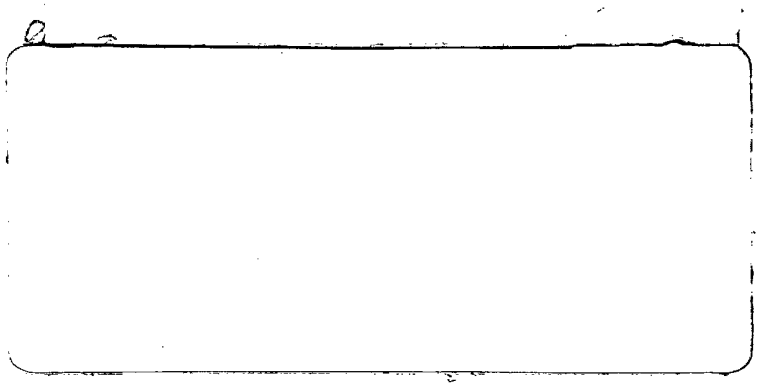
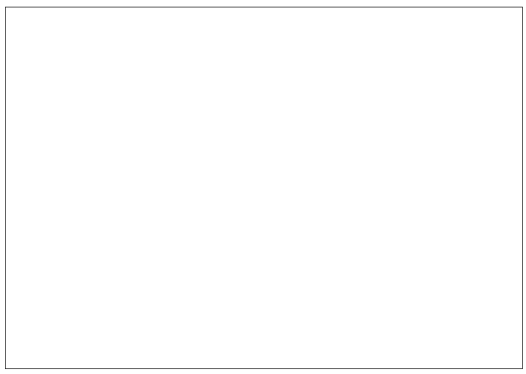
11038





STAT

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UNCLASSIFIED

Project File Copy

STAT

Automated Film Transport S.

UNCLASSIFIED

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STATUS REPORT

for Period

1 January through 31 January 1969

Submitted under Contract to

U. S. Government

[redacted] STAT

File No. 11038

[redacted] STAT

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 of 1 January through 31 January 1969.

[redacted] STAT

[redacted] STAT

# INDEX

# APPENDICES

# PROGRAM STATUS

Summary as of January 31, 1969

Scheduled percentage of program completed - 44.3%

Actual percentage completed this date - 42.8%

Overall program progress during the month of January has followed the original plan, with the exception of the schedule slippage which has been reported by [redacted] This schedule slippage is discussed in greater detail under Tasks 16, 17 and 18. STAT

During this report period, there has been considerable progress which is not readily discernible, as it consists of many minor sub-assemblies and basic checkout. This "unglamorous" activity will continue for the next two months, at which time the larger sub-assembly checkout and test is scheduled to occur.

Task 01 Specifications and Reports

| | |
|---|---|
| Scheduled percentage of completion | 46% |
| Actual percentage of completion | 46% |

No new major specifications were issued during this report period.

Subcontractors' progress reports are being issued as they are received, and are covered under appropriate task headings.

Task 02 Scheduling and Planning

| | |
|---|---|
| Scheduled percentage of completion | 46% |
| Actual percentage this date | 46% |

The Program Planning (PERT) chart, [redacted] number F6826, STAT has been revised, and new schedules have been issued which reflect the schedule slippage reported by the optical and image analysis subcontractors.

Task 03 Test and Inspection Procedures

| | |
|---|---|
| Scheduled percentage of completion | 27% |
| Actual percentage this date | 24% |

Plans for testing the interferometer assembly as a system were initiated during this report period. It is expected that there will be increased activity in the development of test and checkout procedures in the next three report periods, when the majority of the sub-systems assembly and checkout is scheduled.

Task 04 Management, Administration and Supervision

| | |
|---|---|
| Scheduled percentage of completion | 46% |
| Actual percentage this date | 46% |

Program Management was routine during the month of January. A meeting was held with [redacted] - the Image Analysis subcontractor - during the month. Details of this meeting are covered under the appropriate task heading. STAT

Task 05 Meetings

| | |
|---|---|
| Scheduled percentage of completion | 46% |
| Actual percentage of completion | 46% |

During the last two weeks of January, two sets of meetings were held at the [redacted] facilities with the customer. STAT

Progress on the fabrication of the Stereocomparator was reviewed, and the customer was given a tour through the [redacted] STAT shop to observe fabrication techniques and hardware on hand for the various subassemblies.

The customer presented resolution and other test targets for review by [redacted] STAT

The status of the customer designed clean room facility was discussed with a review of [redacted] customer installation interface STAT problems.

Task 06 Facilities Requirements

| | |
|---|---|
| Scheduled percentage of completion | 60% |
| Actual percentage this date | 50% |

All require equipment has been received, and purchase orders placed, for the installation of the air conditioning equipment in [redacted] Clean Room. STAT

The sheet metal (ductwork) has been fabricated in the vendor's plant, and is ready for installation.

We anticipate that considerable progress will be reported in the next issue of the Status Report.

Task 07 Main Frame and Structural Elements

| | |
|---|---|
| Scheduled percentage of completion | 98% |
| Actual percentage this date | 93% |

No additional work was scheduled for this task for the month of January.

This task is virtually complete.

Task 08 Skin

Scheduled percentage of completion 90%

Actual percentage this date 83%

Additional work was performed in the [redacted] shop STAT attaching ribs to the aluminum skin shrouding for the control console and other subassemblies.

This ribbing not only increases the structural rigidity of the machine, but also forms the decorative molding in keeping with the approved concept of the finished machine design.

Task 09 Granite and Ways Assembly for Stages

| | |
|---|---|
| Scheduled percentage of completion | 90% |
| Actual percentage this date | 83% |

The holes and brass plugs in the two "T" granite sections were drilled and tapped by the [redacted] shop during the month of January. These sections were then installed on the granite bases. STAT

The two granite stages on which the film will be mounted were received from the vendor, and the necessary holes and brass plugs are scheduled to be drilled and tapped by the [redacted] shop during the next report period. STAT

The remaining granite sections, consisting of the two laser supports and the four interferometer supports, will be delivered by the vendor during the month of February.

Task 10 Air Bearings

| | |
|---|---|
| Scheduled percentage of completion | 58% |
| Actual percentage this date | 53% |

Air bearings to support and guide the granite "T" sections were installed during the month of January.

As soon as the granite stages are drilled and tapped, these will be mounted onto the "T" sections, and the air bearings required to guide and support the stages will be installed.

Task 11 Stage Drives

| | |
|---|---|
| Scheduled percentage of completion | 58% |
| Actual percentage this date | 53% |

As soon as the granite stages have been mounted into position, the stage drive assemblies will be installed.

It is anticipated that this work will be completed during the next report period.

Task 12 Film Drive and Transport System

| | |
|---|---|
| Scheduled percentage of completion | 50% |
| Actual completion this date | 60% |

Mechanical modifications of the film drive are now being done in the [redacted] shop. When this work is completed, the electronic portion of this subassembly will be operationally tested in a breadboard assembly before it is installed on the granite stages. STAT

Task 13 Film Platen and Film Clamping

| | |
|---|---|
| Scheduled percentage of completion | 36% |
| Actual percentage this date | 33% |

In order to resolve minor difficulties experienced with the film clamping device, the [redacted] shop is building a prototype model to insure a proper film clamping operation for the Stereocomparator. STAT

Task 14 Film Cooling

| | |
|---|---|
| Scheduled percentage of completion | 26% |
| Actual percentage this date | 25% |

The customer's representatives and consultant visited [redacted] and discussed the film cooling environmental control problems as related to the overall Stereocomparator installation in the customer Clean Room facility. STAT

It was agreed that the film cooling air supply (temperature and humidity controlled) equipment would also provide a source for the conditioned air necessary for supporting and controlling the film during its passage over the platen.

The scheme envisioned for handling the film is to float the under side of the film on conditioned air jets and maintain its position by a downward flow of air from the film cooling nozzles, together with any auxilliary air jets found necessary.

It is clear that the dimensional stability of the film under these conditions would be fully as critical, with respect to the control of its environment, as that for the film cooling process alone.

A breadboard is presently in process of construction using the actual platens and film drives to enable the proper dynamics of film handling to be realized.

Tasks 16, 17 and 18 — Viewing Optics, Viewing Illumination, Reticle Projector and Illumination

| | |
|---|---|
| Scheduled percentage of completion | 21% |
| Actual percentage this date | 31% |

The optical subcontractor, [redacted], has delivered approximately twelve drawings of updated subassemblies for most of the major components of the optical train. STAT

[redacted] has continued with their detailed optical redesign in respect to the glass specifications for the material as actually used in making the optical elements. STAT

Redesign has been required for the zoom assemblies in that a third set of independently moveable elements have had to be added to the original two sets of independently moveable elements.

Additionally, redesign was required for the anamorph assembly to separate the drive for one of the four sets of prisms from that for the other three sets of prisms. As now designed, one set of the four sets of prisms performs a displacement with a different angular function compared to that for the other three sets of prisms. These latter prisms are still directly coupled together and have their own particular angular displacement function.

[redacted] is presently predicting maintenance of the sche STAT which was provided to [redacted] early in December and reported last month. STAT

Task 20 General Platen Illumination

| | |
|---|---|
| Scheduled percentage of completion | 55% |
| Actual percentage this date | 41% |

The general platen illumination assembly was tested by the [redacted] shop during the month of January. STAT

This assembly is now ready for installation on the Stereocomparator.

Task 21 Optical Bridge and Supports

| | |
|---|---|
| Scheduled percentage of completion | 90% |
| Actual percentage this date | 90% |

No work was scheduled on this task for the month of January.

The bridge and supports have been sent to the optical subcontractor for installation of the optics.

Task 22 Interferometer Assembly

| | |
|---|---|
| Scheduled percentage of completion | 56% |
| Actual percentage this date | 57% |

Both the mechanical and electronic portions of the interferometer assembly are complete and ready for installation into the Stereocomparator.

Tests will be performed on the assembly in relation to the stage drives during the next report period.

Task 23 Optics Drive Assembly

| | |
|---|---|
| Scheduled percentage of completion | 40% |
| Actual percentage this date | 38% |

Virtually all of the electronic chassis required for the optics drive assembly have been received. A field trip was made to the vendor supplying these chassis, and an approximate delivery date of the first week in February was given for the balance of the chassis.

Information has been received from the optical sub-contractor regarding specifications for two additional chassis required to interface with the optical system.

These specifications have been formulated by [redacted] and fabrication bids have been requested from vendors. STAT

Task 24 Image Analysis System

| | |
|---|---|
| Scheduled percentage of completion | 32% |
| Actual percentage this date | 32% |

During the month of January, a visit was made by [ ] STAT to the [ ] to coordinate the [ ] effort and evaluate their STAT progress.

[ ] has slipped their schedule by approximately one STAT month. [ ] will be able to react to this change without significant STAT effect on the overall Stereocomparator program.

During the discussions, the interface requirements between [ ] were further developed and made firm. Various STAT aerial photographs were shown by [ ] as examples of their thinking STAT with regard to their suitability for acceptance test imagery.

[ ] was asked to proceed with these photographs by STAT making the various optical transformations necessary for the testing effort and submit appropriate prints of the imagery to [ ] for evaluation. STAT

A copy of [ ] monthly progress report is attached STAT as Appendix I.

Task 26 Digitizing Logic Subassembly

| | |
|---|---|
| Scheduled percentage of completion | 82% |
| Actual percentage this date | 82% |

This task is virtually complete. No additional work was scheduled on this task for the month of January.

Task 27 Metric Readout

| | |
|---|---|
| Scheduled percentage of completion | 90% |
| Actual percentage this date | 92% |

No work was scheduled on this task during the month of January.

This task is virtually complete.

Task 28 Output Logic and Interfaces and Systems

| | |
|---|---|
| Scheduled percentage of completion | 84% |
| Actual percentage this date | 68% |

As reported previously, the punch control section of the output interface chassis has been completed. Bench testing of the internal computer interface unit is now in progress.

Due to the re-scheduling of the wiring for the console, this equipment will not be ready for testing with the output interface chassis until the end of the next month.

Task 29 Cabling

| | |
|---|---|
| Scheduled percentage of completion | 86% |
| Actual percentage this date | 82% |

The percent progress of the cabling required to interconnect the various electrical and electronic elements being assembled in the [redacted] shop is as follows: STAT

| | |
|---|---|
| Cabinet #1 (Stage drives, film drive and Transport system) | 100% |
| Cabinet #2 (Optics drive, interface with Image Analysis System) | 100% |
| Cabinet #3 (Metric readout, output logic and interfaces) | 89% |
| Electrical arrangement (floor interconnection of all cables) | 88% |
| Control Console | 97% |
| Display Panel | 10% |
| Optical Bridge | 30% |
| Stage Assembly | 73% |

Task 30 Control Console and Chair

| | |
|---|---|
| Scheduled percentage of completion | 70% |
| Actual percentage of completion | 56% |

We have re-scheduled the wiring of the control console for the month of February.

The operator's chair has been received from the vendor, and the modifications necessary are being scheduled for the [redacted] shop. STAT

Task 32 Computer

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

No work was scheduled on this task during the month of January.

This task is virtually complete.

Task 33 Electronic Racks and Control Cabinets

| | |
|---|---|
| Scheduled percentage of completion | 72% |
| Percentage completed this date | 78% |

The electronic racks and control cabinets were received from the vendor during the month of January.

We have scheduled the installation of the electronic chassis to begin during the next report period.

Task 34 Utilities, Vacuum and Air Systems

| | |
|---|---|
| Scheduled percentage of completion | 39% |
| Actual percentage this date | 35% |

The cabinet housing the utilities, vacuum and air systems has been received from the vendor.

The installation of the mechanical components comprising the utilities assembly is scheduled for the month of February.

Upon completion of this installation, the electronic chassis in the same rack, which are required to operate the utilities, will be installed.

Task 35 Vibration Absorption and Leveling

| | |
|---|---|
| Scheduled percentage of completion | 90% |
| Actual percentage this date | 85% |

As reported last month, [redacted] the vendor STAT supplying the vibration control system, is providing modified control equipment to be used on the Stereocomparator. This equipment was scheduled to be delivered to [redacted] by the end of January, STAT but has been delayed until February.

Checkout of the vibration control system will be done by [redacted] personnel after installation of this equipment is STAT completed.

Task 36 Overall Assembly

| | |
|---|---|
| Scheduled percentage of completion | 21% |
| Actual percentage this date | 10% |

No work was scheduled for this task during the month of January.

Task 37 Radio Frequency Noise Suppression

| | |
|---|---|
| Scheduled percentage of completion | 0% |
| Actual percentage this date | 0% |

No work was scheduled on this task during the month of January.

Task 38 Environmental Control

| | |
|---|---|
| Scheduled percentage of completion | 47% |
| Actual percentage this date | 47% |

During the visit of the customer's representatives and consultant, discussions were held regarding the environmental control problems as related to the overall Stereocomparator installation in the customer Clean Room facility.

The detailed mechanical and electrical drawings for the customer's Clean Room facility were presented and discussed. Certain minor changes were agreed on, with respect to the arrangement of the cable trays beneath the Clean Room computer floor.

These changes would provide maximum access to the electrical cables for installation and service.

In general, the overall arrangement of the Clean Room and the plans for environmental control appear fully compatible with the requirements of the Stereocomparator.

Task 39 Reliability Analysis

Scheduled percentage of completion 0%

Actual percentage this date 0%

No work was scheduled on this task for the month of January.

Task 40 Installation

| | |
|---|---|
| Scheduled percentage of completion | 6% |
| Actual percentage this date | 8% |

[redacted] is continuing to work with the customer's consultant assigned to preparing the Clean Room site. STAT

The proposed customer Clean Room design appears to be fully satisfactory for the Stereocomparator.

Task 42 Breadboards and Test Devices

| | |
|---|---|
| Scheduled percentage of completion | 22% |
| Actual percentage this date | 15% |

Bench testing continues on the film platen and film clamping assembly (see Task #13).

During the month of January, tests were also performed on the general platen illumination assembly (see Task #20), and on the output logic interface assembly (see Task #28).

The construction of a breadboard is in process for testing film handling techniques. (See Task #14.)

Task 43 Computer Programming and Services

| | |
|---|---|
| Scheduled percentage of completion | 34% |
| Actual percentage this date | 42% |

[redacted] personnel are continuing to develop and prepare the programming data for the Stereocomparator, utilizing the computer installed at the [redacted] facilities. STAT STAT

[redacted] has been reporting their progress on a current-month basis. It has been found that this does not give time for adequate review by [redacted] and they will therefore be reporting in the future on the basis of the previous month, as is being done by other subcontractors. STAT STAT

Therefore, there is no progress report included this month for [redacted] STAT

Task 44 Preacceptance Test in Fabrication Plant

| | |
|---|---|
| Scheduled percentage of completion | 0% |
| Actual percentage this date | 0% |

No work was scheduled for this task during the month of January.

Task 45 Acceptance Test in Fabrication Plant

| | |
|---|---|
| Scheduled percentage of completion | 0% |
| Actual percentage this date | 0% |

No work was scheduled for this task during the month of January.

Task 46 Acceptance Test after Installation

| | |
|---|---|
| Scheduled percentage of completion | 0% |
| Actual percentage this date | 0% |

No work was scheduled for this task during the month of January.

Task 47 Instruction Manual and Drawing Submittal

| | |
|---|---|
| Scheduled percentage of completion | 9% |
| Actual percentage this date | 8% |

We are continuing to revise the Stereocomparator design drawings to cover the "as built" status for the various subassemblies.

A representative section of the Operator's Manual is included as Appendix II. This is a preliminary draft of a single chapter. It will be further reviewed, and will be incorporated in the manual which will cover the total operation of the Stereocomparator.

Task 48 Spare Parts List

| | |
|---|---|
| Scheduled percentage of completion | 4% |
| Actual percentage this date | 4% |

A representative portion of the Spare Parts List, listing the spares recommended for the mechanical components of the Stereocomparator, is included as Appendix III.

Task 49 Operator Training

| | |
|---|---|
| Scheduled percentage of completion | 0% |
| Actual percentage this date | 3% |

An excerpt from the Operator Training Manual is included as Appendix IV. This manual will assist in training the operators to use the Stereocomparator.

APPENDICES

PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1968

STAT

1.0 PROGRESS DURING REPORTING PERIOD

1.1 Activity

Layout modifications were completed on the sum and difference board, the modulator board, the modulator module, the extender board and the time base generator board. The procurement cycle is in progress on the materials.

To alleviate the anticipated burden on drafting man-hours and cost, some layout work will be purchased from printed circuit vendors. A purchase specification was generated to control the quality of the purchased services and to assure a consistency in drawing content. In December, the integrator board and the raster delay board layout design and the boards themselves were purchased.

Design modifications were made to the image dissector assembly. The dynode regulator changes consist of reducing voltage stress levels, the addition or current limiting, and the increase in adjustment range of the gain control. The video amplifier was modified by the addition of a complementary emitter-follower driver pair, which stabilizes the amplifier, when it is loaded by the anticipated 65 foot length of coaxial cable. The deflection amplifiers were redesigned to simplify their configuration and to increase the linearity of the deflection current. The two deflection amplifiers have approximately the number of component as one of the previous design. The layout configuration will discard the module usage and bracketry in favor of mounting the three component boards in a triangular fashion on hexagonal rods. Wiring and maintenance should become easier as a result or the improved accessibility. A separate high voltage coaxial connector will be used to input the -2400 volts and the remaining connections routed through a Burndy MS14RM58 connector.

1.1 Activity (continued)

The correlator chassis interconnecting wiring diagram was changed to initiate the modification of the chassis layout. The technipower CS24/2500-15 became obsolete, since its original call out, and is replaced by an Abbot Transistor Labs #AK6B-2470A DC-DC converter. The Abbot converter will operate at a lower percentage of rated current, has short circuit and input spike protection and should therefore be more durable. The unregulated supply was changed to an NP-25.7-3.0 to be used at 26.5 volts. This will provide a margin against dropout of the DC-DC converter in the event of line voltage variations. The connectors were changed from Amphenol to Burndy MS26 and MS14 type connectors which permit flexibility in the use of single contacts and coaxial contacts within the same shell. A test connector was added. A Rotron Sprite fan was added to provide a nominal flow of 25 CFM which should restrict the temperature rise to less than 15°F above ambient. The layout will be configured with the power supplies and card rack mounted on a conventional type of chassis 17 x 19 x 3 1/2 with a bottom plate. A plenum hood with inlet and outlet holes is placed over the chassis and attached to it. A filter covers the inlet at the right side and the Sprite fan attached to the plenum at the outlet on the left.

The design concept for the test stand was completed by [redacted] The detailing has commenced. In an attempt to keep the expenditure of time and money to a minimum, an effort was made to utilize as many commercially available components as possible. In this regard, two "Inter-66" photo enlargers were purchased. Their specifications are: 2 1/4 x 2 1/4 maximum format size, 75 watt bulb, double condensing system, F3.5-75mm lens. Two x-y stages with 1 inch precision micrometers were also purchased. The x-y stage mounts on a 360° rotational stage. STAT

The number of man-hours applied to the project, particularily in the drafting efforts were noticably affected during this period as a result of holidays, vacations and sick leave. These seasonal considerations in view of the amount of work which must be handled sequentially are expected to erode the schedule.

1.2 Summary of Present Position

1.2.1 Layout work to be purchased

Intergrator Board
Raster Delay Board
Video Correlator Board
Channel Selector Board
CH. Selector Logic Board
Parallax Analyzer Board
Distortion Analyzer Board

Only the first two have been purchased. Represented 28% of the items.

1.2.2 In-House Work

| ITEM | MODIFICATION STARTED | MODIFICATION COMPLETED | PURCHASE ORDER |
|---|---|---|---|
| Modules | | | |
| Multiplier, Video | No | No | No |
| Multiplier, Analyzer | No | No | No |
| Modulator | Yes | Yes | Yes |
| Boards | | | |
| Modulator | Yes | Yes | Yes |
| Sum and Difference | Yes | Yes | Yes |
| Time Base Gen | Yes | Yes | Yes |
| Extender | Yes | Yes | Yes |
| Chassis Assembly | Yes | No | No |
| Power Supplies | N/A | N/A | Yes |
| Cables and Harnesses | No | No | No |
| Image Dissector Assembly | Yes | No | No |
| Boards | - | - | - |
| Dynode Reg | Yes | No | No |
| Video Amp | Yes | No | No |
| Deflection Amp | Yes | No | No |
| Holder Assembly | No | No | No |
| Test Fixture | No | No | No |

The layout modification in all cases is started after an evaluation of the existing circuitry and a check on circuit changes to be incorporated. Of the 22 areas listed, the modifications were started on 55%. Modification is complete on 33% of the 15 areas done in-house and purchase requisitions placed in 41% of the applicable areas (including the image dissector tubes - not listed). Please note that percentages given equal weight to each area.

## 2.0 PLANS FOR NEXT PERIOD

During the later part of January, materials are expected to be received and inspected, and assembly of the modulator and sum and difference board begun. Procurement times will extend beyond January in many instances in other areas.

Modification of the top assemblies is not expected to be completed until February.

Detailing of the test fixture is expected to be completed and the remaining parts purchased. The holder assembly modification will be started when the requirements of the test fixture and the image dissector assembly can be reflected on it.

II

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# STEREOCOMPARATOR

## OPERATOR'S MANUAL

## SECTION 1 - START-UP PROCEDURE

### I. MACHINE TURN ON SEQUENCE

1. Circuit breaker 101 - Power supply

   General 24V supply for relays, solenoids, lamps, indicator in the utilities rack. (Flush solenoids, vacuum and pressure solenoids, low pressure control, etc.)

2. Circuit breaker 102 - Engine

   Machine room control pushbuttons.

3. Switch 101 - Hi-pressure System pushbutton

   Switch 102 - Med. Pressure System

   Switch 103 - Low Pressure System

   Switch 104 - Vacuum System

   Switch 105 - Hi-pressure

   Switch 106 - Med. Pressure

   Switch 107 - Low Pressure

4. Circuit breaker 109 - Left main illumination

   Circuit breaker 110 - Left reticle illumination

   Circuit breaker 111 - Right main illumination

   Circuit breaker 112 - Right reticle illumination

   Lamp and reticle are ignited automatically.

5. Circuit breaker 103 - Cabinet #1

Circuit breaker 104 - Cabinet #2

Circuit breaker 105 - Cabinet #3

Circuit breaker 106 - Computer DDP 516

Circuit breaker 107 - Card Punch

Circuit breaker 108 - Teletype

II. ON THE CONSOLE

1. Adjust image brightness (small knob) to minimize brightness C.C.W.

2. Turn "On" platen illumination "On-Off" button.

III. GO TO STAGE TO INSTALL FILM

(There are 4 film control panels - 2 for each stage; 1 front and 1 rear.)

1. Go to front Film Control Panel. Set emulsion switch "IN" or "OUT" loading film. Push "Stage Forward" and "Stage Left" (or Right).

2. Push "Load". (Tension on reel is released.)

3. Install roll of film. Thread film through transport.

4. Push "Clamp". (This activates the control valve and the free end of the film is sucked down to the platen.)

5. Go to rear side of transport. Push "ST.FWD." pushbutton. Push "ST.RIGHT" (or left).

6. Push "Unclamp". (This releases the vacuum on the film.)

7. Thread other side of the film.

8. Push "Release". (The reel motors wind all the slack up until the dancer arm moves off microswitch.

The film is now ready to be moved.

IV. BACK AT THE CONSOLE

The operator is now ready to observe a point.

1. Push "Manual".
2. Push "View Stage Position". (This brings the stages to viewing position on the left and right sides of the operator.) The use of the stage joystick is therefore not necessary for this operation although it could have been used.)
3. Using Left Film Joystick, wind the left film to the desired frame location. The operator has to decide now if he is going to make measurements on both stages simultaneously. Let's assume he is. Using Right Film Joystick, wind the right film to the frame corresponding to the left frame.
4. The following operation can be performed on a simple viewing table or it may be performed directly on the Stereocomparator. Using a special measuring grid, the operator places the grid on the frame of interest. He aligns the grid's point of reference with a reference point located directly on the frame. He takes note of the coordinates of this first reference point.

   Then he proceeds to note the timetic closest to the first point of interest. (Identification Nb of the timetic and coordinates.) Then he notes the coordinates of the first point of interest (Recall Point #1). Same procedure for the second timetic and second point of interest. (Recall Point #2.)

   And so on, up to 6 recall points.
5. Same operation on the left stage - up to 6 recall points corresponding to the right points.

6. The "Enter" pushbutton is depressed.

Walk to computer console.

7. The computer is now set up by the operator to skip to location C1-2. (It will run in a loop testing "Recall", "Auto W", "Auto W/O", "Interlock" and "Enter".)

8. To Teletype:

a) Switch teletype to "Internal Computer".

b) Using teletype keyboard, enter into computer memory all information pertinent to film and frame, such as described on Page 1, Non-Real Time Computation chapter, paragraph 1, Tracking when camera station data available:

1 - type of photograph

2 - exposure time

3 - latitude, longitude, altitude, etc.

4 - timetic (identification Nb and Coordinates)

In addition, enter the coordinates of the left (and/or right) reference point and the left (and/or right) recall points. (Teletype light comes "On" when teletype is used, and the light is turned off after a pre-selected number of questions asked by the computer has been answered by the operator.)

9. If recording of data is going to take place for both stages, press "Both Stages" ("Left Stage" or "Right Stage" if recording data from left or right stage only.)

10. "Reference" light comes "On".

Next step is to record "Reference". However, decision has to be made now on whether data will be recorded on the "Punch" or the "External Computer" or both. (The reference

is the origin point of the image.)

11. Depress "Computer Link" or "Punch" or both. Since we are in "Enter Mode", reference coordinates will be read by the internal computer automatically.

12. At this point, if informations are to be recorded on the punch, the operator prepares the program card to be installed on the drum. Then he proceeds to punch the 22 first columns of the first card with the required information, such as Project, Nb, Date, etc. (See Punch Control.)

13. Next on the console, he pushes the required 4 x 4 and 10 x 10 pushbuttons. (See computer link.) Finally, he depresses "Record Reference". Record Reference coordinates are read by the computer, and recording takes place -

    1 - into External Computer.

    2 - into Punch Control.

14. The same procedure described in 13 above (set required 4 x 4 and 10 x 10 buttons) applies for Record Fiducial and Record Timetic (if necessary).

15. We are now ready to study an area of interest. Let's assume that the area of interest is around point #1, previously recorded. Depress "Left Stage Position #1" (Point recall left #1) and "Right Stage Position #1)(Point recall right #1). Both stages preposition to those two points.

16. While still in the "Enter" mode, the optics can be adjusted by use of the console buttons in order to obtain the best correspondence between two points. At this point, it may also be necessary to move the stages prior to adjusting the optics. Use of trackball here would be recommended, and it may be necessary to have "JS/TB Both" and "Trackball Independent" depressed.

## Recommended Spare Parts List

| Part Number | Part Name | Assemblies Used On | Recommended Spares |
|---|---|---|---|
| B-8014 | Drive Roller Assy. | E4252<br>E4254-1<br>E4254-2<br>E6560 | 6 |
| SA-740A-2 | Tachometer<br>Servo-TEK | E4252<br>E4254-1<br>E4254-2<br>E5795<br>E5800<br>E6560 | 1 |
| ISMI-T | Sub Miniature<br>Switch-Honeywell | D4492 | 1 |
| ISXI-T | Sub Miniature<br>Switch-Honeywell | D4492 | 1 |
| IISM401-T | Micro Switch | E5795<br>E5800<br>E 6030<br>E6305 | 2 |
| DIH-A150 | Pressure Switch<br>Barksdale | E5810 | 1 |
| DIH-H18-P2 | Pressure Switch<br>Barksdale | E5810<br>E6215 | 1 |

## Recommended Spare Parts

| Part Number | Part Name | Assemblies Used On | Recommended Spares |
|---|---|---|---|
| II3MF-F | Air Flow Switch<br>Dietz Co. | E6296 | 1 |
| IISMI-T | Micro Switch | D6580-1<br>D6580-2 | 1 |
| B4464 | Filter Assy. | E4440<br>C4426<br>C4424<br>C4422<br>C4428<br>C4430 | 6 |
| 42300079 | Milliflow<br>Regulator | E4440<br>C4426<br>C4424<br>C4422<br>C4428<br>C4430 | 2 |
| HA<br>0.45 micron | Millipore<br>Filter Paper | B4464 | 1 carton |



Appendix III

## II. THE GENERAL EQUATION OF OPTICAL IMAGING

### 2.1 Gaussian Optics

Most optical lenses consist of a series of interfaces between transparent media of different refractive index, which are all, as nearly as practical, spherical surfaces with their centers lying on a single straight line. The common line of centers is called the optical axis and the various spherical surfaces are incomplete spheres (usually less than hemi-spheres), usually with circular boundaries also centered on the optical axis. In somewhat rare instances lenses include one or more interfaces which are intentionally ground so as to depart from a spherical surface by a small, but definite, amount. These surfaces are, nevertheless, rotationally symmetrical (as nearly as practical) about the optical axis.

So-called "Gaussian optics" consists of a body of mathematical analyses of the refraction occurring at a series of such centered spherical interfaces between various optical media, which preserves only the degree of approximation obtained as the various "rays" considered, approach parallelism to the optical axis and also approach only an infinitesimal displacement from the optical axis. Thus Gaussian optics might be considered as a "zero order" approximation to the true analysis. This approximate analysis results, however, in what might be called a theory of "ideal" imaging, hence it is of prime importance. Real lenses are built so

as to have actual imaging properties substantially like the ideal imaging of Gaussian optics. Deviations from this ideal imaging are referred to as "aberations," and these aberations are made as small as is consistent with the intended price of any particular lens.

## 2.2 Projective Optics

Projective optics is a branch of geometrical optics that states a formal deductive theory of ideal imaging which corresponds closely to that of Gaussian optics. The basic assumptions of projective optics will here be used to derive the "general equation of optical imaging" which is the basis for the optical analysis used in subsequent chapters. This so-called "general" equation is, as stated above, an idealization of the real optical situation which neglects aberations completely.

Projective optics considers that any optical system which has cylindrical symmetry about the optical axis may be treated as having the fundamental elements: (1) two principal planes, which are normal to the optical axis, (2) two focal points, which are on the optical axis, and (3) two nodal points, which are on the optical axis. These elements are illustrated in Figure 2, which also shows three rays diverging from a typical object point O and converging on the corresponding image point O'. These three rays are particular cases of three classes of rays. One class enters the first principal plane in a direction parallel to the optical axis; all such rays continue parallel to the optical axis until they intersect the second principal plane and then become "refracted" by just the right angle so they hence pass through the second focal point (F'). Rays of the second class pass through the first focal point (F) and continue until they intersect the first principal plane, at which point they become "refracted" so as to henceforth be parallel to the optical axis. The

third class consists of rays which pass through the first nodal point (N) without having been previously refracted. All such rays emerge from the second nodal point (N') in a direction which is parallel to the direction in which they entered the first nodal point. Thus the ray $\overline{N'O'}$ is parallel to the ray $\overline{ON}$.

The above stated principles (of projective optics) and Figure 2 may be used to derive the relations between a typical object point (O) and the corresponding image point (O'). For this purpose assume an arbitrary Cartesian coordinate system (moving or stationary). Let $X^a$ and $X_1^a$ be the coordinates of O and N respectively. Likewise let $x^a$ and $x_1^a$ be the coordinates of O' and N' respectively. So long as only Cartesian type coordinate systems are considered, the displacements $X_1^a - X^a$ and $x^a - x_1^a$ may be treated as components of two vectors - which from the discussion above are known to be parallel to each other. (These two vectors are shown in Figure 2 as U and u respectively.) Parallel vectors have corresponding components which are respectively proportional. Hence: $x^a - x_1^a$ must be equal to some scalar quantity times $X_1^a - X^a$.

Figure 2 shows two pairs of similar triangles. One pair of similar triangles has a common junction at F and has a pair of corresponding legs lying along the optical axis. The other pair of similar triangles has a common junction at F' and also has a pair of corresponding legs lying along the optical axis. The lengths of the first pair of corresponding legs are seen to be (p.U - f') and f respectively,

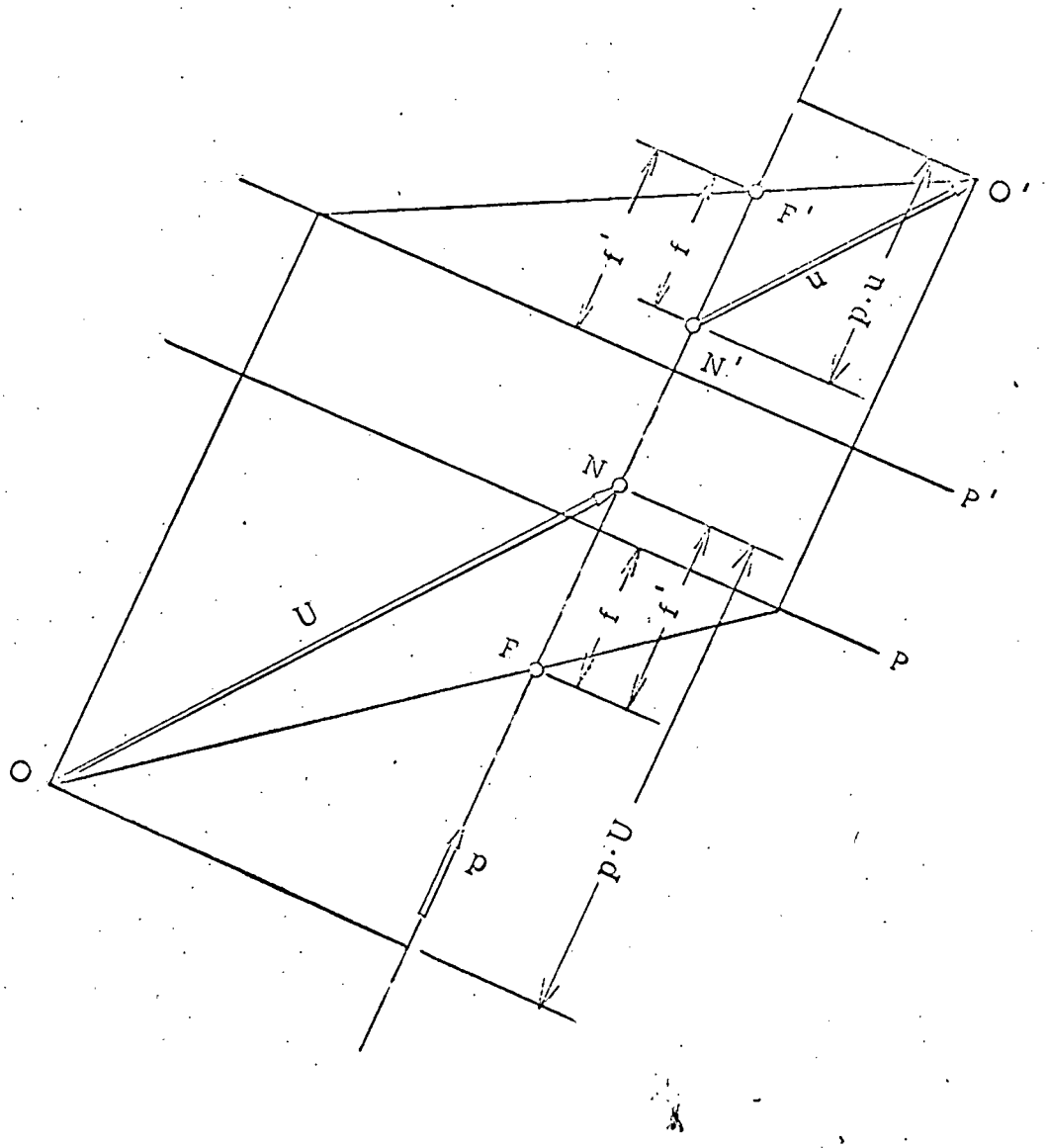


Fig. 2. Relations between an object point O and the image point O' formed by a lens with principal planes P and P'. Drawn for a positive lens, with f and f' both taken positive. For negative lenses f and f' are both negative.

where p is a unit vector parallel to the optical axis. The lengths of the second pair of corresponding legs are likewise seen to be f' and (p.u - f) respectively. Consequently the value of the scalar multiplier, mentioned at the end of the previous paragraph must be:

$$\frac{f}{p.U - f'} = \frac{p.u - f}{f'}.$$

Now let $\lambda_a$ be the components of the unit vector p. Then

$$p.U = \lambda_a (X_1^a - X^a)$$

and

$$p.u = \lambda_a (x^a - x_1^a).$$

Using the ratio from the first pair of similar triangles, the desired relation between the two vectors U and u is thus

$$x^a - x_1^a = \frac{f (X_1^a - X^a)}{\lambda_b (X_1^b - X^b) - f'}$$

$$= \frac{f (X^a - X_1^a)}{f' + \lambda_b (X^b - X_1^b)}.$$

This will be referred to as the optical imaging equation. Multiplying both sides of this equation by $\lambda_a$ gives:

$$\lambda_a (x^a - x_1^a) = \frac{f \lambda_a (X^a - X_1^a)}{f' + \lambda_b (X^b - X_1^b)}.$$

Hence: $p.u - f = \lambda_a (x^a - x_1^a) - f$

$$= \frac{f \lambda_a (X^a - X_1^a)}{f' + \lambda_b (X^b - X_1^b)} - \frac{f [f' + \lambda_a (X^a - X_1^a)]}{f' + \lambda_b (X^b - X_1^b)}$$

$$= \frac{- f f'}{f' + \lambda_b (X^b - X_1^b)} = \frac{f f'}{p.U - f'}.$$

Thus the ratios derived separately from the two pairs of similar triangles are indeed equal to each other.

That the optical imaging equation has been set up so as to be invariant to coordinate rotations, may be checked as follows:

(1.) Let $C_a^m$ be the direction cosines of the (three dimensional) coordinate rotation, and let $C_m^a$ be the reciprocal direction cosines.

(2.) The three vectors then have their components relative to the $x^m$ coordinates given by

$$x^m - x_1^m = C_a^m (x^a - x_1^a),$$

$$X^m - X_1^m = C_a^m (X^a - X_1^a),$$

and

$$\lambda_m = C_m^a \lambda_a.$$

(3.) The above relations may be inverted to give:

$$x^a - x_1^a = C_m^a (x^m - x_1^m),$$

$$X^a - X_1^a = C_m^a (X^m - X_1^m),$$

and

$$\lambda_a = C_a^m \lambda_m$$

(4.) The imaging equation is therefore

$$C_n^a (x^n - x_1^n) = \frac{f\, C_n^a (X^n - X_1^n)}{f' + (C_b^m \lambda_m) C_p^b (X^p - X_1^p)}$$

$$= \frac{f\, C_n^a (X^n - X_1^n)}{f' + C_b^m C_p^b \lambda_m (X^p - X_1^p)} .$$

(5.) Multiplying both sides by $C_a^m$ and using

$$C_a^m C_n^a = \delta_n^m \qquad (\text{and } C_b^m C_p^b = \delta_p^m)$$

then gives

$$x^m - x_1^m = \frac{f (X^m - X_1^m)}{f' + \lambda_n (X^n - X_1^n)} ,$$

which has the desired form.

The preceding discussion assumed that the same coordinate system was used for both the object space and the image space (these two spaces may be considered as separated by the principal planes). In practice, it is often desired to use one coordinate system for the object space and a different coordinate system for the image space. Evidently the imaging equation then takes the form

$$x^m - x_1^m = \frac{f\, C_a^m (X^a - X_1^a)}{f' + \lambda_b (X^b - X_1^b)} .$$

This equation is invariant to transformations among Cartesian coordinate systems both (separately) for the object space and for the image space. $C_a^m$ is, of course, the set of direction cosines of the image space coordinate system with respect to the object space coordinate system.