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AD34183

RESEARCH STUDY AND INVESTIGATION ON TELEVISION TECHNIQUES FOR ADVANCED RECONNAISSANCE SYSTEMS (U)

RADIO CORP OF AMERICA CAMDEN NJ

09 OCT 1957

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PROJECT MX-2226

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~~Supplement to~~

⑨ Final ~~Engineering~~ ~~Report~~ Suppl.

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PREFACE

⑥

This report is a supplement to the Final Report, Project MX-2226 "Research Study and Investigation on Television Techniques for Advanced Reconnaissance Systems," dated October 9, 1957. The project is being performed by Defense Electronic Products of RCA for the Air Force under the direction of Wright Air Development Center. The contract number is AF33(616)2576. The present contract continues the work started on subcontract 52-63 of Contract Number AF33(038)6415. Work on the above contract was reported on in a final report dated 4/15/54.

The study deals with the feasibility, application and implementation of a television system to the problem of reconnaissance from an earth satellite. Because of the high cost of weight and space aboard such a satellite, every effort must be made to make the equipment light and compact. The power consumption should be kept at a minimum, not only because of weight requirements but also because of the difficulty of dissipating degrading heat. Reliability also is a major consideration since long, unattended life with a minimum of remotely controlled adjustments is a design requirement.

The purpose of this project was:

1. To continue studies evaluating the feasibility of a television system for this type of specialized advance reconnaissance.

2. To ~~life test preliminary~~ breadboards for evaluation of component and system reliability.

3. To evaluate alternate approaches to any of the problems where such seem to have a chance of fulfilling the requirements.

4. To construct certain research models where such would be useful in evaluating the problem.

5. To study the electronic implementation of the interpretation and dissemination of the information obtained by the reconnaissance system.

Studies of ~~were made in the individual fields of:~~

a. Optical Systems,
~~b. TV Camera~~
c. Video Recording (magnetic), and
d. TV Transmitters
~~e. Antenna Servo Systems~~
f. Kinescope Recording of photographic images are reported.
g. Information Presentation
h. Reliability Studies
i. Transistor Applicabilities

These studies were coordinated by preliminary systems examinations whenever deemed necessary so that the overall results would be mutually compatible.

The final report on this project reported in full on all the topics mentioned above except Optical Systems, Video Recording (magnetic) and Kinescope Recording, additional work on these being carried past the contract period. This report completes the reporting on these topics.

Defense Electronic Products (formerly Engineering Products Division) of RCA was the prime contractor for this project. The work was supplemented by subcontracts to the RCA Tube Division and to the RCA Laboratories Division.

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I. INTRODUCTION

This report represents the results obtained from a continuation of parts of an overall research and development study program carried out under contract number AF33(616)2576. The results contained herein serve to supplement the information given in the Final Report of this contract, Project MX-2226, Final Engineering Report, dated October 9, 1957.

A. Optics, Ground Imaging System

The delays experienced in obtaining the reflection prisms for the segmentation drums prevented the completion of the optical tests for inclusion in the final report. The results of the optical tests on the completed 38-inch focal length Schmidt cameras and the segmentation device are included in this supplement as well as the alignment procedures for all components of the system. Photographs taken with the completed unit are included. These show that the optical equipment performs as predicted.

B. Magnetic Video Recording System

At the end of the time period covered by the Final Report the status of some phases of the magnetic video recorder development were rather indecisive. During this supplementary period the FM recording system design was finalized and six channels completed. Complete circuit diagrams of the FM recording system including tape record and playback amplifiers are shown in this report. Each of the six FM channels provides excellent one megacycle video performance with no interchannel crosstalk. Tape handling techniques were improved to the extent that the maximum potential performance of the magnetic heads is achieved consistently and the information on six tracks on one-half inch tape can be added together without significant time difference errors resulting from tape skew. It is concluded that no system employing multiplexing within the tape system is feasible for the application. A parallel channel system employing a multiplicity of independently operating narrow band vidicon camera and FM tape recording channels does appear to be feasible.

C. Kinescope Recording

The material on this subject in the final report was not complete, in that the proposed developmental kinescopes were not then available for evaluation. Several engineering-model versions of this kinescope were obtained subsequently and the tests on these, reported herein, give a reasonably good indication of the obtainable phosphor-image quality. It is believed that the results justify the predictions on overall performance which were made in the final report.

II. SUMMARY

A. Optics, Ground Imaging System:

The components of the Schmidt-type system have been tested and reported. This report covers the measurements on the segmentation hubs and prisms, the alignment of the complete system, the mechanical aspects of the systems, the photographic tests, and recommendations for future systems.

B. Magnetic Video Recording Systems:

A number of changes were made in the FM recording system and the present status of this system is presented through block and schematic diagrams.

Considerable work was accomplished in efforts to reduce the flutter, skew and amplitude variations. Head performance on the developmental recorder comparable to the best observed on the loop machine is obtainable using increased tape tension and larger reel motors. It was found that tape skew was very low provided that the distance between the used faces of the edge guides was no more than about one mil more than the width of the tape.

The wiring and cabling of the head circuits were changed to minimize all forms of coupling. Crosstalk is now about 40 db down and all six channels can be used with no interference between channels.

After being designed and constructed the basic delay line from which a series of related bandpass filters could be derived was found to be inadequate. It is still believed that this approach is feasible and is perhaps the only way now known which will provide frequency division multiplexing without reliance on reverse playback. The use of other multiplexing systems and recording methods is discussed.

C. Kinescope Recording:

Three kinescopes were tested; two were development tubes and a third was a previously evaluated tube used as a reference. The present kinescope response was not as favorable as that of the referenced tube.

As a result of these tests it is believed that light scattering and image spread in the phosphor are limiting the rendition of fine detail as much as the distribution in the beam spot itself. It now appears that a ten-inch P-16 tube may be required to get a 560 TV-line response of about 75 percent or better as measured on the phosphor. The development of a new thin transparent phosphor by the RCA tube department may eventually permit satisfactory results even in a five-inch tube.

Figure 1. Complete Schmidt-type Camera and Segmentation System

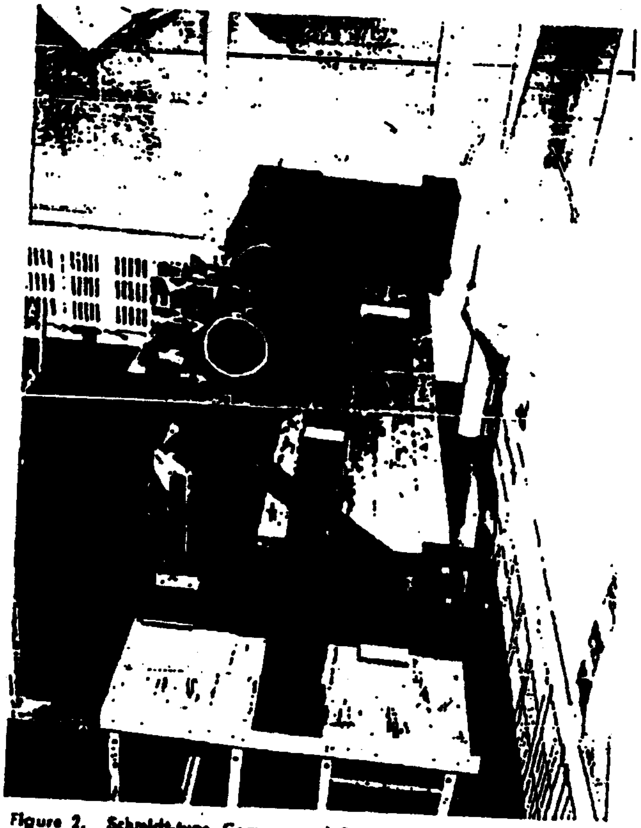


Figure 2. Schmidt-type Camera and Segmentation System with left covers removed

Figure 3. Closeup View of Phasing Dial

Figure 4. Closeup View of the Segmentation Drums and Prism

b. PRISM MOUNTING FACE

In measuring the parallelism error between the drum faces and the shaft axis, means had to be established to identify and fix such a direction. This was done by supporting the ground bearing surfaces on the shaft at either side of the drum in V-blocks. In order to make the supports somewhat self-aligning, the V-blocks were lined with manila paper, light springs lined with manila paper were applied to force the axle down into the V-grooves, and a light lubricating grease was applied. A plane parallel plate was adjustably secured to the end of the shaft and adjusted parallel to the rotation axis by observing that it remains square to the autocollimator after the drum is rotated 180°.

The stability of the axis so determined was tested by securing the V-blocks and the autocollimator in the relative positions described at the end of the preceding paragraph, then rotating the plane parallel on the shaft axis 40°, re-squaring it to the autocollimator for one position of the drum and then checking squareness after the drum is rotated 180°. This was done in 40° steps all the way around the drum. It was concluded from the results of these observations that the axis of rotation did not change direction more than 5 seconds during rotation, and the autocollimator was then squared to its mean direction.

A second autocollimator was pointed to observe the reticle of the first along a line that cleared the drum shaft, after a large flat had been squared to the first autocollimator to permit its transfer to the new observing position. A flat mirror was then clamped to each drum face in turn so that it overhung the edge of the drum. By rotating the drum into positions separated by 180°, the mirror can be brought before either autocollimator and the angle between drum face and shaft axis read with the filar micrometer. The measurements showed three of the faces on the lower drum to be out of parallel with the shaft axis by more than the allowable ±15 seconds. The maximum error was about forty-five seconds. Seven faces of the upper drum exceeded the fifteen second tolerance, the maximum being also about forty-five seconds. The fifteen second tolerance was originally based on a drum rotation of 3° during a five millisecond exposure. With a drum rotation of 0.9° during a 1.5 millisecond exposure, the forty-five second error should not be excessive, although little margin theoretically remains to take care of increases in the exposure interval. In the case of each drum, the faces that were out of parallelism tolerance intersected the shaft axis on the side of the drum away from the drive gear, in the direction of the shaft extension. This would seem to indicate the presence of a systematic error in the vendor's method of test, or at least a systematic difference between the two methods of checking.

Although the parallelism between drum faces and shaft axis is acceptable, experience with its measurement indicates that the drum drawing should not only specify the desired parallelism tolerance but should also reference a specification for performing the tests or, at least, for defining the rotation axis. It should be noted that when the drum rotates on its tapered roller bearings, the direction of the rotation axis is somewhat more unstable than when the bearing journals are supported in V-blocks, as discussed previously in this report.

3. Alignment of the Optical System

a. ALIGNMENT OF SCHMIDT-TYPE CAMERAS

Figure 5 represents a plane view of the framework PQRT of the optical system. This framework consists of two L-shaped parts, which are joined to a central section J along lines XX and ZZ, and to which they are secured by 32 screws. The L-sections are equipped with leveling shelves, S, and are mounted on three jacks. Before securing the L-sections to section J (by tightening the 32 screws) the L-sections are adjusted to proper height and leveled by placing a sensitive level on shelves S. The level sensitivity is about one minute per scale division, and is carefully adjusted beforehand by setting it on an optical flat supported by a leveling table.

The two L-sections mount folded optical systems whose optical axes consist of the parallel segments FA and GB, and the common segment AB. Points A and B are indicated on the upper surfaces of the L-sections by prick punch marks, according to the dimensional requirements of the design, and the line AB is scribed using a straight edge. In order to make it possible to scribe this line with a straight edge whose length is only about one-half AB, plumb lines are carefully supported above points A and B. Two additional plumb lines are supported at C and D, and brought by careful sighting into the plane of those at A and B. The technique is to sight along DA with the eye close to D, and along CB with the eye close to C. The plumb line close to the eye will appear as a blurred vertical bar against which it is easy to judge the centering of the other two plumb lines by moving the head slightly in a horizontal direction during the observation. When the other two plumb lines both appear centered in this bar, the three plumb lines are in a single plane. By observing and making notes of the directions in which C or D might be moved to bring them into a common plane with A, and by noting the same with respect to B, it is possible to deduce the adjustments that must be made in the positions of C and D to bring them both into the plane of A and B. This requires patience and care but is not especially difficult. With the points C and D prick-punched as indicated by the final positions of the plumb bobs at C and D, the line segments AC and DB are scribed.

Segments AF and BG are laid out perpendicular to AB, using the familiar compass and straight edge method of geometry as indicated by the construction about the arbitrary center K.

Spherical mirrors are located at F and G according to the dimensional requirements of the design, and are substantially centered on lines AF and BG respectively. It is necessary that the center of curvature of mirror F shall lie in the plane determined by line AF and the plumb line at A, say at F^1, and that the center of mirror G shall lie at a corresponding point G^1. This is brought about by suspending a plumb line above the point M on AF, after which the eye placed near A can observe when plumb lines A and M, and the image of plumb line A in mirror F are in a common plane. Coplanarity of these lines is attained by lightly tapping the mirror to rotate it on a vertical axis until they are observed to be in alignment. The center of F is then at F^1. The procedure for mirror G is identical.

At each of the points A and B are two plane mirrors m and n respectively. The mirrors of each pair are supposed to lie in a single plane normal to plane FABG and at 45° to line AB, as indicated by the lines m and n that represent their reflecting surfaces. U and V are aspheric Schmidt corrector lenses centered nominally above line AB and located along AB according to the dimensional requirements of the design. Mirrors m are adjusted by removing corrector U and placing an illuminated pinhole at the location of its center. The mirrors m are then adjusted until the light from the pinhole which they reflect to mirror F is returned by them to two images of the pinhole that substantially coincide with each other and with the pinhole. This is possible because mirrors m reflect the center of curvature of spherical mirror F to the center of corrector U. The planes of mirrors m are easily adjusted to substantially contain the point A by making them have linear contact with the plumb line suspended above A. This condition is judged visually and should be maintained at every stage in the adjustment of mirrors m. The same procedure is used to adjust mirrors n. Correctors U and V are then restored to their nominal functioning positions. Because of their very low refracting power, the correctors may be located and squared by ordinary sighting means, using the plumb lines suspended above A, B, C, and D.

b. ALIGNMENT OF 35 MM CAMERA BODIES AT FOCAL PLANE OF OPTICAL SYSTEM

A large aluminized optical flat was placed at the position J, see Figure 5, facing the Schmidt Optical System under alignment. A point source was placed at the approximate position A, where the center of the camera film frame should be. An autocollimator was placed at an intermediate position along AC so that the optical flat could be aligned parallel to the corrector plate, U. The point source was then moved about until the in-focus image of the source fell back upon itself. The system was then autocollimated. A 35 mm illuminated transparent slide was then centered at this point after the removal of the point source. The slide was held at the film plane by the 35 mm camera body at A (the camera body used was the standard Argus, Model A). Rather than repeat the above procedure for the other Schmidt System, the optical flat was removed and the system FAC was used as a collimator for system DBG. The illuminated slide at A was imaged on the ground glass held by the camera body at B. The camera body was adjusted for best focus and proper centering of the image.

C. DRUM AND SHUTTER PHASING

The operating cycle of the segmenting optical system comprises a sequence of 36 exposure phases. These phases are spaced at equal intervals of drum and shutter rotation and therefore at equal intervals of time when the parts are driven at uniform rotational speeds. The drums normally rotate at 100 RPM, but for the purposes of photographic testing, a special speed reducer is used to reduce this rate to 7½ RPM.

AT 100 RPM, the normal television exposure time is 0.0015 second, during which the mirrorstat drums rotate $\frac{100}{60} \text{ x } 360^\circ = .0015 = 0.9^\circ$. With a photographic shutter operating at $\frac{1}{50}$ second, the drum speed must be X RPM where: $\frac{X}{60} \bullet 360^\circ \bullet \frac{1}{50} = 0.9^\circ$.

This makes X = 7½ RPM. At this speed, the drums again rotate 0.9° during the exposure time of $\frac{1}{50}$ second, which is used in photographic testing.

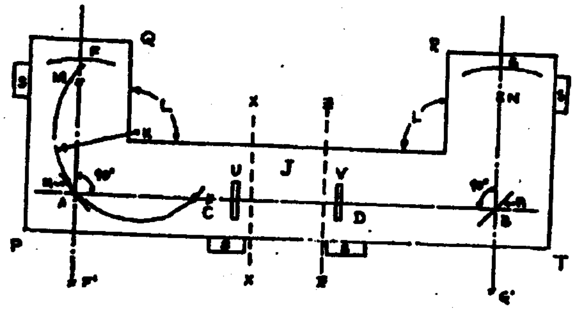


Figure 5. Framework for the Optical System

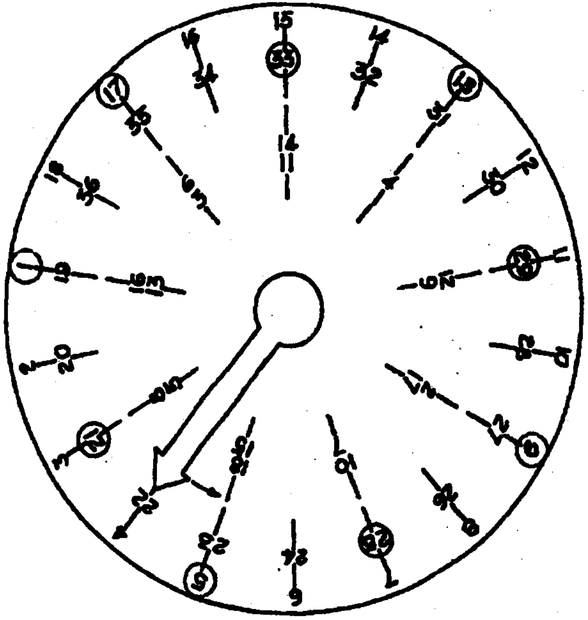
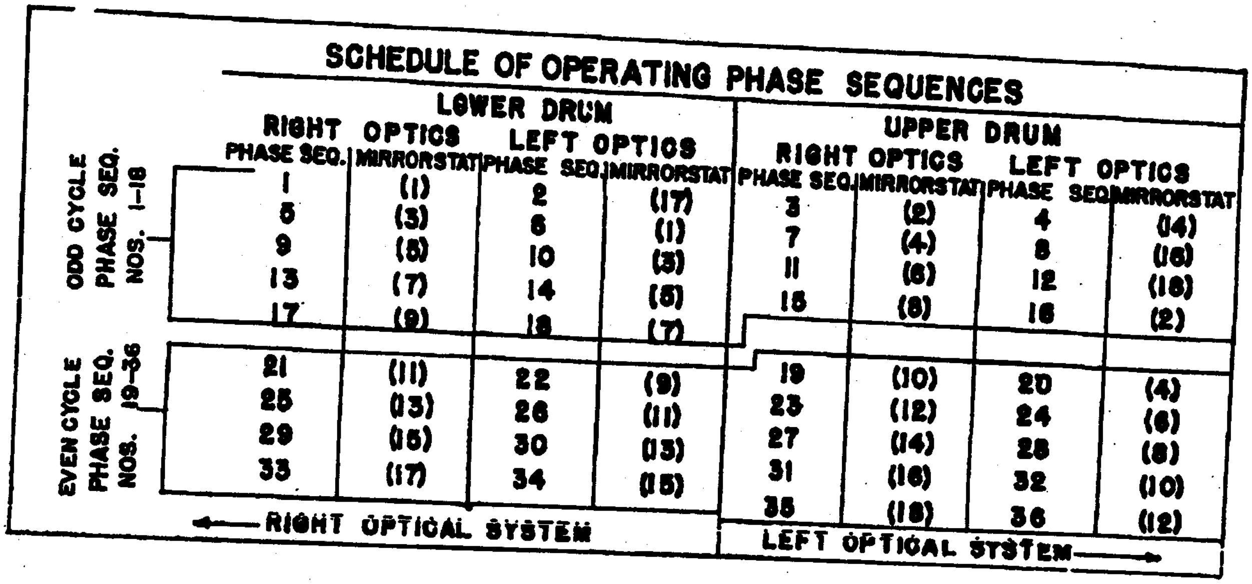


Figure 6. Figure Dial (circled numbers are colored red)



SCHEDULE OF OPERATING PHASE SEQUENCES

	LOWER DRUM				UPPER DRUM			
	RIGHT OPTICS		LEFT OPTICS		RIGHT OPTICS		LEFT OPTICS	
	PHASE SEQ.	MIRRORSTAT	PHASE SEQ.	MIRRORSTAT	PHASE SEQ.	MIRRORSTAT	PHASE SEQ.	MIRRORSTAT
ODD CYCLE PHASE SEQ. NOS. 1–18	1	(1)	2	(17)	3	(2)	4	(14)
	5	(3)	6	(1)	7	(4)	8	(16)
	9	(5)	10	(3)	11	(6)	12	(18)
	13	(7)	14	(5)	15	(8)	16	(2)
	17	(9)	18	(7)				
EVEN CYCLE PHASE SEQ. NOS. 19–36	21	(11)	22	(9)	19	(10)	20	(4)
	25	(13)	26	(11)	23	(12)	24	(6)
	29	(15)	30	(13)	27	(14)	28	(8)
	33	(17)	34	(15)	31	(16)	32	(10)
					35	(18)	36	(12)

← RIGHT OPTICAL SYSTEM

LEFT OPTICAL SYSTEM →

Figure 7. Schedule of Operating Phase Sequences

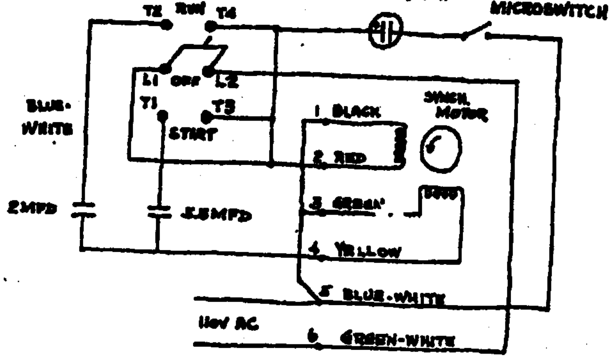


Figure 8. Electrical Wiring Diagram of the Synchronous Motor, Starting Capacitors, Phasing Lamp and Switches

The drums are driven at 100 RPM by a 3600 RPM motor using a model 10B24R speed reducer made by Metron Instrument Co., Denver, Colo. Their model 10B320S reducer is used to obtain the 7½ RPM speed. Interchange of the speed reducers requires reversal of the motor direction to keep the upper drum rotating counterclockwise as seen from above. The two speed reducers are dimensionally interchangeable in all other respects. Details of the method of reversing motor rotation are given elsewhere in this report.

During the exposure cycle each drum rotates two full turns, the upper drum counterclockwise as seen from above, and the lower drum clockwise. The first of these turns is called the odd cycle and the second the even cycle, as will be more fully defined later in this report. Each rotating shutter correspondingly rotates three full turns. The shutters function as optical "switches" to regulate the delivery of light from the drums to the right and left branches of the optical system. "Right" and "left" are referred to an observer who views the system along the direction of the light as it enters the drum compartment. Thus, the shutters admit light alternately to the two branches from the lower drum, then alternately to them from the upper drum, and so on. The drums and shutters are all connected together through a gear train, which is driven by a 3600 RPM synchronous motor. It is important in the completely assembled equipment that it be possible to determine by a simple routine examination that these moving parts have a proper relation to each other, and to restore them to correct relation if they have moved. To this end, indicating means are provided to make such checks easy.

A number has been punched on each corner of the upper surface of each drum. These are the mirrorstat numbers which identify each cooperating pair of reflecting surfaces. They do not appear in numerical order around the drums, but all the numbers on the lower drum are odd, and on the upper even. The numbering of the mirrorstats exactly corresponds to the numbering system that appears in previous report (Progress Report #7, p. 10, F. 8, etc.).

A dial is located on the top of the drum compartment cover, shown in Figure 6, and is provided with a moving hand or pointer that rotates counterclockwise with the upper drum. The dial is numbered serially in the counterclockwise direction at 20° intervals. An outer circle of numbers ranges from 1 to 18 inclusive, while a smaller circle correspondingly ranges from 19 to 36 inclusive. Each of the eighteen positions about the dial is, therefore, identified by two numbers, which are called the phase sequence numbers. They correspond to the 36 exposure phases which occur during every two rotations of the drums. These numbers are white with the exception that number 1 and every fourth number thereafter is colored red. As a result, alternate numbered positions are marked with two white numbers, while the remaining positions each have one red number.

Corresponding to the dial positions that have red numbers, additional numbers appear in pairs closer to the center of the dial. These pairs make up an outer circle of even numbers that correspond to the mirrorstat numbers on the upper drum, and an inner circle of odd numbers that correspond to the mirrorstat numbers on the lower drum. Compared with the mirrorstat numbers on the upper drum, the even numbers of the outer circle have the same order *in the opposite sense about the center.* The odd numbers of the inner circle appear in both the same order and same sense about the center as the mirrorstat numbers on the lower drum.

Near the edge of the dial an observation port appears in the drum compartment cover. A pointer is fixed beneath this port, at an angle 10° clockwise from the axis of bi-lateral symmetry for the entire system. The drums must be phased so that their numbered corners line up directly under this pointer as they pass the observation port, beginning with corner 16 of the top drum in line with corner 13 of the bottom drum.

When these two corners are lined up with the stationary pointer; the moving pointer should be set to indicate position 1-19 at the edge of the dial. One of the openings in the rotating shutter before the right optical system should then also be in its lowermost position. When the mechanism is then turned to swing the moving pointer 20° counterclockwise to position 2-20, one of the openings in the rotating shutter before the left optical system should be in its lowermost position. The drums and shutters are then in their proper relative positions. A hole in the rotating shutter is lowermost when a notch in the edges of the shutters is in a horizontal plane as seen through the shutter shaft axis as seen through one of the two access doors at the rear of the drum compartment cover.

The first rotation, which starts with the pointer at position 1-19 and the opening in the right shutter lowermost, is called the odd cycle of operation. The second rotation is called the even cycle, after which the odd cycle starts over again, and so on. The odd and even cycles are identified by the flashes of a lamp at the rear of the assembly. This lamp is energized by a cam and microswitch each time an opening in the right rotating shutter reaches the lowermost position. The odd cycle is identified by the flashes occurring when the moving pointer is directed toward red numbers in the outer circle of phase sequence numbers (1 to 18 inclusive). During the even cycle, the flashes occur when the pointer indicates red numbers in the inner circle. The even cycle phase sequence numbers are 19 to 36 inclusive.

When the phase sequence number has been identified by observing the dial pointer positions in relation to the occurrence of the lamp flashes, the particular mirrorstat, drum, and optical system which are functioning to produce an image are identified by consulting the schedule of operating phase sequences, Figure 7. This is also attached to the back of the drum compartment cover.

For example: If the rotating pointer is directed to position 12-30 and the lamp flashed when it passed position 11-29, the phase sequence number is 30 (in the even cycle). The schedule then shows that for phase sequence number 30, mirrorstat 13 on the lower drum is directing light into the left optics. If the pointer is directed to position 7-25 and the light is not turned on, the system is at phase sequence number 7 (in the odd cycle). The schedule indicates mirrorstat 4 on the upper drum to be directing light into the right optics. In this last case, however, should the light be turned on with the pointer in position 7-25, the phase sequence number would be 25 (in the even cycle), and mirrorstat 13 on the lower drum would be directing light into the right optics.

The phasing of the drums may be checked very readily by turning the dial pointer to any one of the red numbered positions and observing the alignment of the drum corners through the observation port. For example, if the pointer is at position 13-31, corner 4 of the upper drum should be in line with corner 1 of the lower drum and with the stationary pointer, as indicated by the numbers 4 and 1 beneath the moving pointer. Drum phasing may be similarly checked when the pointer is at any other red numbered position. It is not necessary to know the phase sequence number in order to check drum phasing.

In order to check the phasing of the rotating shutters, the drums and the dial pointer must first be properly phased. A check for this is given in the preceding paragraph. The right shutter should then have an opening in lowermost position when the dial pointer indicates one or the other of any two adjacent (40° apart) red numbered dial positions. The left shutter should then have an opening in lowermost position when the pointer turns just 20° counterclockwise to the next phase sequence number on the dial. As in the case of the check for drum phasing, the check for shutter phasing does not require the phase sequence number to be known. The observation doors at the back of the drum compartment give access to the rotating shutters. In order to make it possible to judge if a shutter opening is at its lowermost point when the shutter is viewed edge-on through the door, three indexing notches are cut in the edge of each shutter. When a shutter opening is lowermost, an indexing notch appears at the same height as the axis of the shutter drive shaft. Corresponding notches in the adjacent fixed baffle plates are at the same height as the drive shaft axis and make it easy to judge shutter phasing.

d. ALIGNMENT OF PRISMS ON DRUM

The objective in aligning the prisms on the drums was to set all the left-hand prism faces on each drum parallel with the rotation axis of the drum within an angle of five seconds (in accordance with Progress Report #7, p. 12). Optical tests which were made to determine the stability of the direction of the drum shaft during rotation showed the direction to wander through an angle of about thirty seconds. The autocollimator was, therefore, set square to the mean direction of the axis, and the left-hand prism faces were set parallel with this direction within thirty seconds. Although the five second accuracy goal on prism alignment may be readily met using standard optical alignment means, experience with the model has shown that further development of the bearings to make the rotation axis stable within comparable limits is necessary before five second tolerances or prism alignment are practically justified.

(NOTE: When the system was fully assembled for testing, it was noted that the images were somewhat unsteady, particularly in a direction parallel to the drum shaft axis. This was partly due to vibration of the entire equipment in resonance with the table on which it was mounted. The frequency of this resonance was satisfactorily reduced by setting the six mounting jacks on sponge rubber pads about 12" x 12" x 1½". It was then noticed that the images projected by certain of the mirrorstats appeared consistently steady while those projected by others consistently showed motion parallel to the drum axis. The addition of opposing screws to the retaining caps for the top bearing of the upper drum and the bottom bearing of the lower drum permitted the very careful readjustment and reseating of the drum shaft roller bearings. Also, the very careful setting of the locations and clearances of the spiral bevel driving gears reduced the parallel motion to the point where it was not distinguishable from random vibration effects. No measurements were made after that time to determine if any improvement had been made in the approximately thirty seconds instability in the direction of the drum rotation axis.)

During the adjustment of the prisms on the drum, the prism clamps were partially tightened and the prisms adjusted to substantial parallelism with the rotation axis by repeatedly tapping the metal prism base. Adjustment was judged with an autocollimator squared to the rotation axis by adjusting it and a plane parallel mounted on the end of the shaft until the parallel appears square to the autocollimator for drum positions that are 180° apart. By then squaring a large optical flat to the autocollimator, the instrument could be transferred to a suitable position for observing the prisms and again squared to the drum axis. In its final observing position, the autocollimator received a return from both the large reference flat and the prism under adjustment, which made it possible to make a direct comparison.

e. BALANCING OF PRISM DRUMS

Because the size of the prisms distributed around the drums varied, the center of gravity shifted away from the rotational axis of the drums. Using an unfinished drum as a mold, Woods metal was poured into the proper segments. The molded piece of metal was then attached to the wheel to be balanced. The molded piece of Woods metal was purposely made too large so that the center of gravity could be brought up to the axis of rotation gradually. The latter process was quite simple because of the low melting point of Woods metal (about 80°C). Because the center of gravity of molded Woods metal could not be placed exactly on a line through the axis of rotation and the unbalanced center of gravity, additional washers made of Woods metal had to be placed on various parts of the drum. The drum was considered statically balanced after repeated movements of the drum resulted in no backward motion of the drum after it came to rest.

4. Auxiliary Mechanics of the Optical System

a. COVERS AND BAFFLES

In addition to the supporting framework of the optical system, the system is provided with baffles and light tight covers to control, exclude and absorb unwanted light. Each branch of the optical system is covered with a light tight sheet aluminum cover which encloses all but the corrector lens. The covers are L-shaped, extend to within about 3 inches of the corrector plates, and are fitted with six baffle partitions each to exclude and trap undesired light as far as possible. The baffles are finished with black flack on both surfaces, and the other interior surfaces of the covers and the base on which the rest are finished dull optical black. At the end of each cover nearest the corrector plate, the first baffle is fitted with two flanges to mount Ilex No. 5 shutters for the photographic testing. These baffles are followed in each cover by two other baffles at about fourteen inch intervals. These additional baffles each have two circular openings to admit light from the upper and lower drums. Each opening is large enough to clear the useful light beam by ½ inch on the radius. Between the diagonal and spherical mirrors are three baffles in each cover, beginning about two inches from the spherical mirror and spaced at about twelve inch intervals. These baffles have long vertical openings with rounded ends since they must permit passage of light from the diagonals to the spherical mirrors and back again to the space between the diagonals near where the image appears. The ¼ inch clearance for the useful light is maintained here also, as far as practical.

b. CAMERAS AND FILM TRANSPORT

Adjustable mounting brackets are provided to mount two photographic camera frames for photographic testing. These are located close to the diagonal mirrors and the cameras are available through access doors at the rear of the corner section of each L-shaped cover. The camera frames act merely as film supports, their lenses, shutters and irises being removed. Controls extend from the camera frames through the cover to permit advancing and rewinding the film without opening the access doors. The control knobs on top of the covers advance the film and those on the sides rewind it. The cable releases that extend through the covers above the cameras are depressed to permit film to be advanced to the next frame and are released as soon as film advance begins, to stop the advance at the proper point. The front of each camera is painted dull optical black to absorb non-useful portions of the image that lie beyond the camera matte.

When the L-shaped covers are bolted in place and all seams, door hinges and edges, and corners sealed with Scotch Photographic Tape, the compartments that enclose the mirrors and camera frames are light tight and light may be admitted to them only by tripping the shutters. Two shutters are provided, and may be moved from one optical system to the other by unscrewing them from their flanges. Access doors are provided for this purpose at the sides of the back panel of the cover for the center section. Near the upper and lower corners of each door is a hole to accommodate one of the shutter cable releases.

c. Segmentation Compartment

The housing for the center section of the optical system houses the motor driven segmentation drums. It comprises four enclosure panels and four baffle assemblies. The enclosure panels are a heavy metal floor, front, back and cover. Two inside baffles are screwed to the floor, and two outside baffles screwed to the front panel form with them continuous access tunnels through which light from the object space reaches the mirrorstats on the rotating drums. The center compartment can obviously not be made light tight, but all its inner surfaces are coated with black flack to dissipate unused light that cannot be prevented from entering the drum compartment through the tunnels that lead through the front panel.

The drum compartment is supplied with power through a cord that passes up through the compartment floor near the front. The motor is controlled by a two stage switch on the back panel that first connects a starting capacitor in the circuit, and then a running capacitor. Two thrusts are necessary to fully actuate the switch in either direction, and in starting a five second to ten second lapse between thrusts is recommended to give time for oscillations to damp out before switching in the running capacitor.

The red phasing lamp is mounted beside the motor switch. This is a neon lamp with a built-in resistor in the lamp socket for 110 volt operation that flashes each time the right shutter has an opening in the lower most position. Its operation may be better observed under certain conditions if the red bullseye is removed. Figure 8 gives the electrical wiring diagram of the synchronous motor, starting capacitors, phasing lamp and switches. The motor connections shown are for operation with the 320X speed reducer or 7½RPM of the drums. For operation with the 24X speed reducer or 100 RPM of the drums, reverse either the red and black or green and yellow motor leads.

The cover panel of the center compartment is provided with a shaft hole and a covered observation port. The upper drum shaft extends through the shaft hole, and the phase indicator dial is affixed to the cover concentric with the shaft. A chrome plated pointer is affixed to rotate with the shaft and sweep the dial. To the rear of the dial and at one side, the schedule of operating phase sequences is affixed to the cover under a protective plastic sheet.

d. Operating Sequence

Once all the mechanical parts are properly phased as described elsewhere in this report, the best procedure for photographic testing is:

1. Decide which branch, left or right is to be tested, locate shutters and load cameras accordingly.
2. Decide which drum, upper or lower, is to be tested and locate on the schedule of operating phase sequences the column of phase sequence numbers that corresponds to the branch and drum selected.
3. Start the motor and switch to running capacitor.
4. With one person watching the moving dial pointer, have a second person call out the lamp flashes until the flashes occur when the pointer is indicating red numbers on the inner circle of the dial, showing the system in the even cycle of operation.
5. The dial watcher then watches the first phase sequence number on the outer circle at which exposure is to be made, and releases the proper shutter when the pointer reaches this position in the *odd* cycle of operation.
6. The second person then advances the film and the process is repeated to produce an exposure at the second phase sequence number of applicable column of the schedule, and so on.
7. When phase sequence numbers in the even cycle are reached, continue to proceed as in 4, 5, and 6 above, except change "inner" to "outer" and vice-versa, and change "even" to "odd" and vice-versa.

5. Photographic Tests with Completed Camera

a. Test Area

The completed segmentation camera was set up on the 8th floor of a building where a view down the Delaware River was available through two 52-inch wide windows. The right-hand side of the camera covered the Camden side of the field of view of the camera through one window, and the left-hand side covered the Philadelphia side through the other window. It was possible to straddle the dividing frame between windows and avoid any restriction of the field of view or of the aperture of the system by the window frames.

The supporting frame work was first set up on its six jacks, levelled and bolted together. The jacks sat on a 12 foot x 4 foot laboratory table. Mirror alignment was then checked by the plumb line technique described elsewhere in this report. The rotating drum assembly was set in position and bolted, and the covers assembled and bolted in place. All seams