observable fraction of a fringe.

It was not the simplest thing in the world to mount mirror optics rigidly in their heavy cast iron cells and to retain their optical perfection.

All of the optics, their testing and alignment were personally handled by the Foreman of the Optics Section, Bill Harris. Not until each mirror or beam-splitter, tested in its cell, met his critical approval was it mounted by its adjusting screws on the angle brackets. A trial and error method was used to determine the best placement for the cork which acted as frictional cushions between the optics and metal parts.

Tests made on the optics in their cells, before the cells were mounted on the wall brackets, include the Foucault knife-edge test for each mirror and the observation under 40× magnification of the images of a pinhole and of a resolution target formed by two mirrors in tandem, one mirror functioning as a collimator and the other as a telescope objective. The beam-splitters were tested by placing them in the parallel light path between two such pairs, observing again the same critical targets.

The tests were exacting and tedious. The requirement that the optics must pass a duplicate test after they had been in cells for a week was a safeguard which was also time consuming.

The method of aligning the collimators is interesting. The first requirement is that the extended axial line of each mirror shall go through the point selected as the center of collimators. Figure 7a shows how this is accomplished. Two thin strings are placed to form a cross at the point selected for the center of collimators; directly above the center of the mirror to be aligned, a similar cross is placed. The second cross, however, is rotated 45 degrees to the first, in order that the two may be quickly distinguished one from the other. A bright pinhole of light is then placed approximately at the center of the radius of curvature of the mirror. An observer positioned near the pinhole, locates the reflected beam, and directs the adjustment of the mirror. The mirror is correctly located when he can see the reflected cross hairs of the center of collimators

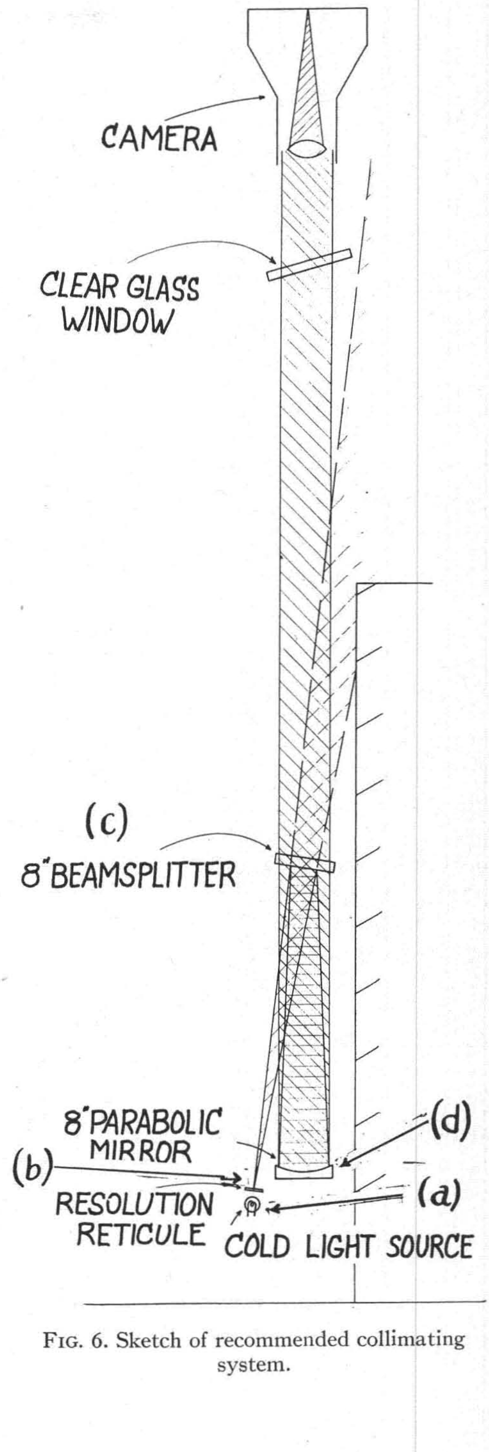


FIG. 6. Sketch of recommended collimating system.

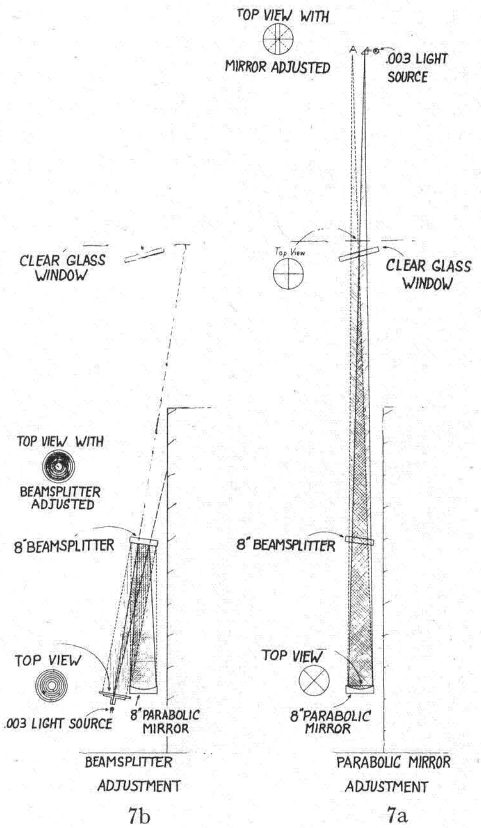


FIG. 7. Layout diagrams.

—side by side with the original—and between the two appears the directly observed cross hairs of the mirror—all this with his eye as nearly in line with the pinhole as is physically possible.

The alignment of the mirror is followed by that of the beam-splitter. To accomplish this (see Figure 7b) a bright point source is placed at the center of the reticle housing—a 25 watt Western Union lamp serves the purpose particularly well. A piece of white cardboard, about 10 inches in diameter, inked with concentric circles $\frac{1}{4}$ inch apart, is placed about six inches above the reticle housing and concentric with its axis. A circular hole is cut from the center of the cardboard to allow the light from the pinhole to reach the beam-splitter.

As can be seen from the sketch, the light coming from the pinhole reaches the beam-splitter and is directed by it toward the mirror. The mirror in turn reflects this light back to the beam-splitter. It should be noted that the light reflected by the mirror is approximately parallel and its cross-sectional area will remain constant, equal to the diameter of the mirror. The beam-splitter re-

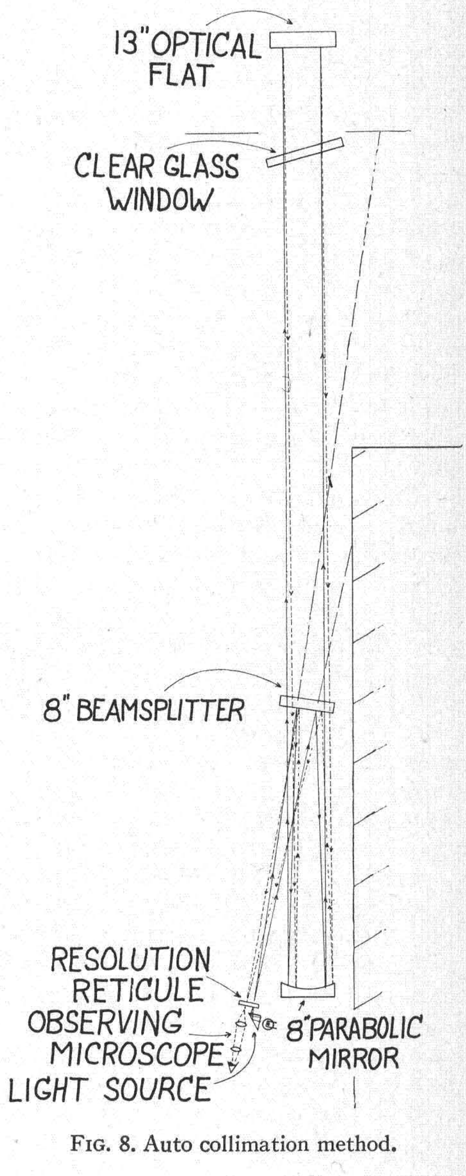


FIG. 8. Auto collimation method.

directs the parallel light back toward the point source. When the beam-splitter is correctly located, this reflected light can be seen on the white cardboard, its outline well centered between two inked circles.

The final adjustment of the collimator is obtained by positioning the reticle at the infinity focus of the system. The autocollimation method, Figure 8—considered to be the most sensitive for this purpose—is the one which is used.

Exploded views of the reticle adapter and lamp housing are shown in Figure 9. The design is such that it is possible to quickly interchange reticles—say from high to low contrast—without disturbing the setting of the infinity focus of the collimators.

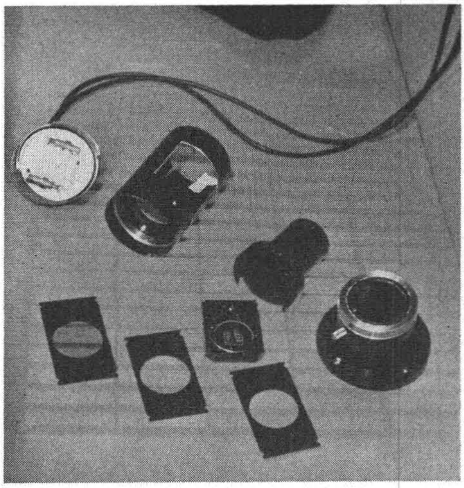

FIG. 9. Reticle adapter and lamp housing.

Three housings provide means of holding filters for controlling the color and intensity of the light source.

The bulk of the testing is done with the cold cathode spiral-wound lamps, rated at 3,500°K. They operate through variacs, further extending control of the light intensity without significantly changing the color temperature.

The lamp housings can be easily removed if another light source is required for test purposes.

In this connection it is easy to see that the "Multi" is an excellent system for testing in the infrared range, first, because it is relatively easy to substitute an infrared source and secondly, because the optical system is free of longitudinal color aberrations, and therefore, is always in focus for all colors.

The method of mounting the camera was one of the design features of the "MULTI" which was most thoroughly discussed. Everyone agreed, and Irving Doyle particularly emphasized that the camera must operate from a vertical position. The vertical mounting of the collimators was dictated by the necessity of meeting this requirement, and the camera mount was designed to conform.

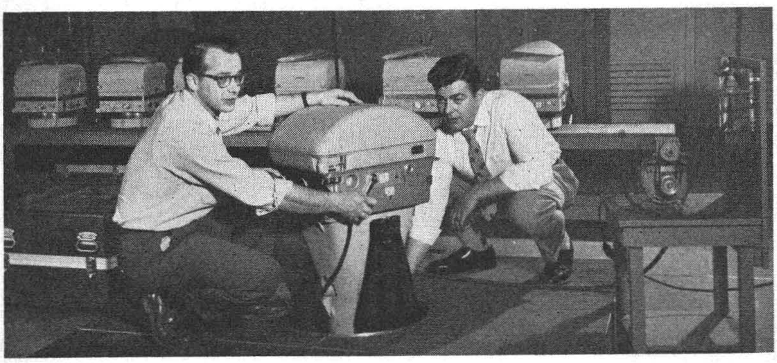

FIG. 10. The camera held in test position.

Figure 10 shows a camera held in test position. Rising from the round donut—this could be seen in the picture of the model (Figure 2) but is not visible here—are two metal supports for the camera adapters. These supports are part of the upper (rotating) ring bearing, both having been machined from the same casting. The adapters which are attached to the supports by four bolts, vary with each camera type in such a way that they mount the camera solely by the means provided on the camera.

Cameras which are supported on their trunnions and are therefore free to swing, are leveled and rigidly held by two opposing screws bearing on the nose piece of the camera.

Positioning of the lens at the entrance pupil of the collimating system is automatically accomplished.

Figure 11 shows the lower ring bearing indexed in units of one degree around its periphery. This feature allows the operator to instantly position the camera in any selected horizontal orientation of the format.

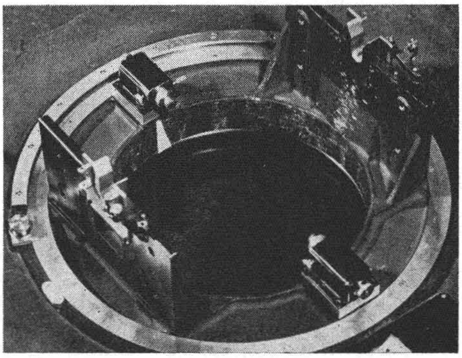

FIG. 11. Lower ring bearing indexed in units of one degree around its periphery.

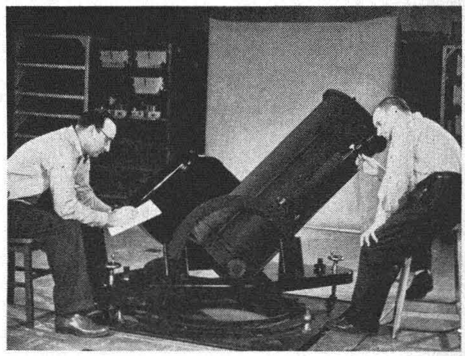

FIG. 12. Telescope mounted on the base plate and aligned to observe one of the off-axis collimators.

An 80″ f″8/mirror telescope was designed by Dr. Baker and the D. W. Mann Co. and was fabricated by the latter as a final test of the quality and setting of the collimators. Figure 12 shows this telescope mounted on the base plate and aligned to observe one of the off-axis collimators. The vernier on the focusing eye-piece permits a reading to 0.1 mm. for a comparison of the infinity focus of the collimators with the infinity focus of the telescope.

A quartz optical flat is now being made for use with the telescope and collimators. This final control was considered desirable due to the variation of the surface of the pyrex flats with temperature.

## SUMMARY

The vertical reconnaissance camera test equipment has been in use for more than a year. During this period many production cameras have been tested on it.

One of the advantages to production has been the ability to report resolution to an AWAR value, as is presently being done with the K-47 cameras.

The Fairchild Engineers have used the "MULTI" for many tests. All of the large prototypes have been tested on it, and it critically checks the performance of cameras before and after they have been subjected to environmental testing.

The effect on optical quality of new and old mechanical devices, motor heat, shutter shock, lower power, i.e.: very long focal length—infrared filters, even the testing of cameras at low IMC speed has been possible on the "MULTI".

Very soon it will be handling the bulk of the critical work to be done on the Lens Correlation Research project now being programmed by Arthur Magill at Fairchild.

Many more problems are being scheduled—some of these cannot be discussed here—but no doubts remain in the minds of those who sponsored it and those who depend on it that the Fairchild Vertical Reconnaissance Camera Test Equipment has done, and will continue to do an excellent production job, and that its use as a research tool is just beginning.

# NEWS NOTES

### Offset Plate Made in One Minute with Kodak Verifax Copier

Low-cost, offset printing plates for office-type duplicators can be produced in one minute by a method announced by Eastman Kodak Company.

The new method employs the Kodak Verifax Copier, an office photocopy machine now widely used for making quick copies of letters, reports, and other business papers where a limited number of copies is required. By using a new type direct-image paper plate in place of the copy paper ordinarily used, a master is produced which can be placed on an offset duplicator for printing hundreds of copies.

Any typed, printed, drawn, or written original may be copied by the new method. Printed pictures from course-screen newspaper clips may be reproduced.

Total materials cost for producing a plate by the Verifax method is only 18 cents. The speed of the new method makes possible substantial savings in labor costs over other methods, and means that the advantages of photographic plate making are now possible for even the smallest business.

### Checks Camera Focus

A new instrument for checking aerial camera focus and lens collimation has been announced by Alan Gordon, President of Gordon Enterprises, camera manufacturers of North Hollywood, Calif. The measuring instrument was developed by the company under contract with United States Air Force, Gentile Air Force Depot, Dayton, Ohio.

Called a Focalscope, the instrument contains devices to measure the position of the lens in relation to the film plane, to check focus, and is also used as an autocollimator. The Focalscope can be used by the camera repair technician when making installations, and by the aerial camera man during actual flight, when he may check the accuracy of the focus of the lens to insure sharp pictures, since both altitude and temperature changes may affect lens focus.

The high-precision unit contains a low-powered microscope on which verniers are mounted. In function, the Focalscope is similar to a portable optical bench. The technician can use an object at great distance when testing. Used as an autocollimator, the Focalscope employs a self-contained light source which is projected from the instrument through the camera body and lens and reflected back into the eyepiece. In this application, the lens acts as its own collimator. The instrument can be adapted to use on both 9×9-inch and 9×18-inch film sizes.

### PSC Participates in Antarctic Expedition

The Photographic Survey Corporation Limited and Kenting Aviation Limited of Toronto, become this year the first aircraft operators in the world to fly aircraft from all seven continents.

In discussing the British Government's plans for an aerial survey expedition to the Antarctic, Douglas N. Kendall, PSC and Kenting President, said two company Canso amphibians would be sent with the expedition. The operation is during the Antarctic Summer from November to April with the possibility of the work continuing another season. Purpose of the undertaking would be to obtain vertical air photographic coverage of some 50,000 square miles of the remote and little known territory of the Grahamland Peninsula, a dependency of the Falkland Islands.

Accurate maps of the area will be made from these photographs, to assist geological and other scientific investigations that are being carried on there. This is the first time that an aerial survey has ever been attempted on such a scale in the polar regions.