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STATUS REPORT

for period

1 May through 31 May 1970

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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 May through 31 May 1970.

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PROGRAM STATUS SUMMARY

| | |
|---|---|
| Scheduled Percentage of Completion | 98.4% |
| Actual Percentage this Date | 86.7% |

This report period is significant in that two of the key subassemblies have been completed by the sub-contractors concerned.

These items are the Image Analysis Equipment (Itek) Task 24, and the Optical System [redacted] Tasks 16, 17 & 18. STAT

On the basis of the Acceptance Tests, it is anticipated that both the above sub-contracts will successfully perform as necessary for the Stereocomparator.

# TASK 11

## STAGE DRIVES

| | |
|---|---|
| Scheduled percentage of completion | 100% |
| Actual percentage this date | 96% |

The new motor systems were fabricated and installed. As mentioned in previous reports, these new assemblies consist of high-precision motor-tachometer sets installed in special high precision bearing and case assemblies. The pitch of the threadless leadscrews was increased to accommodate the 650 rpm top speed of these motors. Greatly improved results were obtained with this equipment from the standpoint of image jitter. Also, the lower shaft speeds completely eliminate any tendency toward shaft whip or vibration, and the systems operate very smoothly at all speeds.

A compensator is being developed for the stage drives that is compatible with the new motors.

A resonance exists at 20 hertz under some conditions of operation. The compensator is being designed to accommodate to this resonance condition.

The presence of electrical noise above 1,000 hertz is compensated by restricting the band width and by filtering to reject the noise.

# TASKS 16, 17 & 18

## VIEWING OPTICS, VIEWING ILLUMINATION, RETICLE PROJECTOR and ILLUMINATION

| | |
|---|---|
| Scheduled percentage of completion | 100% |
| Actual percentage this date | 98% |

The acceptance tests for the entire optical system for the Stereocomparator have been completed at the fabrication plant STAT

These tests showed that the system performed according to the specifications except in three parameters.

These deviations are described in the following Test Report. The various parameters measured, are shown in graphical form in the Appendix I.

It is believed that the optical system will be fully satisfactory for the Stereocomparator.

The optical subassemblies have been shipped to by the optical fabricator. A report covering the shipment STAT is included in Appendix II.

# ACCEPTANCE TEST FOR THE OPTICAL SUBASSEMBLIES FOR THE STEREOCOMPARATOR

## I. INTRODUCTION

The Stereocomparator optical subassembly consists of the complete illumination, reticle, viewing and photodetector systems plus their associated electromechanical drives and electronic readout devices.

These units are variously arranged either for mounting directly on structural elements of the Stereocomparator or are assembled in structural frames which are for mounting on the Stereocomparator.

The optical subassembly was built to meet [redacted] specification No. 8 STAT
and the Acceptance Tests were arranged to measure the equipment performance against this specification.

The test was performed during the period March 18 through May 13, 1970 at the [redacted] plant of the optical subcontractor, [redacted] STAT
[redacted] STAT

## II. CONCLUSIONS

The test data shows that the equipment conforms to specification No. 8 except for the following parameters -

a) Reticle 4X zoom restricted to 2.5X max.

b) Main 10X zoom restricted to 25X min. with the F=40mm objective.

c) Distortion exceeds ± 1% for 2/3 of field of view and exceeds ± 2% at edge of field below 32X magnification with the F=40mm objective.

During the period of the testing program, the electro-mechanical systems were operated almost continuously. Because of this extensive use, various consequent mechanical and electrical difficulties became apparent (this could be expected for any new fabrication).

In all cases these problems were analyzed and corrective measures applied. In some situations design changes were required and new parts were fabricated, and it is therefore possible to predict that further modification work should be minimal.

In summary, the testing and general observations made during use of the optical equipment indicate that [redacted] performed their work STAT
diligently and competently.

The optical equipment should be fully adequate for the requirements of the Stereocomparator.

## III. DISCUSSION

In general the performance of the equipment exceeded the requirements, most notably perhaps, in the case of the high resolution attained with white light. This is a very significant achievement considering the complexities of the optical system and the large number of optical surfaces to be traversed.

The specification deviations presented by the items a), b), and c) II above would seem to have little or no significant effect with respect to the intended use of the Stereocomparator.

The reticle spot is of substantial size at the 2.5X setting and there would seem to be no particular advantage in having the capability of increasing its size over that normally required for convenient use during measuring operations.

There are two zoom magnification ranges provided, namely 10X to 100X and 20X to 200X. The specification deviation consists of vignetting the outside diameter of the field of view progressively below 25X in the 20X to 200X range only, to a maximum of about 20%.

There is of course a "distraction factor" for the operator as the field of view becomes restricted, however the more than 80% of the field remaining is fully useable for measuring etc., and this deviation should not present a significant problem. This is particularly true when it is realized that the region 20X to 25X in the high magnification range is fully covered by the 10X to 100X parameters of the low magnification range.

There may be a problem in connection with the Image Dissector and light level control photoelectric tubes in that the action of either or both of these electronic systems may be affected to some degree by the vignetting. No great significance is attached to this condition at this time.

The distortion deviation occurs relatively far out from the center of the field of view and consequently could have no effect on measurements made with the Stereocomparator. This being due to the fact that the reticle spot, which is used as a reference during measuring, is located at the center of the field of view where the distortion is zero.

## IV. TEST PROGRAM

The Acceptance Test Program was as follows -

1. Connect all electrical cables between the optical subassemblies and the selector switch panel and servo test instrument. 

2. Install a digital voltmeter for readout of the position potentiometers.

3. Operate all systems controlled by the switch panel. Full travel in both directions, three times at least, with low, medium and high speed motor settings.

   Observe vibration, optics, and microswitch stopping of the motor.

4. Determine resolution with all variables independently and then combined. Compare with specifications.

5. Determine distortion using the appropriate targets, for both objectives (F40 & F80) and at maximum, intermediate and minimum zoom levels.

6. Determine the field flatness by measuring the diopter correction, using a microscope adaption at the eyepieces calibrated in diopters. This is required at various positions in the field and the measurement would be performed at various settings covering the full range of the optical parameters.

7. Using appropriate targets determine the anamorph range as compared to its potentiometer output.

8. Using appropriate targets determine the zoom range as compared to its potentiometer output.

9. Using appropriate targets determine the image rotation position as compared to its potentiometer output.

10. Using appropriate targets determine the anamorph rotation position as compared to its potentiometer output.

11. Repeat items 4 and 6 with the second objective in position.

12. With the appropriate targets in position measure the image wander during the full range of focussing of both objectives and during switching between objectives.

13. Measure the image wander during the operations items 7,8,9,10, and 11.

14. Measure the light level at the eyepieces, the image dissector tube position and the light level control photomultiplier tube position for the full filter wheel range.

15. Operate the eyepiece filter wheels and measure light level range at the eyepieces.

16. Operate the eyepiece shutters.

17. Operate the green filter in the main illumination system and repeat item 4.

18. Using appropriate targets operate the reticle 4X and 10X zooms and compare the ranges with their potentiometer outputs. Observe the reticle spot quality for a full range of spot and background illumination levels.

19. Using appropriate targets operate the reticle anamorph over its full range and compare with its potentiometer output. Observe the reticle spot quality for a full range of spot and background illumination levels.

20. Using appropriate targets operate the reticle spot rotator with maximum reticle anamorph effect and compare with its potentiometer output. Observe the reticle spot quality for a full range of spot and background illumination levels.

21. Operate the reticle orange filter.

22. During the specific tests described it is necessary to operate the slave sub systems at their appropriate positions and compare their potentiometer outputs with their visual performance.

23. Operate the reticle spot, light level control. Observe reticle spot quality for all levels of background illumination.

24. Observe stability of reticle spot during objective switching.

25. Observe stability and quality of the reticle spot during operation of all components in the main viewing system at all light levels of spot and background.

26. Repeat items 4 through 25 for the second eyepiece.

27. Place stereophotographs in the film plane and perform stereo viewing and examine reticle spot performance.

## V. TEST RESULTS

The test results have been presented whereever possible in the form of plotted graphs. These are listed below:

D4605. Resolution of left side viewing optics in white light with F=80mm objective lens.

D4606. Resolution of right side viewing optics in white light with F=80mm objective lens.

D4607. Resolution of left side viewing optics in white light with F=40mm objective lens.

D4608. Resolution of right side viewing optics in white light with F=40mm objective lens.

D4609. Resolution of left side viewing optics in green light with F=80mm objective lens.

D4610. Resolution of right side viewing optics in green light with F=80mm objective lens.

D4611. Resolution of right side viewing optics in green light with F=40mm objective lens.

D4612. Resolution of left side viewing optics in green light with F=40mm objective lens.

A4613. Distortion in right side viewing optics in white light with F=40 objective lens at 45X magnification.

A4614. Distortion in right side viewing optics in white light with F=80 objective lens at 47.7X magnification.

A4615. Distortion in left side viewing optics in white light with F40 objective lens at 45X.

A4616. Distortion in left side viewing optics in white light with F80 objective lens at 47.7X magnification.

B4617. Main anamorph ratio right side with F80 objective in white light.

B4618. Main anamorph ratio left side with F80 objective in white light.

B4619. Main zoom right side with F=40 objective in white light.

B4620. Main zoom left side with F=40 objective in white light.

B4621. Depth of focus left side with F40 and F80 objectives. Determination made with the resolution targets.

B4622. Reticle 4X zoom right side with reticle and main Anamorphs set at 1:1.0, and reticle and main zooms set at maximum magnification, with the F40 objective lens.

B4623. Reticle 4X zoom left side with reticle and main Anamorphs set at 1:1.0, and reticle and main zooms set at maximum magnification, with the F40 objective lens.

B4624. Reticle 10X zoom right side with reticle and main Anamorphs set at 1:1.0, and reticle 4X zoom set at minimum magnification and main 10X zoom set at maximum magnification, with the F40 objective lens.

B4625. Reticle 10X zoom left side with reticle and main Anamorphs set at 1:1.0 and reticle 4X zoom set at minimum magnification and main 10X zoom set at maximum magnification, with the F40 objective lens.

A4626. Reticle anamorph right side with reticle 4X zoom set at minimum magnification, main anamorph set at 1:1.0, main and reticle 10X zooms set at maximum magnification, with the F40 objective lens. (Method of testing modified to improve consistency of data. Work repeated. See A4626A)

A4626A. Reticle anamorph right side with reticle 4X zoom set at minimum magnification, main anamorph set at 1:1.0, main and reticle 10X zooms set at maximum magnification, with the F40 objective lens.

A4627. Reticle Anamorph left side with reticle 4X zoom set at minimum magnification, main Anamorph set at 1:1.0, main and reticle 10X zooms set at maximum magnification, with the F40 objective lens.

A4628. Reticle 4X zoom, limits of spot size selection. Magnification plotted with respect to F40 and F80 objectives, and reticle and main 10X zooms.

# TASK 24

## IMAGE ANALYSIS SYSTEM

| | |
|---|---|
| Scheduled percentage of completion | 100% |
| Actual percentage this date | 95% |

During the last report period, the acceptance tests for the Image Analysis System were performed at the [redacted] STAT

[redacted] STAT

The equipment was found to be generally quite acceptable in performance for use in the Stereocomparator, although the minimum performance requirements were not met fully.

The results of this testing are described in the memorandum which follows. Also included is the reduced test data. (Appendix III)

Work on this task is complete until installation of the equipment in the Stereocomparator.

19 May 1970

Memo to: [redacted] STAT
From:
Subject: Results of Acceptance Tests on Image Analysis System purchased from [redacted] STAT

## I. INTRODUCTION

During the period extending from May 4, 1970, through May 15, 1970, acceptance tests for the Image Analysis System to be used in the Stereocomparator were performed [redacted] STAT facility. These tests were generally performed as outlined in the document "Image Analysis System Test Procedures" as revised May 4, 1970, and performed or witnessed by myself. The results of these tests are described in the following paragraphs in terms of performance measured against the specification for this system, [redacted] Specification No. 10 as STAT revised September 4, 1968. Generally speaking, the performance of the equipment is compared to the requirements of paragraph 10E of the above mentioned specification, although many of the design goals described in paragraphs 10B, 10C, and 10D were met and will in some cases be noted. It will be noted that four slide sets were used in the quantitative testing instead of the three specified in the Test Procedures. This was done because the 1:1 copy of slide A (called "A-NEW") yielded peculiar results in the combined error correspondence tests, and it was felt that data from the 2:1 copy (called "A-OLD") would be more informative. It was subsequently found by measurement that the "A-NEW" slide had been printed with the anamorph ratio incorrect, thus causing the strange results. In all probability, "A-NEW" would meet the specification for combined error outputs for the anamorph ratio existing, but this has not been checked due to time problems.

Tests were carried out at approximately 0.2 fc and 0.02fc or about the light level expected in the machine and 1/10 of that value. Higher light level checks were not run, although I noted that the automatic gain control system in the unit was still functioning linearly under open-gate conditions (about 17 fc) which is higher than we will be using in the machine.

## II. CONCLUSIONS

The results of the testing indicates that the equipment should be generally satisfactory for use in the Stereocomparator, although in a few areas the system did not fully meet the minimum performance requirement levels. These areas are generally as follows:

A. The skew pull-in range is slightly under the desired range (by about 10%) for most photography.

B. Linearity is occasionally out of tolerance, depending on imagery.

C. If the system is just barely on the margin of not being able to lock on, the loop gains are such that the pull-in time exceeds 0.2 second.

Although the equipment did not fully meet all specifications in the above areas, it should be noted that the system was never very far out of specification. In particular, at no time were inconsistent or useless outputs obtained. Thus, although an indication may be slightly out of tolerance from the standpoint of linearity, it is still in the correct sense to give a proper direction of corrective action for the optics servos, and the machine is a useful transducer; outputs appeared to be monotonic, so that false nulls are minimal. The fact that the Stereocomparator computer program makes an exact transformation from the correlator outputs to optical differences in "lens space", rather than merely using sum-and-difference approximations to these signals, allows more latitude in these areas, so that minor scale factor changes should have a minimum effect.

At low light levels the performance was nearly as good at 0.02 fc as at 0.2 fc, which is the expected operating level for the Stereocomparator.

All in all, the usefulness of the system as a servo feedback transducer is, I believe, well established in the detailed test summaries and data which follows in this report, and based upon this data, it is recommended that the equipment be accepted for use in the Stereocomparator.

## III. DISCUSSION

The quantitative tests on the Image Analysis System showed that the unit very nearly meets the minimum performance requirements completely. In many areas, the design goals are also met. The fact that absolute criteria were used wherever possible further supports the quality of performance of the equipment, whereas relative measurements would have made the unit appear somewhat better, but would have been less useful in assessing the operation of the unit in the Stereocomparator. For example, using <u>everything</u> causing a deviation from an output of 0.000...... volts in crosstalk measurements gave a good indication of zero point independence with varying imagery as well, but at the cost of a few more points appearing out of specification. For the quantitative testing, therefore, I conclude that

A. The Image Analysis System very nearly meets the Minimum Performance Specification of [redacted] Specification No. 10. STAT

B. Where the system is out of tolerance, it is not out by very large amounts.

C. The system performance is essentially independent of light level.

D. Many of the design goals were met above and beyond the minimum performance requirements.

The qualitative testing is much more difficult to evaluate. Perhaps the best term to describe the results is "no surprises!" In general, the machine appeared to perform quite well with stereo imagery. Two factors in a system such as this make the performance less than perfect, in theory as well as in practice. These are:

A. The outputs of the system are a statistical correlation of an instantaneous point-by-point product of the two video channels, corrected to make this crosscorrelation product as high, on the average, as possible. In other words, if the system can distort noncorresponding objects to match to a sufficient degree, it will do so.

B. By using a two-axis (see-saw) scanning system (or any periodic scanning pattern, for that matter), if an image detail lines up along a scan line, most of the information associated with that detail is lost along that axis. If that detail is the only significant one in the area scanned, the system suffers from lack of sufficient information to develop good output signals.

The consequences of the above facts leads to some general statements which can be made with respect to operation of the system, confirmed during testing. Probably the easiest way to present them is in the form of a "most likely to fail" list of imagery conditions:

A. Man-made objects tend to be so regular that they produce relatively narrow-band outputs which may or may not fall within the correlator passbands. Additionally, such objects as buildings can quite easily have their edges line up with scan lines, causing reduced information and therefore noisy first-order outputs. If an operator is consistently obtaining poor performance, generally a change in magnification can be used to shift the outputs into the useful frequency ranges.

B. Repetitive patterns of almost anything tend to confuse the system if there is insufficient non-repetitive data within the correlator passbands.

C. If an axis of symmetry exists in the scanned area which involves most of the useful detail, then a high probability exists that the system can make a rotational error of 90 or 180 degrees.

D. The presence of large differential distortions between the two photographic views may reduce the pull-in range to a useless value. This is due to the limit of correction available.

As opposed to the above conditions, I found the system to be quite acceptable in that for most conditions I could get the system to within pull-in range by merely observing the reconstructed video displays; that is, my ability to align the images by just observing these low-resolution video displays singly was sufficient to get within the pull-in range.

It should also be remembered that for most cases, once the system has locked on to the images, its tolerance for differences increases; that is, the machine may pull in from (say) 5% of the scanned area, but once locked on, it will hold with errors of up to (say) 10% of the scanned area.

## IV. TEST RESULTS (Quantitative)

1. Spec 10E, paragraph 1. Tests minimum acceptable pull-in range for parallax and minimum detectable error, i.e., signal-to-noise ratio.

This specification was met with all slides at 0.2 fc. Slides "A-OLD" and B did not meet the specification at 0.02 fc with extreme parallax errors. Slides "A-NEW" and B were slightly out of spec at 0.02 fc. The noise of the system was generally well below requirements at 0.2 fc.

2. Spec 10E, paragraph 2. Tests pull-in range and noise for scale outputs.

Pull-in range was met at both 0.2 fc and 0.02 fc on slides "A-NEW", B, and C. "A-OLD" was out of spec at extreme scale differences at both light levels. The system met all noise specs at 0.2 fc and was out of spec by about 6 dB at 0.02 fc on all slides except "A-OLD" which was in spec.

3. Spec 10E, paragraph 3. Tests pull-in range and noise for skew outputs.

Pull-in range was met at 0.2 fc on slides "A-NEW" and B and was out of spec by about 10% on slides "A-OLD" and C at this level. All slides were out of spec at 0.02 fc by about 20 to 30 percent of full range skew error although this still gives a pull-in range of 10 degrees of rotation; most were better, being 12 to 15 degree pull-in ranges.

Noise was met with all slides at 0.2 fc and was out on all slides by about 6 dB at 0.02 fc.

4. Spec 10E, paragraph 4. Tests for consistency in final output signals with combinations of errors present.

This was evaluated in the error correspondence test, next paragraphs. Paragraph 4 is thus considered satisfied.

5. Spec 10E, paragraph 5.

Tests the following:

a) Zero stability with time (and temperature as it turned out).

b) Crosstalk between outputs.

c) Combined error correspondence; i.e., the ability of the equipment to resolve combination errors into their respective components to a specified degree of accuracy.

The results were as follows:

a) The unit easily met the stability requirements over a 20-degree Fahrenheit ambient temperature range.

b) Crosstalk was measured only at 0.2 fc. I interpreted the requirement to include the ability of the machine to give zero outputs plus or minus the minimum detectable difference with identical slides, that is to include any zero offsets present with the slides matched as well as possible for position and rotation. took this specification STAT

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as a deviation from any (constant) residual error outputs with identical slides. Using their interpretation, the machine passed completely; using my interpretation the machine performed as follows:

All combinations passed on slide "A-NEW."

Crosstalk of X and Y parallax into X skew was slightly out in the central parallax range in slide "A-OLD" (due to an initial offset in X-skew which was not correctable). All other combinations were within specification.

Slide B passed with all combinations except at one point X parallax crosstalk into Y-skew was slightly out of spec.

Slide C was out of spec on all channels into X-scale, X-skew, and Y-skew, due partly to an initial zero offset. Also, this slide definitely lacked picture detail along the X-axis, so that the machine had difficulty here. Using Itek's criteria, the machine mainly passed.

c) Combined error correspondence. As stated earlier, slide "A-NEW" was processed to have an incorrect anamorph ratio (1.25:1 vs. 1.56:1) so the data taken did not meet the theoretical specifications. The outputs do, however, look reasonable for a slide with anamorph ratio of 1.25:1.

Slide "A-OLD" passed with one hand behind its back. The system was within 10% of exact correspondence everywhere.

Slide B was also excellent, except for one point in Y-skew, which may have been an erroneous reading of the instrument used to take data (a rather old DVM).

Slide C passed well on X-skew and Y-skew. X-scale and Y-scale were occasionally out of tolerance by a small amount.

Overall, the performance of the machine in this area was far better than hoped for.

6. Spec 10E, paragraph 6. Tests linearity of output voltages vs. optical distortions.

By agreement, the tolerance was plus or minus 5% of full scale output over the central 30% of the operating range and plus or minus 10% of the theoretical value over the remainder of the operating range.

Tests were run at 0.2 fc and 0.02 fc. It should be noted that the theoretical values were based upon the average of the least-squares-fit straight line plots for each variable, measured on all slides, so that the following results are also a measure of the independence of linearity of the unit from image content and also zero-point stability with changing imagery. Thus, the following tests are quite absolute in nature, and indicate that the design goals were met with respect to matching of X and Y constant multiplier factors and also that the desired factors were attained.

All slides met the specification at both light levels for X and Y parallax and for Y-skew. The linearity of parallax outputs is incredible.

Slide "A-NEW" met specification at 0.2 fc on everything except X-scale, with one point slightly out of spec at a scale ratio of 1/1.1 to 1. It met specification for everything except X-scale (1/1.1 to 1) and X-skew (-0.07 and -.14) with these points slightly out.

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Slide "A-OLD" met all spec at 0.2 fc; X-scale, Y-scale, and X-skew were slightly out at 0.02 fc with X-skew showing some compression of its range.

Slide B met all spec at 0.2 fc except X-skew, which was slightly compressed for negative values. Everything met spec at 0.02 fc except X-scale (extreme end) and X-skew being compressed as at 0.2 fc.

Slide C met all spec at 0.2 fc except for one point at 1/1.1 to 1 in X-scale which was out slightly. Performance was similar at 0.02 fc with the same X-scale point out and positive skew values slightly out of tolerance.

Thus, it can be seen that the machine displays generally excellent linearity, substantially independent of image content and light level. If a best fit line had been used for each slide (relative linearity instead of independent or absolute linearity) performance would have looked somewhat better.

7. Spec 10E, paragraph 7. Speed of response of system.

This test was made at 0.2 fc with full-scale errors applied either optically or electrically. The "enable" circuit was activated and the 0 to 90% settling time measured. The system met all specifications (0.2 sec. max.) with all outputs showing overdamped response (i.e., no overshoot or ringing).

8. Spec 10E, paragraph 8. Tests for the frame rate being synchronous to the AC power line.

The system was checked for synchronization to the power line (via its phase-locked time-base oscillator) and it was found to be 480 frames per second with line rates of 7,680 Hz for X and 7,200 Hz for Y, all line-synchronized. Thus, this specification is met fully.

9. Spec 10E, paragraph 9. This defines operation of the "correlation quality" signal which indicates whether the system is working acceptably.



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This test was run by observing this output signal throughout other quantitative tests. In no case did the system give false "correlation good" signals, although the system did occasionally give "correlation unacceptable" signals when it was obvious that the unit was correlating. The system uses the following criteria in order to develop the "correlation acceptable" signal:

a) Cross-correlation (that is, the RMS product of the two video signals multiplied together) must be above a certain threshold level.

b) Orthogonal correlation (that is, the products of in-phase and quadrature components of the picture signals which will be analyzed for errors) must be above a certain threshold at 19 KHz, corresponding to about 30% of the field of view as a maximum permissible parallax error.

c) None of the first-order (scale, skew) outputs must be saturated.

The logical "AND" of (a), (b), and (c) is used; failure of any of the above criteria will give a "correlation unacceptable" signal. Since the thresholds of all of these criteria are adjustable by means of potentiometers, the system can be set for any degree of optimism or pessimism. As set during the tests, the unit appeared to be 100% "runaway-proof," although resetting of the thresholds would give a somewhat larger pull-in range at the cost of a less picky system, more liable to false correlation outputs being used. Experience with stereo photography will show the correct adjustments, and the machine was thus judged as meeting this specification.

10. Spec 10E, paragraph 10. Defines range of light levels over which equipment must operate.

This specification is covered by data taken in other tests, since it defines the photography and light levels. It should be noted that performance of the unit was not substantially degraded at 0.02 fc, even though the noise in the video systems was plainly visible on the test instrumentation. Also, examination of the microdensitometer runs on the slides showed that in many areas the 2:1 contrast ratio was not present, so that I judged the specification met in that the system is definitely usable with poorly-processed or dense photography. Considering the light levels expected in the Stereocomparator, there should be no difficulty.

11. Spec 10E, paragraph 11. This defines the scale factor stabilities as a function of time.

apparently interpreted the specification to mean stability of scale factors with time and image content, so as noted above, this specification was easily met from the standpoint of time drift and is also remarkably free from image content effects. STAT

## V. FURTHER QUALITATIVE TESTS ON STEREO PHOTOGRAPHY

After completing the quantitative testing, further tests were made using real stereo pairs to see that the present of higher order distortions did not upset the system too much. The general procedure used was as follows:

A. The slides were placed in the test fixture so that corresponding areas were being scanned. The system was adjusted for minimum parallax and skew indications. The test fixture micrometers and angle vernier scales were read.

The slides were moved around to find any possible false correlation points. This included both translation and rotations in combination.

B. A Y-parallax was introduced gradually, with the correlator being disabled periodically until a point was reached where the system failed to pull in. The system was then adjusted to barely achieve pull-in. The micrometers were read. Next, a Y-parallax in the opposite direction was introduced and the above procedure followed.

C. The procedure outlined in B above was performed with the Y-axis returned to its reference position and X parallaxes introduced and read.

D. With the X and Y axes returned to the reference position, a rotation was introduced, again periodically disabling the system to find its maximum pull-in range. No nulling of any parallax readings was done, so that these distortions were present as well (the test fixture center of rotation with respect to the image dissector "center of rotation" was misaligned by about 0.01 inch). The vernier dials were read and a rotation of the opposite direction was introduced and the procedure repeated.

E. Where possible, combinations of parallax and rotations were introduced. This was mainly done by "feel" and gave some indication of the combined error performance with stereo photography.

F. In all measurements above, the pull-in time was recorded as well.

The above tests were run at 0.2 fc. A few spot checks at 0.02 fc disclosed no large change in performance characteristics. At the limits of correlation, the video noise at 0.02 fc was, as likely as not, sufficient to kick the system into correlation!

The results of tests with various slides follows:

A. Slide S211. This is a scene having in it a housing tract, some large school or industrial buildings, roads, a rather deep pit or quarry, and some fields planted with regular rows of some sort of bush.

The system was first set up near the pit, where considerable higher order distortions would be present due to ground relief. The system showed a total pull-in range of +7.2%, -7.3% of the area scanned for X-parallax, a range of +8.5%, -8.6% for Y-parallax, and $+22.6^{\circ}$, $-8.3^{\circ}$ rotation range. There were two similar fields in the picture, and it was found that correlation could be obtained on noncorresponding fields. This was not surprising, since the fields look quite identical to the eye as well. The maximum pull-in time for correlation was 0.16 second.

B. Slide S232. This is a hilly scene, partly forested and covered with scrub brush. There is apparently a creek bed in the photograph and some roads and/or foot-paths leading among the trees.

The picture was first zeroed up on a small foot-path or road leading into a grove, where it ends. The scanned area was approximately centered on the visible end of the road. The pull-in range was found to be:

X-parallax: +2.7%, -0.1% of area scanned
Y-parallax: +4.7%, -1.0% of area scanned
Rotation: $+17.5^{\circ}$, $-16.5^{\circ}$

Maximum pull-in time was 0.2 second.

As can be seen, the lack of gross detail greatly reduced the parallax range, since most of the correlation was done on trees. However, the presence of the line (road) is sufficient to give quite good rotation range. Throughout the testing, it was noticed that trees are rather poor objects for correlation since one tree pretty well looks like another.

The slide was moved to get a place where the creek-bed formed a wye and the system was zeroed. The results were:

X-parallax: +5.3%, -5.4% of area scanned
Y-parallax: +4.1%, -7.6% of area scanned
Rotation: $+9.5^{\circ}$, $-8.5^{\circ}$

Maximum pull-in time was 0.3 second.

As can be seen, the presence of some gross terrain features increased the pull-in range on parallax, but the absence of any strong straight lines reduced the rotation range some. It was not found possible to obtain false correlation in this picture anywhere tested, which included rotating the wye area, etc.

 STAT

C. Slide S401. This is a scene similar to the first, containing regular fields, buildings and roads. Its main feature, however, was that it contained great amounts of tilt distortion; the pictures appear to have been taken quite fore or aft of the airplane, and far displaced to port and starboard as well. The net result is, of course, a large amount of differential skew between the two views. The system was zeroed on a cluster of buildings surrounded by fields and roads, and the results were:

X-parallax: +8.8%, -6.8% of area scanned
Y-parallax: +8.6%, -7.9% of area scanned
Rotation: $+19.5^{\circ}$, $-20^{\circ}$

Thus, in spite of the tilt distortion, the machine had good range. It should be noted, however, that the correlation quality signal showed "unacceptable" over most of the range due to saturation of the skew correction circuitry. The maximum pull-in time was 1.0 second. It was not found possible to obtain false correlations on this photograph probably because the presence of the buildings overcame any tendency of the unit to get confused by the regularly-planted fields. The most significant finding on this slide was the fact that even when the raster-correction circuits are saturated and the machine cannot fully correct the distortions present, the saturation signals are generally in the correct direction to cause the optics to run properly. This was most encouraging. However, the correlation quality signal indicating "unacceptable" shows that the apparent pull-in range is a function of the difference between the views; that is the total correcting capability of the unit is a fixed amount, and the sum of the differential picture distortions plus operator misalignment must be less than this amount. Thus, with severely different views (most likely with panoramic views) it is theoretically possible to have zero pull-in capability from the standpoint of operator misalignment. (In practice, the stereo model would probably be so poor anyway that the photography would be rejected for stereo viewing if this were to occur, since the correlator can tolerate larger tilt distortions at times than the optical system can correct.)

D. Slide S210B. This slide comprised a housing tract made up of parallel rows of identical houses. The machine behaved quite poorly on this slide, as may be expected. The pull-in range was practically zero, although acceptable signals were given when corresponding areas were lined up. Any attempt to pull away from this position of exact correspondence caused the correlation quality signal to give "unacceptable" and it was obvious from watching the test instrumentation that the machine was equivocating between adjacent buildings trying to lock on, but couldn't. Throughout the testing it was an interesting observation that if a square or rectangular object came into view, the machine would make a leap towards it, achieve partial correlation, and then, because the objects did not correspond, give up. During this interval, no false quality signals appeared, which was very good.

E. Slide S233. This scene contains some ploughed fields, a large square area in one corner of the picture apparently covered with water, some wooded areas, and either a park or a cemetary. Also, a few small buildings are in evidence. There is a fair amount of ground relief. The wooded area separates the fields from the park. The machine was zeroed up on the wooded strip between the fields and park, and the following range was obtained:

| | |
|---|---|
| X-parallax: | +18.0%, -10.3% of area scanned |
| Y-parallax: | +8.3%, -8.9% of area scanned |
| Rotation: | $+23.1^{\circ}$, $-29.9^{\circ}$ |

The pull-in range is excellent. During this test, I noticed that the video display of the scanned area looked quite symmetrical about the X-axis. I therefore tried rotating one slide 180 degrees and found that a correlation would indeed occur. The pull-in range was similar.

 STAT

Various other areas were tried in the photograph, and it was found that since the park is nearly circular, an occasional false correlation would occur. Thus, it was found that axes of symmetry affect the unit as would be expected. The maximum pull-in time was 0.5 second.

## VI. TEST DATA

In Appendix III are the actual readings taken as the basis for acceptance of the Image Analysis System.



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# TASK 28

## OUTPUT LOGIC & INTERFACES

| | |
|---|---|
| Scheduled percentage of completion | 100% |
| Actual percentage this date | 98% |

Work is continuing on noise reduction and systematic checkout of all circuitry associated with the logic functions in the Stereocomparator. A particular area of work has been concerned with behavior of the machine when switching between the manual and automatic modes of operation, so that all the various registers and status flipflops are properly cleared and set to prevent any sudden jumps or lurches when switching modes. Also, small computer routines simulating various portions of the software are being run in the computer to make certain that no hardware/software interface difficulties exist.

The logic system is now ready for integration of the optics drive systems, and this will be done during the coming report period.

# TASK 43

## COMPUTER PROGRAMMING & SERVICES

| | |
|---|---|
| Scheduled percentage of completion | 100% |
| Actual percentage this date | 92% |

During the month of May work continued [redacted] STAT with programming for the strip and pan photography.

In addition, work was performed by the computer program subcontractor, [redacted] A report of their work STAT follows:

1. During April a simulation program was created to aid in checking out the mathematics for strip photography. Using the simulator, the mathematics for strip photos was checked out. However, toward the end of the month, a reorganization of the mathematics was undertaken in order to improve the interpolations and the sensitivity of the optical partial derivatives.

2. During May, the mathematics for strip photography will be checked out again, and checkout of pan photography will be undertaken. Some time in May, Informatics will again terminate work on the program while waiting for the Stereocomparator hardware to be finished.

3. At this time there exist no pending unresolved technical problems.

4. During April, two informal agreements were made on

technical matters not requiring the approval of the Contracting Officer:

1) the camera station attitude and location angles are to be interpolated on independent intervals.

2) the most recent value of camera station velocity shall be used upon each entry to subroutine PTOP. This makes the optical partials more sensitive to camera station angles.

5. The only other unresolved matter concerns Informatics' temporary suspension of work on the Stereocomparator while awaiting its completion. [redacted] will transmit to [redacted] a letter STAT
stating the reasons for the suspension and requesting that [redacted] STAT
quote to [redacted] a date on which work can resume. STAT