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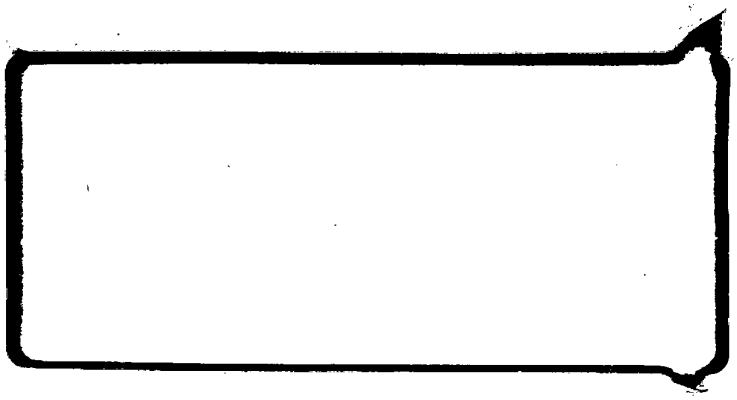

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STATUS REPORT

for period

1 July through 31 July 1970

U.S. GOVERNMENT

STAT

File No. 11038

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This document is presented as the Monthly Status Report under Contract to the U.S. Government, [redacted] STAT
The report period represented herein covers the period 1 July through 31 July 1970.

[redacted] STAT

Project Manager

[redacted] STAT

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PROGRAM STATUS SUMMARY

Scheduled percentage of completion 97%

Actual percentage this date 90.6%

The critical phase of installation and alignment of the optical system is essentially complete.

It appears that so far as the viewing branches of the optics and the main illumination systems are concerned, there has been no apparent damage in shipment and the performance is as anticipated. (This is based on preliminary results only).

The assembly work as a whole is on schedule and the results of the preliminary testing are very encouraging.

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STEREOCOMPARATOR

TASK 11

STAGE DRIVES

Scheduled percentage of completion 100%

Actual percentage this date 96%

The Stereocomparator stages exhibit a resonance of approximately 20 Hz.

The work during this report period involved instrumenting the stages with accelerometers and measuring the frequency of the resonance as various points of possible flexure were experimentally stiffened.

The objective of this work is to isolate the 20 Hz resonance.

Testing of the stage drives during this period was somewhat restricted due to the installation and alignment of the optical system.

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STEREOCOMPARATOR

TASKS 16, 17, & 18

VIEWING OPTICS, VIEWING ILLUMINATION, and RETICLE PROJECTOR and ILLUMINATION

Scheduled percentage of completion 100%

Actual percentage this date 100%

The optical installation and alignment has proceeded to the point where resolution tests have indicated values in white light of the order of 1,000 line pairs per millimeter at 200X magnification.

In addition, stereo photographs have been placed in the Stereocomparator and high quality stereo fusion has been readily achieved.

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STEREOCOMPARATOR

TASK 23

OPTICS DRIVE ASSEMBLY

Scheduled percentage of completion 100%

Actual percentage this date 98%

Work on phasing and servo loop compensation for the Optics Drive systems is continuing. As explained in the previous report, in many systems it has been found that current drive to the servo motors has yielded greatly improved performance characteristics. The status of this work is as follows:

A. Main Viewing Zoom

It was found that the gear reduction system used in this system was difficult to couple electrically from a servo standpoint. The system as originally constructed consisted of a high torque printed-circuit motor followed by a PIC 80 to 1 gear reducer. The output shaft of this gear reducer was coupled through a further spur gear reduction to operate the barrel cam controlling the position of the lens elements. It was found that the high torque output of the printed-circuit motor, when multiplied by the gear reduction ratio, was sufficient to cause slippage of the spur gear mounted on the output shaft of the gear reducer.

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In order to overcome this difficulty an experimental setup was made which eliminated the use of the PIC gear reducer. In its place was substituted a straight 1/4" diameter shaft. The effect of removing the gear reducer was, of course, to reduce the motor operating speeds by a factor of 80. Additionally, the tachometer generator voltage is also reduced by the same factor. The purpose of the experimental setup was to determine whether or not the system could be made to operate properly at such low speeds using very small tachometer feedback signals (full speed with this configuration gives a tachometer voltage of less than 0.1 volt).

It was found that the system could be made to perform properly under these circumstances provided that the velocity feedback loop gain was increased by a large factor. This requirement was due to the fact that the reflected inertia and friction loads on the motor shaft are quite high. The final configuration for this system gave a rate loop bandwidth of approximately 400 Hz and a position loop bandwidth of approximately 4.5 Hz. Rate loop control of the systems as is encountered in the manual operating mode was judged to be sufficiently

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smooth to provide satisfactory viewing characteristics.

Only one difficulty remains with this system and that lies in the fact that when the servo drive is not commanding the system, the mechanism tends by gravity to preferentially seek the end limits of travel.

In most of the systems in the Stereocomparator, a sufficient gear reduction exists such that the motor brush friction, when multiplied by the gear reduction ratio, is sufficient to hold the mechanical system in place under both power-off conditions and with the rate loop only connected. With the low gear reduction provision now installed in the viewing zooms, the motor brush friction torque does not get multiplied to a high enough value to prevent the load unbalance from driving the system back through the gear train. Means for leveling out the load characteristic over the range of travel of this assembly are being investigated, and it is expected that it will be possible to reduce the load unbalance in the system to a sufficiently low value that the friction in the system can hold the mechanism in any selected location.

B. Reticle 10X Zoom

This system has been set up to follow the main viewing zoom in order to maintain a constant reticle pattern

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size with varying magnification in the main optics. This system was found to have considerable backlash present in the integral gear reducer package attached to the motor/tachometer assembly. In order to achieve system stability, it was found necessary to reduce the position loop gain by a factor of 3; the rate loop gain was correspondingly increased to achieve the same steady-state resolution. Additionally, since this is a Type II system, containing two complex motor integration poles, there is no velocity following error at constant speeds. The reduction of the position loop gain has, however, increased the acceleration error characteristics for the system, and there is a noticeable delay in response if the main viewing zoom is suddenly accelerated. However, since under normal operating conditions the speeds and accelerations present in the optical systems are rather low, it has been found that the acceleration tracking errors present in this system produce no visible effects. Thus, the operating characteristics of the reticle zoom system appear to be satisfactory.

Due to the sensitivity of the reticle projector system to vibration, no attempt has been made to measure the bandwidthof the rate and position loops, but both appear adequate and the system is overdamped so that no overshoots or hunting is present.

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C. Main Viewing Anamorph Ratio System

This system has the compensation network designed and installed and the system appears to operate satisfactorily. The bandwidth of this system is somewhat less than the 4.5 Hz bandwidth attained in some of the other systems due to the fact that a very large gear reduction between the motor and the movable prisms exists. The motor therefore has to reach very high velocities in order to cause significant motion of the prisms, and an acceleration limit is present in the system since the servo-amplifier has a voltage limit. Additionally, in order to secure sufficient feedback potentiometer travel from the small angular motions of the anamorph prisms, a precision step-up gearing arrangement is used between the prism pinions and the potentiometer shaft. A small amount of backlash is present in this system and it was found that a wideband system displayed an unstable limit cycle caused by both this backlash and the backlash present in the gear reducer which is integrally mounted to the motor/tachometer assembly. Reduction of the rate loop bandwidth and the use of the current source servo-amplifiers described previously yielded a stable system which has good transient characteristics (overdamped). It is expected that the operation of this system as configured is satisfactory for use in the

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Stereocomparator because the anamorph optical function itself is not as drastic to the operator's eyes as are the parallax and image rotation functions.

D. Reticle Anamorph Ratio System

The reticle anamorph ratio system is mechanically similar to the main viewing anamorph ratio assembly, but of much smaller and lighter construction. Since virtually all of the optics drives systems, with the exception of the main viewing zoom, are instrument-type servo loops (i.e., the load mass reflected to the motor is insignificant compared to the inertia of the motor itself) a compensation network similar to that used on the main viewing anamorph system was installed on the reticle anamorph ratio subassembly. Operation of this system appeared to be similar to that of the main anamorph system except that it was found possible to increase the bandwidth of the system by approximately 25% in order to minimize following errors. Satisfactory results were obtained with this configuration.

The reticle anamorph system was found to have some difficulties associated with the limit switch system; specifically the prelimits, which command a velocity slowdown as the limit of travel is approached, have an operating point which extends a great distance into the active operating area

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of the range of travel of the system. The result is that if the main anamorph is slewed rapidly there is an appreciable lag in the reticle anamorph system response due to the velocity of the reticle anamorph being limited to approximately 10% of full speed over most of its range. The operator therefore could see the reticle spot become elongated for a brief period of time until the reticle anamorph system catches up the main anamorph, at which time the reticle spot becomes round. Since during normal measuring operations, the optical elements are generally moving quite slowly, it is expected that this characteristic will not produce any troublesome effects.

The limit switch arrangement in this system also has a difficulty that arises from the fact that the actuating cam motions are very small, and there is some hysteresis in the microswitch. This situation precludes the use of an integrator in the rate loop for the system, because once a limit of travel is reached, further velocity commands in the direction of the limit are not permitted to pass into the system. (This is effected by means of blocking diodes on the velocity input to the servo). With an integrator in the system even though the input has no command applied, miscellaneous bias and offset currents are present and will cause the integrator to drift. (The position loop is

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opened by the blocking diode). Thus this particular system could drift of its own accord into the second limit microswitch actuation point which would require activation of the second limit bypass circuitry in order to pull the system back into its operating range. It was therefore decided that a non-integrating (Type I) loop configuration would be used. This type of system has a finite, although small, velocity following error, but this small error is not noticeable to the operator even at very high anamorph ratios.

E. 4X - Reticle Size Zoom

This relay operated system is under manual control of the operator and allows him to set the diameter of the reticle spot in each eyepiece to a convenient size for viewing. Two speeds of operation in each direction are provided. This system operates in a satisfactory manner.

F. Reticle Brightness Control System

This system consists of a pair of counter-rotating variable-density filter wheels placed in the reticle optical path to control the apparent brightness of the reticle spot. The system has been connected to the relay control system and operates entirely satisfactorily, giving two speeds in each direction of operation.

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G. Illumination Condenser Permutation Systems

When changing from the low range to the high range of magnification in the Stereocomparator, it is necessary to switch three optical assemblies in the illumination system. These consist of a large afocal condenser lens assembly, and reorientation of the outer ring of the variable beam-defining iris located below the illumination condenser zoom assembly. These changeover systems are operated by means of geneva drive mechanisms. An exception is the iris changeover which utilizes a slip clutch to allow overtravel of the motor pinion. These systems have been connected to the relay control unit, and it is found that the changeover occurs in approximately six seconds. As has been mentioned in previous reports, it is necessary to drive the variable beam-defining iris systems to a predetermined location before changeover can occur. Depending on the setting of the main viewing zoom, this motion could take as long as three seconds. After the permutation changeover has occurred, the variable iris must then slew to the proper point corresponding to the new zoom setting which could also take as long as three seconds. Thus it can be seen that a complete changeover sequence from one magnification range to the other will require a maximum of 12 seconds. These systems work satisfactorily.

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STEREOCOMPARATOR

TASK 36

OVERALL ASSEMBLY

Scheduled percentage of completion 100%

Actual percentage this date 90%

During this report period the optical subassemblies received from the optical subcontractor were assembled into the Stereocomparator. The optical alignment has now proceeded to the point where resolution tests have indicated values in white light of the order of 1,000 line pairs per millimeter at 200X magnification.

In addition, stereo photographs have been placed in the Stereocomparator and high quality stereo fusion has been readily achieved.

The main viewing branch on the right side optics appeared generally satisfactory, based on preliminary tests.

The left side optics exhibited difficulties with image wander. This necessitated the performance of additional alignment procedures obtained from the optical subcontractor. This realignment work is presently almost complete, with good results being achieved.

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STEREOCOMPARATOR

TASK 43

COMPUTER PROGRAMMING AND SERVICES

Scheduled percentage of completion 100%

Actual percentage this date 93%

Recoding of the teletype data input package of subroutines to incorporate real formats and real units (see Status Report for June, Task 43) was completed. The information available on the formats desired for the pan and strip systems was believed to be accurate and complete. The information available for the frame system was somewhat less so, but was utilized as well as possible. The lists of items used in normal operation include a number of items which are not actually required for the Honeywell computer. These were included in order to keep the lists standard. They can be readily deleted if they turn out to be undesirable. Provision was incorporated both for punching paper tape simultaneously with typing the requested information and for reading from a paper tape if one is available. Both of these features are optional to the operator.

During the next several weeks [redacted] will be doing such recoding of the computer program as is required to utilize the additional 16K core memory which has been added to the Honeywell computer. Otherwise Task 43 is completed, except for the final system integration. STAT

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