IMAGE DATA PROCESSING SYSTEM (IDAPS)
USER MANUAL
S-056 EXPERIMENT
SYSTEM DESCRIPTION
VOLUME I
BATCH IDAPS
VOLUME II
INTERACTIVE IDAPS
VOLUME III

CONTRACT NO. NAS8-30740

31 MARCH 1975
TM-HU-037/000/00
FOREWORD

The IDAPS facility is maintained by the Marshall Space Flight Center as a service to S-056 researchers for processing S-056 image data. The IDAPS facility became operational in November 1974. Since that time the facility has been in joint use by the S-056 researchers for data processing and by the system development contractor for continued facility development. As additional facility capabilities are incorporated, the IDAPS User Manual will be updated by the insertion of change pages.
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Figure 1-1. IDAPS Terminal Room
1.0 INTRODUCTION

IDAPS (Image Data Processing System) was developed by the Marshall Space Flight Center (MSFC) to satisfy the image processing requirements of the Skylab S-056 experiment. The S-056 experiment was designed to obtain high-resolution photographs of the sun in the far ultraviolet, or soft X-ray portion, of the electromagnetic spectrum. Thirty-five thousand photographs were obtained by the three flights of the program; and, faced with such a massive volume of imagery, the designers of the experiment decided to develop a computer-based system which would reduce the image processing workload by

- Eliminating the processing of image frames which contain little or no information of scientific value.
- Treating only those regions within a frame which are of scientific value.
- Allowing the individual researcher to tailor the nature and sequence of image processing operations to satisfy his own needs.

The purpose of the IDAPS User Manual is to give the IDAPS user the necessary information and instructions to effectively utilize the system. The Manual is divided into three volumes:

Volume I - System Description
Volume II - Batch IDAPS
Volume III - Interactive IDAPS

Volume I presents a suggested training plan, an introduction to the IDAPS hardware configuration, and a description of overall system capabilities. A brief discussion of digital image processing fundamentals is provided in Appendix A. The IDAPS Terminal Room is shown in Figure 1-1 on the facing page.
2.0 TRAINING PLAN

A training plan, outlined below, is suggested for the beginning user of IDAPS.

**IDAPS Orientation**

Step 1 - Read Volume I

Step 2 - Attend an IDAPS orientation demonstration (approximately 30 minutes)

<table>
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<th>Interactive IDAPS Use</th>
<th>Batch IDAPS Use</th>
</tr>
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<tr>
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<td>Step 3 - Read Volume II</td>
</tr>
<tr>
<td>Step 4 - Attend an Interactive IDAPS Training Session (approximately two hours)</td>
<td>Step 4 - Attend a Batch IDAPS Training Session (approximately one hour)</td>
</tr>
</tbody>
</table>

An IDAPS Orientation Demonstration, an Interactive IDAPS Training Session, or a Batch IDAPS Training Session can be scheduled through the MSFC Data Systems Laboratory, EF32, phone (205) 453-3706.
3.0 HARDWARE DESCRIPTION
This section provides the IDAPS user with a description of the IDAPS hardware configuration and the general capabilities of the individual hardware components. Detailed instructions in the use of the various components are presented in Volume III.

The IDAPS hardware configuration is presented in Figure 3-1. The components are discussed in the following paragraphs in five functional groupings:

- Terminal Minicomputer
- Film Scanner
- Interactive Display and Control
- Hardcopy Devices
- Host Computer

3.1 TERMINAL MINICOMPUTER
An Interdata Model 70 serves as the control and communication device for the IDAPS terminal. It interfaces directly to the host computer through a selector-channel to selector-channel interface. The terminal minicomputer consists of the following items:

- Computer Mainframe, I/O and Memory
- Magnetic Tape Units
- Disk Drive
- Card Reader
- Printer
- Teletype

3.1.1 Computer Mainframe, I/O and Memory
The Interdata 70 mainframe, I/O and memory incorporates the following design features:
Figure 3-1. IDAPS Hardware Configuration
• Core of 65,536 bytes
• Cycle time of 1.0 µs
• Multiplexor channel for up to 255 devices
• Four selector channels

3.1.2 Magnetic Tape Units
Two magnetic tapes, used primarily for image input/output, are included in the system. These tape units have the following characteristics:

• IBM compatibility
• Nine track
• Density of 800 bits/inch

3.1.3 Disk Drive
A disk drive, used for program storage, temporary image storage and data storage, is a part of the system and has the following design features:

• Capacity of 9,830,000 bytes
• Selector channel interface at 250,000 bytes per second
• Average rotational latency of 12.5 ms
• Average access time of 38 ms

3.1.4 Card Reader
A card reader, used primarily for data or table input, is provided. It reads at a rate of 400 cards/minute.

3.1.5 Printer
A line printer, used primarily for data output, history data, etc., is provided. It has a standard 64-character set and prints 132 characters per line at a rate of 200 lines/minute.
3.1.6 Teletype
A Model 33 ASR teletype is included as an aid to programming and maintenance and as a backup to other peripherals.

3.2 FILM SCANNER
The image-dissector scanner used in the S-056 system is the Dicomex Model 57 image scanner. With 35-mm optics, the Dicomex scanner will scan an entire 35-mm frame or, under program control, it can scan any smaller area of any aspect ratio, including a single point. Thus, it provides both raster scans and random point scanning. The scanner incorporates variable signal limiting and expansion, which allow preliminary image analysis and preprocessing within the scanner itself. The scanner has the following pertinent specifications:

- Film Size: 35 mm in individual, mounted frames or up to 10-inch reels
- Film Density Range: 2.45 \( D \)
- Maximum Area Scanned: 35 X 35 mm
- Scan Axis Orthogonality: Horizontal and vertical axes are at 90° ± 0.05°
- Scan Line Curvature: Less than 0.2 percent
- Scan Nonlinearity: Less than 1.5 percent
- Scan Matrix Resolution: 2048 X 2048 maximum
- Effective Scan Aperture: 35 microns
Scan Times: (See Figure 3-2)

Signal Conditioning: The transmittance or density signal produced by an image when scanned at a fixed illuminator level is divided into eight segments, each containing approximately 12.5 percent of the total signal. Any continuous set of these segments may be selected for digitization and are represented by the full range of output codes. The lowest amplitude segment is provided with a vernier adjustment to allow suppression of background "noise" when desired.

Logarithmic Amplifier: A switch-selectable logarithmic amplifier is included in the amplifier chain of the output of the image dissector tube. A rotary switch on the front panel allows selection of linear output of transmittance codes or a log output of density codes. The log output corresponds to an inverse linear output of density. A log output can be selected to cover two decades (i.e., 100:1 ratio of density).

Output Code Formats: Eight bits (256 gray levels), linearly proportional to film transmittance (with the log amplifier, the output codes are approximately proportional to film density).

Scan Position Drift: Less than two scan points out of 2048 after one hour (after thermal equilibrium is reached).

Digitizing Drift: The mean output code representing a specific point is within ± two, six-bit output codes over a one-hour period (after thermal equilibrium is reached).

The Dicomed scanner interfaces with the terminal minicomputer through a selector channel. The scanner is completely controllable through the
<table>
<thead>
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<th>NO. 1</th>
<th>NO. 2</th>
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<td>1280</td>
<td>320</td>
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<td>335</td>
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<td>22 seconds</td>
<td>6.3 seconds</td>
<td>2.3 seconds</td>
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<tr>
<td>When m=n=512</td>
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<td>88 seconds</td>
<td>25 seconds</td>
<td>9.2 seconds</td>
</tr>
<tr>
<td>When m=n=1024</td>
<td>23 minutes</td>
<td>5.9 minutes</td>
<td>1.7 minutes</td>
<td>37 seconds</td>
</tr>
<tr>
<td>When m=n=2048</td>
<td>91 minutes</td>
<td>24 minutes</td>
<td>6.7 minutes</td>
<td>2.5 minutes</td>
</tr>
</tbody>
</table>

(1) Sum of point integration time plus 15 microseconds point-to-point travel time. Maximum scan line flyback is 125 microseconds.

(2) m = number of scan lines in the image
n = number of points in a scan line

Figure 3-2. Film Scanner Scan Times

(3) Timing data above reflects scanner characteristics only and does not include external computational or data handling requirements.
minicomputer so that adjustments such as scan position, scan resolution, and film density can be made without manual intervention by the user. A roll film transport is included in the configuration for convenience in handling up to 200-foot rolls of 35-mm film.

3.3 INTERACTIVE DISPLAY AND CONTROL
The interactive display and control equipment design is based on the use of a disk refreshed digital television system. This system accepts image data in a digital matrix format and stores the digital data on a high-speed disk. The digital data is then converted to a high-quality television signal for display on commercial grade television monitors. Major components of this system are:

- Digital Television Display Generator
- D/A Video Driver/Distributor
- Video Monitors
- User Console Keyboard
- Graphic Trackball

3.3.1 Digital Television Display Generator
A digital television display generator, with its associated interface to the Interdata 70 computer and display refresh disk, provides a capability to produce 16 single-bit digital images. The digital television consists of a display generator, a 128-character ASCII character generator, a refresh memory, and 16 digital video output channels plus proper timing channels to produce composite video signals. The digital television output is fed to the D/A video driver/distributor, where the signals are grouped to provide analog television outputs of various configurations.

3.3.2 D/A Video Driver/Distributor
A D/A video driver/distributor accepts inputs from the digital television refresh memory and provides the following outputs:
Two six-bit, 64-level, gray-scale signals obtained by combining digital video channels 0, 1, 2, 3, 8, and 9 for the first, and 4, 5, 6, 7, 10, and 11 for the second. The two resulting 64-levels-of-gray, analog television channels are displayed on two black-and-white monitors (Monitors 1 and 2).

Three four-bit, 16-level, gray-scale signals from video amplifiers, connected to contiguous digital video channels 0 to 11. These three analog signals are displayed as the red, green and blue components of the Color Monitor.

Three single-bit, 2-level, video signals representing digital video channels 12, 13, and 14. These three analog signals are displayed as the red, green and blue components of the Master Monitor.

3.3.3 Video Monitors
Four video monitors are provided, two black-and-white (Monitors 1 and 2) and two color (Color Monitor and Master Monitor). Each monitor is a standard, 14-inch diagonal, commercial grade television with appropriate amplification, control, and deflection circuitry to display the video data from the digital television display system. The Master Monitor serves the user in controlling and monitoring his image processing operations. While system control information is being displayed on the Master Monitor, the user may view before-and-after results of his image processing runs on the two black-and-white monitors. When working with color data, the user may monitor the color image on the Color Monitor.

3.3.4 User Console Keyboard
The interactive display and control station of the user terminal includes a keyboard for alphanumeric input of parameters and instructions to the system. This keyboard interfaces with the Interdata 70 and serves as the primary
man-to-machine terminal interface. In addition to 95 standard ASCII characters, special function keys are included on the keyboard. These keys are used to initiate frequently repeated options or special functions.

3.3.5 **Graphic Trackball**
A graphic trackball, used primarily as a pointing device, is interfaced with the digital television display and with the Interdata 70 so that a position cursor appears on all of the video monitors and can be controlled to an accuracy of one picture element in a 480 X 640 array. The Interdata 70 reads the cursor X-Y position from the trackball electronics. An "enter" button is normally used to signal the terminal minicomputer that position data should be read.

3.4 **HARDCOPY DEVICES**
IDAPS possesses a capability for producing permanent copies of printed, graphic, and image data. Two different hardcopy devices are provided at the user console:

- Video Facsimile Copier
- Image Recorder (Color or black and white)

3.4.1 **Video Facsimile Copier**
A video facsimile copier, the Tektronix 4632, provides quick-look gray tone (approximately 12 gray levels) hardcopy from the user console. This unit makes permanent facsimile copy from static television signals at a rate of 10 seconds per image. The copy command is initiated by pressing a front panel control. Contrast and density are adjusted by the operator with simple-to-use front panel controls.

3.4.2 **Image Recorder (Color or Black and White)**
A capability for recording on color film, for making permanent black-and-white photographs, and for obtaining quick snapshots of image data on Polaroid
film is provided by the image recorder. This device can record a 2048 X 2048 resolution image in color in 10.5 minutes and in black-and-white in 3.5 minutes. The film recorder exposes photographic film to any of 256 different exposure levels and features a 4 X 5 inch Grafloc back so that a number of standard film formats may be accommodated. Film carriers are provided for making Polaroid prints as well as 4 X 5 inch cut film and 120 roll film photographs. Except for film loading, film advance and exposure adjustment, the D47 is completely controllable through the terminal minicomputer.

3.5 HOST COMPUTER

The host computer of the S-056 configuration of IDAPS is an IBM 360/65. This computer, used primarily for performing the image processing techniques specified by the user, has the following features:

- 1 million bytes of core memory
- 1.2 billion bytes of disk
- Both seven-and nine-track tape drives
- Standard I/O peripherals, such as printers and card reader
- OS/MVT/HASP operating system
4.0 SYSTEM FUNCTIONAL DESCRIPTION
This section provides the IDAPS user with a functional description of the system by specifying what the system does without describing how to operate it. Instructions for operating the system are presented in Volumes II and III.

IDAPS performs in two modes: interactive and batch. Each mode has its particular place in the processing of S-056 images. In general, Interactive IDAPS is used for image familiarization, sequence and parameter optimization, selective feature extraction and analysis, i.e., those operations which require real-time visual analysis or trial-and-error processing. Batch IDAPS is best used where the desired parameters and sequence of operations are known and when long images-processing times are required.

The emphasis of this section is on the capabilities of Interactive IDAPS. Once Interactive IDAPS is understood, the understanding and operation of Batch IDAPS reduces to a straight-forward lesson in control-card formatting. The following functional areas are discussed:

- Picture Input
- Picture Storage
- Interactive User Control
- Picture Display
- Picture Recording
- Special Functions
- Application Programs

4.1 PICTURE INPUT
The picture input function of Interactive IDAPS refers to those functions necessary to enter picture data into the system. Picture input may be accomplished through the on-line scanner or through one of the magnetic tape units.
4.1.1 On-Line Scanning
Interactive IDAPS gives the user the capability to digitize an image and transfer the results to one of several devices as follows:

- **SCANNER TO DISPLAY:** This operation is used in viewing the data stored on film and for making quick on-line analysis of images.

- **SCANNER TO TAPE:** This operation allows the user to scan a picture and store it on magnetic tape for later processing or display.

- **SCANNER TO FILM:** This operation provides for direct transmittance of an image from the scanner to the film recorder, making such changes in the film data as can be accomplished by the scanning and film recording equipment itself. No computer image processing is performed.

- **SCANNER TO SYSTEM:** This operation allows the user to scan a film and transmit an image to the host computer system for subsequent use in image processing operations. The host computer logs the image into the system and assigns it a unique file name.

- **SCANNER TO PRINTER:** This operation allows the user to scan a small portion of a film and to print the gray values of the selected portion on the terminal line printer.

4.1.2 Tape Input
A capability exists to input picture data from magnetic tape. Such tapes may have been produced by a scanner-to-tape operation or by an off-line scanner. Off-line scanning may be desired to obtain resolutions and accuracies beyond the capabilities of the on-line scanner or to avoid tying up the terminal when scanning large volumes of data. Capabilities exist to transmit picture data from one of the terminal magnetic tape transports to a number of system devices:
• **TAPE TO DISPLAY**: A capability for transmitting picture data from magnetic tape to one of the console displays for previewing information on the tape is provided. The ability to automatically fit the picture to the display format is a feature of this operation.

• **TAPE TO TAPE**: A capability for transmitting picture data from one magnetic tape to another is provided in order to strip off single files from multiple file tapes or to extract a small portion of a large array from a master tape.

• **TAPE TO FILM**: The ability to transmit picture data to the film recorder is provided. This operation features the ability to extract a small window or subarray from the scanned tape for the film recording process.

• **TAPE TO SYSTEM**: The ability to enter picture data from magnetic tape into the host computer is provided.

• **TAPE TO PRINTER**: The ability to print the gray-scale values of a selected small area of a picture array stored on magnetic tape is provided.

4.2 PICTURE STORAGE
To provide timely input of picture data to various image processing operations of the system, it is necessary to store image data arrays on a high speed, highly accessible, mass storage device. Ease of use, speed, and accessibility also require an efficient file management and data retrieval capability. These features are included in IDAPS.

4.2.1 *Storage Media*
The primary storage device for picture data in the system is the host computer disk. All images input to the system during a run and all subsequent images
that are created as a result of an image processing operation reside on the host computer disk. A limited amount of additional image storage exists on the minicomputer disk.

4.2.1.1 System Files
The host computer provides adequate high-speed disk storage capacity for storing a number of image arrays. The host computer disk features rapid access and high-speed transfer of data. All input images, as well as all subsequently processed images, are available to the user at any time during his sequence of operations, and can be referenced by unique file names assigned to them by the system.

4.2.1.2 Terminal Files
Storage of image arrays on the minicomputer disk is limited to those image arrays which are actively being displayed on one of the console television monitors. Picture display on console monitors is limited to a square array of 480 X 480 elements. Thus, picture storage on the minicomputer disk consists of up to five files of 480 X 480 eight-bit bytes, that is, one file for each of the two black-and-white picture monitors and one file for each of the red, green, and blue color guns of the color monitor. Such active storage in the user console minicomputer disk allows immediate query by the minicomputer of the actual gray-scale value of any picture element being displayed on one of the display monitors. Terminal files are referenced by the monitor on which they are displayed.

4.2.2 Storage Format
Picture data is generally stored in integer format such that each picture element is represented by an eight-bit byte. This allows up to 256 levels of gray for each picture element. Picture files are so arranged that a single scan line of picture information is represented as a single computer record and one record exists in the picture file for each scan line of picture data within the frame. In addition to the integer format, certain
4.3 INTERACTIVE USER CONTROL

To provide an effective interactive control of the image processing capabilities of the system, the following features are provided:

- Operator Specification
- Parameter Specification
- Input Image Specification
- Data Specification
- "HELP" Feature
- Error Trapping and Recovery
- Repeatability

4.3.1 Operator Specification

A multiple choice menu selection process is used to control the sequence of image processing operations. Each of these operations, such as scanning an image and transferring it to the host computer, is referred to as an "operator". Because of the number of operators which the system employs, two levels of menu selection are used. The first, referred to as the Master Menu and presented in Figure 4-1, identifies the various categories of image processing that may be performed by the system. Upon selection of a particular category, a second level or submenu is presented for the selected image processing category. The entries on the submenu identify specific image processing operators. If, for example, the user selects the Image Input/Output category from the Master Menu, a submenu is displayed as shown in Figure 4-2. The user can then select and request a specific operator from the submenu.

4.3.2 Parameter Specification

To provide flexibility in controlling the image processing operations, the user is given the opportunity to specify operator variables. These variables
Figure 4-1. Interactive IDAPS Master Menu

INTERACTIVE IDAPS

360 STATUS: DOWN

MAIN MENU

IMAGE PROCESSING CATEGORY
A - IMAGE INPUT/OUTPUT
B - FUNCTION GENERATION
C - GRAY SCALE ADJUSTMENT
D - MANUAL IMAGE MODIFICATION
E - FILTER OPERATIONS
F - GEOMETRIC OPERATIONS
G - CLASSIFICATION/PATTERN RECOGNITION
H - MATH/LOGIC FUNCTIONS
I - IMAGE ANALYSIS
J - PSEUDOCOLOR
K - IMAGE DATA PRESENTATION
L - LOGOUT

OPTION =

Figure 4-2. Image Input/Output Submenu

INTERACTIVE IDAPS

TIME: 11:07:10
ELAPSED: 03H.01MIN

IMAGE INPUT/OUTPUT

OUTPUT TO:

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>TAPE</th>
<th>FILM</th>
<th>PRINTER</th>
<th>SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanner</td>
<td>A (S-D)</td>
<td>B (S-T)</td>
<td>C (S-F)</td>
<td>D (S-P)</td>
</tr>
<tr>
<td>Tape</td>
<td>F (T-D)</td>
<td>G (T-T)</td>
<td>H (T-F)</td>
<td>I (T-P)</td>
</tr>
<tr>
<td>System</td>
<td>K (DIS)</td>
<td>L (OUT)</td>
<td>M (FIL)</td>
<td>N (PRI)</td>
</tr>
</tbody>
</table>

INPUT FROM:

OPTION =
may be in forms such as multiple choice options, numeric values, or positional data. Once a specific operator is selected from a submenu, a parameter specification display is presented. Figure 4-3 presents the parameter specification display for the SCANNER TO SYSTEM operator. It can be seen from this display that entries are already provided for each of the required parameters. Such entries are designated "system defaults" and are the best estimate of the most desired option or value available. If the user desires to change any or all of these parameters, he may do so by entering the desired values through the keyboard or trackball. Upon specifying the operator parameters, the user may request execution of the operator. Upon initiation of operator execution, the system will return to the Master Menu and the user may proceed with his sequence of operations.
4.3.3 Input Image Specification

With the exception of the operators which perform an input image function, most operators require the specification of one or more images to be processed by that particular operator. The images to be processed are referred to as "input images"; that is, they are input as far as that particular operator is concerned.

As previously mentioned, each image input into the system is given a unique name by the system. In order for the user to perform an operation on a particular image, he must specify the image by name. Since the user typically processes an image in a serial manner (that is, he performs one operation on image "A" to create image "B" and then perform some other operation on image "B"), the system provides a default capability for those operators which require only one input file. If the default capability is used, the input file name is the last generated file. For those operators which require more than one input image, or where there is ambiguity, the user must specify all input images by name. For those operators which require an input image, such specification is done in the parameter specification process. Figure 4-4 shows the specification of an input file name (first line under Parameter Description).

4.3.4 Data Specification

Control of an operator may require input data other than the simple parameter specification. Such input data is typically in the form of a one-dimensional table of values. Here again, system default tables are provided to assist the user. Depending on the particular operator, data tables may be entered by the user through the keyboard, card reader, trackball, or scanner. Figure 4-4 illustrates how a data source is specified (second line under Parameter Description).
Data tables, like images, are uniquely named. They may be modified through use of the Table Modification operator by specifying the table name and editing selected values. Figure 4-5 presents a typical Table Modification process.

4.3.5 "HELP" Feature

If the user needs assistance during the parameter specification process, he can obtain help from the system by pressing the special function key on the keyboard which is labeled "HELP". The system will display an explanatory message at the bottom of the screen to assist him. "HELP" messages either explain what a particular parameter is or more clearly define the various options available to the user. Figure 4-4 shows a typical "HELP" message (bottom of screen) which was requested to help clarify the term Input (last major entry under Parameter Description).
4.3.6 **Error Trapping and Recovery**

To the extent possible, IDAPS assists the user in the parameter specification process by identifying and trapping erroneous input or operating conditions. Operation is suspended at the point of erroneous input and the user is given the chance to correct the input or condition. After correction, normal operation is continued. Error messages and the recovery procedure are displayed at the bottom of the screen.

4.3.7 **Repeatability**

To utilize the full power of the image processing system, the user must be able to repeat a sequence of operations without having to specify every single operator and parameter in the sequence that he has previously performed. IDAPS makes provision for such repeatability through use of the following features:
4.3.7.1 User Default Parameters

System default parameters, discussed in Section 4.3.2, provide the user with standard values for each parameter. These system defaults are active only until changed by the user, at which time the values entered by the user become the default values. For the next use of that operator in the same processing session, the user supplied parameter values will be displayed as the default parameters. Thus, when using an operator repetitively, the user can establish his own set of parameters the first time and not have to modify them on subsequent calls to that operator. When the user terminates his processing session, the system defaults are automatically restored.

4.3.7.2 User Default Tables

Tables, like parameters, may be modified by the user with the user entered table values replacing the system defaults during a specific processing session.

4.4 PICTURE DISPLAY

Pictures are displayed on one of the black-and-white monitors designated Monitor 1 or Monitor 2, or on the second color monitor, designated Color Monitor. Pictures can be displayed from a number of sources: scanner, tape drive, or host computer.

Pictures displayed on one of the black-and-white monitors will exhibit 64 levels of gray; that is, the black-and-white monitors are refreshed with the six most significant bits of the normal eight-bit picture element. Pictures displayed on the Color Monitor will be displayed at 16 levels for each color gun; that is, the red gun, as well as the green and blue gun, will be modulated by the four most significant bits of the normal eight-bit picture element. Sixteen levels of intensity for each of the three color guns provide a capability for displaying 4096 different colors.
Spatial resolution of all monitors is standardized to 480 X 480 picture elements. On a 14-inch diagonal monitor, such an image will appear as approximately 8 X 8 inches.

4.5 PICTURE RECORDING

Three types of image recording are provided by IDAPS:

- Magnetic tape recording
- Film recording
- Facsimile hardcopy recording

4.5.1 Magnetic Tape Recording

If images are to be stored in digital form, they may be recorded by transferring them to tape. This operation is performed by the SYSTEM TO TAPE operator.

4.5.2 Film Recording

Permanent, high resolution recording of images on film is accomplished by use of the image recorder. This device is capable of exposing several types of film (cut film, film packs, roll film and Polaroid film packets) at a resolution that will produce a 2048 X 2048 array of picture elements in a 57 X 57 mm area.

The image recorder is controlled by the user through the interactive keyboard. The capability is provided for specifying such parameters as the source of the image data to be recorded, the filter to be used, the size of the image to be produced, and its resolution.

Depending upon the size of the picture, the resolution desired, and whether or not the picture is color or black and white, film recording time will vary from 5.5 minutes to as little as 0.5 minute. This does not include, of course, film processing time.
4.5.3 Facsimile Hardcopy Recording
If high resolution film hardcopy is not required, the user may obtain quick image hardcopy through use of the facsimile copier. This device uses a dry silver paper process and produces an 8 1/2 X 11 copy of the image presented on the black-and-white monitor to which it is connected. This device is controlled manually and requires about 10 seconds to produce one copy.

4.6 SPECIAL FUNCTIONS
There are several functions performed by IDAPS which are outside the menu-selection/parameter-specification concept of operation. They are functions that are often repeated, have few or no parameters, or for some other reason require minimal transfer of information from the user to the system. These functions are designated "Special Functions" and are generally activated by a single special function key on the keyboard. Examples of special functions are:

- Histogram
- Quick-look Scan
- Coordinates
- Erase

4.7 APPLICATION PROGRAMS
The majority of IDAPS functions discussed thus far are executed entirely by the terminal minicomputer. The real power of IDAPS, however, lies in its ability to execute image processing algorithms on large images in a very short time. This is accomplished by using an on-line host computer for the "number crunching" jobs which require large amounts of core, disk, and central processing unit time.

A basic set of image processing algorithms or operators are currently operational on the IBM 360/65, the S-056 IDAPS host computer. As the development of IDAPS continues, more operators will be added. Examples of currently operational operators are:
- ROTATE
- REGISTER
- AUTOMATIC SCALE
- FRAME

See Volumes II and III for a complete description of the available operators.
1.0 IMAGE PROCESSING

Digital image processing involves the manipulation of imagery by digital computers to restore, enhance, or analyze the imagery. Images are two-dimensional fields of intensity recorded in a medium, frequently photographic film, by a sensor. The goal of image processing is to render the information in the processed image more useful to the analyst than the same information in the unprocessed form.

Increasing the utility of the image information begins with the removal of degrading effects introduced by the sensor, environment, or the systems through which the image passes in being translated to a form amenable to digital computation.

Subsequent processing operations enhance the availability of the information to the user. Operations can be conducted to increase the contrast or to move the average intensity to a level more visible to the eye. Levels of brightness can be converted to shades of color, either to emphasize features or to provide better intensity discrimination. If the discernment of fine structure is required, high-frequency emphasis filters may be invoked.

Finally, image processing provides direct analysis aids; and, in many cases, actually performs analyses. Features, for example, can be isolated, and computations can be performed on the elements of entire areas or centroids.

Digital image processing normally involves three steps. The image is first converted to a form which can be manipulated by a digital computer, processed by appropriate algorithms to accomplish the desired effects, and then reconverted to a form convenient for the analyst to interpret. Since the reconversion and recording of the image at the end of the process is usually the
inverse of the initial conversion, or digitization, these two steps are
discussed below under a single heading. The processing technique is discussed
as three types of data transformations: intensity transformations, geometric
transformations, and transformations to nonimage domains.

2.0 DIGITIZATION AND RECORDING
Since an image is a continuous intensity field, it must be sampled and converted
to an array of numbers before processing by a digital computer. The process,
called digitization or scanning, involves running a small, sampling spot
along sequential horizontal lines. As the spot moves along each line, a
sensor regularly samples the amount of light transmitted through the trans­
parency and encodes the transmitted intensity as an eight-bit integer number.
When the spot is positioned over a dense, dark area of the transparency, the
encoded intensity is near zero. Conversely, a bright area is encoded as the
maximum integer value. The intensity field in the image is thus converted
to a two dimensional array of numbers.

The process of conversion from digital form to film proceeds in an analogous
manner. A small, illuminated spot is scanned over unexposed film. As the
spot moves along each line, either its intensity or sample-position dwell
time is modulated proportional to the corresponding numeric value in the
digital array.

3.0 PROCESSING TECHNIQUES
The basic tools of digital image processing consist of hundreds of processing
algorithms largely developed over the last ten years. Some are general
purpose, others are "application specific". The application-specific algo­
rithms, however, are usually variations of more general purpose procedures.
The following section undertakes to review some of the basic operations from
which the more sophisticated procedures are developed.
3.1 INTENSITY TRANSFORMATION
The transformation of each level of intensity to a new value provides a widely used tool to increase the visibility of information in imagery. If, for example, a feature of primary interest in an image contains intensities which fall in a narrow range, the visibility of structure within the feature can be enhanced by performing an intensity transformation which converts the lowest intensity in the feature to a lower level, the upper intensity to a higher level, and all intensities between to proportional values. The feature in the transformed image would then contain intensities falling in a broader range, thereby exhibiting greater contrast and improved visibility of interval structure.

3.2 GEOMETRIC TRANSFORMATIONS
Geometric transformations modify the spatial relationships among image points. These operations serve both to remove distortions, such as "pincushion" distortion produced in the optical system of a sensor, and to reorient the image, as in image registration where the features of one image are moved to achieve coincidence with corresponding points in a second image. A geometric transformation is the application of either a mathematical function of position defined over the entire image or a displacement map (occasionally referred to as a "rubber sheet" transformation) which is either directly specified at each point of the image or is interpolated based on specified points scattered throughout the image.

Geometric transformations of the mathematical function type may be defined by specifying parameters such as angle of rotation, magnification factor, and horizontal or vertical translation, or by identification of the locations of a set of points in the input and a set in the output to which the input points are to be transformed. In the latter approach, the functional parameters are computed either to yield the specific transformation of points or a "best-fit" transformation which optimizes pre-established error criteria.
3.3 TRANSFORMATIONS TO NONIMAGE DOMAINS

In both intensity and geometric transformations, the product of the transformation is an image generally resembling the input. There also exists a class of quite useful mathematical transformations which produce sampled arrays which may be treated as images but which exhibit no similarity to the input image. Fourier, Hadamard, Walsh, and "Z" transformations are of this class. Their primary utility occurs in filtering, data compression, and pattern recognition. The Fourier is the most commonly used of these transformations, and its most frequent application is that of filtering to remove noise or sharpen edges.

The Fourier transform converts the gray values of the image into an array of complex numbers which represent the image in terms of sinusoidal components of amplitude, phase, and frequency. The Fourier transformation results in an array which has the same number of lines and columns as the image, but in which there is no simple relationship between samples in the input and Fourier arrays. The complex value of each sample point in the Fourier array is the amplitude and phase of a sinusoidal component. The frequency of the component is given by the location of the sample point in the transform. The center location of the transform represents a zero frequency (which corresponds to the average of all gray values in the image). The maximum frequencies, which occur at the edge of the transform, correspond to a wavelength of two input-image samples. An important property of the Fourier transformation is that an inverse transformation can be performed whereby the image is recovered from the transformation.

An image which contains a high proportion of small scale information will generate a Fourier transform with higher values toward the edges than will an image of nearly uniform intensity with few sharp features. The crispness of an image, therefore, can be enhanced by increasing the magnitudes of the samples of its Fourier transformation which fall in the vicinity of the
edges of the transform. Similarly, noise exhibiting a speckled appearance can be removed by reducing samples near the transform edges. These processes, referred to as filtering, consist of:

1. Computation of the Fourier transformation of the image.

2. Point-by-point multiplication of the transform by an overlaid filter function.

3. Computation of the inverse Fourier transformation of the filtered transform to yield the enhanced image.

Due to certain properties of the Fourier transformation, a different filtering procedure exists which accomplishes a result identical to that produced by Fourier domain filtering. This process, known as convolutional filtering, consists of:

1. Computation of the inverse Fourier transformation of the filter function.

2. Convolution of the inverse transformed filter function with the image to obtain the enhanced image.

Convolution is accomplished by overlaying the input image with the inverse transformed filter function so that the center of the overlay coincides with a specific sample of the input image. The sum of the products of all coincident points in the input image and the overlay is then computed. The process is repeated at each sample in the input image, yielding a corresponding sample in the output equal to the sum of products computed with the overlay positioned at the sample.
In general, convolutional filtering requires greater computation than does Fourier domain filtering. However, when the inverse Fourier transformation of the filter function contains significant areas of zero magnitude, convolutional filtering becomes more efficient. Useful filter functions exist for which the inverse transforms are of sufficiently limited extent to render convolutional filtering more economical, but the performance of these filters tends to be less than optimal. Algorithms are available which construct filter functions exhibiting inverse transforms of limited extent and which approximate within constraints optimal filter functions. Using these substitute filters, admittedly poorer enhancements may be obtained, but in many cases great computational economy can be achieved.
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1.0 INTRODUCTION

The S-056 Image Data Processing System (IDAPS) is a flexible, high-volume image processing system. Flexibility and responsiveness to the user are provided by an interactive mode, and high-volume capacity by a batch mode. This document, Volume II of the IDAPS User Manual, is the Batch IDAPS Manual. It is a companion document to Volume III, the Interactive IDAPS Manual. Volume I describes the general features and capabilities of the IDAPS concept, hardware, and software.

Batch IDAPS operations utilize an extensive library of image processing operators (software modules) and an image processing control system. Each image processing operator is an independent software module capable of performing a specific image processing task or technique. An operator may be executed by itself or in series with other operators. The Batch IDAPS system provides a capability for applying sequences of operators to sizable image data arrays with minimal user interaction.

The user exercises complete and straight-forward control over the capabilities of the Batch IDAPS system by writing instructions in simple computer-card formats. Jobs are submitted by computer card deck, and image data arrays are input from magnetic tape. The Batch IDAPS system assigns appropriate file names, keeps track of and adjusts data formats as needed, opens and closes files, maintains a file directory, generates printed information required by the user or system, and outputs data files on magnetic tape for user reference. On the basis of a deck of control card instructions, the system will apply selected IDAPS operators for restoration, enhancement, and analysis of the input data.

This manual provides concise instructions for the use of Batch IDAPS, assuming the user has some minimal experience with computer card preparation and a general understanding of image processing techniques. The manual has three major sections:
• A Glossary section to acquaint the user with Batch IDAPS nomenclature.

• A System Use section to describe the mechanics of preparing a Batch IDAPS run. This section defines card formats, system features, capabilities and limitations encountered in controlling the Batch IDAPS run.

• A Batch IDAPS Operators section to define the purpose, individual card formatting, parameters, Data card format, input/output data types, and restrictions for each operator.

The user of this manual, after acquiring a general understanding of the IDAPS system by following the Training Plan outlined in Volume I, should be able to select the operators required to process his data, prepare his Batch IDAPS Run Deck, submit his job, and retrieve his processed image data. If the user is uncertain of the operators to be used to accomplish a desired objective, or of the sequence of operators, or of the parameters to be specified, he should explore these variables with Interactive IDAPS, described in Volume III.

Appendix A, Batch IDAPS Operator Index, provides an alphabetical list of the operators currently in the system. A brief statement of purpose is included for each operator.

Appendix B, Batch IDAPS Operator CPU Time Requirements, provides the number of minutes of CPU time that each operator is estimated to require.
2.0 GLOSSARY

Account Number - The accounting number against which the job will be charged. (Same as charge number)

Array - A rectangular array of picture elements; an image file.

Asterisk (*) - When used in a data table on a Data card, the asterisk indicates that the preceding number in the table is the number of times the following data value is to be repeated (see paragraph 3.10).

Batch IDAPS - The high-capacity data processing mode of IDAPS requiring minimum user interaction.

Batch IDAPS Initiator Card - Indicates to the IDAPS system that the job is a Batch IDAPS job as opposed to an Interactive IDAPS job.

Batch IDAPS Run Deck - The set of cards which define the sequence of image processing operations to be performed by Batch IDAPS.

Bin Number - The bin in which the output of the job will be deposited.

Charge Number - The accounting number against which the job will be charged. (Same as account number)
Clipping - Defines the upper and lower limits of gray values on which a process is to be performed. All signals outside the clipping limits are set equal to either the maximum or minimum gray value (0 or 255).

Column - A one-dimensional vertical array of picture elements. The first column of a picture is designated as column 1.

CPU Time Requirement - Minutes of Central Processor Unit time that the job is allowed to run. An estimate may be obtained by reference to Appendix B.

Data Card - Provides data for the operator in addition to the parameters on the operator card.

Data Definition (DD) Card - Identifies the required image input and output tapes.

DD Card - Data Definition card.

Delimiter /* Card - Signifies the end of the IDAPS Control cards. The last card in the Batch IDAPS run deck.

EOF Code - End of File code is an electronic mark on magnetic tape which is used to signal the end of a data file.
EXEC Card
- Invokes the Batch IDAPS system.

File Identification
- A parameter which tells the computer operations personnel which tape to mount. (Same as Tape Identification)

File Name
- A unique temporary identification name automatically assigned to each image file which is stored on the host computer disk during an IDAPS run.

File Number
- The Tape File Number; it identifies a specific image file on a given tape.

Flags
- Alphabetic characters used to signify options in an IDAPS operator.

Floating Point
- Numeric values containing a decimal point.

Frame
- An image or data file.

Gray Scale
- A value (0-255) assigned to a picture element to indicate its degree of grayness. 0 = black; 255 = transparent.

IDAPS
- Image Data Processing System.

IDAPS Control Card
- Cards which control the operators and the associated data input.
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<td>Same as image data array.</td>
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<td>Image Data Array</td>
<td>A rectangular array of picture elements; an image file.</td>
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<td>Image File</td>
<td>A two-dimensional array of numbers filed on disk or tape representing the gray levels of pixels in a digitized picture.</td>
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<td>Image Number</td>
<td>The sequential index within a run deck of the image files to be input by the INP Operator or output by the OUT Operator.</td>
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<td>Input Tape</td>
<td>The image data tape which is the source of data for the Batch IDAPS run.</td>
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<td>Interactive IDAPS</td>
<td>The operating mode of IDAPS which provides interactive user control of image processing.</td>
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<td>Job Control Language card.</td>
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<td>JOB Submittal Card</td>
<td>The card under which the Batch IDAPS job is submitted to the IBM 360 control desk.</td>
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<tr>
<td>JOB Cards</td>
<td>The first two cards in the Batch IDAPS run deck. The first JOB card is used by computer operations personnel for job control; the second for job accounting.</td>
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Line - A one-dimensional horizontal array of picture elements. The first line of a picture is designated as line 1.

Line and Column Coordinates - A pair of integer numbers used to describe the location of a single picture element within a frame of data; the row and column numbers of a picture element.

Operator - A single image processing technique or control process. It may be a subroutine or a collection of subroutines, called by an identifying name, which carries out a specific task.

Operator Card - Designates that a specific operator is to be run.

Operator Code - The unique three letter code for each IDAPS operator.

OS-MVT - Operating System — Multiprocessing with a Variable Number of Tasks. The IBM operating system under which Batch IDAPS runs.

Output Tape - The tape on which the image output of the Batch IDAPS run is written for permanent record.

Parameter - Variables entered on the Operator card to define and control a process.
Picture Element - The smallest unit of a digitized picture representing the average gray level (0-255) of a single area sample of an image. (One data point)

Pixel - Picture element.

RET Code - Retention code, used on output tape labels.

Row - A line.

Run Deck - The set of JCL and IDAPS Control cards which controls a Batch IDAPS run.

Scanner - Refers to the on-line Dicomed Film Digitizer or similar off-line film digitizing device.

Size - The vertical and horizontal dimensions of an array expressed in terms of picture elements. A 320 X 480 image has 320 pixels in the vertical line and 480 pixels in the horizontal line. Size should not be confused with the physical dimensions of an image on film.

SYSIN Card - Defines the set of IDAPS Operator cards that belong to the job being run.

Table - A one-dimensional array of real or integer data used as input to the IDAPS...
system for use by an operator. Tables are input to the computer by data cards.

Tape Identification - A parameter which tells the computer operator which tape to mount. (Same as File Identification)
3.0 SYSTEM USE.
This section provides the user of Batch IDAPS with the information and procedural instruction required to set up an image processing run and to enter it into the computer for execution. Also provided is a brief explanation of Batch IDAPS image data input/output techniques so that the user will better understand overall system performance and capability. The instructions in this section are directed toward the user who has a general knowledge of image processing techniques.

3.1 CAPABILITY, LIMITS, AND APPLICATIONS
Proper application of Batch IDAPS is important to the efficient utilization of NASA resources and to the timely turn-around of image processing jobs. The IDAPS concept centers on the use of both batch and interactive processing. The two mutually supporting approaches provide a means for setting up and testing a job run by interactive operation and for performing the more time-consuming processing of whole and multiple frames in a batch mode.

In preparing to use Batch IDAPS, three steps are usually required:

- Prepare IDAPS format image data tapes using an available film scanner.
- Interactively process a representative subset of the input data using Interactive IDAPS to establish operator sequences, parameters, and data tables.
- Set up the Batch IDAPS run deck in accordance with the instructions in this manual.

As the user becomes more familiar with IDAPS, he will find that less time is required with the interactive mode and that man-machine time can be greatly reduced by increased use of the batch mode.
Since Batch and Interactive IDAPS are designed to complement each other, special capabilities exist in the interactive system which are not available to the batch user and vice versa. Because all image I/O is through magnetic tape in the batch mode, operators are provided for reading and writing image format tapes. Because some interactive tasks require peripheral hardware which is not directly available to the host computer, such operators as Pseudocolor-SYSTEM TO DISPLAY and Image I/O-SCANNER TO FILM are only available to the interactive user. Section 4.0 of this manual presents descriptions of the operators available to the Batch IDAPS user.

3.2 HOST COMPUTER
The Batch IDAPS runs described in this manual are processed by the NASA Marshall Space Flight Center's IBM 360/65 computer. A full compliment of standard computer peripherals is available, including high-speed line printers, card reader/punch, and magnetic tape drives. Batch IDAPS runs utilize the IBM OS-MVT software system. By operating under OS-MVT, it is possible to take advantage of the many utility features of the IBM software and to run multiple tasks concurrently. Batch IDAPS is set up as a procedure under OS-MVT and is invoked by a small card deck as explained in the following paragraphs. The user then instructs the Batch IDAPS system which input data to use, which operations to perform, and how to record the results. These instructions are conveyed to the Batch IDAPS system by the Batch IDAPS Run Deck.

3.3 BATCH IDAPS RUN DECK SET-UP
Two types of run-deck card inputs are required: JCL cards and IDAPS Control cards. The JCL cards and IDAPS Control cards are as follows:
The JCL cards perform the following functions:

- Establish the user's job, including name, job number, and run time.
- Define input and output images.
- Provide a delimiter to signify the end of the IDAPS Control cards.

Several of the parameters of each JCL card are constant and are of no concern to the average user. Only those parameters which require specification for each user job are described.

The IDAPS Control cards perform the following functions:

- Initiate the Batch IDAPS Control card series.
- Identify the selected IDAPS image processing operators.
- Provide additional data and tables as required beyond the basic operator parameters.

Figure 3-1 presents a typical deck set-up for a Batch IDAPS run. The deck as shown consists of the following cards:
Figure 3-1. Typical Deck Set-Up for Batch IDAPS Run
JOB
EXEC
Data Definition (DD)
SYSIN
Batch IDAPS Initiator
Batch IDAPS Operator
Batch IDAPS Data
Delimiter /*

The JCL and IDAPS Control cards are discussed in the following paragraphs in the order in which they occur in the Batch IDAPS run deck. The number of characters used to specify a parameter may be less than that shown in the examples. For example, the user's bin number may be A2 which requires only two character spaces. In general, however, strict adherence to the character spacing shown in the example of JCL cards should be maintained. All control card parameters start in column one and each parameter is separated by a comma unless otherwise noted.

3.4 JOB CARDS
The first two cards in the Batch IDAPS run deck are JOB cards. They are punched identically. The first JOB card is used by computer operations personnel for job control; the second is used for job accounting.

//A11,20,10),LHNTSVSE3000USERNAME,MSGLEVEL=(1,1)

The variable parameters on the JOB cards, underlined and numbered above, are:
1. Bin Number - The bin in which the output of the job will be deposited. The job output will normally consist of the user run deck plus the job print out. Bin numbers are three spaces. (See computer control desk personnel.)

2. CPU Time Limit - The number of minutes (integer) of CPU time that the job is allowed to run. It should be the sum of the estimated CPU times for each use of the operators in the run deck. (See Appendix B for estimated operator times.) There is no digit limitation on this parameter.

3. Charge Number - The accounting number against which the job will be charged. (See Mr. D. T. Thomas, EF32, Data Systems Laboratory.) Charge numbers are six characters.

4. Name - The job identification (maximum of eight characters).

3.5 EXEC CARD
The EXEC card invokes Batch IDAPS.

```
//BATCH EXEC IDAPS,TIME,GO=20.
```

The variable parameter is the CPU time limit, which should be the same as entered on the JOB card.

3.6 DATA DEFINITION (DD) CARDS
For each input and output image there must be a corresponding DD card. The DD cards provide the required image input and output information such as reel number and file number. The format for the Input Image DD card is as follows:
The characters "DD" must have leading and trailing blanks as in the example.

The variable parameters on the Input Image DD card are:

1. **Image number** - The sequential index to the image files to be input via the **INPUT (INP)** operator during the run. Image number 01 corresponds to the first use of INP, 02 to the second INP, etc., in a run deck. This parameter requires that two character spaces be used to specify the image number.

2. **File number** - The tape file number of the image data to be input from the tape identified below. There is no character limitation on this parameter.

3. **Tape ID** - This parameter tells the computer operator which input tape to mount. It may be the reel number (in the case of IBM 360 library tapes) or the tape label ID (in the case of a user tape). A maximum of six characters may be used for reel number identification.

The format of the Output Image DD card is as follows:

```
//GO.TAPE1F01 DD UNIT=TAPE9, LABEL=(1, NL, , IN), VOL=SER=SDC008, DISP=OLD
```

The characters "DD" must have leading and trailing blanks as in the example.

The variable parameters on the Output Image DD card are:
1. Image number - The sequential index to the image files to be output via the OUTPUT (OUT) operator during the run. Image number 01 corresponds to the first use of OUT, 02 to the second OUT, etc., in a run deck. This parameter requires that two character spaces be used to specify the image number.

2. File number - The tape file number of the output image data to be recorded on the tape below. There is no character limitation on this parameter.

3. Tape ID - File Identification as specified on the Output Tape Label (Tape Save Label). It identifies the tape on which the output image data is to be recorded. A maximum of six characters may be used.

3.7 SYSIN CARD

```
//GO.SYSIN DD *
```

The SYSIN card identifies the subsequent cards as being the IDAPS operator cards that belong to the current job.

3.8 BATCH IDAPS INITIATOR CARD

This IDAPS Control card indicates to the IDAPS Control Program that the job is a Batch IDAPS job as opposed to an Interactive IDAPS job.

```
BATCH RUN
```
3.9 BATCH IDAPS OPERATOR CARDS
A free field format is used for Batch IDAPS Operator cards. The general
form of a Batch IDAPS Operator card is:

\[
\text{OPERATOR CODE [SPACE] (File Name(s)) 1, 2, 3, n} \]

OR

\[
\text{OPERATOR CODE [SPACE] 1, 2, 3, n (File Name(s))} \]

For convenience, file name(s), which appear enclosed within parentheses, may
precede or follow the parameter string.

3.9.1 Operator Code
Each IDAPS operator is identified by a three letter code which is usually
the first three letters of the operator name. For instance, the operator
code for the AVERAGE operator is AVE. This code is used to designate the
operators that the user wishes to apply to his data. The three letter
operator code is punched on the operator card beginning in column 1 of the
card. The three letter code must be followed by a blank in column 4. The
proper operator code for every operator in Batch IDAPS is presented in
Appendix A.
3.9.2 Operator Parameters

Most IDAPS operators require the specification of more information than just the operator code. Such information as starting line and column or the size of an area to be processed must be supplied by the user through parameter values on the Operator card.

Parameters are of three types:

- Integer values
- Real values
- Flags

Integer values consist of a sign (a plus is implied if no sign is specified) and 1-8 decimal digits (i.e. 3; -.6; .89; 57691832). Real values are written with a sign, decimal point, and 1-8 decimal digits (i.e. -.37; 1.5916371; -10015.). Flags are generally single alphabetic characters which are used to select one of several options.

Parameters are specified on the operator card following the operator code and a blank in column 4. Parameters are separated from each other by commas as in the following example:

```
```

Because the IDAPS system checks the number of parameters that the user specifies for an operator against the number required for the operator, it is important that there be an entry for every parameter on the operator card. Note that no comma precedes or follows the parameter string.
3.9.3 File Name

File names are assigned by the Batch IDAPS system to designate and keep track of input and output images during a run. File names are assigned to the output of an operator using the convention that a file is based on the operator code of the operator that created it and the sequence of operator use. For example, the first time the INPUT (INP) operator is used, its output file is designated IINP. The next time the INPUT operator is used, its output will be 2INP and so on. This convention simplifies the problem of keeping track of files in IDAPS.

When an operator creates a new file it is assigned a name by the above convention and stored on disk for future use during the run. To use an IDAPS file that has been stored on disk, the user refers to it by its assigned name. In preparing the Batch IDAPS Operator card, the user may or may not specify an input file or files. If he does wish to specify an input file(s), he does so by enclosing its name in parenthesis following the operator code (separated by the blank in column 4) or following the last specified parameter. For example:

\[
\begin{align*}
\text{COL. 4} & \\
\text{AUT (1INP)256,256,101,245,C,A,36.,251.}
\end{align*}
\]

\[
\begin{align*}
\text{OR} & \\
\text{COL. 4} & \\
\text{AUT 256,256,101,245,C,A,36.,251. (1INP)}
\end{align*}
\]

For those operators that require more than one input file, the user must specify all input files as in the following example:
For those operators which require only one input file, the user may elect not to specify an input file on his Operator card. In this case a default condition occurs in which the Batch IDAPS system assumes that the last file created by the user is desired to be the input for the next operation. This case is often true and the default capability can simplify the user control deck considerably.

3.10 BATCH IDAPS DATA CARDS

Many operators require the input of data or tables in addition to the parameters on the Operator card. Such Data cards are included in the Batch IDAPS run deck immediately following their associated Operator card. Data cards begin with a table name followed by an equal sign followed by the data values separated by commas followed by a dollar sign. Since the system does not check the name of the operator but simply looks for the equal sign, the actual name of the data set is unimportant and may be chosen by the user to satisfy his own identification needs.

A free field format is used for the data values. This means that the user does not have to be concerned with numbers of columns of a card in which a data value is punched. The user simply punches his data values in sequence, separating the values with commas. Multiple entries of the same value may be indicated by specifying the number of times the value is repeated, followed by an asterisk (*), followed by the desired value. For example, to repeat the value 1 ten times, the following format is used:

.....,10*1,.....

The last value in the data table must be followed by a dollar sign ($). Data may be written in any card column and multiple cards may be used. Care
should be taken to include the correct number of values and to signal the end of the data table with the dollar sign.

Data may be integer or floating point depending on the requirements of the particular operator. Integer data may be as large as eight digits while floating point data should be restricted to sixteen characters including plus and minus signs, decimal points, numerals, and the letter E for scientific notation.

The following examples illustrate Data card formats:

```
RUN3-2=0,,1.,6.,16.,36.8,19.,12.3,6.,1.25,.86$
```

```
GROUP=32*1,32*2,32*3,32*4,32*5,32*6,32*7,32*8$
```

```
60,60,2*61,2*62,2*63,2*64,2*65,2*66,193*255$
```

```
39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,
```

```
K1=10*0,2,4,6,8,10,12,14,16,18,20,22,24,26,28,30,32,34,36,38,
```

One exception to the general Data card format above is the use of a Data card to specify alphabetic character strings used in such operators as FRAME. An explanation of the format required for such exceptions is included in the operator descriptions in Section 4 of this manual.
3.11 DELIMITER /* CARD

/*

The Delimiter /* card signifies the end of the IDAPS Control cards. It is the last card in the Batch IDAPS run deck.

3.12 TYPICAL SET OF BATCH IDAPS CONTROL CARDS

A typical set of Batch IDAPS Control cards, consisting of the Initiator card, Operator cards, and Data cards, is shown in Figure 3-2. The cards are numbered from one to eleven for discussion. These sample cards would control the Batch IDAPS system as follows:

1. Identify job as a Batch job (Initiator card)
2. Input an image from tape into the system (INPUT Operator card)
3. Extract a specific subframe from the image (EXTRACT Operator card)
4. Prepare an isogram of the extracted subframe (ISOGRAM Operator card)
5. Data for the isogram (Data card for ISOGRAM operator)
6. Subtract the isogram from the extracted subframe (MATH Operator card)
7. Linearly scale the results between 0 and 255 (AUTO SCALE Operator card)
Figure 3-2. Typical Set of Batch IDAPS Control Cards
8. Prepare a presentation frame with appropriate annotation (FRAME Operator card)

9. The top label (Data card for FRAME Operator)

10. The bottom label (Data card for FRAME Operator)

11. Write the results on magnetic tape (OUTPUT Operator card)

3.13 JOB SUBMITTAL
Once the job deck has been set up, there are additional steps prior to submittal, such as completing the Job Submittal card and preparing tape labels.

3.13.1 Job Submittal Card

The Job Submittal card for a Batch IDAPS job is completed as indicated. The only variables are entries 2, 5, and 6:
1 - Core Size - enter 335K
2 - Bin Number - enter assigned bin number
3 - Punch $ - check "No"
4 - Plots - check "No"
5 - Input Tapes - list the tape identification for each input tape
6 - Output Tapes - list the tape identification for each output tape.

If the user wishes return of any user supplied tapes (either input or output) along with his job output, he should request it by special note in this space. Checkout of IBM 360 tape on which his output may have been recorded must be arranged through the IBM 360 control desk.

Refer to "MSFC 360 Operations Bulletin Number 1", available at the IBM 360 control desk, for further information.

3.13.2 Output Tape Labels
Each output tape, as indicated by the DD cards, must have an associated tape label. The Output Tape Label (Tape Save Label) is completed as indicated.
1 - Programmer – enter your last name and initial

2 - Account Number – enter change number; must agree with JOB card

3 - File Identification – enter output tape identification; must agree with DD card

4 - RET Code – enter retention code as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>14 days</td>
</tr>
<tr>
<td>3</td>
<td>30 days</td>
</tr>
<tr>
<td>4</td>
<td>90 days</td>
</tr>
<tr>
<td>5</td>
<td>180 days</td>
</tr>
</tbody>
</table>

3.13.3 Job Submission
Batch IDAPS jobs are submitted to the IBM 360 control desk personnel in the west end of the basement of building 4708.

3.14 IMAGE DATA INPUT/OUTPUT
When operating under Batch IDAPS, image data is entered into and removed from the system on magnetic tapes. For IDAPS image input, this means that film images must be scanned off-line and stored on tape in the format described in the paragraph below. For picture output, the OUTPUT operator will prepare a magnetic tape which may be analyzed at an off-line viewer. The magnetic tape format for image data input is the same as for image data output and the format required for magnetic tape I/O for Batch IDAPS is the same as for Interactive IDAPS. This means that input tapes may be prepared by Interactive IDAPS which can be submitted to and processed by Batch IDAPS, and that the results of Batch IDAPS runs may be saved for analysis or further processing using Interactive IDAPS.
The required magnetic tape format is as follows: Magnetic tape should be a nine-track, 800 BPI standard half-inch computer tape. The tape may be contained in reels up to and including 10 inches in diameter. Image data on the tape should not be preceded by a label. Each frame of picture data shall constitute one tape file and each file shall be made up of a number of tape records. The number of records contained in a file shall be the same as the number of scanned lines in the image data array; that is, the first record in a file shall correspond to the first scanned line of picture data; the second record, to the second scan line and so on. Each record shall consist of a number of 8-bit binary codes or data bytes. Each picture element (pixel) in the scanned image array shall occupy one byte and shall correspond to one of 256 possible transmittance values. Several frames of picture data may be stored on a magnetic tape provided care is taken to mark the end of each file with an EOF code.

3.15 IMAGE FILE SIZE
In most cases, the user can keep track of his image file sizes; however, there are certain operators which calculate the output image-size based on input parameters in which case the exact size of a particular output file is not known. Operators ROTATE and REGISTER are in this category.

For those operators which request "Number of Lines" and "Number of Columns" in the parameter string and this information is not known, a default capability is provided to allow the user to omit the file size specification. To omit the file size specification from the parameter string, replace Number of Lines and/or Number of Columns with a null field. For example, if size parameters are known to be 512 lines by 512 columns, the user might specify

ISO (IALT) 512,512,1,1,0

If the size parameters are not known, he might specify

ISO (IALT) ,,1,1,0

where the null fields are indicated by commas.
3.16 IMAGE STORAGE FOR SUBSEQUENT RUN

If the user wishes to save image files from one run to the next, the files must be dumped to tape by using the OUTPUT operator. Thus, they can be re-input on a subsequent run by using the INPUT operator. It is the user's responsibility to know what each output file consist of since there is no automatic labeling of the files by the system when they are dumped to tape.

3.17 ABNORMAL JOB TERMINATION

Certain conditions can cause abnormal termination of a job, such as:

- Illegal operator name
- Undefined file specification
- Violation of column 4 on Operator card
- No data table where required
- Out-of-bounds parameters

Abnormal termination is indicated on the user's printed output with a brief explanation of the error condition. Special notice of the stated restrictions for a particular operator will help the user avoid abnormal job termination.
4.0 **BATCH IDAPS OPERATORS**

The following section contains descriptions of each operator available to the Batch IDAPS user.

4.1 **OPERATOR DESCRIPTIVE FORMAT**

Each operator is described in the format presented below.

**Name:** Name of the operator and the three-letter identification code.

**Purpose:** A brief explanation of the purpose of the operator. An explanation of the technique used is included if required to clarify the purpose of the operator.

**Card Format:** Illustration of the Operator card image.

```
Identification Code (Input File) Parameter 1, Parameter 2, ...Parameter n
```

**Parameter Definitions:** Definition of each parameter.

**Data Card Format:** Example and Explanation.

```
Data Table = N_1, N_2, N_3, ............. N_n$
```

A written statement explaining the Data card and any limitations are included if required to clarify the Data card input.

**Output Data Type:** The number of files produced and whether those files are integer or floating point.
Input Data Type: The type of file input to the operator.

Restrictions: Brief outline of pertinent data that may be important to the user. Any limitations on image size, operator capacities or formats are noted.

Notes: Comments on the technique used by the operator, accuracies, and special features which may be of interest to the user.

4.2 OPERATOR DESCRIPTIONS
The operator descriptions are presented in alphabetic order. This manual will be updated periodically to include new Batch IDAPS operator descriptions as they are developed.
NAME:  ALTER(ALT)

PURPOSE:  The ALTER operator modifies the gray scale value of each element in a picture in accordance with a table of values supplied by the user. The original gray values in the input array are used as an index and the appropriate values in the table are substituted by the ALTER operator for the original values and appear in the output array.

CARD FORMAT:

ALT (Input File Name)

DATA CARD FORMAT:  The table of alteration values (table ALT) is input immediately following the ALTER Operator card. The first entry on the ALT data table card will replace gray value 0 (black) in the input image, the second will replace gray value 1, etc.

ALT=255,252;3*248,244,...,3,2,1,$0

The ALT table contains 256 integer values. In the above example, all gray values of 0 (black) in the input picture will be replaced by 255's (white); all 1's by 252; 2's, 3's, and 4's by 248; 5's by 244; etc.

OUTPUT DATA TYPE:  Integer

INPUT DATA TYPE:  Integer

RESTRICTIONS:  256 values must be accounted for in the data table.
NAME: AUTOMATIC SCALE (AUT)

PURPOSE: The AUTOMATIC SCALE operator scales an image file to values between 0 and 255 based on a selected scaling curve. The user may specify upper and lower limits of the gray scale range on which the scaling will take place. The output of AUTO SCALE is an array of values between 0 and 255.

CARD FORMAT:

```
AUT (Input File Name) NL,NC,SL,SC,KF,LF,BC,TC
```

PARAMETER DEFINITIONS:

- **NL** - Number of lines to be processed (may be null).
- **NC** - Number of columns to be processed (may be null).
- **SL** - Starting line.
- **SC** - Starting column.
- **KF** - Type of scaling:
  - **KF = A** - Linear.
  - **KF = B** - Logarithmic.
  - **KF = C** - Square root.
  - **KF = D** - Cube root.
  - **KF = E** - Square.
- **LF** - Clipping flag.
  - **LF = A** - No clipping.
  - **LF = B** - Clip outside TC and BC.
- **BC** - Lower clipping level. Values below BC (floating point or integer) will be set to 0.
- **TC** - Upper clipping level. Values above TC (floating point or integer) will be set to 255.

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Floating point or integer
NAME: AVERAGE(AVE)

PURPOSE: The AVERAGE operator creates an image which is the average of a number of input images. This operator is useful for smoothing images which have a high degree of noise.

CARD FORMAT:

```
AVE (From 2 to 5 Input File Names)
```

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer

RESTRICTIONS AND LIMITATIONS: 1) Maximum of 5 files may be averaged.
2) All input images must be the same size and registered. (The EXTRACT, REGISTER, or ROTATE operators may be used to accomplish sizing and registration.)
NAME:  DELETE (DEL)

PURPOSE:  The DELETE operator, on user request, deletes files maintained by the File Manager in the File Directory and thereby frees disk space for reuse by subsequent operators.

CARD FORMAT:

DEL (From 1 to 5 Input File Names)

NOTES:  If more than five files are to be deleted, DEL must be used repetitively.
NAME: EXTRACT_SUBFRAME(EXT)

PURPOSE: The EXTRACT_SUBFRAME operator extracts a specified rectangular portion of an image from an input file.

CARD FORMAT:

```
EXT (Input File Name) NL,NC,SL,SC
```

PARAMETER DEFINITIONS: NL - Number of lines to be extracted.
NC - Number of columns to be extracted.
SL - Starting line.
SC - Starting column.

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer

RESTRICTIONS AND LIMITATIONS: Number of lines or columns plus starting line or column must not exceed size of input image.
NAME: FAST FOURIER TRANSFORM (FFT)

PURPOSE: The FAST FOURIER TRANSFORM operator performs a two-dimensional Fourier transformation on the input array (file) and produces two output arrays (files) which contain the complex components in the frequency domain. The output arrays (files) may be in the form of real and imaginary components or in the form of magnitude and phase components.

CARD FORMAT:

```
FFT (Input File Name) OF,NM,KW,KT
```

PARAMETER DEFINITIONS: OF - Output format:

- OF = A - Real/imaginary, DC term at location 1, 1.
- OF = B - Real/imaginary, DC term centered.
- OF = C - Magnitude/phase, DC term at location 1, 1.
- OF = D - Magnitude/phase, DC term centered.

NM - Normalization option:

- NM = A - Normalize.
- NM = B - Do not normalize.

KW - Window option:

- KW = A - Apply window.
- KW = B - Do not apply window.

KT - Window type:

- KT = A - Hanning.
- KT = B - Hamming.
OUTPUT DATA TYPE: Floating point

INPUT DATA TYPE: Floating point or integer

RESTRICTIONS AND LIMITATIONS: 1) The number of rows (and columns) in the input file must be a power of 2.
2) The input file must have at least 64 rows and columns, but not more than 1024 rows and columns.

NOTE: The normalized transform is obtained by dividing the frequency terms by the volume under the curve and reversing the sign of alternate terms.
NAME: FILTER GENERATOR (FGN)

PURPOSE: To generate filter files to be used with the convolutional filter operator in the spatial domain or the Fourier filter in the frequency domain. A symmetrical filter is generated from internally generated or user input (via data tables) x-z plane normalized frequency domain profile. A non-symmetrical filter is generated from x-z plane and y-z plane normalized frequency domain profiles by using an elliptical fit algorithm to produce the filter surface.

CARD FORMAT:

```
FGN ISYM,KXZ,AXZ,BXZ,KYZ,AYZ,BYZ,AMAX,AMIN,KTYPE,NSIZ,KINV,FMAX
```

PARAMETER DEFINITIONS:

<table>
<thead>
<tr>
<th>ISYM</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rotationally symmetric filter</td>
</tr>
<tr>
<td>B</td>
<td>Elliptically fit non-symmetric filter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>KXZ</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Circular aperture diffraction function</td>
</tr>
<tr>
<td>B</td>
<td>Modified exponential function</td>
</tr>
<tr>
<td>C</td>
<td>Gaussian distribution</td>
</tr>
<tr>
<td>D</td>
<td>Quarter wave, zero order Bessel function</td>
</tr>
<tr>
<td>E</td>
<td>Defocused perfect lens modulation transfer function</td>
</tr>
<tr>
<td>F</td>
<td>Low pass filter</td>
</tr>
</tbody>
</table>


KXZ = G - High pass filter
KXZ = H - Band pass filter
KXZ = I - Band reject filter
KXZ = J - Circular aperture modulation transfer function
KXZ = K - Data card input

AXZ - For KXZ = A, B, C, D or E, AXZ is the normalized frequency at which the x-z plane profile equals zero.
For KXZ = F, G, H or I, AXZ is the initial transition point for the filter profile.
For KXZ = J, AXZ is aperture diameter (in pixels)

BXZ - For KXZ = A, B, C or D, this input value is not used.
For KXZ = E, BXZ is the defocus factor.
For KXZ = F, G, H, I or J, BXZ is the final transition for the filter profile.

KYZ - Type of filter cross section in the y-z plane (see description of KXZ for options).

AYZ - For KYZ = A, B, C, D or E, AYZ is the normalized frequency at which the y-z plane profile equals zero.
For KYZ = F, G, H or I, AYZ is the initial transition point for the filter profile.

BYZ - For KYZ = A, B, C or D, this input value is not used.
For KYZ = E, BYZ is the defocus factor.
For KYZ = F,G,H or I, BYZ is the final transition point for the filter profile.

AMAX - Maximum amplitude which will be assigned to the value of 1. in the normalized profile(s).

AMIN - Minimum amplitude which will be assigned to the value of 0. in the normalized profile(s).

KTYPE - Type of filter to be generated.

KTYPE = A - Frequency domain filter (Fourier)

KTYPE = B - Spatial domain filter (convolution)

NSIZ - Size of filter array to be generated.

KINV - Inversion option

KINV = A - Filter array will not be inverted.

KINV = B - Filter array will be inverted.

FMAX - If inversion is selected, FMAX is the maximum allowable value in the inverted filter array.

DATA CARD FORMAT:

The tabular values of the x-z plane and y-z plane profiles as required) are input immediately following the FILTER GENERATOR operator card in the format of the following example:

FGN2 = 1.0, .95, .86, .71, .46, .16, .11, .07, .04, .02, .01, 241* 0.$

FGN1 = 1.0, .99, .92, .79, .61, .39, .12, .03, .02, .01, 241* 0.$
NOTE: In the above example a non-symmetrical filter has been selected and therefore both profiles must be input. The values for the x-z plane profile are input in table FGN1 and correspond to the values of the modulation transfer function at .004 intervals of the normalized frequency. The first value corresponds to a frequency of 0.0, the second to a frequency of 0.004, etc. There must be 251 values in the table. The values for the y-z plane profile are input in table FGN2 in the same format as the x-z plane profile.

METHOD: In the case of rotational symmetry, the x-z plane profile is generated internally using input parameters or from the user supplied profile in table FGN1. The normalized profile is then altered according to

\[ P_1 = (A_{\text{MAX}} - A_{\text{MIN}})x + A_{\text{MIN}} \]

where \( P_1 \) is the scaled profile value and \( x \) is the normalized profile value. If the filter is to be inverted this is accomplished in the following manner

\[ P_2 = \begin{cases} \frac{1}{P_1} & \text{if } P_2 \leq F_{\text{MAX}} \\ F_{\text{MAX}}, & \text{if } \frac{1}{P_1} > F_{\text{MAX}} \end{cases} \]

where \( P_2 \) is the inverted profile value and \( P_1 \) is the scaled profile value. The resulting profile is then either rotated about the axis of symmetry to give a frequency domain filter or used by the JPL "WTGEN" package to generate a set of spatial domain weights for use in convolutional filtering.

In the case of elliptically fit non-symmetrical filters, the y-z plane profile must also be generated internally using input parameters or the user supplied profile in table FIL2. The normalized profile is scaled and, if required, inverted. The resulting profiles
are then used to generate a frequency domain filter surface where intersections of a constant magnitude result in elliptical cross sections in the z plane. This surface is used directly as a frequency domain filter. The spatial domain filter weights used in convolutional filtering are generated by the JPL "WTGEN" package from the unnormalized x-z plane and y-z plane profiles.

The internally generated circular aperture diffraction function is generated by the equation

\[ x = \frac{2}{\pi} \left[ \cos^{-1} \left( \frac{f}{AXZ} \right) - \frac{f}{AXZ} \left( 1 - \left( \frac{f^2}{AXZ^2} \right)^{1/2} \right) \right] \]

where \( 0 \leq f \leq AXZ \), and
\( x = 0 \), where \( f > AXZ \)
and \( 0 < AXZ < 1 \).

The internally generated modified exponential function is generated by the equation

\[ x = \left[ \frac{e \left( 1 - \frac{f}{AXZ} \right) - 1}{e - 1} \right] \]

where \( 0 \leq f \leq AXZ \), and
\( x = 0 \), where \( f > AXZ \)
and \( 0 < AXZ < 1 \).

The internally generated Gaussian distribution function is generated by the equation

\[ x = e^{-\frac{1}{2} \left( \frac{3f}{AXZ} \right)^2} \]

where \( 0 < AXZ < 1 \).
The internally generated quarter wave, zero order Bessel function is generated by the equation

\[ x = J_0 \left( \frac{2.4048f}{AXZ} \right) \]

where \( 0 \leq f < AXZ \), and \( x = 0 \), where \( f > AXZ \), and \( 0 < AXZ < 1 \).

The internally generated defocused perfect lens function is generated by the equation

\[ x = \frac{2}{\pi} \left[ \cos^{-1} \left( F - \frac{F}{\sqrt{1 - F^2}} \right) \right] \left[ \frac{2J_\frac{1}{2}(k)}{k} \right] \]

where \( k = 8\pi(BXZ)f(1-F) \),

\[ F = \frac{f}{AXZ} \text{ for } 0 \leq f < AXZ, \text{ and } x = 0 \text{ for } f > AXZ, \]

and \( 0 < AXZ < 1 \), \( 0 < BXZ < 1.6 \).

The internally generated low pass filter is generated by the equation

\[ x = 1 \text{ where } f < AXZ \]

\[ x = \left[ \sin \left( \frac{\pi}{2} \left( \frac{f - BXZ}{AXZ - BXZ} \right) \right) \right]^2 \text{ where } AXZ < f < BXZ \]

\[ x = 0 \text{ where } f > BXZ \]

and
The internally generated high pass filter is generated by the equation

\[
x = 0 \quad \text{where } f < AXZ,
\]
\[
x = \left[ \cos \left( \frac{\pi}{2} \left( \frac{f - BXZ}{AXZ - BXZ} \right) \right) \right]^2 \quad \text{where } AXZ < f < BXZ, \text{ and}
\]
\[
x = 1 \quad \text{where } f > BXZ
\]

and

\[0. < AXZ < 1., \quad 0. < BXZ < 1., \quad \text{and } AXZ < BXZ\]

The internally generated band pass filter is generated by the equation

\[
x = 0 \quad \text{where } f < AXZ,
\]
\[
x = \left[ \sin \left( \frac{\pi}{2} \left( \frac{f - BXZ}{AXZ - BXZ} \right) \right) \right]^2 \quad \text{where } AXZ < f <BXZ, \text{ and}
\]
\[
x = 0 \quad \text{where } f > BXZ
\]

and

\[0. < AXZ < 1., \quad 0. < BXZ < 1., \quad \text{and } AXZ < BXZ\]

The internally generated band reject filter is generated by the equation

\[
x = 1 \quad \text{where } f < AXZ,
\]
\[
x = \left[ \cos \left( \frac{\pi}{2} \left( \frac{f - BXZ}{AXZ - BXZ} \right) \right) \right]^2 \quad \text{where } AXZ < f < BXZ, \text{ and}
\]
\[
x = 1 \quad \text{where } f > BXZ
\]

\[0. < AXZ < 1., \quad 0. < BXZ < 1., \quad \text{and } AXZ < BXZ\]
The internally generated circular aperture modulation transfer function is generated by the equation

\[ x = \frac{2J_1(k)}{k} \]

where \( k = \frac{\pi f(AXZ)}{2} \)

The internally generated profiles for the y-z plane are generated by the same equations substituting AYZ for AXZ and BYZ for BZ.

OUTPUT DATA TYPE: Floating Point
NAME: FOURIER FILTER(FOU)

PURPOSE: The FOURIER FILTER operator multiplies a two-dimensional frequency domain filter by the magnitude component of a Fourier transformed input image and inverse transforms the resulting file with the corresponding phase component file to give a filtered image file.

CARD FORMAT:

FOU (Image File Name, Filter File Name)KW,KT

PARAMETER DEFINITIONS: KW - Window option:
- KW = A - Apply window.
- KW = B - Do not apply window.

KT - Window type:
- KT = A - Hanning.
- KT = B - Hamming.

OUTPUT DATA TYPE: Floating point

INPUT DATA TYPE: Floating point or integer

RESTRICTIONS AND LIMITATIONS: 1) The input file must be square. 2) The number of rows (and columns) in the input file must be a power of 2. 3) The input file must have at least 64 rows and columns, but not more than 1024 rows and columns.

NOTES: 1) The input file names must be specified in the order shown. 2) The image file name may be replaced with a magnitude component file name for a previously transformed image file. In this case
the Fourier transform step is omitted, the filter is multiplied by the magnitude component file, and the resulting file with the corresponding phase component file is inverse transformed to give the filtered image file.
NAME: FRAME(FRA)

PURPOSE: The FRAME operator adds a gray scale step wedge to the right of the picture, a gray scale histogram below the picture, and tick marks around the picture border. Options are provided for a 32 X 32 pixel grid overlay of the picture, up to five lines of alphanumeric labels above and/or below the picture, and a user-specified rectangle superimposed on the picture. The FRAME background may be either black with white annotation or vice versa. The picture gray values may be reversed, if desired, to produce a negative or positive picture.

CARD FORMAT:

FRA (Input File Name) NTL,NBL,G,GSI,FCOL,LLL,LLC,LRL,LRC

PARAMETERS DEFINITIONS: NTL - Number of 80 character lines (5 maximum) for top label of frame.

NBL - Number of 80 character lines (5 maximum) for bottom label of frame.

G - Grid Option.

G = A - No grid.

G = B - Grid.

GSI - Gray Scale Inversion.

GSI = A - No inversion.

GSI = B - Inversion.

FCOL - Frame Color.

FCOL = A - Black.

FCOL = B - White.

LLL - Rectangle Option - Upper Line Number.
LABEL CARD FORMAT:

(80 Characters of Label)

There should be one Label Card for every label line specified by NTL and NBL above, and they should occur in top to bottom sequence.

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer

NOTES:  
1) If no rectangle is desired, set LLL, LLC, LRL, and LRC=0.
2) Each label character requires a space of 10 pixels horizontally and 14 lines vertically (including spacing).
3) The FRAME is generated around the input image which makes its output file larger than its input. Care must be taken to account for the size change. The number of columns in the output frame is equal to the number of columns in the input frame plus 126, or 290, whichever is larger. The number of lines in the output frame is equal to the number of lines in the input frame plus 201, plus 14 times the total number of label lines provided.
4) The starting column of the label line in the frame of data is determined by the number of columns left blank in front of the label data on the Label Card.
NAME: H-D CORRECTION(HDC)

PURPOSE: The H-D CORRECTION operator applies a film correction curve to the input data or converts gray values to density or energy values depending on the input table used.

CARD FORMAT:

| HDFC (Input File Name) NL,NC,SL,SC,J |

PARAMETER DEFINITIONS: NL - Number of lines to be processed (may be null).
NC - Number of columns to be processed (may be null).
SL - Starting line.
SC - Starting column.
J - Output data format option.
    J = A - output file is floating point.
    J = B - output file is integer.

DATA CARD FORMAT: The table of H and D values (table HDC) is input following the HDC Operator card. The HDC table contains 256 floating point energy or density values. In the following example gray values of 0 are replaced by .1E-4, all 1's by .5E-4, all 2's by 1.E-4 and all 255's by 1.E+3.

| HDC=.1E-4,.5E-4,1.E-4,...,1E+3$ |

OUTPUT DATA TYPE: Integer or floating point (optional)

INPUT DATA TYPE: Integer
NAME:  INPUT(INP)

PURPOSE:  The INPUT operator inputs image data from tape. The input image tape is read and converted from tape format into a format suitable for storage as an IDAPS file, a file name is assigned and the image is made available for processing by other IDAPS operators.

CARD FORMAT:

```
  INP NL,NC,SL,SC
```

PARAMETER DEFINITIONS:  
- NL - Number of lines to be processed.
- NC - Number of columns to be processed.
- SL - Starting line.
- SC - Starting column.

OUTPUT DATA TYPE:  Integer

RESTRICTIONS AND LIMITATIONS:  
1) Input data tape must be 9 track, non-labeled, unblocked, 800 bpi density.
2) For each use of the INPUT operator a DD card must be provided (See Section 3).

NOTES:  If the number of lines and/or columns on tape is less than NL or NC, the system file will be adjusted automatically to that of the tape dimensions.
NAME: INSERT SUBFRAME (INS)

PURPOSE: The INSERT SUBFRAME operator inserts a portion of one image (the overlay) into another image (the underlay). Facility is provided to place the resultant image into a background of constant specified intensity.

CARD FORMAT:

```
INS (Overlay File Name, Underlay File Name) LU,KU,LSO,KSO,NLO,NKO,LLO,KLO,L,K,IB
```

PARAMETER DEFINITIONS: 

- **LU**: Line location in output image at which upper left corner of underlay is placed.
- **KU**: Column location in output image at which upper left corner of underlay is placed.
- **LSO**: Starting line of overlay image section (with respect to the original overlay file).
- **KSO**: Starting column of overlay image section (with respect to the original overlay file).
- **NLO**: Number of lines in overlay image section.
- **NKO**: Number of columns in overlay image section.
- **LLO**: Line location in output image at which upper left corner of overlay section is placed.
- **KLO**: Column location in output image at which upper left corner of overlay section is placed.
- **L**: Number of lines in output.
- **K**: Number of columns in output.
- **IB**: Background intensity.
  - **IB = A**: Background intensity is 0.
  - **IB = B**: Background intensity is 255.

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer
NAME: INVERSE FAST FOURIER TRANSFORM (IFF)

PURPOSE: The INVERSE FAST FOURIER TRANSFORM operator transforms two input arrays (files) containing the complex components in the frequency domain into an output array (file) in the spatial domain. The input arrays (files) may be in the form of real and imaginary components or in the form of magnitude and phase components.

CARD FORMAT:

IFF (Real or Magnitude File Name, Imaginary or Phase File Name) OF

PARAMETER DEFINITION: OF - Input format:

OF = A - Real/imaginary, DC term at location 1,1.
OF = B - Real/imaginary, DC term centered.
OF = C - Magnitude/phase, DC term at location 1,1.
OF = D - Magnitude/phase, DC term centered.

OUTPUT DATA TYPE: Floating point

INPUT DATA TYPE: Floating point or integer

RESTRICTIONS AND LIMITATIONS: 1) The input files must be the same size.
2) The number of rows (and columns) in the input files must be a power of 2.
3) The input files must have at least 64 rows and columns, but not more than 1024 rows and columns.
NOTES: 1) The input file names must be specified in the order shown.
2) If a real component file name is given, then the other file name must refer to an imaginary component file.
3) If a magnitude component file name is given, then the other file name must refer to a phase component file.
NAME: INVERT(INV)

PURPOSE: The INVERT operator inverts (complements) the gray value of an image file. The gray scale value of 0 is changed to 255, 1 is changed to 254, etc.

CARD FORMAT:

```
INV (Input File Name)
```

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer
NAME: ISOGRAM(ISO)

PURPOSE: The ISOGRAM operator produces an image consisting of continuous contour lines which separate the elements of the input picture into groups according to their gray scale value. The user may specify the number of contour lines used and the gray level intersections at which they occur.

CARD FORMAT:

```
ISO (Input File Name) NL,NC,SL,SC,SM,NG,G1,G2,G3,G4,G5,G6,G7,G8,G9,G10
```

PARAMETER DEFINITIONS:
- NL - Number of lines to be processed (may be null).
- NC - Number of columns to be processed (may be null).
- SL - Starting line.
- SC - Starting column.
- SM - Smoothing flag:
  - SM = A - Smooth data.
  - SM = B - Do not smooth data.
- NG - Number of contour levels.
- G1,G10 - Levels at which the NG contours are to be drawn.

OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer

RESTRICTIONS AND LIMITATIONS: All ten contour levels must be specified. If less than ten are needed the remaining levels are ignored and may be nulled out by repeated
commas. For example, if three contours are to be drawn at gray scale values of 64, 128, and 192, the card format would be as follows:

```
ISO (1INP)512,512,1,1,A,3,64,128,192,,,,,,
```
NAME: LABEL(LAB)

PURPOSE: The LABEL operator inserts alphanumeric labels in a frame of data.

CARD FORMAT:

```
LAB (Input File Name) NLAB, LCOL
```

PARAMETER DEFINITIONS:  NLAB - Number of labels.  
                           LCOL - Color of label: 
                                   A - white labels. 
                                   B - black labels. 

DATA CARD FORMAT: The following two Data cards are required for each label:

CARD 1:

```
COL. 6 COL. 12
```

CARD 2:

```
80 columns of alphanumeric data
```

SL - Starting line of the label. 
SC - Starting column of the label. 

OUTPUT DATA TYPE: Integer 

INPUT DATA TYPE: Integer
NOTES: The starting column of the label line in the frame of data is determined by the number of columns left blank in front of the label data on Data card 2.

RESTRICTIONS AND LIMITATIONS: Each label is restricted to 80 characters; however, a longer label may be written on one line by specifying a maximum of three sets of Data cards with the same starting line number. The maximum number of characters that can be written in one label is determined by the size of the input file. Each alphanumeric character requires 10 pixel horizontally (including 3 spaces), and 9 lines vertically. Printing a full 80-character label thus requires an input-file horizontal line of 800 pixels. If the input file line is less than 800 pixels, an 80-character label will be proportionately truncated. A difference of at least 12 lines should be specified between two vertically spaced labels to provide spacing.
NAME: MATH(MAT)

PURPOSE: The MATH operator performs the following operations on files A and B: A+B, A-B, A*B, A/B, A+CN, A*CN, CN/A, A**CN where CN is a constant.

CARD FORMAT:

```
MAT (Input File A, Input File B) CN,KF
```

PARAMETER DEFINITIONS: CN - Constant.
KF - Operation flag:

- KF = A - A+B
- KF = B - A-B
- KF = C - A*B
- KF = D - A/B
- KF = E - A+CN
- KF = F - A*CN
- KF = G - CN/A
- KF = H - A**CN

OUTPUT DATA TYPE: Floating point

INPUT DATA TYPE: Floating point or integer

RESTRICTIONS: The mathematical operations are performed on corresponding picture elements of frames A and B. Care should be taken to properly register the frames if necessary.

NOTES: 1) If a pixel in File A is zero, CN/A = 0 for that element.
2) If a pixel in File B is zero, A/B = A for that element.
3) If KF = A, B, C, or D, CN must be specified but may be any integer value.
4) If K = E, F, G, or H, it is not necessary to specify Input File B.
NAME: OUTPUT(OUT)

PURPOSE: The OUTPUT operator outputs image data to tape. The image file is recorded on magnetic tape in the same format as required for tape input images.

CARD FORMAT:

```
OUT (Input File Name) NL,NC,SL,SC
```

PARAMETER DEFINITIONS: NL - Number of lines to processed (may be null).
                      NC - Number of columns to processed (may be null).
                      SL - Starting line.
                      SC - Starting column.

INPUT DATA TYPE: Integer

RESTRICTIONS AND LIMITATIONS: 1) Output data tape will be 9 track, non-labeled, unblocked, 800 bpi density.
                               2) For each use of the OUTPUT operator a DD card and Output Tape Label must be provided by the user (See Section 3).
NAME: OVERLAY(OVE)

PURPOSE: The OVERLAY operator overlays lines (e.g., contours and grids) or portions of a supplemental image into a reference position in a primary image. In the inscribed-line application the operator obtains the line locations on a pixel-by-pixel basis from a supplemental image. Several modes are provided to inscribe the lines in such ways as to ensure visibility of the inscribed features against a variety of backgrounds. In the image-overlay application the operator inserts sections of the supplemental image into the primary image. The image sections to be inserted are stored in the supplemental image, and are inserted at locations in the primary image where the primary image pixel values are equal to a specified level.

CARD FORMAT:

OVE (1,2)SLI,SCI,NLI,NCI,SLM,SCM,NLM,NCM,RL,RC,SUBLEV,M0DE,P1,P2

PARAMETER DEFINITIONS:
1  - Primary File Name.
2  - Supplemental File Name.
SLI  - Starting line of primary image section.
SCI  - Starting column of primary image section.
NLI  - Number of lines in primary image section.
NCI  - Number of columns in primary image section.
SLM  - Starting line of supplemental image section.
SCM  - Starting column of supplemental image section.
NLM  - Number of lines in supplemental image section.
NCM  - Number of columns in supplemental image section.
RL   - Reference line in primary image section.
RC   - Reference column in primary image section.
SUBLEV  - Value of data points in the supplemental image (or in the primary image in the case of image section insertion.)
from the supplemental image) which are to trigger substitution at the corresponding points in the primary image. A single SUBLEV gray value between 0 and 255 must be specified.

**MODE** - Key which indicates the mode of substitution.

**MODE = A:** The primary image is modified by adding the constant P1 to the primary image points which coincide with supplemental image points of value equal to SUBLEV. This mode might be used to draw lines which vary by a constant brightness from the background.

**Mode = B:** The primary image is modified by substituting the constant P1 for the primary image points which coincide with supplemental image points of value equal to SUBLEV. This mode might be used to draw lines of constant intensity against a varying background.

**MODE = C:** The primary image is modified by alternately substituting one of the two constants P1 or P2 for the primary image points which coincide with supplemental image points of value equal to SUBLEV. If only one of the line or column coordinates of the point is odd, P1 is substituted. Otherwise P2 is substituted. This mode produces lines of alternating intensity which maintain a constant appearance regardless of background.

**MODE = D:** The primary image is modified by substituting point values from the supplemental image at every point where the primary image
is equal to the SUBLEV value. This mode might be used to insert a feature on the primary image against a background supplied from the supplemental image.

**MODE = E:** The primary image is modified by substituting P1 or P2 whenever the corresponding supplemental image points equal the SUBLEV value. If the primary image point value is less than 128, P1 is substituted; otherwise P2 is used. This mode might be used to place bright lines on a dark background and dark lines on a bright background in a single operation. It guarantees the visibility of contours in all backgrounds, however the contours may appear disjointed where the primary image equals 128.

P1 & P2 - These parameters have definitions which are different for each mode.

**MODE = A:** P1 is the constant added to appropriate image points.
P2 is ignored but must be set to some value.

**MODE = B:** P1 is the constant which is substituted for appropriate image points.
P2 is ignored but must be set to some value.

**MODE = C:** P1 and P2 are constants which are alternately substituted for appropriate image points.

**MODE = D:** P1 and P2 are ignored but must be set to some values.

**MODE = E:** P1 is the constant substituted for appropriate image points less than 128; P2 is substituted otherwise.
OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer
NAME: PICTURE DIFFERENCE (DIF)

PURPOSE: The PICTURE DIFFERENCE operator detects changes in registered imagery. The registered images are adjusted for contrast. The standard deviation of the gray values in the difference picture is used as a threshold to detect changes and to account for non-linearities in the contrast. The user may specify the standard deviation coefficient which is used for the picture difference threshold.

CARD FORMAT:

DIF (Input File 1, Input File 2) NL, NC, SL, SC, DSC

PARAMETER DEFINITIONS: NL - Number of lines to be processed (may be null). NC - Number of columns to be processed (may be null). SL - Starting line. SC - Starting column. DSC - Difference coefficient.

METHOD: The actual difference between input file 1 and input file 2 may be determined by two secondary (SEC) output files. That is, the two secondary output files indicate the features that are in input file 1 that are not in input file 2, and vice versa, using the picture difference threshold.
Pixel values in output file 1SEC are set to a gray value of 128 when,
\[ d > D_l + DSC \times SIGD \] where;

\[ d \] is an element in difference image,
\[ D_l \] is the mean of the difference image,
\[ DSC \] is the sigma coefficient, and
\[ SIGD \] is the computed sigma of the difference image.

Thus output file 1SEC indicates features that are in input file 1 that are not in input file 2.

Pixel values in output file 2SEC are set to a gray value of 128 when,
\[ d < D_l - DSC \times SIGD \] thus output file 2SEC indicates features that are in input file 2 that are not in input file 1.

**INPUT DATA TYPE:** Integer

**RESTRICTIONS:** 1) All input images must be the same size and registered. (The EXTRACT, REGISTER or ROTATE operators may be used to accomplish sizing and registration.)

**NOTES:** 1) The sigma coefficient typically ranges from 0.0 to 3.0.
2) The difference is calculated by subtracting File 2 values from corresponding File 1 values after contrast adjustment.
NAME: PRINT (PRI)

PURPOSE: The PRINT operator prints a specified portion of an image file on the IBM 360 line printer.

CARD FORMAT:

PRI (Input File Name) NL,NC,SL,SC

PARAMETER DEFINITIONS: NL - Number of lines to be printed.
                        NC - Number of columns to be printed.
                        SL - Starting line.
                        SC - Starting column.

INPUT DATA TYPE: Integer or floating point

NOTES: 1) Integer data will be printed in array format, 32 columns per page.
        2) Floating point data will be printed in block format such that the specified number of columns will be printed as a block, 10 columns per line.
        3) The user should avoid printing large portions of a file due to the large amount of output that may be generated.
NAME: PSF GENERATOR (PSF)

PURPOSE: The PSF GENERATOR operator allows the user to prepare a three-dimensional function which is an inverse of the Fourier transform of the point spread function of the S-056 system from input tables of data which represent the profile of the 3-D surface.

CARD FORMAT:

```
PSF NLO,ALIM,ISYM
```

PARAMETER DEFINITIONS: NLO - Size of PSF to be generated.
ALIM - Amplification limit (0.0 = No limit).
ISYM - Symmetry flag
ISYM = A - Rotationally symmetric PSF.

DATA CARD FORMAT: The tabular values of the profile of the 3-D surface are input immediately following the PSF GENERATOR operator card in the format of the following example:

```
PSF = 1.,2.,08.,03.,08.,01.,005.,002.,005.,001,246*0.$
```

NOTE: The data table must contain 256 floating point values. The first value will represent the intensity of the centermost point in the PSF. PSF data is usually normalized to make this value equal to unity. The second value in the data table corresponds to the relative intensity of the PSF at a radial distance of one pixel from the central point, and therefore is dependent on the sampling interval of the data. Succeeding values reflect the relative intensities of the PSF as samples at increasing distances from the central point.
METHOD: Using the input data table, a three-dimensional surface is produced which is a rotation of the PSF profile about the Z axis. The output of this process becomes an intermediate output file in IDAPS. Because the number of values in a PSF data table is limited to a maximum of 256, the maximum PSF array that can be produced by the operator is 512 x 512 values. For arrays smaller than this (N<512) only the first N/2+1 values in the data table are used and the remainder of the 256 are ignored. Output points which are at a radial distance from the center greater than N/2 pixels are automatically set to the same value as the N/2+1 value in the data table. Thus, for example, if a PSF is to be built that is 128 x 128 array, only the first 65 terms will be used from the PSF data table and all others ignored.

Once the PSF surface has been generated, it is transformed to the frequency domain as a complex array of magnitude and phase terms with the DC term at the center of the array ((2N+1),(2N+1)). The transform output is normalized in such a way that the DC term will be unity.

Each of the magnitude terms of the transformed PSF are examined for zero amplitude and if a term is not zero, its inverse value is calculated. The inverse of the term is then compared to the maximum Amplification Limit (if any). If the inverse of the term is greater than the limit, it is set equal to the limit. If not, it is left alone. If a frequency term is equal to zero, however, it is not inverted but is set either to the amplification limit (if one has been specified) or to an arbitrary limit of 10^{12}. The output of the PSF operator is two floating point files (magnitude and phase, named nPSM and nPSP, respectively) and represents an inverse correcting filter for the given PSF.
OUTPUT DATA TYPE: Floating point

RESTRICTIONS AND LIMITATIONS: 1) The size of the PSF generated must be a power of 2.
2) The minimum size PSF is 64 and the maximum size PSF is 512.
NAME: REGISTER(REG)

PURPOSE: The REGISTER operator accomplishes registration of one image to another through application of a geometric transformation consisting of rotation, magnification and translation. The registration is specified by identification of the spatial coordinates of two points in the input image and the coordinates of corresponding points in the output to which the input pair are to be transformed. The amounts of rotation, magnification and translation required to achieve the specified transformation are computed automatically by the program.

CARD FORMAT:

REG (Input File Name)IN1L,IN1C,IN2L,IN2C,OUT1L,OUT1C,OUT2L,OUT2C

PARAMETER DEFINITIONS: IN1L - Line coordinate of point 1 in input image.
IN1C - Column coordinate of point 1 in input image.
IN2L - Line coordinate of point 2 in input image.
IN2C - Column coordinate of point 2 in input image.
OUT1L - Line coordinate of point 1 in output image to which point 1 in input is to be transformed.
OUT1C - Column coordinate of point 1 in output image to which point 1 in input is to be transformed.
OUT2L - Line coordinate of point 2 in output image to which point 2 in input is to be transformed.
OUT2C - Column coordinate of point 2 in output image to which point 2 in input is to be transformed.
OUTPUT DATA TYPE: Integer

INPUT DATA TYPE: Integer

NOTES: The geometric manipulations performed by the REGISTER operator are based *solely* on the point coordinate parameters supplied by the user. These may have been obtained by Interactive IDAPS operations or other techniques. No automatic cross correlations are performed by this operator.
NAME:  ROTATE(ROT)

PURPOSE:  The ROTATE operator rotates the image. The image is rotated a specified amount and enlarged by inserting zero values to produce an output file which contains the whole rotated image.

CARD FORMAT:

```
ROT (Input) THETA
```

PARAMETER DEFINITIONS:  THETA  -  Angle of rotation in degrees counterclockwise.  (-360 ≤ THETA ≤ 360)

OUTPUT DATA TYPE:  Integer

INPUT DATA TYPE:  Integer
NAME: STONYHURST(STO)

PURPOSE: The STONYHURST operator creates a Stonyhurst grid of specified size, grid, spacing, and orientation.

CARD FORMAT:

```
STO KSIZ,RLON,GSLON,RLAT,GSLAT,ROT,NL,NC
```

PARAMETER DEFINITIONS:

- **KSIZ** - Size of grid (i.e., diameter in pixels).
- **RLON** - Longitude closest to observer (degrees).
- **GSLON** - Longitude spacing of grid lines (degrees).
- **RLAT** - Latitude closest to observer (degrees).
- **GSLAT** - Latitude spacing of grid lines (degrees).
- **ROT** - Rotation of N-S axis (+ is counter-clockwise).
- **NL** - Number of lines in output image.
- **NC** - Number of columns in output image.

OUTPUT DATA TYPE: Integer

RESTRICTIONS AND LIMITATIONS: 1) Maximum size of Stonyhurst grid is $(1024)^2$.
2) Maximum value for RLAT is such that $|RLAT| < 7$.

NOTES:

1) The output file consists of a Stonyhurst grid for the full solar disk, the diameter of which is KSIZ. (See CENTER/DIAMETER operator in Interactive IDAPS.)
2) The output file is a background of 0's with grid lines of 255.
3) RLON and RLAT are determined from solar ephemeris tables based on date and time of image exposure.
4) The Stonyhurst grid will be centered in the output image.
NAME: TRANSPOSE(TRA)

PURPOSE: The TRANPOSE operator is used to rotate a picture about its major axis, minor axis, vertical axis, horizontal axis, +90 degrees, -90 degrees, or 180 degrees (plus angles are clockwise rotation).

CARD FORMAT:

```
TRA (Input File Name) NL,NC,SL,SC,REV
```

PARAMETER DEFINITIONS:  
NL - Number of lines to be processed.  
NC - Number of columns to be processed.  
SL - Starting line.  
SC - Starting column.  
REV - Flag to indicate type of rotation:  
REV = A - Rotate about major axis.  
REV = B - Rotate +90 degrees.  
REV = C - Rotate -90 degrees.  
REV = D - Rotate about minor axis.  
REV = E - Rotate about vertical axis.  
REV = F - Rotate about horizontal axis.  
REV = G - Rotate 180 degrees.

OUTPUT DATA TYPE: Integer or floating point (depending on input data type).

INPUT DATA TYPE: Integer or floating point.

NOTES: The results of transposing the letter J illustrates the various options:
A = (major axis)  
B = (+ 90 degrees)  
C = (- 90 degrees)  
D = (minor axis)  

E = (vertical axis)  
F = (horizontal axis)  
G = (180 degrees)
APPENDIX A - BATCH IDAPS OPERATOR INDEX

The currently available IDAPS Operators are listed below in alphabetical order with the three-letter identification code in parentheses. A brief statement of purpose is included for each operator.

ALTER(ALT)

The ALTER operator modifies the gray scale value of each element in a picture in accordance with a table of values supplied by the user. The original gray values in the input array are used as an index and the appropriate values in the table are substituted by the ALTER operator for the original values and appear in the output array.

AUTOMATIC SCALE(AUT)

The AUTOMATIC SCALE operator scales an image file to values between 0 and 255 based on a selected scaling curve. The user may specify upper and lower limits of the gray scale range on which the scaling will take place. The output of AUTO SCALE is an array of values between 0 and 255.

AVERAGE(AVE)

The AVERAGE operator creates an image which is the average of a number of input images. This operator is useful for smoothing images which have a high degree of noise.

CONVOLUTIONAL FILTER(CON)

The CONVOLUTIONAL FILTER operator numerically convolves an image array with a filter array. An option is provided for limiting the application of the filter to only those regions designated by a filter map. The filter array may be obtained from user supplied cards, system files, or generated internally.

DELETE(DEL)

The DELETE operator, on user request, deletes files maintained by the File Manager in the File Directory and thereby frees disk space for reuse by subsequent operators.
DEPENDENT ALTER (DEP)

The DEPENDENT ALTER operator modifies the gray scale values of each pixel in an input image in accordance with its relative position in the field of view of the telescope and as a function of a polynomial \((A+Bx)\) for which the user supplies the coefficients.

EXTRACT SUBFRAME (EXT)

The EXTRACT SUBFRAME operator extracts a specified rectangular portion of an image from an input file.

FAST FOURIER TRANSFORM (FFT)

The FAST FOURIER TRANSFORM operator performs a two-dimensional Fourier transformation on the input array (file) and produces two output arrays (files) which contain the complex components in the frequency domain. The output arrays (files) may be in the form of real and imaginary components or in the form of magnitude and phase components.

FILTER GENERATOR (FGN)

The FILTER GENERATOR operator generates filter files to be used with the convolutional filter operator in the spatial domain or the Fourier filter in the frequency domain. A symmetrical filter is generated from internally generated or user input (via data tables) x-z plane normalized frequency domain profile. A non-symmetrical filter is generated from x-z plane and y-z plane normalized frequency domain profiles by using an elliptical fit algorithm to produce the filter surface.

FOURIER FILTER (FOU)

The FOURIER FILTER operator multiplies a two-dimensional frequency domain filter by the magnitude component of a Fourier transformed input image and inverse transforms the resulting file with the corresponding phase component file to give a filtered image file.

FRAME (FRA)

The FRAME operator adds a gray scale step wedge to the right of the picture, a gray scale histogram below the picture, and tick marks around the picture border. Options are provided for a 32 X 32 pixel grid overlay of the picture, up to five lines of alphanumeric labels above and/or below the picture, and a user-specified rectangle superimposed on the picture. The FRAME background may be either black with
white annotation or vice versa. The picture gray values may be reversed, if desired, to produce a negative or positive picture.

**H-D CORRECTION (HDC)**

The H-D CORRECTION operator applies a film correction curve to the input data or converts gray values to density or energy values depending on the input table used.

**INPUT (INP)**

The INPUT operator inputs image data from tape. The input image tape is read and converted from tape format into a format suitable for storage as an IDAPS file, a file name is assigned and the image is made available for processing by other IDAPS operators.

**INSERT SUBFRAME (INS)**

The INSERT SUBFRAME operator inserts a portion of one image (the overlay) into another image (the underlay). Facility is provided to place the resultant image into a background of constant specified intensity.

**INVERSE FAST FOURIER TRANSFORM (IFF)**

The INVERSE FAST FOURIER TRANSFORM operator transforms two input arrays (files) containing the complex components in the frequency domain into an output array (file) in the spatial domain. The input arrays (files) may be in the form of real and imaginary components or in the form of magnitude and phase components.

**INVERT (INV)**

The INVERT operator inverts (complements) the gray value of an image file. The gray scale value of 0 is changed to 255, 1 is changed to 254, etc.

**ISOGRAM (ISO)**

The ISOGRAM operator produces an image consisting of continuous contour lines which separate the elements of the input picture into groups according to their gray scale value. The user may specify the number of contour lines used and the gray level intersections at which they occur.
LABEL (LAB)

The LABEL operator inserts alphanumeric labels in a frame of data.

MAGNIFY (MAG)

The MAGNIFY operator performs a geometric transformation which expands or reduces the size of an image. Four way linear interpolation is used to provide values from the input array which are not at the exact location of an input pixel.

MATH (MAT)

The MATH operator performs the following operations on files A and B: A+B, A-B, A*B, A/B, A+CN, A*CN, CN/A, A**CN where CN is a constant.

OUTPUT (OUT)

The OUTPUT operator outputs image data to tape. The image file is recorded on magnetic tape in the same format as required for tape input images.

OVERLAY (OVE)

The OVERLAY operator overlays lines (e.g., contours and grids) or portions of a supplemental image on a primary image. In the inscribed-line application, the operator obtains the line locations on a pixel-by-pixel basis from a supplemental image. Several modes are provided to inscribe the lines in such ways as to ensure visibility of the inscribed features against a variety of backgrounds. In the image-overlay application, the operator inserts sections of the supplemental image into the primary image. The image sections to be inserted are stored in the supplemental image and are inserted at locations in the primary image where the primary image pixel values are equal to a specified level.

PICTURE DIFFERENCE (DIF)

The PICTURE DIFFERENCE operator detects changes in registered imagery. The registered images are adjusted for contrast. The standard deviation of the gray values in the difference picture is used as a threshold to detect changes and to account for non-linearities in the contrast. The user may specify the standard deviation coefficient which is used for the picture difference threshold.
PRINT(PRI)

The PRINT operator prints a specified portion of an image file on the IBM 360 line printer.

REGISTER(REG)

The REGISTER operator accomplishes registration of one image to another through application of a geometric transformation consisting of rotation, magnification and translation. The registration is specified by identification of the spatial coordinates of two points in the input image and the coordinates of corresponding points in the output to which the input pair are to be transformed. The amounts of rotation, magnification and translation required to achieve the specified transformation are computed automatically by the program.

ROTATE(ROT)

The ROTATE operator rotates an image file. The image is rotated a specified amount and enlarged by inserting zero values to produce an output file which contains the whole rotated image.

STONYHURST(STO)

The STONYHURST operator creates a Stonyhurst grid of specified size, grid, spacing, and orientation.

TRANSPOSE(TRA)

The TRANSPOSE operator is used to rotate a image about its major axis, minor axis, vertical axis, horizontal axis, +90 degrees, -90 degrees, or 180 degrees (plus angles are clockwise rotation).
APPENDIX B - BATCH IDAPS OPERATOR CPU TIME REQUIREMENTS

The estimated number of minutes of CPU time that each operator requires is provided in the figure below. The sum of the estimated run times for those operators to be executed should be entered on the JOB card and the EXEC card in the Batch IDAPS run deck as the CPU Time Limit, unless experience or specific information indicates otherwise. As indicated, the estimated CPU run time is dependent on the size of the image array. For operators with one or more options, the times given are for the worst case.

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INTRODUCTION

The Interactive IDAPS User Manual provides instructions for setting up and controlling the interactive run, summarizes the capabilities of the interactive system, and describes the characteristics of the equipment available to the interactive user. The Interactive Manual, Volume III, is a companion document to Volume II, the Batch Manual. Volume I describes the general features and capabilities of the IDAPS concept, hardware, and software.

Interactive IDAPS is designed to provide on-line, interactive control of image processing operations. User control procedures and tutorial aids are built into the system to assist the user in setting up and executing his image processing jobs. The potential user, however, must be familiar with hardware and software facilities provided by Interactive IDAPS and must understand the control and use procedures. Prior to using Interactive IDAPS it is recommended that the beginning user complete the four steps of the Training Plan outlined in Volume I, Section 2, as follows:

**IDAPS Orientation**

Step 1 - Read Volume I

Step 2 - Attend an IDAPS Orientation Demonstration (approximately 30 minutes)

Step 3 - Read Volume III

Step 4 - Attend an Interactive IDAPS Training Session (approximately two hours)

Interactive IDAPS should be used to set up and optimize image processing runs, to prepare longer jobs to be run under Batch IDAPS, and to review the results obtained from previous runs. Large, time-consuming jobs should not be run with Interactive IDAPS because such use ties up the resources of the interactive system at the expense of other users. Specifically, the following general procedure should be followed:
1. Study the image processing job. Identify those tasks which may be run in Batch IDAPS, those tasks which may be run in Batch IDAPS but which must be set up through Interactive IDAPS, and those tasks which must be done in Interactive IDAPS.

2. Prepare a work plan for Interactive IDAPS processing. Identify the techniques required, the data to be processed interactively, and the preparations which must be made through the use of Interactive IDAPS for processing larger runs in Batch IDAPS.

3. Schedule time on the Interactive IDAPS. Time is scheduled through the MSFC Data Systems Lab.

4. Make the interactive run. Interactive IDAPS has capabilities that are not available in Batch IDAPS. Plan to take full advantage of these capabilities during the interactive run.

5. Use the results of Interactive IDAPS runs as a guide to processing larger amounts of data in Batch IDAPS. By exploring procedures on a sample of data in Interactive IDAPS, an optimum series of operations may be derived for batch processing. This approach not only reduces the requirements for use of the IDAPS facility but also reduces the computer time required for processing large jobs. The user's own operating time is also reduced.

This manual has three major sections:

- A Glossary to acquaint the user with Interactive IDAPS nomenclature.
- A Control and Use section to describe the user procedures for normal interactive operation of the system.
• An Equipment Description section to describe the Interactive IDAPS hardware, including set-up and operation, principles of operation, and capability specification.

Host computer Error Messages are defined in Appendix A and a detailed explanation of how to use each interactive operator is presented in Appendix B. Cross-reference indices of the operators by Operator (listed alphabetically) and by Submenu Category are provided in the first section of Appendix B.
2.0 GLOSSARY

Array - A rectangular array of picture elements; an image file.

Batch IDAPS - The high-capacity data processing mode of IDAPS requiring minimum user interaction.

Clipping - Defines the upper and lower limits of gray values on which a process is to be performed. All signals outside the clipping limits are set equal to either the maximum or minimum gray value (0 or 255).

Column - A one-dimensional vertical array of picture elements. The first column of a picture is designated as column 1.

Data Card - Provides data for the operator in addition to the parameters.

Density (D) - Log to base 10 of the inverse of the transmittance.

EOF Code - End of File code is an electronic mark on magnetic tape which is used to signal the end of a data file.

File Identification - A parameter which tells the computer operator which tape to mount. (Same as Tape Identification)
A unique identification label automatically assigned to each image file used or produced by the IDAPS system.

The Tape File Number.

Alphabetic characters used to signify options in an IDAPS operator.

Numeric values containing a decimal point.

An image or data file.

A value (0-255) assigned to a picture element to indicate its degree of grayness.

Image Data Processing System.

Same as image data array.

A rectangular array of picture elements; an image file.

A two-dimensional array of numbers filed on disk or tape representing the gray levels of pixels in a digitized picture.

The time required to record an image; a function of the number of points in the array, exposure levels, resolution mode, and the number of overlays.
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image Number</td>
<td>The sequential index to the image files to be input by the INP Operator or output by the OUT Operator.</td>
</tr>
<tr>
<td>Input Tape</td>
<td>The image data tape which is the source of data for the Batch IDAPS run.</td>
</tr>
<tr>
<td>Interactive IDAPS</td>
<td>The operating mode of IDAPS which provides interactive user control of image processing.</td>
</tr>
<tr>
<td>Intersample Spacing</td>
<td>Horizontal or vertical distance between pixels.</td>
</tr>
<tr>
<td>Line</td>
<td>A one-dimensional horizontal array of picture elements. The first line of a picture is designated as line 1.</td>
</tr>
<tr>
<td>Line and Column Coordinates</td>
<td>A pair of integer numbers used to describe the location of a single picture element within a frame of data; the row and column numbers of a picture element.</td>
</tr>
<tr>
<td>Operator</td>
<td>A single image processing technique or control process. It may be a subroutine or a collection of subroutines, called by an identifying name, which carries out a specific task.</td>
</tr>
<tr>
<td>Operator Code</td>
<td>The unique three letter code for each IDAPS operator.</td>
</tr>
</tbody>
</table>
Orthogonality (O) - A measure of image geometric accuracy, a percentage of the matrix diagonals \( M_1 \) and \( M_2 \) where

\[
O = \pm \left( \frac{M_1 - M_2}{M_1 + M_2} \right) \times 100
\]

Output Tape - The tape on which the image output of the Batch IDAPS run is written for permanent record.

Parameters - Variables which define and control a process.

Picture Element - The smallest unit of a digitized picture representing the average gray level (0-255) of a single area sample of an image.

Pixel - Picture element.

RET Code - Retention code, used on output tape labels.

Row - A line.

Scan Line Straightness - Ratio of deviation of a scan line from the best fit straight line to the length of the scan line.

Scanner - Refers to the on-line Dicomedi Film Digitizer or similar off-line film digitizing device.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning Aperture</td>
<td>The effective circular diameter of the scanning spot.</td>
</tr>
<tr>
<td>Size</td>
<td>The vertical and horizontal dimensions of an array expressed in terms of picture elements. A 320 X 480 image has 320 pixels in the vertical line and 480 pixels in the horizontal line. Size should not be confused with the physical dimensions of an image on film.</td>
</tr>
<tr>
<td>Table</td>
<td>A one-dimensional array of real or integer data used as input to the IDAPS system for use by an operator. Tables are input to the computer by data cards.</td>
</tr>
<tr>
<td>Tape Identification</td>
<td>A parameter which tells the computer operator which tape to mount. (Same as File Identification)</td>
</tr>
<tr>
<td>Trackball</td>
<td>A device for entering or retrieving pixel position data on a display by hand positioning a floating ball.</td>
</tr>
<tr>
<td>Transmittance</td>
<td>Ratio of light transmitted through a medium to the light incident to the medium.</td>
</tr>
</tbody>
</table>
3.0 INTERACTIVE CONTROL AND USE
This section describes the operations involved in setting up and using Interactive IDAPS. The procedures are described in the proper order for normal operation, and illustrations are provided as required. Typical Interactive IDAPS runs consist of the following basic steps:

- Run Preparation - to prepare the data and appropriate equipment for interactive operations.
- Log In - to initialize the Interactive IDAPS system and identify the user.
- Operator Selection - to select desired Interactive IDAPS operators.
- Parameter Specification - to specify the necessary parameters and controls for the selected operators.
- Special Functions - to apply special Interactive IDAPS user aids for setting up and/or analyzing image processing runs.
- Operator Execution - to carry out the specified operations.
- Log Out - to clear system records and obtain user run data.

3.1 RUN PREPARATION
The Interactive IDAPS facility is maintained by the Marshall Space Flight Center as a service to the researcher who wishes to process image data from the S-056 experiment. The following devices are normally maintained in a "powered up" condition to be available for the Interactive IDAPS user:
Interative IDAPS Minicomputer
Minicomputer Disk Storage
Digital Television Disk, Power Supplies, and Display Generator
User Keyboard
Trackball

Should any of these devices fail to be in an operating condition, the user should request help from one of the operations personnel.

A number of Interactive IDAPS devices may or may not be ready for immediate use. Depending on the operations which the user intends to carry out, the following devices should be turned on and made ready by the user (see Section 4.0):

Digital Television Displays
Film Scanner
Image Recorder
Video Facsimile Copier
Card Reader
Printer
Magnetic Tape Units

The video facsimile copier and film scanner require about twenty minutes "warm up" for proper operation.

The user should prepare his image data for input into IDAPS. If he plans to use the on-line film scanner, he should place his film in one of the available film holding fixtures. Careful attention should be paid to cleanliness in handling and loading film in the recorder. If the image data has been prescanned, the scan tape should be mounted on an available drive and made ready for use (see Section 4.0). If the user intends to write data onto tape during his operations, a blank tape may be mounted and made ready at this time.
The Interactive IDAPS host computer is operated on a predetermined shift basis by MSFC operations personnel. Due to the shift allocation and because of "down" time resulting from system modification, hardware malfunction, or preventive maintenance, the host computer is not always available for the Interactive IDAPS user. The host computer status is constantly monitored by the minicomputer and displayed on the Interactive IDAPS Master Monitor in the upper left corner of the screen. The following status messages are provided:

- 360 STATUS READY - means that the host computer is properly functioning, is "on-line" to the minicomputer and is available for Interactive IDAPS operations.

- 360 STATUS BUSY - means that the host computer is temporarily occupied in processing an Interactive IDAPS run. This may or may not inhibit local operation of the Interactive IDAPS user terminal, depending on whether or not terminal equipment is involved in the host computer operations.

- 360 STATUS DOWN - means that, for any of a number of reasons, the host computer is not available for Interactive IDAPS operations.

3.2 LOG IN

Figure 3-1 is the Interactive IDAPS LOG IN display. It should be the first display presented to the user at the beginning of his run. Failure by a previous user to properly LOG OUT the system will leave Interactive IDAPS in an improper initial condition. Before the user can proceed, he must LOG OUT any previous, unterminated run using the procedures in Section 3.7. The purpose of LOG IN is to provide initial instructions to the user, to provide a mechanism for identifying the user to the system, and to give the user the opportunity to reinitialize the system to its default status. If the reinitialize option is chosen, the system resets the default parameters and
restores all data tables to the system default values. Also, the 360 file directory is purged and all associated parameters are set to initial values. The user identification which is entered is carried through the run to provide proper identification of output data at the end of the run.

3.3 OPERATOR SELECTION

Figure 3-2 is the Interactive IDAPS Master Menu, which is provided immediately following the LOG IN display. The Master Menu is a list of the major categories of image processing operations available to the interactive user. The Master Menu is the logical starting point for all Interactive IDAPS operations. It is displayed at the completion of each Interactive IDAPS operation, or whenever the RETURN TO MASTER key is pressed. The user selects the category of image processing operations that he wishes to use by
pressing the appropriate key on the keyboard. Changes may be made by pressing a different key. Once a selection is made the user proceeds by pressing the EXEC key. For experienced users of the system who know the three letter mnemonics associated with each parameter specification display, the capability is provided to input the three letters and skip the submenu display.

Figures 3-3 through 3-13 are the Submenu displays provided by Interactive IDAPS which can be selected by the user from the Master Menu. Each Submenu lists the available Interactive IDAPS operators which are appropriate to the category selected. If the user is not certain in which category a particular operator may be found, he may select a likely category as a trial—using the RETURN TO MASTER MENU key as often as necessary—or he may consult the
Figure 3-3. Image Input/Output Submenu

Figure 3-4. Function Generation Submenu
Figure 3-5. Gray Scale Adjustment Submenu

Figure 3-6. Manual Image Modification Submenu
FILTER OPERATIONS

IMAGE PROCESSING OPERATOR
A - CONVOLUTIONAL FILTER (CON)
B - FOURIER FILTER (FOU)
C - FFT (FFT)
D - IFFT (IFF)
E - FILTER GENERATION (FGN)

OPTION =

Figure 3-7. Filter Operators Submenu

GEOMETRIC OPERATIONS

IMAGE PROCESSING OPERATOR
A - POTATE (ROT)
B - TRANSPOSE (TRA)
C - REGISTER (REG)
D - EXTRACT SUBFRAME (EXT)
E - INSERT SUBFRAME (INS)
F - MAGNIFY (MAG)

OPTION =

Figure 3-8. Geometric Operations Submenu
Figure 3-9. Classification/Pattern Recognition Submenu

Figure 3-10. Math Logic Submenu
Figure 3-11. Image Analysis Submenu

Figure 3-12. Pseudocolor Submenu
Figure 3-13. Image Data Presentation Submenu
is provided with an appropriate scenario which assists the user in establishing the necessary parameters for a specific need. A variety of techniques are used in this man/machine dialogue, including explanatory messages, multiple choice lists, and blanks to be filled in. Figure 3-14 is an example of an Interactive IDAPS operator scenario. It is typical of most of the parameter specification scenarios and should be referred to in the following discussion of operator specification procedures. Illustrations of all Interactive IDAPS operator parameter specification scenarios are provided in alphabetical order in Appendix B of this volume along with other pertinent information. Information and data required by IDAPS for control of an operator typically fall into three categories:

### Figure 3-14. Sample Interactive IDAPS Operator Scenario

<table>
<thead>
<tr>
<th>Option</th>
<th>Parameter Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Scanning factor</td>
</tr>
<tr>
<td>B</td>
<td>Sampling interval</td>
</tr>
<tr>
<td>C</td>
<td>Integration time</td>
</tr>
<tr>
<td>D</td>
<td>Filter</td>
</tr>
</tbody>
</table>

#### Option A
- Scanning factor:
  - A: Function of density (log)
  - B: Function of transmittance (linear)

#### Option B
- Sampling interval (micrometers):
  - A: 17.5 (2048 pts/line max)
  - B: 35 (1024 pts/line max)
  - C: 70 (512 pts/line max)
  - D: 140 (256 pts/line max)

#### Option C
- Integration time (microseconds):
  - A: 20 (28 dB S/N)
  - B: 80 (34 dB S/N)
  - C: 320 (40 dB S/N)
  - D: 1280 (46 dB S/N)

#### Option D
- Filter:
  - A: Neutral
  - B: Red
  - C: Green
  - D: Blue
  - E: Manual/Current Setting

Note: Trackball input of these values is based on a neutral quick-look scan.
3.4.1 File Name Assignment and Usage

File names are assigned by Interactive IDAPS to designate and keep track of input and output images. File names are assigned to the output of an operator using the convention that a file is named after the operator code of the operator that created it and after the sequence of operator use.

The operator code is a three character code assigned to each operator. It is usually the first three letters of the operator name and is displayed in parenthesis on the operator scenario at the right of the operator name.

The leading character in a file name signifies the number of output files that have been generated during a run by a specific operator. For example, the first time the SCANNER-TO-SYSTEM (SCA) operator is used, its output file is designated 1SCA. The next time the SCANNER-TO-SYSTEM (SCA) operator is used, its output file is designated 2SCA, and so on. This convention simplifies the problem of keeping track of files in IDAPS.

When an operator creates a new file it is assigned a name by the above convention and stored on the host computer disk for future use. For all operators which require a single input file, IDAPS provides a default Input File Name which is the last generated file. The user may accept this "default" parameter, or change it to another file name as desired. New entries are entered from the keyboard and will appear at the location of the red cursor. Cursor positioning is controlled by the ARROW keys in the lower-right portion of the keyboard.

Some operators require more than one input file and therefore the default file name feature cannot be applied. Multiple input file operators require the user to specify all input file names.
3.4.2 Parameter Assignment

IDAPS operators are designed to apply a specific processing technique to an input image. The techniques often involve a number of decision points which must reflect the nature of the input data itself and the desires of the user. Therefore, most Interactive IDAPS operator scenarios contain a number of control parameter fields which must be provided prior to execution. As in the case of the Input File Name parameters, a convention of default parameter values is provided by Interactive IDAPS. Such default parameters reduce the number of keyboard entries that a user must make and therefore streamline the interactive control process. Several conventions are used for providing default parameters. In many cases the default values are simply the IDAPS designers "guess" as to what the user will normally want to enter. In such cases, whenever default values are changed by user input, the user input values are stored and used by IDAPS as the default value for that parameter in all subsequent applications of the operator.

Control parameters are of three general types:

- Options
- Numeric Information
- Character Strings

3.4.2.1 Options

The ability to select one of several possible options is provided by displaying the name of the parameter along with the possible options. The Scaling Factor parameter in Figure 3-14 is such a parameter. The user is asked to specify the scaling factor as a function of density or as a function of transmittance. In this case the system defaults to Option A. Should the user wish to use the other default selection, he simply places the cursor beneath the default value and enters Option B by keyboard.
3.4.2.2 Numeric Information

Many IDAPS operators require that certain information be supplied in numeric form. In Figure 3-14 the Illumination level is an example of a numeric parameter. A value of 8 is provided as the system default. The user may change this value through keyboard entry as desired. Although keyboard entry is the normal means for inputting numeric parameters, some operators allow the use of the trackball for this purpose. In such cases, specific instructions are provided as a part of the operator scenario.

3.4.2.3 Character Strings

Such operators as LABEL and FRAME require that the user input strings of alphanumeric characters. In such cases the user composes his input one line at a time using the RIGHT and LEFT ARROW keys to control cursor position along the line. When the DOWN ARROW key is pressed, the cursor automatically goes to the initial position of the next line. Returning to a previously composed line for corrections is not allowed after the user moves the cursor to a lower line.

3.4.3 Data Input

Some IDAPS operators require the input of sizable tables of data. Interactive IDAPS features a Default Data Table option whereby prestored tables may be transmitted to the host computer by the minicomputer in lieu of user input data. This allows the user to employ operators for which he has not prepared his own special data table. A default data table is provided by Interactive IDAPS for every operator which requires data table input.

3.4.3.1 Card Data Input

If the user wishes to provide his own input data table, he may do so by entering properly formatted data through the user terminal card reader, user keyboard, or in some cases through the graphic trackball. User supplied data tables replace the IDAPS default data table values for a specific operator so that all subsequent uses of that table reflect the user supplied data instead of the default values.
Because of the volume of data that often may be required, user input of data is normally by punched cards. As illustrated in Figure 3-15, the user specifies card data input on the operator scenario at the parameter Table Source. He then loads his data cards into the card reader and readies the card reader for operation before proceeding any further (see Section 4.0 for card reader instructions). Once the operator begins executing, the mini-computer reads the cards, checks their format, stores the data in the appropriate operator data table, and then uses the modified table as input for the operator. Some operators require more than one input data table. In such cases, the data cards for all tables may be placed in the card reader at the same time, taking care to keep them in proper order.

The proper format for data cards for all Interactive IDAPS operators that have data table input is provided in Appendix B of this volume.
card reader instructions). Once the operator begins executing, the mini-
computer reads the cards, checks their format, stores the data in the appro-
priate operator data table, and then uses the modified table as input for
the operator. Some operators require more than one input data table. In
such cases, the data cards for all tables may be placed in the card reader
at the same time, taking care to keep them in proper order.

The proper format for data cards for all Interactive IDAPS operators that
have data table input is provided in Appendix B of this volume.

3.4.3.2 Trackball Data Input
Such operators as the PSEUDOCOLOR operators allow data table entry by
trackball (see Figure 3-15). In the case of PSEUDOCOLOR, trackball data
entry is accomplished by pointing to a color which is displayed on the Color
Monitor and pressing the trackball ENTER key. Trackball position is then
obtained by the minicomputer and is used to derive the color components
(red, green, blue) to be assigned to a specific gray value. Such color
component data is then stored in the PSEUDOCOLOR data table for use by the
operator. Specific instructions for using the trackball for data input are
provided on an appropriate television monitor.

3.4.3.3 Data Table Edit
A facility for reviewing the contents of a specific data table and for
ingoing the data values is provided by Interactive IDAPS. The DATA TABLE
EDIT operator may be found in the Function Generation Submenu. Selecting
the DATA TABLE EDIT operator results in a display of the names of every data
table for every Interactive IDAPS operator. From this display, the user may
select a specific data table by name. Figure 3-16 is an example of the
Figure 3-16. Sample Data Table Edit

data table for the Alter operator. The table may also be displayed in
graphic format. In this example the data table consists of 256 integer
numbers. Any one or all of these displayed numbers may be modified by
keyboard entry using the data table EDIT keys at the upper right corner of
the user keyboard and optionally by the trackball. The red cursor is positioned
by the four edit cursor controls EDIT UP, EDIT DOWN, EDIT LEFT, and EDIT
RIGHT; the desired entries are then input from the alphanumeric keys. When
the table has been modified to the user's desire, it may be stored as the
default table by depressing the EDIT ENTER key. This terminates the editing
process. Another feature available is the ability to enter a series of
points and have the system interpolate between them, creating a smoothed
curve.
3.5 SPECIAL FUNCTIONS
Interactive IDAPS features a capability for carrying out certain operations in direct response to keyboard entries under control of the minicomputer and independent of the host computer. Such special functions enhance the overall system by assisting the user in previewing and setting up runs, reviewing the results of previous runs, and controlling local terminal operations without having to go through the Menu Selection control process. Two categories of Special Functions are provided—operations functions, and processing functions.

3.5.1 Operations Functions
Special Functions keys are provided to control and assist Interactive IDAPS operations. The row of red keys along the top of the alphanumeric key set have been assigned to this class of special function.

3.5.1.1 HELP
The HELP function provides explanatory messages about specific operator parameters. The user positions the cursor at the parameter for which he wishes help and presses the HELP Key. A brief message will then appear in the space provided at the bottom of the screen and will remain until the cursor is moved to another parameter. Appropriate messages are provided for every parameter of every operator in the Interactive IDAPS.

3.5.1.2 Return to Master Menu
In the event the user has addressed an operator scenario or is performing some operation involving the minicomputer and wishes to terminate his operations and return the control to the Master Menu, he may press the RETURN TO MASTER MENU key. He should be aware, however, that if he terminates an operation, such as TAPE TO SYSTEM which has established a system file, that system file will remain in the host computer in its incomplete form.
3.5.1.3 Special Function Exit
The SPECIAL FUNCTION EXIT key is provided as a means for terminating a special function operation without returning control to the Master Menu.

3.5.2 Processing Functions
A number of simple image processing and display functions may be carried out using the Special Function capabilities of the minicomputer. The group of 18 keys at the left of the user keyboard control such operations. The user presses the appropriately labeled key and then usually indicates the monitor on which the object picture is to be displayed. Since these special functions are performed by the minicomputer using actively displayed data, they may be exercised independently of most host computer operations.

3.5.2.1 COORDINATES
The COORDINATES Special Function allows the user to obtain a display of the gray values of a specific region of a picture along with the line and column location. The trackball cursor is used to indicate the points for which gray values and locations are desired.

3.5.2.2 HISTOGRAM
Using the trackball cursor with the HISTOGRAM special function, the user first defines a rectangular area on a displayed picture. The minicomputer calculates a HISTOGRAM of the frequency of gray value occurrence and displays it at the left of the picture. The gray value maximum, minimum, mean, and sum are also calculated and displayed. A printout of the total values for each gray scale value may be obtained before exiting the HISTOGRAM special function.

3.5.2.3 SLICE
Using the SLICE operator, the user first defines a line segment on a displayed picture by locating its end points with the trackball cursor. The minicomputer prepares and displays a plot of gray value vs. position along the line segment.
3.5.2.4 QUICK LOOK SCAN
The QUICK LOOK SCAN Special Function causes the on line film scanner to scan its entire field of view at its lowest resolution and highest speed settings. The resulting image is displayed on one of the display monitors. This special function is used as a reference for control of the on line digitizer in defining the area to be scanned.

3.5.2.5 RESTORE
Whenever a picture is displayed on one of the monitors by an operator, a digital representation of the image is also stored on the minicomputer disk. The RESTORE Special Function causes a specific monitor to be erased and rewritten from the minicomputer disk. This is useful for clearing the display when a number of Special Functions such as SLICE and HISTOGRAM have been performed.

3.5.2.6 ERASE
This Special Function simply erases all information from a specified monitor.

3.5.2.7 GRAY SCALE WEDGE
When comparing pictures on the display monitors or as a simple reference of the gray values within a picture, the GRAY SCALE WEDGE function may be used. This special function writes a gray scale step wedge along the left hand border of the displayed pictures on both black and white display monitors.

3.5.2.8 LIST FILES
This Special Function displays the names of any 360 files which are displayed on the terminal monitors.

3.5.2.9 REPEAT
Whenever multiple entries from the same keyboard key are to be made, it is helpful to use the REPEAT Function. The user presses the REPT key first and then the key for which multiple entries are desired.
3.6 OPERATOR EXECUTION

Once an Interactive IDAPS operator has been selected through menu selection, all necessary parameters indicated, and preparations made for data table input, the operator may be executed. This causes the minicomputer to accept the user supplied control information, convert it to proper format, and transmit it to the host computer along with the input file identification. Several checks are made by the minicomputer during this initial setup phase and by the host computer during operator execution. Should a malfunction occur, the operation is suspended and an error status message is generated.

3.6.1 Normal Operation

Under normal conditions, an operator may be executed by either pressing the DOWN ARROW Key after the cursor is at the last parameter position or, if the cursor is not in the last parameter position, by simply pressing the EXEC key. Once the host computer begins executing the operator and if the minicomputer is not actively involved in the operator being exercised, the terminal control reverts to the Master Menu.

3.6.2 Error Conditions

If, for some reasons, an error is detected by the minicomputer, further operations are suspended and an error message is displayed at the bottom of the Master monitor. Minicomputer generated error messages indicate the nature of the error and provide instructions for correcting the error condition. In the event that an error is detected by the host computer, an error code is transmitted to the user terminal for display. The host computer error codes must be interpreted by the user. A list of host computer error codes along with their interpretations is included as Appendix A to this volume.

To continue processing following detection of an error, the user must correct the condition that caused the error. In most cases this is done by entering a legal value or by adjusting a hardware device, followed by depressing the
EXEC Key. Under a few specific error conditions it is not possible to recover without reinitializing the minicomputer. Such recovery is accomplished by depressing the INT Key on the minicomputer console panel, Figure 3-17.

Figure 3-17. Terminal Minicomputer Console Panel

3.7 LOG OUT
At the end of an interactive image processing run, the user should always log out. He does this from the Master Menu by selecting the LOG OUT Option and then pressing the EXEC key. He is then given instructions listing any devices which must be turned off as illustrated in Figure 3-18.
Because all image file data may be deleted when the next user logs in, the user may make provisions for retaining any data that he wants to keep. The normal procedure is to use the SYSTEM-TO-TAPE operator to store the image files on magnetic tape. In this way, image data may be re-entered into the system at a later time using the TAPE-TO-SYSTEM operator and further image processing may then be done. A record of his 360 operations may be obtained either on tape or on the printer if he so desires.
4.0 EQUIPMENT DESCRIPTION

This section describes the following interactive IDAPS equipment:

- Digital Television Displays
- Film Scanner
- User Console Keyboard
- Graphic Trackball
- Card Reader
- Printer
- Magnetic Tape Units
- Video Facsimile Copier
- Image Recorder

Each of these hardware components is shown in an illustration and described in an introductory paragraph, followed, as appropriate, by a discussion of principles of operation, capability specification, and set-up and operation. Additional Interactive IDAPS equipment, which is not directly operated by the user, is briefly discussed in a final paragraph.

4.1 DIGITAL TELEVISION DISPLAYS

A digital television system is provided by Interactive IDAPS to provide high quality displays of image data. Four video monitors are provided, two color (Master Monitor and Color Monitor) and two black-and-white (Monitors 1 and 2). The Master Monitor serves the user in controlling and monitoring his image processing operations. The Master Menu, Submenus, Operator Parameter Specification Scenarios, and Data Cards are all displayed on the Master Menu for user interactive control. While system control information is being displayed on the Master Monitor, the user may view before-and-after results of his image processing runs on the two black-and-white monitors. When working with color data, the user may monitor the color image on the Color Monitor. The Digital Television Displays are shown in Figure 4-1.
4.1.1 Set-Up and Operation

Operation of the digital television is controlled automatically by the system with the exception of the ON/OFF, INTENSITY, and CONTRAST controls on the monitors themselves. The INTENSITY and CONTRAST controls may be adjusted to suit the user's desires. The user should not attempt to adjust any other monitor controls, particularly in the color monitors.

Occasionally, a timing error will require that the digital display generator be reset. When this occurs, a message will be displayed on the master monitor instructing the user to press the CLEAR button on the display generator. The display generator is housed in the second from the left equipment rack in the Interactive IDAPS Terminal Room.
4.1.2 Principles of Operation
Data that is to be displayed on the digital television system is first converted to a proper format by the Interactive IDAPS minicomputer and transmitted through interface and control electronics to a high-speed digital disk. The data is stored on the disk in a format which allows it to be read off as a standard television raster, but in digital form. Additional electronic circuitry is used to superimpose a cursor on the television displays. The cursor is electronically coupled to the graphic trackball discussed in Paragraph 4.4.

Sufficient storage is provided to refresh sixteen frames of binary imagery. The first twelve of the binary image channels are used for displaying picture data. Binary channels 0-5 are used to refresh one of the two black and white television monitors, and binary channels 6-11 are used to refresh the other black and white monitor. To make more efficient use of the digital television refresh disk, the color image monitor is refreshed from the same twelve binary channels as the two black and white monitors. The red color gun is refreshed from channels 0-3, the green color gun from channels 6-9, and the blue color gun from channels 4, 5, 10, and 11. In this way, Interactive IDAPS provides displays of black-and-white as well as full color images.

4.1.3 Capability Specification
The digital television displays have the following capability:

Displays - Four commercial grade 14-inch diagonal television monitors. Two black-and-white and two color monitors.

B/W Monitors - Conrac monitors with P40 phosphor.

Viewing Area - Approximately 8 X 10 inches.

Refresh Rate - Thirty frames per second.

Resolution - 480 lines X 640 columns (480 X 480 used for image display).

4.2 FILM SCANNER

The film scanner (Figure 4-2) included in the interactive IDAPS is electrically and operationally integrated into the interactive system and is capable of satisfying the major requirements for digitizing S-056 images. However, some scanning requirements may exceed the capabilities of the on-line scanner; in such cases, the user should be prepared to employ a high resolution, high accuracy, off-line film scanner. The user can establish a basis for judgement of the adequacy of the on-line scanner for his particular application by review of the principles of operation and capabilities description which follow.

4.2.1 Set-Up and Operation

The on-line film scanner has a field of view of 35 X 35 mm. Film holders are provided for scanning individual 2 X 2 inch mounted frames and a roll film transport is available for scanning 35 mm film on reels up to eight inches in diameter. A swing-down mirror is provided to aid positioning of the film in the scanner. The on-line film scanner is operated as follows (refer to Figure 4-2):

1. Turn on the scanner with the key lock switch.

2. Place the scanner in the operate mode by pressing the OPERATE switch-light.
Figure 4-2. Film Scanner
3. Swing the view mirror back, using the knobs on either side of the dissector tube housing.

4. Position the film in the scanner. (With the film positioned in the scanner, normal scanning takes place from left to right and top to bottom of the film as viewed from above.) When using the hand-driven film transport, care should be taken to keep tension on the film at all times to prevent scratching of the film through contact with the holder.

5. Place the LOWER LIMIT switch in either the 0 or VER positions. In the 0 position a gray level of zero will normally correspond to a fixed, high density. In the VER position, a gray level of zero may be shifted slightly under control of the control on the digitizer control panel. When scanning in a log mode, the control capability is particularly useful for adjusting out background noise by setting the gray level zero slightly above the film noise level.

6. Return the view mirror to the down position.

Because the on-line film scanner is completely computer controlled, the user need not be concerned with manual controls other than the initial set-up described above.

4.2.2 Principles of Operation

The on-line film scanner is an electro-optical device which employs an image dissector tube as its central element. The image dissector is similar to a standard television vidicon in that it produces an analog voltage proportional to the intensity of light at a point in an image. The analog output of the dissector is converted electronically to digital form, buffered into appropriate data blocks, and transmitted to the computer through an electrical
interface. Electronic control circuitry is provided so that samples may be taken in a rectangular matrix pattern. Computer controls of such parameters as the point-to-point spacing of the sampled data, the region of the film to be digitized, and the intensity of the film illumination source are also provided. The exact controls provided by the on-line scanner are presented on the scanner control parameter specification displays which are discussed in Section 3.0.

4.2.3 Capability Specification
The on-line film scanner has the following capabilities:

- **Film Density**
  - Diffuse density range of 2.45 density units. Actual densities corresponding to gray levels 0 to 255 depend on factors such as illumination intensity and clipping levels.

- **Scan Image Size**
  - 35 X 35 mm at film plane.

- **Output Data**
  - 8 bits to the minicomputer (256 gray levels) codes are linearly proportional to film transmissivity, except when operating in log mode; then codes are approximately proportional to the inverse of film density.

- **Scanning Aperture**
  - Effective circular diameter of 36 μm.

- **Intersample Spacing**
  - 256 X 256 resolution = 137 μm
  - 512 X 512 resolution = 66 μm
  - 1024 X 1024 resolution = 33 μm
  - 2048 X 2048 resolution = 16 1/2 μm
Effective Bit Precision  - Scan Speed 1 = 93%
(Percentage of codes which are within ± 1 code of the mean) Scan Speed 2 = 64%
Scan Speed 3 = 32%
Scan Speed 4 = 16%

Scan Line Straightness  - Curvature Less than 0.15%.

Signal Amplitude Uniformity  - Maximum deviation over a circular area with a diameter equal to 80% of the scan-area diagonal is within ± 10%.

4.3 USER CONSOLE KEYBOARD

The major interactive user control instrument is an extended alphanumeric keyboard which interfaces with the Interactive IDAPS minicomputer. The user console keyboard layout is presented in Figure 4-3. The left hand group of eighteen keys of the keyboard are assigned to control special function operations. The right hand group of fourteen keys are used primarily for cursor control and operator execution. The top row of the middle section of keys is dedicated to the control of system operations. The remaining keys are used for input of alphabetic or numeric data.
Figure 4-3. User Console Keyboard Layout
4.4 GRAPHIC TRACKBALL

Image processing operations often require that the user specify point locations within an image array. A graphics trackball (Figure 4-4) is provided for this purpose. With the trackball, the user can identify points within a picture which is being displayed on one of the digital television monitors and can transmit the line and column coordinates of the points to the Interactive IDAPS minicomputer.

4.4.1 Set-Up and Operation

The following procedure is recommended for locating and transmitting a point to the minicomputer:

1. Identify the cursor on the television monitor. Occasionally, it may be helpful to adjust the monitor intensity and contrast.
controls in order to give the cursor sufficient contrast to be seen. Pressing the HOME button on the trackball returns the cursor to the upper left corner of the screen.

2. Move the cursor to the desired location on the monitor by "rolling" the trackball in the direction of desired cursor movement. Once the cursor is in the desired position, its location may be transmitted to the system by pressing the ENTER button.

4.4.2 Principles of Operation

When the trackball is moved by the user, sensors within the device detect the movement and cause electronic counters to be either incremented or decremented—depending on the direction of movement. The numbers contained in the counters correspond to the position of the cursor on the screen. When the trackball ENTER key is pressed, the contents of the counters are fed to the minicomputer as the x and y location of a point. Additional circuitry connects the trackball counters directly to the digital television electronics to control the position of the displayed cursor described in Paragraphs 4.1.2 and 4.4. The HOME button resets both the x and y counters which causes the counters to go to zero and the cursor to return to the upper left corner of the display monitors.

4.5 CARD READER

Control of image processing operators in IDAPS often requires that the user supply data in tabular form. This requirement is facilitated by the card reader (Figure 4-5).
Figure 4-5. Card Reader

4.5.1 Set-Up and Operation

Data contained on punched cards is read as follows:

1. Place the deck in the input hopper such that the first card in the deck is on the bottom, and the top edge of all cards is toward the front of the reader. Place the plastic card weight on top of the deck with the black weight to the left.

2. Press the card reader POWER button.

3. Press the card reader MOTOR button.

4. Press the card reader START button.
Should a card jam or other abnormal condition occur, the condition will be signalled by one of the red check (CK) lights on the reader.

4.5.2 Capability Specification
The card reader has the following capability:

Card Read Rate - 400 cards per minute.

Capacity - Up to 500 cards in input hopper and output stacker.

Card Format - Standard 80-column cards, 12 zones per column.

Character Codes - IBM 029 punch character set.

4.6 PRINTER
Printed copy of alphanumeric data is provided through the Interactive IDAPS printer (Figure 4-6). The printer is interfaced to and controlled by the minicomputer.
4.6.1 Set-Up and Operation
The printer is operated as follows:

1. Turn on the printer by pressing the ON/OFF switch-light.

2. Press the SELECT switch-light to place the printer on-line.

3. To remove printout from the printer, press the TOP OF FORM switch-light to eject the page.

Should the printer run out of paper, an audible tone will be sounded and the PAPER OUT light will light. Operations personnel will install new paper in the printer on request.

4.6.2 Capability Specification
The printer has the following capability:

Printing Method - Dot matrix. Each letter is a 5 X 7 inch array of dots.

Print Rate - 165 characters/second; 60 lines/minute with 132 characters.

Input Language - USASCII - 64 characters.

Paper - Standard, fan fold, sprocketed paper 14 7/8 inches wide.

Printing Structure - 132 characters/line; 6 lines per inch.
4.7 MAGNETIC TAPE UNITS

Two magnetic tape units (Figure 4-7) are provided to input image data which has been scanned on an off-line film scanner and to remove image data from the system in a computer-compatible form for processing and/or analysis at a later date.

4.7.1 Set-Up and Operation

The two tape units are designated Tape No. 1 and Tape No. 2. As the user faces the tape units, the unit on the left is Tape No. 1. The user should become familiar with the following procedures:

- Mounting a tape on a drive.
- Preparing the drive for use.
• Manually rewinding a tape.
• Removing a tape from a drive.

Tape is mounted on a drive as follows (refer to Figure 4-7):

1. With power on the drive, place the reel on the supply reel hub and lock in place by pressing on the metal tab in the center of the hub.

2. Thread the tape through the upper tension pulleys, through the read/write head slot, under the capstan, through the lower tension pulleys, and over the take up reel. A threading diagram is on the inside of the tape drive doors.

3. Holding the end of the tape against the hub of the take up reel, rotate the take-up reel clockwise through three revolutions.

To prepare the drive for use:

1. Press the LOAD switch-light. This causes the tension arms to move to the operating position--applying tension to the tape.

2. Press the LOAD switch a second time, the drive will advance the tape to the reflective load point marker.

3. Press the ON LINE switch to place the drive on line with the minicomputer.

At this point the LOAD, ON LINE, WRT EN, and HI DEN lamps should be lit. The HI DEN lamp signifies that the drive is set to read 800 BPI tapes. The WRT EN lamp signifies that the supply tape reel has a "Write Ring" in place. The Write Ring is necessary if the drive is to be used for writing data on
the tape. The Write Ring is a plastic ring which fits in a groove on the back side of a tape reel. It is used to prevent accidental writing on a magnetic tape. Its presence is mechanically sensed by the drive when the tape is mounted.

To rewind a tape using the manual drive controls:

1. Press the ON LINE switch to take the drive off-line from the minicomputer.

2. Press the REWIND switch. The tape will rewind to the reflective load point marker and the LOAD lamp will light.

3. Press the ON LINE switch to make the drive ready for use.

To remove a mounted tape from a drive:

1. Rewind the tape to its load point marker using the procedure above, but do not press the ON LINE switch.

2. Press the REWIND switch. This will rewind the tape past its load point and remove the tension arms.

3. Remove the tape from the drive hub.

4. Remove the Write Ring if protection from accidental overwriting on the tape is desired.

5. Prepare a tape label and affix it to the reel for future identification.
4.7.2 Capability Specification

Each magnetic tape unit has the following capability:

Tape Speed - 45 IPS; rewind 200 IPS.

Recording Format - 9 track NRZI IBM compatible.

Tape Capacity - Up to 2400 feet.

Inter-record Gap - 0.75 inch nominal.

Bit Density - 800 bits per inch.

4.8 VIDEO FACSIMILE COPIER

A video facsimile copier (Figure 4-8) is provided to make quick-look hard-copies of images displayed on one of the black and white monitors.

Figure 4-8. Video Facsimile Copier
4.8.1 Set-Up and Operation

1. Turn the hardcopy unit ON/OFF switch to ON and allow approximately twenty minutes for warm up.

2. Rotate the LIGHT-DARK knob to the twelve o'clock position.

3. With the desired picture displayed on Monitor 2, press the COPY switch.

4. If the copy is too light or too dark adjust the LIGHT-DARK knob and repeat step 3.

4.8.2 Principles of Operation
When the copy operation is initiated, an analog television tube within the hardcopier exposes a piece of photosensitive paper. The exposed paper is moved past a heat bar which causes the latent image to appear. The hardcopy is then automatically cut from the supply roll and deposited in the device output tray.

4.8.3 Capability Specification

Resolution - 480 X 640 matrix--the same as the television monitor.

Hardcopy Size - Approximately 8 1/2 X 11 inches.

Number of Effective Gray Levels - Approximately twelve.

Recording Time - Approximately 15 seconds.
Controls

- ON/OFF switch. COPY switch. LIGHT-DARK contrast control to adjust black/white ratio.

4.9 IMAGE RECORDER

The ability to reproduce processed digital image data on photographic film is provided by the on-line image recorder (Figure 4-9). With this device, the interactive IDAPS user can obtain photographic hardcopy of his image data on either Polaroid or a number of wet-process films in color or black and white. The resolution and accuracy of the device is adequate for most S-056 applications and the speed is sufficient to provide a high rate of throughput.

4.9.1 Set-Up and Operation

Set-up and operation of the image recorder requires user familiarity with the following procedures:

- Loading Polaroid Film.
- Loading Cut Film.
- Loading Roll Film.
- Calibrating the Recorder.
- Preparing the Recorder for Use.

4.9.1.1 Loading Polaroid Film

Polaroid film is useful for obtaining quick photographic prints from the system. A Polaroid Film Adapter (Figure 4-10) is provided. The adapter accepts 4 X 5 inch film packets of the following film types:
Figure 4-9. Image Recorder
Figure 4-10. Polaroid Film Adapter

- Type 52 for black-and-white prints.
- Type 55 for black-and-white negatives (Requires wet stabilizer solution).
- Type 58 for color prints.

The following procedure applies to all types of 4 X 5 inch Polaroid films:

1. Lift the film holder assembly and insert the Polaroid film adapter from the right (See Figure 4-10).

2. Move the film adapter load/process lever to the LOAD position.
3. Insert a film packet with the side which says "This Side Toward Lens" down. Take care to push the packet completely into the film holder to engage the metal clip of the packet in the film holder mechanism.

4. Pull the packet out of the holder as far as possible with moderate pressure. This withdraws the light protective paper cover from the sensitive film.

5. After the digital film recording is complete, push the packet back into the film holder and move the load/process lever to the PROCESS position.

6. Grasping the film packet by its exposed tabs, pull the film with moderate speed out of the holder.

7. Follow the instructions for film development printed on the packet.

4.9.1.2 Loading Cut Film
Standard 4 X 5 inch cut film in double sided cut-film holders are loaded into the film recorder by simply inserting the holder under the spring loaded, ground glass viewplate and then withdrawing the plastic film slide.

4.9.1.3 Loading Roll Film
A roll film holder (Figure 4-11) is provided for using 120 roll film. This holder allows up to ten full size images to be recorded on a roll of 120 film. The roll film holder is loaded by the following procedure:
1. Actuate the advance level until the last number on the exposure counter passes the white index dot and the counter no longer turns.

2. Open the holder by squeezing both release latches together and lifting the cover (Figure 4-11A). The carriage can now be removed.

3. Hold the full spool of film so that the paper leader will unwind counter-clockwise and place on the spring loaded stud on the left (supply) side. Press down until the spool can be snapped into place (Figure 4-11B).

Figure 4-11. Roll Film Holder and Loading Procedure
4. Break the seal on the film and unwind enough paper leader to pass around the front of the carriage and into the take-up spool. Insert the paper tab into the wider slot on spool (Figure 4-11C). Actuate the advance lever approximately 1/2 stroke to make one complete turn of the take-up spool. The paper must wind evenly between the two flanges of the spool. Continue to actuate the lever until the starting marker on the film is opposite the arrow inside the carriage (Figure 4-11D).

5. Rotate the exposure counter in the direction of the arrow until it "clicks" into place near "S" and resists further turning. Do not attempt to rotate beyond this point.

6. Replace the carriage in the holder and press down firmly on the cover to close, engaging both latches.

7. Actuate the advance lever until it locks. Initial winding is now completed and the exposure counter is set at "1".

8. The advance lever locks automatically after each exposure to prevent accidental film transport and overlapping exposure. To bring film into position for the next exposure, move the release lever to the left, then wind the film with a full stroke of the advance lever. Follow this sequence for all exposures. When the last exposure has been made, again move release lever to the left. Actuate the advance lever--it is now "free wheeling"--until drag on the take-up spool is no longer felt. Film is now fully wound. Remove the full spool and transfer the empty spool to the take-up position. Carriage is ready for reloading.
4.9.1.4 Calibrating the Recorder

The image recorder must be calibrated prior to use because different films have different light sensitivities and because the film recorder "drifts" with the passage of time. An accurate digital readout of the exposure index is provided by the Test and Calibration panel. Exposure index values for a number of recommended film types are tabulated in Figure 4-12. The

<table>
<thead>
<tr>
<th>Film Type</th>
<th>Nominal Exposure Level</th>
<th>Nominal Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/White Super XX 4142</td>
<td>6</td>
<td>190</td>
</tr>
<tr>
<td>Black/White Polaroid Type 52</td>
<td>0</td>
<td>120</td>
</tr>
<tr>
<td>Color Polaroid Type 58</td>
<td>10</td>
<td>310</td>
</tr>
<tr>
<td>Color Ektachrome 6115</td>
<td>10</td>
<td>310</td>
</tr>
<tr>
<td>Type 55 Positive</td>
<td>5</td>
<td>175</td>
</tr>
<tr>
<td>Type 55 Negative</td>
<td>10</td>
<td>310</td>
</tr>
</tbody>
</table>

Figure 4-12. Film Exposure Index Values

The procedure for exposure calibration is as follows (see Figure 4-9):

1. Verify that the recorder power is on, that the high voltage is off, and that the recorder is in the OPERATE mode.

2. Select a reference filter on the image recorder. The exposure index for a given type of film must be referenced to a particular filter.
3. Press the EXPOSURE CALIBRATE switch. After a delay the lamp will light and the exposure index will be displayed on the readout.

4. Adjust the EXPOSURE control on the Operator Control Panel to the indicated value for the film in use.

5. Adjust the EXPOSURE TRIM dial to arrive at the tabulated exposure index given on the exposure chart.

6. Press the EXPOSURE CALIBRATE switch to return the recorder to operational status.

4.9.1.5 Preparing the Recorder for Use
Once the recorder is properly calibrated, it is prepared for use as follows:

1. Verify that the recorder POWER is on, and that the desired film is properly loaded.

2. Press the OPERATE switch. The OPERATE lamp should light.

3. Verify that the plastic slide has been removed from in front of the film or that the Polaroid film packet has been withdrawn as described in Paragraph 4.9.1.1.

4. Turn on the HIGH VOLTAGE switch.

NOTE: Because it is possible for a minor malfunction to turn on the electron beam in the recorder CRT and burn the faceplate of the CRT, it is advisable to maintain the recorder with the HIGH VOLTAGE off except when the recorder is being used. Therefore, the user should turn off the high voltage when he has completed his recording tasks.
4.9.2 Principles of Operation
Digital image data is formatted by the minicomputer and transmitted, a line at a time, to the recorder. The data is buffered, converted to analog voltages, and applied to a high resolution cathode ray tube to modulate its electron beam intensity and hence to control the brightness of each pixel of light emitted. The image produced on the CRT is focused onto the photographic film contained in a light-tight housing. Color filters may be inserted to produce red, green, and blue components for exposing color film.

4.9.3 Capability Specification
The capability of the image recorder is as follows:

- **Spot Size**
  - 1.3 mils (33 microns) diameter on face of CRT.

- **Orthogonality**
  - ± 0.5%.

- **Line Curvature**
  - ± 0.15%.

- **Image Generation Time**
  - Black and White = 1 1/2 minutes; color = 4 1/2 minutes.

- **Exposure Range**
  - 2.0 diffuse density units measured on 6115 film.

- **Exposure Levels**
  - 256 levels with either a linear or log₁₀ relation to input gray codes.

- **Image Format**
  - 57 X 57 mm area maximum exposure field.

- **Film Format**
  - 4 X 5 inch film pack or sheets; 4 X 5 inch Polaroid packets; and 120 roll film. Film can be either black and white or color.
4.10 EQUIPMENT NOT DIRECTLY OPERATED BY THE USER

In addition to the hardware described above, which is directly manipulated or operated by the user, Interactive IDAPS uses the following additional equipment:

- Minicomputer mainframe, I/O, and memory
- Disk Drive
- Host Computer Interface
- Host Computer
- Digital Television Display Generator
- D/A Video Driver/Distributor
- Teletype

These items are discussed in Section 3.0 as required to describe their control and use in Interactive IDAPS.
APPENDIX A

HOST COMPUTER ERROR MESSAGES.
IDAPS ERROR CODES (S/360)

<table>
<thead>
<tr>
<th>Code</th>
<th>Operator</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>- - -</td>
<td>Column 4 nonblank in command card.</td>
</tr>
<tr>
<td>102</td>
<td>- - -</td>
<td>Operator not found in directory.</td>
</tr>
<tr>
<td>103</td>
<td>- - -</td>
<td>Error in file name specification.</td>
</tr>
<tr>
<td>104</td>
<td>- - -</td>
<td>File names neither first nor last in parameter list.</td>
</tr>
<tr>
<td>105</td>
<td>- - -</td>
<td>More than 5 files input.</td>
</tr>
<tr>
<td>106</td>
<td>- - -</td>
<td>Incorrect number of parameters for operator.</td>
</tr>
<tr>
<td>107</td>
<td>- - -</td>
<td>More than 8 characters in a command parameter.</td>
</tr>
<tr>
<td>108</td>
<td>- - -</td>
<td>ASCII to EBCDIC conversion error.</td>
</tr>
<tr>
<td>109</td>
<td>- - -</td>
<td>ASCII to EBCDIC conversion error, number of columns less than or equal zero.</td>
</tr>
<tr>
<td>110</td>
<td>- - -</td>
<td>EBCDIC to ASCII conversion error.</td>
</tr>
<tr>
<td>111</td>
<td>- - -</td>
<td>EBCDIC to ASCII conversion error, number of columns less than or equal zero.</td>
</tr>
<tr>
<td>112</td>
<td>- - -</td>
<td>End of data in batch mode.</td>
</tr>
<tr>
<td>113</td>
<td>- - -</td>
<td>Attempt to run batch mode without BATCH RUN card.</td>
</tr>
<tr>
<td>114</td>
<td>- - -</td>
<td>NOP out of range in INIT.</td>
</tr>
<tr>
<td>201</td>
<td>- - -</td>
<td>Number of files input is greater than number expected by operator.</td>
</tr>
<tr>
<td>202</td>
<td>- - -</td>
<td>Attempt to use more than 36 files for an operator.</td>
</tr>
<tr>
<td>203</td>
<td>- - -</td>
<td>Input file name not in directory.</td>
</tr>
<tr>
<td>204</td>
<td>- - -</td>
<td>All files in directory are in use.</td>
</tr>
<tr>
<td>205</td>
<td>- - -</td>
<td>All pixel files are in use.</td>
</tr>
<tr>
<td>206</td>
<td>- - -</td>
<td>All floating point files are in use.</td>
</tr>
<tr>
<td>207</td>
<td>- - -</td>
<td>Attempt to delete a file when there are no active files.</td>
</tr>
<tr>
<td>Code</td>
<td>Operator</td>
<td>Condition</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>208</td>
<td>- - -</td>
<td>Attempt to delete a pixel file whose logical unit is out of range.</td>
</tr>
<tr>
<td>210</td>
<td>- - -</td>
<td>Attempt to delete a floating point file whose logical unit is out of range.</td>
</tr>
<tr>
<td>301</td>
<td>- - -</td>
<td>Incorrect data length.</td>
</tr>
<tr>
<td>302</td>
<td>- - -</td>
<td>Record too long.</td>
</tr>
<tr>
<td>303</td>
<td>- - -</td>
<td>Incorrect LRC.</td>
</tr>
<tr>
<td>304</td>
<td>- - -</td>
<td>S/360 hardware detected error.</td>
</tr>
<tr>
<td>305</td>
<td>- - -</td>
<td>Front-end detected error.</td>
</tr>
<tr>
<td>306</td>
<td>- - -</td>
<td>Illegal function code.</td>
</tr>
<tr>
<td>307</td>
<td>- - -</td>
<td>DCB not open in ITRANS.</td>
</tr>
<tr>
<td>308</td>
<td>- - -</td>
<td>DCB not open in INTFAC.</td>
</tr>
<tr>
<td>309</td>
<td>- - -</td>
<td>S/360 hardware detected error.</td>
</tr>
<tr>
<td>310</td>
<td>- - -</td>
<td>Front-end detected error.</td>
</tr>
<tr>
<td>311</td>
<td>- - -</td>
<td>ITRANS error not in directory.</td>
</tr>
<tr>
<td>312</td>
<td>- - -</td>
<td>Transfer length error.</td>
</tr>
<tr>
<td>313</td>
<td>- - -</td>
<td>Cannot enable front-end.</td>
</tr>
<tr>
<td>401</td>
<td>- - -</td>
<td>Data card format error.</td>
</tr>
<tr>
<td>402</td>
<td>- - -</td>
<td>More than 24 columns in multiple value data.</td>
</tr>
<tr>
<td>403</td>
<td>- - -</td>
<td>More than 8 columns in multiplier.</td>
</tr>
<tr>
<td>404</td>
<td>- - -</td>
<td>More than 16 columns in data value.</td>
</tr>
<tr>
<td>405</td>
<td>- - -</td>
<td>Incorrect number of data values.</td>
</tr>
<tr>
<td>406</td>
<td>- - -</td>
<td>Error expecting type 3 message.</td>
</tr>
<tr>
<td>407</td>
<td>- - -</td>
<td>Error converting ASCII to EBCDIC.</td>
</tr>
<tr>
<td>501</td>
<td>- - -</td>
<td>Error echoing HELLO.</td>
</tr>
<tr>
<td>502</td>
<td>- - -</td>
<td>Data input out of sequence.</td>
</tr>
<tr>
<td>503</td>
<td>- - -</td>
<td>Image-file-ready message out of sequence.</td>
</tr>
<tr>
<td>504</td>
<td>- - -</td>
<td>Image-file-record message out of sequence.</td>
</tr>
<tr>
<td>505</td>
<td>- - -</td>
<td>End-of-file out of sequence.</td>
</tr>
<tr>
<td>506</td>
<td>- - -</td>
<td>Operation complete message from ID-70.</td>
</tr>
<tr>
<td>507</td>
<td>- - -</td>
<td>Error echoing GOOD-BYE.</td>
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<tr>
<td>508</td>
<td>- - -</td>
<td>Message type not supported.</td>
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### Condition Table

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<th>Condition</th>
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<tr>
<td>509</td>
<td></td>
<td>Error sending operation complete message.</td>
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<tr>
<td>1001-1013</td>
<td>SCA</td>
<td>Interface error sending image file ready message (See Note).</td>
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<td>1014</td>
<td>SCA</td>
<td>Message out of sequence, expecting type 4.</td>
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<td>1015</td>
<td>SCA</td>
<td>Message out of sequence, expecting type 5 or 6.</td>
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<tr>
<td>1021-1033</td>
<td>SCA</td>
<td>Interface error transmitting image data (See Note).</td>
</tr>
<tr>
<td>2001-2013</td>
<td>INF</td>
<td>Interface error sending image file ready message (See Note).</td>
</tr>
<tr>
<td>2014</td>
<td>INF</td>
<td>Message out of sequence, expecting type 4.</td>
</tr>
<tr>
<td>2015</td>
<td>INF</td>
<td>Message out of sequence, expecting type 5 or 6.</td>
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<td>INF</td>
<td>End-of-file skipping to starting record in batch mode.</td>
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<tr>
<td>2017</td>
<td>INF</td>
<td>Starting column greater than or equal to number of columns on tape.</td>
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<tr>
<td>2021-2033</td>
<td>INF</td>
<td>Interface error transmitting image data (see Note).</td>
</tr>
<tr>
<td>3001-3013</td>
<td>DIS</td>
<td>Interface error sending image file ready message (See Note).</td>
</tr>
<tr>
<td>3014</td>
<td>DIS</td>
<td>System to display called in batch mode.</td>
</tr>
<tr>
<td>3015</td>
<td>DIS</td>
<td>Attempt to display more lines than in input file.</td>
</tr>
<tr>
<td>3016</td>
<td>DIS</td>
<td>Attempt to display floating point file, use automatic scale operator to convert to image data format.</td>
</tr>
<tr>
<td>3021-3033</td>
<td>DIS</td>
<td>Interface error transmitting image data (See Note).</td>
</tr>
<tr>
<td>3041-3053</td>
<td>DIS</td>
<td>Interface error sending end-of-file message (See Note).</td>
</tr>
<tr>
<td>Code</td>
<td>Operator</td>
<td>Condition</td>
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<tr>
<td>---------</td>
<td>----------</td>
<td>---------------------------------------------------------------------------</td>
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<tr>
<td>4001-4013</td>
<td>OUT</td>
<td>Interface error sending image-file-ready message (See Note).</td>
</tr>
<tr>
<td>4014</td>
<td>OUT</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>4015</td>
<td>OUT</td>
<td>Attempt to write floating point file on tape, use automatic scale to convert to image data format.</td>
</tr>
<tr>
<td>4021-4033</td>
<td>OUT</td>
<td>Interface error transmitting image data (See Note).</td>
</tr>
<tr>
<td>4041-4053</td>
<td>OUT</td>
<td>Interface error sending end-of-file message (See Note).</td>
</tr>
<tr>
<td>5001-5013</td>
<td>FIL</td>
<td>Interface error sending image-file-ready message (See Note).</td>
</tr>
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<td>5014</td>
<td>FIL</td>
<td>Attempt to record more lines than in input file.</td>
</tr>
<tr>
<td>5015</td>
<td>FIL</td>
<td>Attempt to record floating point file on film, use automatic scale to convert to image data format.</td>
</tr>
<tr>
<td>5021-5033</td>
<td>FIL</td>
<td>Interface error transmitting image data (See Note).</td>
</tr>
<tr>
<td>5041-5053</td>
<td>FIL</td>
<td>Interface error sending end-of-file message (See Note).</td>
</tr>
<tr>
<td>6001-6013</td>
<td>PRI</td>
<td>Interface error sending image-file-ready message (See Note).</td>
</tr>
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<td>PRI</td>
<td>Segment requested exceeds limits of input file.</td>
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<tr>
<td>6015</td>
<td>PRI</td>
<td>Attempt to print floating point file on ID-70.</td>
</tr>
<tr>
<td>6021-6033</td>
<td>PRI</td>
<td>Interface error transmitting image data (See Note).</td>
</tr>
<tr>
<td>6041-6053</td>
<td>PRI</td>
<td>Interface error sending end-of-file message (See Note).</td>
</tr>
<tr>
<td>Code</td>
<td>Operator</td>
<td>Condition</td>
</tr>
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<td>----------</td>
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</tr>
<tr>
<td>9002</td>
<td>DIF</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>11001</td>
<td>AUT</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>12001</td>
<td>EXT</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>13001</td>
<td>INS</td>
<td>Task not executed--input specification exceeds bounds.</td>
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<tr>
<td>15001</td>
<td>LAB</td>
<td>Label message is not type 3.</td>
</tr>
<tr>
<td>15002</td>
<td>LAB</td>
<td>ASCII to EBCDIC error converting label message.</td>
</tr>
<tr>
<td>15003</td>
<td>LAB</td>
<td>ASCII to EBCDIC error in label preparation.</td>
</tr>
<tr>
<td>17001</td>
<td>MAT</td>
<td>Attempt to divide by zero--output value set to input value.</td>
</tr>
<tr>
<td>19001</td>
<td>TRA</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>20001</td>
<td>FRA</td>
<td>Frame message is not type 3.</td>
</tr>
<tr>
<td>20002</td>
<td>FRA</td>
<td>ASCII to EBCDIC error converting frame message.</td>
</tr>
<tr>
<td>20003</td>
<td>FRA</td>
<td>ASCII to EBCDIC error in frame preparation.</td>
</tr>
<tr>
<td>21001</td>
<td>AVE</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>21002</td>
<td>AVE</td>
<td>Attempt to average a floating point file.</td>
</tr>
<tr>
<td>22001</td>
<td>HDC</td>
<td>Segment requested exceeds limits of input file.</td>
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</tbody>
</table>

NOTE: Interface errors which occur during the use of input and output operators (SCA, INP, DIS, OUT, FIL, PRI) are reported as errors in the appropriate operator. These will occur if an input/output operator is aborted before the task is completed. Any other occurrence of interface errors should be reported to IDAPS system programmers.
<table>
<thead>
<tr>
<th>Code</th>
<th>Operator</th>
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<td>DIF</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>11001</td>
<td>AUT</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>11002</td>
<td>AUT</td>
<td>Attempt to scale a file whose minimum and maximum are equal.</td>
</tr>
<tr>
<td>12001</td>
<td>EXT</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>13001</td>
<td>INS</td>
<td>Task not executed—input specification exceeds bounds.</td>
</tr>
<tr>
<td>15001</td>
<td>LAB</td>
<td>Label message is not type 3.</td>
</tr>
<tr>
<td>15002</td>
<td>LAB</td>
<td>ASCII to EBCDIC error converting label message.</td>
</tr>
<tr>
<td>15003</td>
<td>LAB</td>
<td>ASCII to EBCDIC error in label preparation.</td>
</tr>
<tr>
<td>17001</td>
<td>MAT</td>
<td>Attempt to divide by zero—output value set to input value.</td>
</tr>
<tr>
<td>19001</td>
<td>TRA</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>20001</td>
<td>FRA</td>
<td>Frame message is not type 3.</td>
</tr>
<tr>
<td>20002</td>
<td>FRA</td>
<td>ASCII to EBCDIC error converting frame message.</td>
</tr>
<tr>
<td>20003</td>
<td>FRA</td>
<td>ASCII to EBCDIC error in frame preparation.</td>
</tr>
<tr>
<td>21001</td>
<td>AVE</td>
<td>Attempt to average a floating point file.</td>
</tr>
<tr>
<td>22001</td>
<td>HDC</td>
<td>Segment requested exceeds limits of input file.</td>
</tr>
<tr>
<td>28001</td>
<td>FEA</td>
<td>No subsets occur within given threshold limits.</td>
</tr>
<tr>
<td>32001</td>
<td>ARE</td>
<td>Feature point is outside the sphere, correction is impossible.</td>
</tr>
<tr>
<td>33001-13</td>
<td>BOR</td>
<td>Interface error transmitting border points (See Note 1).</td>
</tr>
<tr>
<td>34001</td>
<td>CON</td>
<td>A set of weights with more than 15 X 15 elements has been specified.</td>
</tr>
<tr>
<td>Code</td>
<td>Operator</td>
<td>Condition</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
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<tr>
<td>35001</td>
<td>SIM</td>
<td>Window does not fit on image 1.</td>
</tr>
<tr>
<td>35002</td>
<td>SIM</td>
<td>Window does not fit on image 2.</td>
</tr>
<tr>
<td>38001</td>
<td>FFT</td>
<td>Attempt to Fourier transform a file smaller than 64 by 64.</td>
</tr>
<tr>
<td>39001</td>
<td>IFF</td>
<td>Input files to IFFT are not square.</td>
</tr>
<tr>
<td>39002</td>
<td>IFF</td>
<td>Input files to IFFT are not same size.</td>
</tr>
<tr>
<td>39003</td>
<td>IFF</td>
<td>Attempt to Inverse Fourier transform a file smaller than 64 by 64.</td>
</tr>
<tr>
<td>40001</td>
<td>FOU</td>
<td>Attempt to Fourier filter a file smaller than 64 by 64.</td>
</tr>
<tr>
<td>42001</td>
<td>FGN</td>
<td>A &lt; 0.0 or A &gt; 1.0.</td>
</tr>
<tr>
<td>42002</td>
<td>FGN</td>
<td>B &lt; 0.0 or B &gt; 1.6.</td>
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<td>42003</td>
<td>FGN</td>
<td>A &lt; B for pass filter.</td>
</tr>
<tr>
<td>42004</td>
<td>FGN</td>
<td>A &lt; 0.0 for pass filter.</td>
</tr>
<tr>
<td>42005</td>
<td>FGN</td>
<td>B &gt; 1.0 for pass filter.</td>
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<tr>
<td>42006</td>
<td>FGN</td>
<td>Order of Bessel function is negative.</td>
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<tr>
<td>42007</td>
<td>FGN</td>
<td>Argument to Bessel function &lt; 0.0.</td>
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<tr>
<td>42008</td>
<td>FGN</td>
<td>Required accuracy in fitting algorithm not obtained.</td>
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<tr>
<td>42009</td>
<td>FGN</td>
<td>Range of N compared to X not correct in Bessel function.</td>
</tr>
<tr>
<td>42010</td>
<td>FGN</td>
<td>Elliptical fit did not converge in 5000 iterations.</td>
</tr>
<tr>
<td>42011</td>
<td>FGN</td>
<td>Elliptical fit did not converge, UPLIM = X.</td>
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<tr>
<td>42012</td>
<td>FGN</td>
<td>Input profiles are not both monotonic.</td>
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<tr>
<td>42013</td>
<td>FGN</td>
<td>Input profiles are not the same type.</td>
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<tr>
<td>42014</td>
<td>FGN</td>
<td>Requested spatial domain filter larger than 41 by 41.</td>
</tr>
<tr>
<td>42015</td>
<td>FGN</td>
<td>Requested frequency domain filter less than 64 by 64 or larger than 1024 by 1024.</td>
</tr>
</tbody>
</table>
NOTE 1: Interface errors which occur during the use of input and output operators (SCA, INP, DIS, OUT, FIL, PRI) are reported as errors in the appropriate operator. These will occur if an input/output operator is aborted before the task is completed. Any other occurrence of interface errors should be reported to IDAPS system programmers.

NOTE 2: A 600 level error which occurs while attempting to write a file indicates that the write operation was not successful and any attempt to use that file will result in erroneous results. Repeat the operator and if the error persists report the error to the IDAPS systems programmers. A 600 level error which occurs while attempting to read a file indicates that the read operation was not successful and the operator being executed was aborted. Repeat the operator and if the error persists repeat the operator(s) which generated the input file(s). If the problem still exists report the condition to the IDAPS systems programmers.
APPENDIX B

INTERACTIVE IDAPS OPERATORS

1.0 OPERATOR CROSS-REFERENCE INDEX
1.1 OPERATOR VS. SUBMENU CATEGORY
1.2 SUBMENU CATEGORY VS. OPERATOR

2.0 INTERACTIVE IDAPS OPERATORS
1.0 OPERATOR CROSS REFERENCE INDEX

1.1 OPERATOR VS. SUBMENU CATEGORY CROSS-REFERENCE INDEX

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<td>Gray Scale Adjustment (C)</td>
<td>B-8</td>
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<tr>
<td>Automatic Scale (AUT)</td>
<td>Gray Scale Adjustment (C)</td>
<td>B-9</td>
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<tr>
<td>Average (AVE)</td>
<td>Math/Logic Functions (H)</td>
<td>B-11</td>
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<tr>
<td>Center Radius (CEN)</td>
<td>Image Analysis (I)</td>
<td>B-12</td>
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<tr>
<td>Convolutional Filter (CON)</td>
<td>Filter Operations (E)</td>
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<tr>
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<td>Gray Scale Adjustment (C)</td>
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<tr>
<td>Distance (DIS)</td>
<td>Image Analysis (I)</td>
<td>B-12e</td>
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<tr>
<td>Extract Subframe (EXT)</td>
<td>Manual Image Modification (D)</td>
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<tr>
<td>Fast Fourier Transform (FFT)</td>
<td>Filter Operations (E)</td>
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<td>Feature Analysis (FEA)</td>
<td>Image Analysis (I)</td>
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<td>Filter Generation (FGN)</td>
<td>Filter Operations (E)</td>
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<td>Fourier Filter (FOU)</td>
<td>Filter Operations (E)</td>
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<tr>
<td>Frame (FRA)</td>
<td>Image Data Presentation (K)</td>
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<tr>
<td>Hand Drawn Shapes (HAN)</td>
<td>Function Generation (B)</td>
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<tr>
<td>H-D Correction (HDC)</td>
<td>Gray Scale Adjustment (C)</td>
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<td>Inverse Fast Fourier Transform (IFF)</td>
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<td>Gray Scale Adjustment (C)</td>
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<td>Label (LAB)</td>
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<td>Image Analysis (I)</td>
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<td>3.56</td>
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<td>PRINT(PRI)</td>
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<td>PSF GENERATOR (PSF)</td>
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<td>7.06</td>
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<td>REGISTER(REG)</td>
<td>1.06</td>
<td>5.81</td>
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<td>ROTATE(ROT)</td>
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<td>STONYHURST(STC)</td>
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<td>.83</td>
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<td>TRANSPOSE(TRA)</td>
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## 1.2 SUBMENU CATEGORY VS. OPERATOR CROSS-REFERENCE INDEX

<table>
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<th>PAGE</th>
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<tr>
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<td>Scanner to Display (S-D)</td>
<td>B-28</td>
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<tr>
<td>(B)</td>
<td>Scanner to Tape (S-T)</td>
<td>B-36</td>
</tr>
<tr>
<td>(C)</td>
<td>Scanner to Film (S-F)</td>
<td>B-30</td>
</tr>
<tr>
<td>(D)</td>
<td>Scanner to Printer (S-P)</td>
<td>B-34</td>
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<td>(E)</td>
<td>Scanner to System (SCA)</td>
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<td>(F)</td>
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<td>(G)</td>
<td>Tape to Tape (T-T)</td>
<td>B-53</td>
</tr>
<tr>
<td>(H)</td>
<td>Tape to Film (T-F)</td>
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<td>(I)</td>
<td>Tape to Printer (T-P)</td>
<td>B-51</td>
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<td>(J)</td>
<td>Tape to System (INP)</td>
<td>B-52</td>
</tr>
<tr>
<td>(K)</td>
<td>System to Display (DIS)</td>
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<td>(L)</td>
<td>System to Tape (OUT)</td>
<td>B-44</td>
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<td>(M)</td>
<td>System to Film (FIL)</td>
<td>B-41</td>
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<td>System to Printer (PRI)</td>
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<td>Hand Drawn Shapes (HAN)</td>
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<td>(B)</td>
<td>Filter Generation (FGN)</td>
<td>B-13d</td>
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<tr>
<td>(C)</td>
<td>Table Modification (DTE)</td>
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<td><strong>Gray Scale Adjustment</strong></td>
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<td>(C)</td>
<td>Automatic Scale (AUT)</td>
<td>B-9</td>
</tr>
<tr>
<td>(D)</td>
<td>Invert Gray Scale (INV)</td>
<td>B-19</td>
</tr>
<tr>
<td>(E)</td>
<td>Math (MAT)</td>
<td>B-22</td>
</tr>
<tr>
<td>(F)</td>
<td>Hand Drawn Shapes (HAN)</td>
<td>B-15a</td>
</tr>
<tr>
<td>(C)</td>
<td>H-D Correction (HDC)</td>
<td>B-16</td>
</tr>
</tbody>
</table>
### 1.2 SUBMENU CATEGORY VS. OPERATOR CROSS-REFERENCE INDEX (Cont'd.)

<table>
<thead>
<tr>
<th>SUBMENU CATEGORY (OPTION CODE)</th>
<th>OPERATOR NAME (CODE)</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Image Modification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Extract Subframe (EXT)</td>
<td></td>
<td>B-13</td>
</tr>
<tr>
<td>(B) Insert Subframe (INS)</td>
<td></td>
<td>B-18</td>
</tr>
<tr>
<td>(C) Test Image Generation (IMA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Convolutional Filter (CON)</td>
<td></td>
<td>B-12a</td>
</tr>
<tr>
<td>(B) Fourier Filter (FOU)</td>
<td></td>
<td>B-13f</td>
</tr>
<tr>
<td>(C) FFT (FFT)</td>
<td></td>
<td>B-13a</td>
</tr>
<tr>
<td>(D) IFFT (IFF)</td>
<td></td>
<td>B-18a</td>
</tr>
<tr>
<td>(E) Filter Generation (FGN)</td>
<td></td>
<td>B-13d</td>
</tr>
<tr>
<td>Geometric Operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Rotate (ROT)</td>
<td></td>
<td>B-27</td>
</tr>
<tr>
<td>(D) Transpose (TRA)</td>
<td></td>
<td>B-54</td>
</tr>
<tr>
<td>(E) Register (REG)</td>
<td></td>
<td>B-26</td>
</tr>
<tr>
<td>(D) Extract Subframe (EXT)</td>
<td></td>
<td>B-13</td>
</tr>
<tr>
<td>(E) Insert Subframe (INS)</td>
<td></td>
<td>B-18</td>
</tr>
<tr>
<td>(F) Magnify (MAG)</td>
<td></td>
<td>B-21a</td>
</tr>
<tr>
<td>Classification/Pattern Recognition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Feature Analysis (FEA)</td>
<td></td>
<td>B-13a</td>
</tr>
<tr>
<td>(B) Similarity (SIM)</td>
<td></td>
<td>B-37a</td>
</tr>
<tr>
<td>Math/Logic Functions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Average (AVE)</td>
<td></td>
<td>B-11</td>
</tr>
<tr>
<td>(B) FFT (FFT)</td>
<td></td>
<td>B-13a</td>
</tr>
</tbody>
</table>
1.2 SUBMENU CATEGORY VS. OPERATOR CROSS-REFERENCE INDEX (Cont'd.)

<table>
<thead>
<tr>
<th>SUBMENU CATEGORY (OPTION CODE)</th>
<th>OPERATOR NAME (CODE)</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C)</td>
<td>IFFT (IFF)</td>
<td>B-18a</td>
</tr>
<tr>
<td>(D)</td>
<td>Math (MAT)</td>
<td>B-22</td>
</tr>
<tr>
<td>Image Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A)</td>
<td>Feature Analysis (FEA)</td>
<td>B-13a</td>
</tr>
<tr>
<td>(B)</td>
<td>Distance (DIS)</td>
<td>B-12e</td>
</tr>
<tr>
<td>(C)</td>
<td>Center/Radius (CEN)</td>
<td>B-12</td>
</tr>
<tr>
<td>(D)</td>
<td>Isogram (ISO)</td>
<td>B-20</td>
</tr>
<tr>
<td>(E)</td>
<td>Overlay (OVE)</td>
<td>B-23</td>
</tr>
<tr>
<td>(F)</td>
<td>Picture Difference (DIF)</td>
<td>B-25</td>
</tr>
<tr>
<td>Pseudocolor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A)</td>
<td>Scanner to Display</td>
<td>B-29</td>
</tr>
<tr>
<td>(B)</td>
<td>Scanner to Film</td>
<td>B-32</td>
</tr>
<tr>
<td>(C)</td>
<td>Tape to Display</td>
<td>B-48</td>
</tr>
<tr>
<td>(D)</td>
<td>Tape to Film</td>
<td>B-50</td>
</tr>
<tr>
<td>(E)</td>
<td>System to Display</td>
<td>B-40</td>
</tr>
<tr>
<td>(F)</td>
<td>System to Film</td>
<td>B-42</td>
</tr>
<tr>
<td>Image Data Presentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A)</td>
<td>Frame (FRA)</td>
<td>B-14</td>
</tr>
<tr>
<td>(B)</td>
<td>Label (LAB)</td>
<td>B-21</td>
</tr>
<tr>
<td>(C)</td>
<td>Stonyhurst Grid (STO)</td>
<td>B-38</td>
</tr>
</tbody>
</table>
SECTION 2.0  INTERACTIVE IDAPS OPERATORS

(In alphabetical order by name)
ALTER (ALT)

This operator modifies the gray values of an input image array by a technique of table look-up in accordance with a data table supplied by the user. This operator may be used for such purposes as contrast enhancement, pseudocontouring, or masking of specific gray levels.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Data Card Format: The data source must be specified by card input of 256 integer values in the following format:

```
ALT=255,252,3*248,244,...,3,2,1,0$
```

In the above example, all gray values of 0 in the input picture will be replaced by 255's; all 1's by 252; 2's, 3's, and 4's by 248; 5's by 244; etc.

Note:
1. The input file for this operator must be integer.
AUTOMATIC SCALE (AUT)

This operator automatically scales integer or floating point image data to a range of 0-255 integers. The operator is particularly useful in presenting a floating-point image array as a picture. Scaling may be specified to one of a number of standard curves between user-selected upper and lower limits.

Both the host computer and the terminal minicomputer are required by this operator.

---

Note:
1. Specifying the Starting Line, Starting Column, Number of Lines and Number of Columns allows the user to apply this operator to any subframe of the input file.

2. When specified, one of the following operations is used for automatic scaling:

   Linear: \[ n = \frac{f - b}{a - b} \times 255 \]
   Cube Root: \[ n = \left( \frac{f^{1/3} - b^{1/3}}{a^{1/3} - b^{1/3}} \right) \times 255 \]

   Logarithmic: \[ n = \frac{\log_{10} (f/b)}{\log_{10} (a/b)} \times 255 \]
   Square: \[ n = \left( \frac{f^2 - b^2}{a^2 - b^2} \right) \times 255 \]
AUTOMATIC SCALE (Continued)

Note (Continued):

Square Root: \[ n = \left( \frac{f^{1/2} - b^{1/2}}{a^{1/2} - b^{1/2}} \right)^{255} \]

Where:  
\( a \) = maximum value in the data set or upper limit.  
\( b \) = minimum value in the data set or lower limit.  
\( f \) = original input value.  
\( n \) = computed output value (0-255).
AVERAGE (AVE)

This operator averages several frames of image data. This operation is often helpful in reducing the signal-to-noise ratio where a number of nearly identical frames exist, but which individually are corrupted by random noise.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. A maximum of five files may be averaged.

2. All input files must be the same size and registered (the EXTRACT, REGISTER, or ROTATE operators may be used to accomplish sizing and registration).

3. The input files must be integer.
CENTER DIAMETER (CED)

This operator calculates the location of the center and the length of the
diameter of the solar disk based on the location of three points. The user
supplies the line and column coordinates for three points on the apparent
limb of the sun.

The host computer is not required by this operator.

Note:
1. The three points must not be colinear.
2. For maximum accuracy, the three points should be approximately evenly
   spaced around the solar limb.
EXTRACT SUBFRAME (EXT)

This operator extracts a subframe from a larger input image array, creating a new output file of reduced size.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1SCA</td>
<td>INPUT FILE FROM WHICH PICTURE SUBSET IS EXTRACTED.</td>
</tr>
<tr>
<td>1</td>
<td>STARTING LINE.</td>
</tr>
<tr>
<td>1</td>
<td>STARTING COLUMN.</td>
</tr>
<tr>
<td>480</td>
<td>NUMBER OF LINES.</td>
</tr>
<tr>
<td>480</td>
<td>NUMBER OF COLUMNS.</td>
</tr>
</tbody>
</table>

Note:
1. The input file for this operator must be integer.
FAST FOURIER TRANSFORM (FFT)

This operator performs a two-dimensional Fourier transformation on the input array (file) and produces two output arrays (files) which contain the complex components in the frequency domain. The output arrays (files) may be in the form of real and imaginary components or in the form of magnitude and phase components.

Both the host computer and the terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

**OPTION | PARAMETER DESCRIPTION**

- **D** OUTPUT FORMAT
  - A - REAL/IMAGINARY - DC TERM AT LOCATION 1,1
  - B - REAL/IMAGINARY - DC TERM CENTERED
  - C - MAGNITUDE/PHASE - DC TERM AT LOCATION 1,1
  - D - MAGNITUDE/PHASE - DC TERM CENTERED

  **NOTE:** FFT PRODUCES TWO OUTPUT FILES WHICH REPRESENT THE REAL AND IMAGINARY OR THE MAGNITUDE AND PHASE COMPONENTS OF THE TRANSFORM.

- **B** NORMALIZATION OPTION
  - A - NORMALIZED BY DIVIDING FREQUENCY TERMS BY THE VOLUME UNDER THE CURVE AND REVERSING THE SIGN OF ALTERNATE TERMS.
  - B - NOT NORMALIZED

- **B** WINDOW OPTION
  - A - APPLY WINDOW FUNCTION TO INPUT FILE
  - B - DO NOT APPLY WINDOW FUNCTION

- **A** TYPE OF WINDOW
  - A - HANNING
  - B - HAMMING

**Note:**
1. The number of rows (and columns) in the input file must be a power of 2.
2. The input file must have at least 64 rows and columns, but not more than 1024 rows and columns.
3. The "image to be analyzed" may or may not be the same as the "input file" and may be either integer or floating point format. Typically the "input file" will be an integer picture while the "image to be analyzed" will be a floating point file which has been "H and D" corrected.

4. An intermediate output is generated which is the feature map. The feature map may be displayed on either of the B/W console monitors. Since the feature map is in the standard output format, it may be used again if an analysis is desired of other features within the map. This is done by choosing option "B" for the second parameter.
FILTER GENERATION (FGN)

This operator generates filter files to be used with the convolutional filter in the spatial domain or the Fourier filter in the frequency domain. Rotationally symmetric filters are generated by rotating the input x-z plane profile about the z-axis. Non-symmetric filters are generated by elliptically fitting the filter surface to input x-z and y-z plane profiles. The input profile(s) may be input via cards or default tables or internally generated using one of the optional algorithms.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

```
<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>SYMMETRY FUNCTION</td>
<td>1.</td>
<td>MAXIMUM AMPLITUDE</td>
</tr>
<tr>
<td>A</td>
<td>ROTATIONAL SYMMETRY</td>
<td>0.</td>
<td>MINIMUM AMPLITUDE</td>
</tr>
<tr>
<td>B</td>
<td>ELLIPTICAL FIT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>FILTER CROSS SECTION IN X-Z PLANE</td>
<td>A</td>
<td>TYPE OF FILTER</td>
</tr>
<tr>
<td></td>
<td>A - CIRCULAR APERTURE DIFFRACT.</td>
<td>B</td>
<td>FREQUENCY DOMAIN</td>
</tr>
<tr>
<td></td>
<td>C - GAUSSIAN DISTRIBUTION</td>
<td>S12</td>
<td>SIZE OF FILTER (WXH)</td>
</tr>
<tr>
<td></td>
<td>D - ZERO ORDER BESSEL FUNCTION</td>
<td>B</td>
<td>INVERSION OPTION</td>
</tr>
<tr>
<td></td>
<td>E - LOW PASS FILTER</td>
<td></td>
<td>A - DO NOT INVERT FILTER</td>
</tr>
<tr>
<td></td>
<td>G - HIGH PASS FILTER</td>
<td></td>
<td>B - INVERT FILTER</td>
</tr>
<tr>
<td></td>
<td>H - BAND PASS FILTER</td>
<td></td>
<td>S. INVERSION LIMIT (MAXIMUM)</td>
</tr>
<tr>
<td></td>
<td>I - BAND REJECT FILTER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J - CARD INPUT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K - DATA TABLES (FGN1, FGN2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>SIGMA POINT (0.&lt;R&lt;1.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.75</td>
<td>X-Z PLANE 3 SIGMA POINT (0.&lt;R&lt;1.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.9</td>
<td>Y-Z PLANNE 3 SIGMA POINT (0.&lt;R&lt;1.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Data Card Format: The data source may be specified by card input of 251 floating point values corresponding to the normalized amplitudes at normalized frequency values of 0., .004, .008, ..., .992, .996, 1.0. One table is required for symmetric filters and two tables are required for non-symmetric filters. The table formats are given in the example below:
FGN2=1.0,.95,.86,.71,.66,.61,.57,.53,.50,.47,.46,.44,.43,.42,.41,.40,.39,.38,.37,.36,.35,.34,.33,.32,.31,.30,.29,.28,.27,.26,.25,.24,.23,.22,.21,.20,.19,.18,.17,.16,.15,.14,.13,.12,.11,.10,.09,.08,.07,.06,.05,.04,.03,.02,.01,241*0.\$

FGN1=1.0,.99,.92,.79,.61,.39,.12,.03,.02,.01,241*0.\$

Note:
1. Both input profiles for non-symmetric filters must be monotonic and either increasing or decreasing.
2. The filter size is limited to 1024 by 1024 for frequency domain filters and 15 by 15 for spatial domain filters.
FOURIER FILTER (FOU)

This operator applies a two-dimensional frequency domain filter to an image file by multiplying the magnitude component of a Fourier transformed image by the filter file and inverse transforming the resulting file with the corresponding phase component file to give a filtered image file.

Both the host computer and the terminal computer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. If the input image name references an image file, that file will be Fourier transformed before the filter is applied. If the input image has previously been Fourier transformed, then that step may be skipped by specifying the magnitude component (e.g., IFPM) as the input image name.
FRAME (FRA)

This operator adds user annotations to an image file to identify the image, to explain the processing which it has undergone, and to call attention to regions of special interest. Such annotations are helpful in preparing processed pictures for final hardcopy output. The operator also provides a reference gray scale wedge, reference tick marks around the border, a histogram of gray values within the image, and an optional rectangular grid overlay.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>GRAY SCALE INVERSION</td>
</tr>
<tr>
<td></td>
<td>A - NO INVERSION</td>
</tr>
<tr>
<td></td>
<td>B - PICTURE IS INVERTED</td>
</tr>
<tr>
<td>B</td>
<td>FRAME COLOR</td>
</tr>
<tr>
<td></td>
<td>A - BLACK</td>
</tr>
<tr>
<td></td>
<td>B - WHITE</td>
</tr>
<tr>
<td>A</td>
<td>GRID OPTION</td>
</tr>
<tr>
<td></td>
<td>A - NO GRID</td>
</tr>
<tr>
<td></td>
<td>B - 32 X 32 SECTORS</td>
</tr>
</tbody>
</table>

Note:
1. Since the FRAME is generated around the input image, the output file is larger than the input by 126 columns and at least 201 lines. An additional 14 lines must be added for each label provided in the FRAME.

2. The input picture may be gray scale inverted before output and the user has the option of a white frame (255's) with black labels (0's) or a black frame with white labels.

3. The user may specify overlay of a rectangle on the image to aid identification of a region of interest.
FRAME (Continued)

Note (Continued):

4. Labels are entered directly from the user keyboard and appear at the top or bottom of the scenario, as specified.

5. The following character set is available:
   ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789+-(),/=.'*(space)
H-D CORRECTION (HDC)

This operator converts image data group values to energy or intensity values using the proper film characteristic data and scanner calibration. The user must provide a set of calibration data, which should be obtained at the time the image data is scanned.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>H-D CORRECTION SOURCE</td>
<td>A</td>
<td>SCALING FACTOR</td>
</tr>
<tr>
<td>A</td>
<td>SCAN FILM SAMPLES</td>
<td>A</td>
<td>FUNCTION OF DENSITY (LOG)</td>
</tr>
<tr>
<td>B</td>
<td>CARDS</td>
<td>B</td>
<td>FUNCTION OF TRANSMITTANCE (LINEAR)</td>
</tr>
<tr>
<td>C</td>
<td>DATA TABLES (&lt;HDC1, HDC2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1SCA</td>
<td>INPUT FILE NAME</td>
<td>A</td>
<td>SCAN POLARITY</td>
</tr>
<tr>
<td>1</td>
<td>STARTING LINE</td>
<td>A</td>
<td>NORMAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>COMPLEMENT</td>
</tr>
<tr>
<td>400</td>
<td>STARTING COLUMN</td>
<td>B</td>
<td>INTEGRATION TIME (MILLISECONDS)</td>
</tr>
<tr>
<td>480</td>
<td>NUMBER OF LINES</td>
<td>A</td>
<td>FILTER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>NEUTRAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>RED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>GREEN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>BLUE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MANUAL/CURRENT SETTING</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G</td>
<td>ILLUMINATION LEVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>LOWER CLIPPING LIMIT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>UPPER CLIPPING LIMIT</td>
</tr>
</tbody>
</table>

Note:
1. H-D correction data may be generated on-line if the on-line scanner is used for image input. The user scans a set of sensitometry strips (e.g., five to twenty) using the same scanner settings used for the input image scan and then specifies the energy/intensity corresponding to each step. Interpolation is automatically performed to derive a table of 256 floating point values which relate gray value directly to energy/intensity.

2. The user may supply H-D correction data by card or keyboard input. The data format is shown on the following page.
H-D CORRECTION (Continued)

Note (Continued):
3. The scenario displayed above is used when Scan Film Samples is chosen for the H-D correction source. The user may scan up to 256 sensitometry strips and enter the same number of energy values, repeating the process until he presses the "down arrow". The values thus entered are stored in the data tables (HDC1 and HDC2). The gray values as well as the energy/intensity values are averages for the strip scanned.

Data Card Format:

```
HDC1=20,62,125,197,236$
```

```
HDC2=3.6,92,273.7,9.63E2,1.635E04$
```

The first gray value of HDC1 corresponds to the first energy/intensity value of HDC2, etc.
HAND DRAWN SHAPES (HAN)

This operator is employed to create an image file which contains up to five user-input shapes. The user traces the boundary of the shape with the trackball. He is given the option of setting the insides and outsides of the shapes to either a specified gray scale value or to the gray scale value of an existing 360 image.

Both the host computer and terminal minicomputer are required by this operator.

Note:
1. The example HAND DRAWN SHAPES scenario shown above is for the case where the user wishes to define a shape with a specified gray scale value inside and overlay the shape on an existing 360 file.

2. Intermediate output files are generated by the BORDER, AVERAGE, and FEATURE ANALYSIS operators during the course of execution of the HAND DRAWN SHAPES operator.
INSERT SUBFRAME (INS)

This operator inserts a portion of one image (the overlay) into another image (the underlay). The user has the option of specifying where the overlay is to be inserted in the underlay.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

---

**Note:**

1. The user controls the position in the output array of both the underlay and overlay input images.

2. Specifying the **Starting Line**, **Starting Column**, **Number of Lines** and **Number of Columns** allows the user to extract the overlay image from a larger file.

3. The output array may be specified as larger than the input image combination in which case a black or white background is included in the output file.
INVERSE FAST FOURIER TRANSFORM (IFF)

This operator transforms two input files containing the complex components in the frequency domain into an output file in the spatial domain. The input files may be in the form of real and imaginary components or in the form of magnitude and phase components.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>INPUT FILE NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>REAL/IMAGINARY</td>
<td>DC TEPH AT LOCATION 1,1</td>
</tr>
<tr>
<td>REAL/IMAGINARY</td>
<td>DC TEPH CENTERED</td>
</tr>
<tr>
<td>MAGNITUDE/PHASE</td>
<td>DC TEPH CENTERED</td>
</tr>
</tbody>
</table>

Note:
1. The input files must be the same size.
2. The number of rows (and columns) in the input files must be a power of 2.
3. The input files must have at least 64 rows and columns, but not more than 1024 rows and columns.
4. The output file is in floating point format.
INVERT (INV)

This operator reverses the gray scale relationships within an image array. All 0's become 255's; 1's become 254's; 2's become 253's; etc.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. The input file for this operator must be integer.
ISOGRAM (ISO)

This operator produces a graphic plot of the locus of the intersection of gray scale bands specified by the user. In order to reduce the point content of the input data, a low pass filter operation may be performed prior to calculating the isogram.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>144</td>
<td>INPUT FILE NAME</td>
</tr>
<tr>
<td>128</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>128</td>
<td>NUMBER OF COLUMNS</td>
</tr>
<tr>
<td>1</td>
<td>STARTING LINE</td>
</tr>
<tr>
<td>1</td>
<td>STARTING COLUMN</td>
</tr>
<tr>
<td>9</td>
<td>INPUT</td>
</tr>
<tr>
<td>A</td>
<td>- SMOOTH DATA</td>
</tr>
<tr>
<td>B</td>
<td>- DO NOT SMOOTH DATA</td>
</tr>
<tr>
<td>5</td>
<td>NUMBER OF CONTOURS</td>
</tr>
<tr>
<td>65</td>
<td>GRAY VALUE OF FIRST CONTOUR</td>
</tr>
<tr>
<td>75</td>
<td>GRAY VALUE OF SECOND CONTOUR</td>
</tr>
<tr>
<td>85</td>
<td>GRAY VALUE OF THIRD CONTOUR</td>
</tr>
<tr>
<td>95</td>
<td>GRAY VALUE OF FOURTH CONTOUR</td>
</tr>
<tr>
<td>200</td>
<td>GRAY VALUE OF FIFTH CONTOUR</td>
</tr>
</tbody>
</table>
LABEL (LAB)

This operator superimposes alphanumeric labels directly on an image.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. The following character set is available:
   ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789+-(),/=.'*(space)

2. A maximum of 12 lines of label may be specified.
MAGNIFY (MAG)

This operator performs a geometric transformation which expands or reduces the size of an image. Four way linear interpolation is used to provide values from the input array which are not at the exact location of an input pixel.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. After the user specifies the input file and magnification factor, the number of lines and columns in the output is computed and displayed before the magnification is actually executed. This allows the user to adjust his magnification factor to make the output file a specific size.

2. The size of the output is constrained to be less than or equal to 2048 X 2048 samples. An expansion factor which would otherwise, produce a larger output will yield an output of the upper left hand 2048 X 2048 portion of the magnified image.

3. Size reductions are obtained by specifying a magnification factor M where 0 < M < 1.
MATH (MAT)

This operator performs a number of ordinary arithmetic operations on one or two input image arrays.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. The following definitions apply:

   X - First input file specified.
   Y - Second input file specified.
   CN - A user-specified constant.

2. Operations A, B, C, and D result in a displayed request for a second input file and the respective operation is performed between corresponding pixels of the two arrays (X & Y).

3. Operations E, F, G, H, I, and J result in a displayed request for keyboard specification of the constant (CN).

4. Although the input files may be integer or floating point, the output of this operator is always in floating point format.
OVERLAY (OVE)

Several modes are available to produce output files in which the pixels of the primary image are replaced by values controlled by the overlay image. The image is a standard, integer image file. The primary image is a standard, integer image file. The overlay image is either a bilevel map or an image in which a specified Substitution Level acts as a flag to cause pixels in the primary image to be set to a value determined by the mode and the user specified constants.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMAGE FILE NAME</td>
<td>1</td>
<td>STARTING LINE</td>
</tr>
<tr>
<td>STARTING LINE</td>
<td>1</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>NUMBER OF LINES</td>
<td>255</td>
<td>SUBSTITUTION LEVEL</td>
</tr>
<tr>
<td>OVERLAY FILE NAME</td>
<td>1</td>
<td>STARTING LINE</td>
</tr>
<tr>
<td>STARTING LINE</td>
<td>1</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>NUMBER OF LINES</td>
<td>300</td>
<td>NUMBER OF COLUMNS</td>
</tr>
<tr>
<td>NUMBER OF COLUMNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REFERENCE POSITION IN IMAGE FILE</td>
<td>1</td>
<td>REFERENCE LINE</td>
</tr>
<tr>
<td>REFERENCE LINE</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. The Substitution Level specifies a gray value in the overlay image for modes A, B, C, & E and in the primary image for Mode D. Wherever a pixel equals the Substitution Level, the overlay is performed.

2. The user must specify either one or two constant values, depending on the mode. A description of the required constant appears after all of the parameters shown above have been specified.
OVERLAY (Continued)

Note (Continued):

3. The following overlay modes are provided:

A - A constant value is added to the gray value of the primary image wherever the *Substitution Level* is found in the overlay image.

B - A constant is substituted for the primary image pixels wherever the *Substitution Level* is found in the overlay image.

C - Two constants are alternately substituted for the primary image pixels wherever the *Substitution Level* is found in the overlay image.

D - Wherever a *Substitution Level* gray value occurs in the image the corresponding pixel value is substituted from the overlay image.

E - Wherever the *Substitution Level* is found in the overlay image, either of two constants is placed in the primary image, depending on the primary image pixel gray value.
PICTURE DIFFERENCE (DIF)

This operator detects differences in two registered images. The registered images are adjusted for contrast. The standard deviation of the gray values in the difference picture is used as a threshold to eliminate insignificant differences from the output and to account for nonlinearities in contrast.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

Note:
1. A coefficient (n) of the standard deviation (sigma) is used as a threshold. Picture differences which are different from the mean value of all pixel differences by no more than n (sigma coefficient) are excluded from the output. The Sigma Coefficient typically ranges from 0.1 to 5.0.

2. Both input files must be the same size and in integer format.

3. Two secondary output files are available for specific information about the picture difference. Output file 1SEC contains those features that are in the reference image but not in the subtrahend input image. Output file 2SEC contains those features that are in the subtrahend image but not in the reference image.
REGISTER (REG)

This operator performs the necessary translation, rotation, and size adjustment to position one frame in registration with another. The registration is specified by identifying the spatial coordinates of two points in the input image and the coordinates of corresponding points in the output image to which the input pair are to be transformed. The amounts of rotation, magnification and translation required to achieve the specified transformation are computed automatically.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISCA</td>
<td>INPUT FILE NAME</td>
</tr>
<tr>
<td>1.0</td>
<td>INPUT POINT 1 - LINE COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>COLUMN COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>POINT 2 - LINE COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>COLUMN COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>OUTPUT POINT 1 - LINE COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>COLUMN COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>POINT 2 - LINE COORDINATE</td>
</tr>
<tr>
<td>1.0</td>
<td>COLUMN COORDINATE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VALUE</th>
<th>COMPUTED PARAMETERS</th>
<th>VALUE</th>
<th>COMPUTED PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>.00000000 E 0</td>
<td>ANGLE OF ROTATION</td>
<td>.00000000 E 0</td>
<td>COLUMN TRANSLATION</td>
</tr>
<tr>
<td>.00000000 E 0</td>
<td>MAGNIFICATION</td>
<td>1</td>
<td>NO. OF LINES OUTPUT</td>
</tr>
<tr>
<td>.00000000 E 0</td>
<td>LINE TRANSLATION</td>
<td>1</td>
<td>NO. OF COLUMNS OUTPUT</td>
</tr>
</tbody>
</table>

Note:
1. Parameter specification is simplified if one thinks of the input and output points as being the location of two points in the input file before registration and after registration. Only the input file is actually modified by this operator.

2. The size of the input file is automatically adjusted by a border of zeros so that after it is registered the entire image is still visible.

3. After the calculations of rotation, translation, and size adjustment are made, based on the registration point parameters, the calculated results are displayed for visual verification and general user information.
### GEOMETRIC OPERATION - ROTATE (ROT)

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>ISCA</td>
<td>INPUT FILE NAME</td>
</tr>
<tr>
<td>0.0</td>
<td>ANGLE OF ROTATION (DEGREES COUNTERCLOCKWISE)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VALUE</th>
<th>COMPUTED PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NUMBER OF LINES IN OUTPUT</td>
</tr>
<tr>
<td></td>
<td>NUMBER OF COLUMNS IN OUTPUT</td>
</tr>
</tbody>
</table>

**Note:**
1. The angle should be specified in degrees measured positively counterclockwise $\pm 360^\circ$. 
This operator scans image data from film using the film scanner and displays the image on one of the display monitors. The displayed picture consists of 480 lines by 480 columns of image data.

The host computer is not required by this operator.

### INTERACTIVE IDAPS

**IMAGE INPUT/OUTPUT - SCANNER TO DISPLAY (S-D)**

<table>
<thead>
<tr>
<th>PLACE FILM IN SCANNER</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>SCALING FACTOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - FUNCTION OF DENSITY (LOG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B - FUNCTION OF TRANSMIT-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TANCE (LINEAR)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>SCAN POLARITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - NORMAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B - COMPLEMENT</td>
<td>64</td>
<td>UPPERMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LEFTMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>SAMPLING INTERVAL (MICROMETERS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - 17.5 (2048 PTS/LINE MAX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B - 35 (1024 PTS/LINE MAX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - 79 (512 PTS/LINE MAX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D - 140 (256 PTS/LINE MAX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>INTEGRATION TIME (MICROSECONDS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - 20 (20 DB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B - 80 (34 DB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - 320 (40 DB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D - 1280 (46 DB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>FILTER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - NEUTRAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B - RED</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - GREEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D - BLUE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E - MANUAL/CURRENT SETTING</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

1. The **Sampling Interval** parameter determines the number of data values scanned from a unit area of the film and therefore the portion of the total film displayed.

2. The more **Integration Time** that is used in sampling a single spot on the film, the more accurate and noise free will be the sampled data. A trade off must be made between sampling accuracy and total scan time.

3. The portion of the film displayed is determined by the **Scan Address**. The "Quick Look Scan" Special Function is helpful in locating the required **Scan Address**.

4. The **Clipping Limit** parameters allow the user to select the range of film densities between which the gray values will be scaled. An integer value between 0-8 should be specified.
SCANNER TO DISPLAY (PSEUDOCOLOR)

This operator is employed to scan image data from black and white film, assign selected colors to input pixel gray values, and display the output on the color monitor.

The host computer is not required by this operator.

Data Card Format:

```
FBLU=0*132*4196*128*140*192*248*255
PGRN=128*0*32*64*128*140*192*248*255
PRED=64*0*32*64*96*128*140*192*248*255
```

Three tables must be specified: PRED, PGRN, and FBLU. Each table contains 256 integer values which control the red, green and blue components of the colors which are assigned to the 256 possible input gray values. The first value in each data table corresponds to zero gray value in the input.

Note: See Notes for SCANNER TO FILM (PSEUDOCOLOR).
This operator scans image data from film using the film scanner and records the digital image data on photographic film using the image recorder.

The host computer is not required by this operator.

Note:
1. The Sampling Interval parameter determines the number of data values scanned from a unit area of the film and therefore the amount of data that will result from scanning the selected area of the film.

2. The more Integration Time that is used in sampling a single spot on the film, the more accurate and noise free will be the sampled data. A trade off must be made between sampling accuracy and total scan time.

3. The portion of the film that is to be digitized and recorded on film is determined by the Scan Address. The "Quick Look Scan" Special Function is helpful in locating the required Scan Address.

4. The Clipping Limit parameters allow the user to select the range of film densities between which the gray values will be scaled. An integer value between 0-8 should be specified.
Note:
1. The Exposure Characteristic determines the relationship between the input gray values (0-255) and the film exposure.

   Log - relates film exposure to gray value as the $\log_{10}(\text{Gray Value})$.

   Linear - relates film exposure linearly to image data gray values.

2. Recording Resolution determines the area of the film exposed by each input gray value. Since a maximum 57 mm X 57 mm film area may be exposed, this parameter determines the size of the picture produced by a given input array. The maximum array size for each resolution setting which will result in recording of the entire array is as follows:

   Low - 512 X 512
   Medium - 1024 X 1024
   High - 2048 X 2048
SCANNER TO FILM (PSEUDOCOLOR)

This operator is employed to scan image data from black and white film, assign selected colors to input pixel gray values, and record the output on color film.

The host computer is not required by this operator.

Data Card Format: See SCANNER TO DISPLAY (PSEUDOCOLOR)

Note:
1. All PSEUDOCOLOR operators share the same data tables. This means that a color scheme defined by cards or trackball in one operator may be used for other operators by specifying Data Tble for Table Source.

2. When using the trackball for defining a color scheme, a palette of more than 1000 colors is displayed on the color monitor. The user then uses the trackball to point to the colors that he wishes assigned to specific gray levels. By pressing the trackball "enter" the color is stored and the gray value assignment index is incremented by an increment factor (n). The factor n may be modified from the color monitor using the trackball as a pointer.
**INTERACTIVE IDAPS**

**PSEUDOCOLOR - SCANNER TO FILM** *(PAGE 2 OF 2)*

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>RECORDER CHARACTERISTIC</td>
</tr>
<tr>
<td>A</td>
<td>LOG</td>
</tr>
<tr>
<td>B</td>
<td>LINEAR</td>
</tr>
<tr>
<td>B</td>
<td>RECORDER RESOLUTION</td>
</tr>
<tr>
<td>A</td>
<td>LOW</td>
</tr>
<tr>
<td>B</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>C</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

Images are normally recorded in the upper left corner of a 2048x2048 addressable film locations. To specify alternate film positions, enter

*UPPER FILM ADDRESS* 

*LEFT FILM ADDRESS*

Exposure settings on the recorder is a manual process and should be set based on the film type. It may also be desirable to adjust exposure for each color.

<table>
<thead>
<tr>
<th>A</th>
<th>EXPOSURE ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CONSTANT FOR ALL 3 COLORS</td>
</tr>
<tr>
<td>B</td>
<td>VARIABLE</td>
</tr>
</tbody>
</table>
This operator scans image data from film using the film scanner and prints out the gray values of a selected region of the film on the IDAPS printer.

The host computer is not required by this operator.

<table>
<thead>
<tr>
<th>Option</th>
<th>Parameter Description</th>
<th>Option</th>
<th>Parameter Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>SCALING FACTOR</td>
<td>A</td>
<td>FUNCTION OF DENSITY (LOG)</td>
</tr>
<tr>
<td></td>
<td>B - FUNCTION OF TRANSMIT-TANCE (LINEAR)</td>
<td>B</td>
<td>SCANNER CAN ADDRESS ANY POINT IN AN ARRAY OF 2048X2048 ADDRESS LOCATIONS. USING THE TRACKBALL, LOCATE THE UPPER LEFT CORNER OF THE AREA TO BE SCANNED OR ENTER FROM THE KEYBOARD: ***</td>
</tr>
<tr>
<td>A</td>
<td>SCAN POLARITY</td>
<td>A</td>
<td>NORMAL</td>
</tr>
<tr>
<td></td>
<td>B - COMPLEMENT</td>
<td></td>
<td>UPPERMOST SCAN ADDRESS</td>
</tr>
<tr>
<td>C</td>
<td>SAMPLING INTERVAL (MICROMETERS)</td>
<td>A</td>
<td>17.5 (2048 PTS/LINE MAX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>35 (1024 PTS/LINE MAX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>70 (512 PTS/LINE MAX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>140 (256 PTS/LINE MAX)</td>
</tr>
<tr>
<td>B</td>
<td>INTEGRATION TIME (MICROSECONDS)</td>
<td>A</td>
<td>20 (28 DB S/N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>50 (34 DB S/N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>320 (49 DB S/N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>1280 (46 DB S/N)</td>
</tr>
<tr>
<td>A</td>
<td>FILTER</td>
<td>A</td>
<td>NEUTRAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>RED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>GREEN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>BLUE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
<td>MANUAL/CURRENT SETTING</td>
</tr>
</tbody>
</table>

Note:
1. The Sampling Interval parameter determines the number of data values scanned from a unit area of the film and therefore the amount of data that will result from scanning the selected area of the film.

2. The more Integration Time that is used in sampling a single spot on the film, the more accurate and noise free will be the sampled data. A trade off must be made between sampling accuracy and total scan time.

3. The portion of the film that is to be digitized and printed is determined by the Scan Address. The "Quick Look Scan" Special Function is helpful in locating the required Scan Address.

4. The Clipping Limit parameters allow the user to select the range of film densities between which the gray values will be scaled. An integer value between 0-8 should be specified.

5. A maximum of 96 lines and 32 columns may be printed with each application of this operator.
SCANNER TO SYSTEM (SCA)

This operator scans image data from film using the film scanner and sends it to the host computer where it is established as an IDAPS user file.

Both the host computer and terminal minicomputer are required by this operator.

### IMAGE INPUT/OUTPUT - SCANNER TO SYSTEM (SCA)

**PLACE FILM IN SCANNER**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>SCALING FACTOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A - FUNCTION OF DENSITY (LOG)</td>
<td></td>
<td>THE SCANNER CAN ADDRESS ANY POINT</td>
</tr>
<tr>
<td></td>
<td>B - FUNCTION OF TRANSMIT-</td>
<td></td>
<td>IN AN ARRAY OF 2048X2048 ADDRESS</td>
</tr>
<tr>
<td></td>
<td>TANCE (LINEAR)</td>
<td></td>
<td>LOCATIONS. USING THE TRACKBALL,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LOCATE THE UPPER LEFT CORNER</td>
</tr>
<tr>
<td>A</td>
<td>SCAN POLARITY</td>
<td></td>
<td>OF THE AREA TO BE SCANNED OR ENTER</td>
</tr>
<tr>
<td></td>
<td>A - NORMAL</td>
<td></td>
<td>FROM THE KEYBOARD: **</td>
</tr>
<tr>
<td></td>
<td>B - COMPLEMENT</td>
<td></td>
<td>UPPERMOST SCAN ADDRESS</td>
</tr>
<tr>
<td>C</td>
<td>SAMPLING INTERVAL (MICROMETERS)</td>
<td></td>
<td>LEFTMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>A - 17.5 (2848 PTS/LINE MAX)</td>
<td></td>
<td>LOCATE THE LOWER RIGHT CORNER OR</td>
</tr>
<tr>
<td></td>
<td>B - 35 (1624 PTS/LINE MAX)</td>
<td></td>
<td>ENTER FROM THE KEYBOARD: **</td>
</tr>
<tr>
<td></td>
<td>C - 79 (512 PTS/LINE MAX)</td>
<td></td>
<td>2047 LOWERMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>D - 140 (256 PTS/LINE MAX)</td>
<td></td>
<td>2047 RIGHTMOST SCAN ADDRESS</td>
</tr>
<tr>
<td>B</td>
<td>INTEGRATION TIME (MICROSECONDS)</td>
<td></td>
<td>ILLUMINATION LEVEL</td>
</tr>
<tr>
<td></td>
<td>A - 26 (28 DB S/N)</td>
<td>B</td>
<td>LOWER CLIPPING LIMIT</td>
</tr>
<tr>
<td></td>
<td>B - 96 (34 DB S/N)</td>
<td>C</td>
<td>UPPER CLIPPING LIMIT</td>
</tr>
<tr>
<td></td>
<td>C - 320 (40 DB S/N)</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D - 1280 (46 DB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>FILTER</td>
<td></td>
<td>** NOTE: TRACKBALL INPUT OF</td>
</tr>
<tr>
<td></td>
<td>A - NEUTRAL</td>
<td></td>
<td>THESE VALUES IS BASED ON</td>
</tr>
<tr>
<td></td>
<td>B - RED</td>
<td></td>
<td>QUICK-LOOK SCAN.</td>
</tr>
<tr>
<td></td>
<td>C - GREEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D - BLUE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E - MANUAL/CURRENT SETTING</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. The **Sampling Interval** parameter determines the number of data values scanned from a unit area of the film and therefore the amount of data that will result from scanning the selected area of the film.

2. The more **Integration Time** that is used in sampling a single spot on the film, the more accurate and noise free will be the sampled data. A trade off must be made between sampling accuracy and total scan time.

3. The portion of the film that is to be digitized and established as an IDAPS user file in the host computer is determined by the **Scan Address**. The "Quick Look Scan" Special Function is helpful in locating the required Scan Address.

4. The **Clipping Limit** parameters allow the user to select the range of film densities between which the gray values will be scaled. An integer value between 0-8 should be specified.
SCANNER TO TAPE (S-T)

This operator scans image data from film using the film scanner and stores the digital image data on magnetic tape on one of the user console magnetic tape units.

The host computer is not required by this operator.

<table>
<thead>
<tr>
<th>INTERACTIVE IDAPS</th>
<th>TIME: 11:08:45</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMAGE INPUT/OUTPUT - SCANNER TO TAPE (S-T)</td>
<td>ELAPSED: 03H, 02MIN</td>
</tr>
<tr>
<td>PLACE FILM IN SCANNER AND BLANK TAPE ON DRIVE</td>
<td>PAGE 1 OF 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>SCALING FACTOR</td>
<td>B</td>
<td>THE SCANNER CAN ADDRESS ANY POINT</td>
</tr>
<tr>
<td></td>
<td>A - FUNCTION OF DENSITY (LOG)</td>
<td></td>
<td>IN AN ARRAY OF 2048x2048 ADDRESS</td>
</tr>
<tr>
<td></td>
<td>B - FUNCTION OF TRANSMISSION (LINEAR)</td>
<td></td>
<td>LOCATIONS. USING THE TRACKBALL,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LOCATE THE UPPER LEFT CORNER OF</td>
</tr>
<tr>
<td></td>
<td>A - NORMAL</td>
<td></td>
<td>THE AREA TO BE SCANNED OR ENTER</td>
</tr>
<tr>
<td></td>
<td>B - COMPLEMENT</td>
<td></td>
<td>FROM THE KEYBOARD: **</td>
</tr>
<tr>
<td></td>
<td>SCAN POLARITY</td>
<td></td>
<td>UPPERMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>A - NORMAL</td>
<td></td>
<td>LEFTMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>B - COMPLEMENT</td>
<td></td>
<td>LOCATE THE LOWER RIGHT CORNER OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ENTER FROM THE KEYBOARD: **</td>
</tr>
<tr>
<td></td>
<td>SAMPLING INTERVAL (MICROMETERS)</td>
<td></td>
<td>LOWERMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>A - 17.5 (2048 PTS/LINE MAX)</td>
<td></td>
<td>2647 LEFTMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>B - 35 (1924 PTS/LINE MAX)</td>
<td></td>
<td>2647 RIGHTMOST SCAN ADDRESS</td>
</tr>
<tr>
<td></td>
<td>C - 70 (512 PTS/LINE MAX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D - 140 (256 PTS/LINE MAX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>INTEGRATION TIME (MICROSECONDS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A - 29 (28 dB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B - 89 (34 dB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C - 329 (40 dB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D - 1280 (46 dB S/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>FILTER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A - NEUTRAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B - RED</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C - GREEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D - BLUE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E - MANUAL/CURRENT SETTING</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. The **Sampling Interval** parameter determines the number of data values scanned from a unit area of the film and therefore the amount of data that will result from scanning the selected area of the film.

2. The more **Integration Time** that is used in sampling a single spot on the film, the more accurate and noise free will be the sampled data. A trade off must be made between sampling accuracy and total scan time.

3. The portion of the film that is to be digitized and stored on tape is determined by the **Scan Address**. The "Quick Look Scan" Special Function is helpful in locating the required **Scan Address**.

4. The **Clipping Limit** parameters allow the user to select the range of film densities between which the gray values will be scaled. An integer value between 0-8 should be specified.
SCANNER TO TAPE (Continued)

Note (Continued):

5. Tape drive No. 1 is the left hand drive of the two IDAPS user terminal tape drives.
STONYHURST GRID (STO)

This operator generates a spherical-coordinate reference grid for use as an overlay to S-056 images. Such overlays are useful in locating points and determining distances.

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>SIZE OF GRID</td>
</tr>
<tr>
<td>0.0</td>
<td>LONGITUDE CLOSEST TO OBSERVER (DEGREES)</td>
</tr>
<tr>
<td>10.0</td>
<td>LONGITUDE GRID SPACING (DEGREES)</td>
</tr>
<tr>
<td>0.0</td>
<td>LATITUDE CLOSEST TO OBSERVER (DEGREES)</td>
</tr>
<tr>
<td>10.0</td>
<td>LATITUDE GRID SPACING (DEGREES)</td>
</tr>
<tr>
<td>0.0</td>
<td>ROTATION OF SPIN AXIS WITH RESPECT TO IMAGE (DEGREES)</td>
</tr>
</tbody>
</table>

Note:
1. The Stonyhurst Grid generated by this operator is composed of white (255's) lines on a black (0's) background.

2. An entire spherical map is produced. If a Stonyhurst overlay is desired for a smaller array, the user should use the EXTRACT operator.

3. If a Stonyhurst is to be overlayed on a full solar disk, it should be inserted into a black background using INSERT to make the total size equal to the image on which it is to be overlayed.

4. In normal operation, the user should limit Latitude Closest to Observer to $\pm$ 7 degrees.
SYSTEM TO DISPLAY (DIS)

This operator takes image data stored on the host computer disk and displays the image on one of the IDAPS display monitors.

Both the host and user terminal computers are required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FILE NAME</td>
</tr>
<tr>
<td>1</td>
<td>STARTING LINE</td>
</tr>
<tr>
<td>1</td>
<td>STARTING COLUMN</td>
</tr>
<tr>
<td>480</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>480</td>
<td>NUMBER OF COLUMNS</td>
</tr>
<tr>
<td>1</td>
<td>DISPLAY MONITOR (1, 2, R, G OR B)</td>
</tr>
<tr>
<td>0</td>
<td>IMAGE SIZE ADJUSTMENT FACTOR</td>
</tr>
<tr>
<td>0</td>
<td>AUTOMATIC SIZE ADJUSTMENT TO FIT DISPLAY SCREEN</td>
</tr>
<tr>
<td>1</td>
<td>NO SIZE ADJUSTMENT</td>
</tr>
<tr>
<td>N</td>
<td>REDUCTION FACTOR</td>
</tr>
</tbody>
</table>

Note:
1. A digital image of up to 480 lines and 480 columns may be displayed. If the system image file is larger than this, the user may select a subset for display with no reduction of the image array or he may select the Size Adjustment feature to reduce the image so that it will fit on the display monitor. Automatic size adjustment may be selected which will automatically reduce the image file by an integer factor sufficient to allow it to be displayed on one of the display monitors.
SYSTEM TO DISPLAY (PSEUDOCOLOR)

This operator is employed to pseudocolor an image file stored on the host computer disk, or displayed on one of the B/W monitors. Selected colors are assigned to input pixel gray values and displayed on the color monitor.

Both the host computer and the terminal minicomputer are required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TABLE SOURCE</td>
</tr>
<tr>
<td>A</td>
<td>DATA TBLS(PRED,PGN,PBLU)</td>
</tr>
<tr>
<td>B</td>
<td>TRACK BALL</td>
</tr>
<tr>
<td>C</td>
<td>CARDS</td>
</tr>
<tr>
<td>FILE NAME OR MONITOR KEY</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>STARTING LINE</td>
</tr>
<tr>
<td>1</td>
<td>STARTING COLUMN</td>
</tr>
<tr>
<td>2</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>2</td>
<td>NUMBER OF COLUMNS</td>
</tr>
<tr>
<td>2</td>
<td>SIZE ADJUSTMENT FACTOR</td>
</tr>
<tr>
<td>0</td>
<td>AUTOMATIC SIZE ADJUSTMENT</td>
</tr>
<tr>
<td>1</td>
<td>NO SIZE ADJUSTMENT</td>
</tr>
<tr>
<td>2-N</td>
<td>REDUCTION FACTOR</td>
</tr>
</tbody>
</table>

Data Table Format: See SCANNER TO DISPLAY (PSEUDOCOLOR)

Note:
1. All PSEUDOCOLOR operators share the same data tables. This means that a color scheme defined by cards or trackball in one operator may be used for other operators by specifying Data Tbls for Table Source.

2. When using the trackball for defining a color scheme, a palette of more than 1000 colors is displayed on the color monitor. The user then uses the trackball to point to the colors that he wishes assigned to specific gray levels. By pressing the trackball "enter" the color is stored and the gray value assignment index is incremented by an increment factor (n). The factor n may be modified from the color monitor using the trackball as a pointer.

3. A system file name may be specified as the input source or a picture displayed on B/W monitor No. 1 or No. 2 may be specified.
SYSTEM TO FILM (FIL)

This operator takes image data stored on the host computer disk and records it on film using the image recorder.

Both the host and user terminal computers are required by this operator.

### Note:
1. The Exposure Characteristic determines the relationship between the input gray values (0-255) and the film exposure.

   - **Log** - relates film exposure to gray value as the \( \log_{10} \) (Gray Value).
   - **Linear** - relates film exposure linearly to image data gray values.

2. Recording Resolution determines the area of the film exposed by each input gray value. Since a maximum 57 mm X 57 mm film area may be exposed, this parameter determines the size of the picture produced by a given input array. The maximum array size for each resolution setting which will result in recording of the entire array is as follows:

   - **Low** - 512 X 512
   - **Medium** - 1024 X 1024
   - **High** - 2048 X 2048
SYSTEM TO FILM (PSEUDOCOLOR)

This operator is employed to pseudocolor an image file stored on the host computer disk or displayed on one of the B/W monitors. Selected colors are assigned to input pixel gray values and recorded on color film.

Both the host computer and the terminal minicomputer are required by this operator.

Data Card Format: See SCANNER TO DISPLAY (PSEUDOCOLOR)

Note:
1. All PSEUDOCOLOR operators share the same data tables. This means that a color scheme defined by cards or trackball in one operator may be used for other operators by specifying Data Tables for Table Source.

2. When using the trackball for defining a color scheme, a palette of more than 1000 colors is displayed on the color monitor. The user then uses the trackball to point to the colors that he wishes assigned to specific gray levels. By pressing the trackball "enter" the color is stored and the gray value assignment index is incremented by an increment factor (n). The factor n may be modified from the color monitor using the trackball as a pointer.

3. A system file name may be specified as the input source or a picture displayed on B/W monitor No. 1 or No. 2 may be specified.
SYSTEM TO PRINTER (PRI)

This operator takes a selected region of digital image data stored on the host computer disk and prints out the gray values on the IDAPS line printer. Both the host and user terminal computers are required by this operator.

Note:
1. A maximum of 96 lines and 32 columns may be printed with each application of this operator.
SYSTEM TO TAPE (OUT)

This operator takes image data stored on the host computer disk and records it on magnetic tape.

Both the host and user terminal computers are required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1SCA</td>
<td>FILE NAME</td>
</tr>
<tr>
<td>1</td>
<td>STARTING LINE</td>
</tr>
<tr>
<td>2</td>
<td>STARTING COLUMN</td>
</tr>
<tr>
<td>460</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>480</td>
<td>NUMBER OF COLUMNS</td>
</tr>
<tr>
<td>2</td>
<td>TAPE DRIVE NUMBER (1 OR 2)</td>
</tr>
<tr>
<td>6</td>
<td>OUTPUT FILE NUMBER</td>
</tr>
</tbody>
</table>

NOTE: A 'G' ENTRY WILL RESULT IN THE IMAGE BEING WRITTEN AS THE NEXT FILE. ANY OTHER INTEGER ENTRY WILL CAUSE THE TAPE TO BE REWOUND AND N-1 FILES SKIPPED TO POSITION THE TAPE.
TABLE MODIFICATION (DTE)

This operator serves two purposes. First, it allows a user to review the contents of a specific data table for an operator. Second, it allows the user to modify individual values, whole sections of the table, and complete tables through keyboard, trackball and tape entry.
Both integer and real tables may be displayed in tabular format (as shown above) and, if desired, in graphic display (see below). Integer tables are scaled between 0 and 255. Real tables are scaled between the maximum and minimum values found in the table, with one exception: the tables used for the Function Generation operator (FGN1 and FGN2) are automatically scaled between 0 and 1.

When the keyboard is chosen as the desired method of modification, any changes may be made by using the regular edit keys (EDIT UP, EDIT DOWN, EDIT RIGHT, EDIT LEFT, EDIT PAGE UP, EDIT PAGE DOWN, and ENTER), as described in the main instruction display for TABLE MODIFICATION.
INTERACTIVE MODIFICATION OF DATA TABLES MAY BE ACCOMPLISHED THROUGH USE OF THE EDIT KEYS. POSITION CURSOR TO DESIRED ENTRY USING EDIT RIGHT, EDIT LEFT, EDIT DOWN AND EDIT UP KEYS. CHANGE ENTRY TO DESIRED VALUE AND REPOSITION CURSOR. WHEN LAST ENTRY HAS BEEN MODIFIED, PRESS EDIT ENTER.

<table>
<thead>
<tr>
<th>OPERATOR</th>
<th>TABLE NAME(S)</th>
<th>NUMBER OF ENTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSEUDOCOLOR (ALL)</td>
<td>PRED, PGRO, PBLU</td>
<td>256, 256</td>
</tr>
<tr>
<td>ALTER</td>
<td>ALT</td>
<td>256, 256</td>
</tr>
<tr>
<td>H AND D CORRECTION</td>
<td>HDCI, HDC2</td>
<td>2, 256</td>
</tr>
<tr>
<td>CONVOLUTIONAL FILTER</td>
<td>CON</td>
<td>2, 256</td>
</tr>
<tr>
<td>DEPENDENT ALTER</td>
<td>DEPA, DEPB</td>
<td>101, 191</td>
</tr>
<tr>
<td>FILTER GENERATION</td>
<td>FGN1, FGN2</td>
<td>251, 251</td>
</tr>
<tr>
<td>USER GEN. OPERATOR</td>
<td>USE1, USE2</td>
<td>1, 256</td>
</tr>
</tbody>
</table>

When the keyboard and trackball modification mode is chosen, a monitor must be selected for graphics display of the desired table. The display does not alter the image data which is stored on the display file and may be re-displayed with the RESTORE special function.

The user may step through the values in the table with the regular EDIT keys, modifying them by using the keyboard as described above.

If a section of the table is to be modified, rather than entering each new value individually from the keyboard, the user may choose to enter only selected points and have the system interpolate them to produce a smoothed curve. To do this, he must first position the keyboard cursor to the value he wishes to use as his lower bounds and hit the key labeled "INTERPOLATE
BOUND". Then, following the displayed instructions, he must similarly indicate the upper bounds. Interior points may be entered either by 1) positioning the cursor and changing the value by keyboard and then hitting the key labeled "ENTER INTERPOLATE POINT", or 2) with the trackball, positioning the trackball cursor to the relative graphic location and hitting the trackball ENTER key. When all points to be interpolated have been input, the user must hit the edit key marked "ENTER" to begin the interpolation procedure. The new values resulting from the interpolation are stored as the current data table values and may be examined by the Table Modification operator.

Copies of whole data tables may be saved on tape or restored from tape. A table is saved by writing it to the indicated tape drive in consecutive 80 character card images. No file marks are used to separate multiple tables on the tape. To restore a table from tape, the first card image of each stored table is read and the table name is checked against the requested name. When a match is found, the table is read in and permanently stored as the current version of the table. No rewinds are made.

Note:
1. Each IDAPS operator which requires data table input will contain default values supplied by the system until modified by the user through either keyboard, card, or trackball input. Once the user inputs data values by such means, the data tables will retain those values throughout the Interactive IDAPS session until further modified by the user. When a new user logs in, the default values may be restored to all tables.

2. The interpolation scheme used is the SPLINE interpolation method. The SPLINE curve fitting technique is designed for use with data which has no discontinuities. The algorithm forces the function which is fitted to the input points to be continuous and to have continuous first and second derivatives. Approximate values of the first and second derivatives at each of the input points are calculated. These values and a weighting factor are adjusted after each iteration until the sum of the weighting factors is within a specified limit. At this point these parameters define a continuous function and interpolation using these parameters gives the value of the curve at each point in the table.

3. A maximum of 32 points, including both boundaries, may be entered for interpolation.
4. The boundary point values may be changed only if they are the first and last physical values in the table. This is allowed in order to permit complete regeneration of a table by a single interpolation procedure.

5. The modified values are not stored permanently until the "ENTER" key has been hit.

6. Both linear and non-linear interpolation may occur, but the two modes may not be mixed. In order to effect a linear interpolation between two points, the first point must be the lower bounds, the second point must be the upper bounds, and there should be no interior points.

7. Interpolation results for integer tables which fall beyond the limits 0 and 255 are forced to those limits.
TAPE TO DISPLAY (T-D)

This operator transfers digital image data stored on magnetic tape to one of the IDAPS digital television monitors for display.

The host computer is not required by this operator.

Note:
1. The Starting Record and Pixel determine the upper left corner of the digital image stored on tape that will be displayed.

2. A digital image of up to 480 lines and 480 columns may be displayed. If the image stored on tape is larger than this, only a 480 X 480 subset will be displayed unless the image size is adjusted. If specified, the Automatic Size Adjustment will reduce the image by an integer factor to allow the image to be displayed on one of the display monitors.
TAPE TO DISPLAY (PSEUDOCOLOR)

This operator is employed to read image data from tape, assign selected colors to input pixel gray values, and display the output on the color monitor.

The host computer is not required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TABLE SOURCE</td>
</tr>
<tr>
<td></td>
<td>A - SYSTEM DEFAULT</td>
</tr>
<tr>
<td></td>
<td>B - TRACK BALL</td>
</tr>
<tr>
<td></td>
<td>C - CARDS</td>
</tr>
<tr>
<td>1</td>
<td>INPUT TAPE DRIVE NUMBER (1 or 2)</td>
</tr>
<tr>
<td>9</td>
<td>FILE NUMBER</td>
</tr>
<tr>
<td>1</td>
<td>STARTING RECORD WITHIN FILE</td>
</tr>
<tr>
<td>1</td>
<td>STARTING PIXEL WITHIN RECORD</td>
</tr>
<tr>
<td>1</td>
<td>SIZE ADJUSTMENT FACTOR</td>
</tr>
<tr>
<td></td>
<td>0 - AUTOMATIC SIZE ADJUSTMENT</td>
</tr>
<tr>
<td></td>
<td>1 - NO SIZE ADJUSTMENT</td>
</tr>
<tr>
<td></td>
<td>2-N - REDUCTION FACTOR</td>
</tr>
</tbody>
</table>

Data Card Format: See SCANNER TO DISPLAY (PSEUDOCOLOR)

Note:
1. All PSEUDOCOLOR operators share the same data tables. This means that a color scheme defined by cards or trackball in one operator may be used for other operators by specifying Data Tbls for Table Source.

2. When using the trackball for defining a color scheme, a palette of more than 1000 colors is displayed on the color monitor. The user then uses the trackball to point to the colors that he wishes assigned to specific gray levels. By pressing the trackball "enter" the color is stored and the gray value assignment index is incremented by and increment factor (n). The factor n may be modified from the color monitor using the trackball as a pointer.
TAPE TO FILM (T-F)

This operator takes selected regions of image data stored on magnetic tape and records the image on photographic film using the on-line image recorder. The host computer is not required by this operator.

### Interactive IDAPS

#### Image Input/Output - Tape to Film

<table>
<thead>
<tr>
<th>PLACE FILM IN RECORDER AND VERIFY</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECORDER POWER ON</td>
<td>1</td>
<td>INPUT TAPE DRIVE NUMBER (1 OR 2)</td>
<td>B</td>
<td>RECORDING RESOLUTION</td>
</tr>
<tr>
<td>RECORDER IN OPERATE MODE</td>
<td></td>
<td></td>
<td></td>
<td>A - LOW</td>
</tr>
<tr>
<td>PROPER EXPOSURE CONTROL</td>
<td></td>
<td></td>
<td></td>
<td>B - MEDIUM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - HIGH</td>
</tr>
</tbody>
</table>

| FILE POSITION | 0 | NEXT FILE ON TAPE |
| 1 | FILE NUMBER |

| STARTING RECORD WITHIN FILE | 1 |
| STARTING PIXEL WITHIN RECORD |

| RECORDER FILTER | A | NEUTRAL DENSITY |
| E | RED |
| C | GREEN |
| D | BLUE |
| | MANUAL/CURRENT SETTING |

| EXPOSURE CHARACTERISTIC | A | LOG |
| B | LINEAR |

| RECORDING POLARITY | A | NORMAL |
| B | COMPLEMENTED |

| UPPER FILM ADDRESS | 9 |
| LEFT FILM ADDRESS |

Note:
1. The Exposure Characteristic determines the relationship between the input gray values (0-255) and the film exposure.

   - Log - relates film exposure to gray value as the $\log_{10}(\text{Gray Value})$.
   - Linear - relates film exposure linearly to image data gray values.

2. Recording Resolution determines the area of the film exposed by each input gray value. Since a maximum 57 mm x 57 mm film area may be exposed, this parameter determines the size of the picture produced by a given input array. The maximum array size for each resolution setting which will result in recording of the entire array is as follows:

   - Low - 512 X 512
   - Medium - 1024 X 1024
   - High - 2048 X 2048
TAPE TO FILM (PSEUDOCOLOR)

This operator is employed to read image data from tape, assign selected colors to input pixel gray values, and record the output on color film.

The host computer is not required by this operator.

### Interactive IDAPS

**TIME:** 16:14:15
**ELAPSED:** 3:06:15

**TAPE TO FILM (PSEUDOCOLOR)**

**OPTION** | **PARAMETER DESCRIPTION** | **OPTION** | **PARAMETER DESCRIPTION**
--- | --- | --- | ---
A | TABLE SOURCE | G | IMAGES ARE NORMALLY RECORDED IN THE UPPER LEFT CORNER OF 2048X2048 ADDRESSABLE FILM LOCATIONS. TO SPECIFY AN ALTERNATE FILM POSITION, ENTER UPPERS rapid ADDRESS.
A | DATA TBL(PRED, PGREEN, PBLUE) | G | LOWER FILM ADDRESS.
B | TRACKBALL | G | EXPOSURE SETTING ON THE RECORDER IS A MANUAL PROCESS AND SHOULD BE SET BASED ON THE FILM TYPE. IT MAY ALSO BE DESIRABLE TO ADJUST EXPOSURE FOR EACH COLOR.
C | CARDS | | EXPOSURE ADJUSTMENT A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
1 | TAPE DRIVE NUMBER (1 OR 2) | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
1 | FILE NUMBER | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
1 | STARTING RECORD WITHIN FILE | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
1 | STARTING PIXEL WITHIN RECORD | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
2048 | NUMBER OF RECORDS | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
2048 | NUMBER OF PIXELS | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
A | EXPOSURE CHARACTERISTIC | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
A | LOG | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
B | LINEAR | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
B | RESOLUTION | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
A | LOW | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
B | MEDIUM | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE
C | HIGH | | A - CONSTANT FOR ALL 3 COLORS B - VARIABLE

Data Card Format: See SCANNER TO DISPLAY (PSEUDOCOLOR)

**Note:**

1. All PSEUDOCOLOR operators share the same data tables. This means that a color scheme defined by cards or trackball in one operator may be used for other operators by specifying Data Tbls for Table Source.

2. When using the trackball for defining a color scheme, a palette of more than 1000 colors is displayed on the color monitor. The user then uses the trackball to point to the colors that he wishes assigned to specific gray levels. By pressing the trackball "enter" the color is stored and the gray value assignment index is incremented by an increment factor (n). The factor n may be modified from the color monitor using the trackball as a pointer.
TAPE TO PRINTER (T-P)

This operator takes a selected region of digital image data stored on magnetic tape and prints out the gray values on the IDAPS line printer.

The host computer is not required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>INPUT TAPE DRIVE NUMBER (1 OR 2)</td>
</tr>
<tr>
<td>G</td>
<td>FILE POSITION</td>
</tr>
<tr>
<td></td>
<td>G- - NEXT FILE ON TAPE</td>
</tr>
<tr>
<td></td>
<td>I-N - FILE NUMBER</td>
</tr>
<tr>
<td>S</td>
<td>STARTING RECORD WITHIN FILE</td>
</tr>
<tr>
<td>I</td>
<td>STARTING PIXEL WITHIN RECORD</td>
</tr>
<tr>
<td>32</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>32</td>
<td>NUMBER OF COLUMNS</td>
</tr>
</tbody>
</table>

Note:
1. A maximum of 96 lines and 32 columns may be printed with each application of this operator.
TAPE TO SYSTEM (INP)

This operator transfers digital image data from magnetic tape to the host computer where it is stored on disk and established as a system file.

Both the host and terminal minicomputer computers are required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INPUT TAPE DRIVE NUMBER (1 OR 2)</td>
</tr>
<tr>
<td>0</td>
<td>FILE POSITION</td>
</tr>
<tr>
<td>0</td>
<td>- NEXT FILE ON TAPE</td>
</tr>
<tr>
<td>1</td>
<td>I-N - FILE NUMBER</td>
</tr>
<tr>
<td>1</td>
<td>STARTING RECORD WITHIN FILE</td>
</tr>
<tr>
<td>2048</td>
<td>STARTING PIXEL WITHIN RECORD</td>
</tr>
<tr>
<td>2048</td>
<td>NUMBER OF LINES</td>
</tr>
<tr>
<td>2048</td>
<td>NUMBER OF COLUMNS</td>
</tr>
</tbody>
</table>

Note:
1. If the Number of Lines and/or Number of Columns specified is greater than are actually stored on the tape, the operator will only transmit the data stored on the tape and the file that is established will be adjusted correspondingly.
TAPE TO TAPE (T-T)

This operator transfers digital image data from one magnetic tape to another. The operation may be used to reduce the number of reels needed to store several image files or to extract one file from several previously stored on a single tape.

The host computer is not required by this operator.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INPUT TAPE DRIVE NUMBER (1 OR 2)</td>
</tr>
<tr>
<td>0</td>
<td>INPUT FILE POSITION</td>
</tr>
<tr>
<td>0</td>
<td>NEXT FILE ON TAPE</td>
</tr>
<tr>
<td>1</td>
<td>STARTING RECORD WITHIN FILE</td>
</tr>
<tr>
<td>1</td>
<td>STARTING PIXEL WITHIN RECORD</td>
</tr>
<tr>
<td>0</td>
<td>OUTPUT FILE NUMBER</td>
</tr>
</tbody>
</table>

NOTE: A '0' ENTRY WILL RESULT IN THE IMAGE BEING WRITTEN AS THE NEXT FILE. ANY OTHER INTEGER ENTRY WILL CAUSE THE TAPE TO BE REWOUND AND N-1 FILES SKIPPED TO POSITION THE TAPE.
TRANSPOSE (TRA)

This operator performs a number of useful axial transpositions on an input image array (plus angles are clockwise rotation).

Both the host computer and terminal minicomputer are required by this operator until the operator goes into execution, then only the host computer is required.

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISCA</td>
<td>INPUT FILE NAME</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>STARTING LINE.</td>
</tr>
<tr>
<td>480</td>
<td>480</td>
<td>NUMBER OF LINES.</td>
</tr>
<tr>
<td>480</td>
<td>480</td>
<td>NUMBER OF COLUMNS.</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
<td>TRANSPOSITION OPTION</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>- ROTATE ABOUT MAJOR AXIS</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>- ROTATE -90 DEGREES</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>- ROTATE ABOUT MINOR AXIS</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>- ROTATE ABOUT VERTICAL AXIS</td>
</tr>
<tr>
<td>�</td>
<td>F</td>
<td>- ROTATE ABOUT HORIZONTAL AXIS</td>
</tr>
<tr>
<td>�</td>
<td>G</td>
<td>- ROTATE 180 DEGREES</td>
</tr>
</tbody>
</table>

Note:
1. The results of transposing the letter J illustrates the various options.

A =  (major axis)   E =  (vertical axis)
B =  (+ 90 degrees)  F =  (horizontal axis)
C =  (-90 degrees)   G =  (180 degrees)
D =  (minor axis)