UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Office of Earthquake Studies
345 Middlefield Road
Menlo Park, California 94025

Operator's Manual for a Four-Film, Computer-Based, Sonic Digitizing Table to Locate Earthquakes

By

Mary C. Astrue, Jack R. Pelton, W. H. K. Lee, and Robert A. Page

Open-File Report 83-319

1983

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FOUR-FILM DIGITIZER MANUAL

A. INTRODUCTION

The purpose of this report is to describe and illustrate the step-by-step operation of a four-film, computer-based sonic digitizing table. A very brief summary of the principles behind the system is included here. This report is divided into five sections: General Description and Principles of Operation, System Controls, Operation Procedures, Maintenance Procedures, and Problems.

The four-film, computer-based sonic digitizing table is a data processing system designed for the routine interactive location of earthquakes recorded on as many as four 16-mm Develocorder films. The operator uses it to convert analog seismic wave information into digital form, which is then processed by a computer. This system allows the operator in one sitting to digitize all relevant P- and S-wave arrivals and magnitude-related parameters and to obtain a preliminary location of the earthquake. Projecting four films simultaneously increases the processing efficiency by allowing the processor to: 1) see on the films the overall pattern of seismic wave arrivals across an entire network of stations, and 2) check for and immediately correct major errors in picking arrivals.

B. GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION

1. INTRODUCTION

The digitizing system consists of four major units:

(a) an optical projection-film transport unit that advances and projects portions of up to four 16-mm develocorder films

(b) a sonic digitizing unit activated by a hand-controlled cursor that allows the operator to time seismic phases and to measure waveform amplitude and period, and signal duration

(c) a microcomputer that controls the bookkeeping and processing tasks, reduces the digitized data, computes a preliminary hypocenter location, and provides an interface with a larger computer for final processing

(d) a video screen that displays the current step in any given processing sequence, and a printer, which may be used at the operator's discretion.

Communication with the microcomputer is accomplished via a keyboard mounted on an adjustable sliding arm approximately 20 to 25 cm above the digitizing table. Figure 1 is a schematic diagram of the system.

The system processes one earthquake at a time, and the software provides options which allow the operator to selectively remeasure most of the digitized data. The objective is to eliminate obvious errors in the digitized data and to arrive at a satisfactory preliminary location which may be transmitted along with its list of phase times to a larger computer where final processing is accomplished. Until recently, this larger computer has been an IBM machine housed at the Stanford Linear Accelerator Center (SLAC). Currently, the final processing is accomplished on a USGS computer, a Vax 11/780.

2. OPTICAL PROJECTION-FILM TRANSPORT UNIT

The optical projection-film transport unit is a modified Vanguard Instrument Corporation Model H scanning table which was initially developed to satisfy the needs of the high energy physics community--specifically, to search for and project with high precision three 35-mm stereo views of particle tracks in a bubble chamber. The original Model H optical system allows any combination of three 35-mm film images of an event to be reflected off a rigidly supported overhead mirror onto a horizontal table to provide three separate views of the event.

Optics and Mechanics. Optical qualities are excellent: with a film to table magnification factor of 18, the local image resolution on the table is 0.02-0.04 mm (corresponding to 1-2 microns on the film), and total distortion of the image over a 1-meter section displayed on the table is less than 0.1 mm. The original Model H film transport system consists of a supply reel and take-up reel mounted on each of three independent pairs of motorized capstans with the three 35-mm films passing between the reels and beneath three apertures. While a film is in motion, air pressure can be used to lift it clear of the glass aperture bottom. When the film stops, it is held stationary and in contact with the glass aperture bottom by means of a solenoid clamp above the film and vacuum grooves below it. To facilitate coordination of the three film images, the original Model H film transport system was made quite versatile. In the variable low speed mode, the capstans merely maintain tension on the film which is driven by means of rubber drive rollers at a speed selected by the operator (0.01 m/min to 10 m/min, continuously variable). The high speed mode disengages the rubber drive and drops the torque on either the supply or take-up side, creating an imbalance which moves the film at roughly 50 m/min, allowing a 30-meter roll of film to be rewound in less than a minute. The variable low or high speed mode in either the forward or reverse direction can be applied to any combination of the three film transports.

Modifications. Several modifications to the original Model H optical and film transport systems were necessary to adapt them for viewing the four 16-mm Develocorder films generated daily by the USGS southern Alaska seismic network. All components sized for 35 mm had to be replaced with 16-mm components. This modification included adjustments in the capstan tension to a level appropriate to the smaller film reels, and required that the tungsten projector lamps be replaced with quartz cycle lamps (G.E. Quartzline, 21-v, 150-watt) so that a bright enough image could be projected through the smaller 16-mm apertures. To accommodate the fourth Develocorder film, an additional pair of motorized capstans was mounted in a position that made it possible for the first and second films to share the optics originally designed for a single 35-mm film. This involved a slight enlargement of one 35-mm aperture to fit two 16-mm films side by side. The other two apertures were each resized to 16 mm and hold the third and fourth films.

3. SONIC DIGITIZING UNIT.

The x-y coordinates of any point within an area on the scanning table are determined with a Science Accessories Corporation Model GP-6-50 Sonic Digitizer. This instrument consists of two one-meter microphone detectors positioned at right angles along two of the scanning table edges, a small processing unit, and a hand-held sonic cursor. The sonic cursor is centered over the point to be digitized and emits (when activated by the operator) an inaudible high-frequency tone which is detected by the microphones and then located by the processing unit in an x-y coordinate system with selectable origin. The x-y coordinates (cm) of the point are output with a repeatability of $\pm$ 0.1 mm.

4. MICROCOMPUTER AND SOFTWARE.

The organizational and computational tasks required for the interactive timing and location of an earthquake are performed by two FORTRAN IV computer programs (WWVFLM and LOCATE). These programs are currently in use on a Cromemco System III microcomputer with 64 kbytes of internal storage and two 8-inch floppy disk drives providing another 512 kbytes of mass storage. The Cromemco software package includes a FORTRAN IV compiler, a text editor, and various system routines for manipulating mass storage files on floppy disk.

Program WWVFLM organizes the timing of a single earthquake and performs data reduction on the x-y coordinate output from the sonic digitizer to produce a phase list suitable for input to the LOCATE program. WWVFLM offers three basic options to the user: (i) an initial measurement routine for the first attempt at timing of an earthquake, (ii) a remeasurement routine for selective remeasurement of data that were missed or incorrectly measured in the first timing, and (iii) a coda-length measurement routine for adding Q points (the arbitrary coda length cutoff point) to very long waveforms whose Q points are off the viewing table and thus require repositioning of the film. The first timing attempt is organized by views with the option to skip an entire view if that view contains no useful data. If a particular view is not skipped, then the operator is prompted to digitize two primary fiducial points on the top time code and the corresponding primary fiducial points on the bottom time code. The leftmost (earliest) primary fiducials are assumed to be on an integral 10-second mark, and are furthermore assumed to be separated from the rightmost primary fiducials by exactly 60 seconds. Ordinarily, the primary fiducials bracket the time interval within which the first P arrivals occur across the view. The x-y coordinate data for the primary fiducials are used by WWVFLM to define a rotated and translated local x-y coordinate system which is suitable for determining the absolute time of any point on any trace within the view. Subfiducial points digitized at ten-second intervals along the top time code between the primary fiducial points are used to minimize the effect of non-uniform spacing of time marks. Such non-uniform spacing could be caused by out-of-round film drive wheels in the develocorder mechanism. A digitized point is automatically associated with the correct trace and trace name (i.e., the station name) by comparison with a trace setup data file specifying the number, spacing, and names of traces within each view. In principle, the trace setup data file is reset by the operator only when develocorder adjustments affect the trace spacing or when the input signals at the recording center are reorganized on the films.

5. VIDEO MONITOR AND PRINTER.

A Sanyo Model VM4215 video monitor displays current processing sequences and is mounted so the operator can easily view it from any point alongside the digitizing table.

An Epson line printer is available to provide a permanent record of an entire data analysis session, if desired. This permits the operator to document any system malfunctions to aid in obtaining a diagnosis.

C. DESCRIPTION OF SYSTEM CONTROLS

The locations of controls described below are shown in Figures 2, 4, and 5.

1. MAIN POWER PANEL (Figure 2)

   a. On/Off Power Switch for entire control console and video monitor.

2. DIGITIZER CONTROL PANEL (Figure 2)

   b. Power button to digitizer is illuminated when on.

   c. Point/Line switch controls digitizer input mode from the cursor. Point mode allows operator to digitize one point at each depression of the cursor button. Line mode allows the operator to digitize several points at each depression of the cursor button. Line mode is useful in digitizing lines. The rate at which the cursor emits signals in line mode is controlled by the rate dial.

   d. Rate dial can be adjusted to a maximum rate of 140 points/second, and the desired rate is selected by the operator.

   e. Clear button clears digitizer electronics and resets digital display to zeroes.

   f. Start button activates, initializes, and terminates various digitizer programs and subroutines.

   g. Origin button allows operator to select a specific origin within the active work area. All subsequent digitizations are processed relative to this point.

   h. Increment button activates a mode which inhibits the generation of new data unless the incremental difference between the present point and the last output point is greater than $\pm$ 2 counts.

   i. Menu button activates the menu which allows the operator either to select programs or to transmit alphanumeric ASCII character data from the menu by depressing the cursor button when the cursor is centered within the various boxes in the menu area of the digitizing table.

j. English/metric switch is located behind the front panel and allows the operator to digitize in English (.01 inches/count) or metric (.01 cm/count) units.

k. Cursor connector is a special location for hooking up the cursor to the digitizer.

l. Sensor connector allows digitizer signals from sonic cursor received by L-Frame sensors to be transmitted to computer.

3. COMPUTER (Figure 2)

Power switch has four settings: (1) off, (2) lock, (3) on, and (4) reset. Off is the normal position when not in use; on is the normal position during use; and reset is used to reset the computer before booting it up again. Lock is not used. The operator turns the key on the power switch past lock to settings for on and reset.

4. FILM CONTROL PANEL (Figures 2 and 4)

Although the film transport was modified to accommodate four develocorder films, there are still only three projectors to project all four films. This necessitated projecting two films through one lens, which reverses the two images on the table. Please see Figure 3 for a diagram of the layout. The original power and lamp view designations on the control panel have been altered to correspond with the view designations in program WWVFLM and on the table.

a. Film power control buttons. The numbers below the buttons are the view designations. The operator can depress the buttons simultaneously or individually to activate power to the desired views. The left-most button is the off button, which, when depressed, cancels any or all of the previously depressed buttons providing power to the three views.

b. Film speed (toggle) switch has two settings: (1) high and (2) vari. High designates a mode in which the film is run at approximately 50 m/min directly from reel to reel and not through the apertures. High is used for running through a large percentage of the total film on the reel (usually three or more hours of recording time). Vari designates variable mode in which the films are run through the apertures. The maximum speed in this mode is approximately 10 m/min. Vari speed is used to pick a position on the films more accurately than at high speed.

c. Large film direction control lever varies the direction and speed of film transport for views 1, 3, and 4. With high/vari switch in high mode, this lever only controls the direction. With the switch in vari mode, this lever constantly varies the speed of the film in either direction.

d. Film speed dial is for view 2 only and constantly varies the film speed when film is running through apertures or reel-to-reel.

e. Small film direction control lever is for view 2 only and controls whether film winds in forward or reverse direction.

f. Film lamp buttons. The numbers below the buttons, as with the film power controls, are the view designations. The operator can depress the buttons simultaneously or individually to turn on lamps to desired views. The button for view 1 controls the lamp which also illuminates view 2. The left-most button is the off button which, when depressed, cancels any or all of the previously depressed lamp buttons.

Note: There are three features on the film control console that currently are not functional. They are a toggle switch and two single-frame film direction buttons in the lower left corner.

5. FILM REEL POWER PANEL (Figure 2)

This panel is located at the bottom of the control console, and contains three kinds of controls.

(1) Film power switches are the three switches on the top row and control whether any power reaches each view. The view designations are directly above the switches.

(2) Film direction switches determine whether films wind off and onto bottoms of reels or tops of reels.

(3) Projector lamp intensity dials control the intensity of the projector lamps. Clockwise increases the intensity. Each view is separately controlled except views 1 and 2 which are controlled by the same dial.

6. FILM TRANSPORT AND OPTICAL ASSEMBLY (Figure 5)

There is a main power switch (see Figure 5), which, in addition to the film power control buttons and film lamp buttons on the film control panel, controls power to the film transport motors and clutches and the projector lamps. This is also referred to as the power to the transport assembly.

D. OPERATION PROCEDURES

1. SETTING UP FILMS.

There are four stages in the process of setting up the films and getting them ready to use:

(a) Mounting films

(b) Advancing films

(c) Threading films

(d) Framing films

For each day of earthquakes to be processed, there may be up to four develocorder films. You can determine from the scan sheet data which films need to be digitized for a given day.

a. MOUNTING FILMS

The drive spindles on which the films are mounted are square in cross-section. If the center holes in the necessary reels are not already squared out, you must do so with a squaring tool.

Typically, the develocorder films are not rewound after being recorded, so the leading end is at 2400 hours. To mount each film, put the full reel on the upper spindle according to the view arrangement in Figure 6. Film should unwind off the bottom of the upper reel. Wind the leading end onto the empty takeup reel from the bottom.

Manually wind a few turns of film onto the takeup reel to prevent film from slipping off when film power is turned on and off. (There is a delay built into the film speed switch to prevent film breakage. This delay causes the drive spindles to recoil or reverse direction unwinding some of the film when film speed switch is turned off.)

b. ADVANCING FILMS

Turn power on for film transport by flipping the switch up on film transport assembly. To wind films, move film speed switch on film control panel to high position, depress each of the three film power control buttons, one at a time, and use the large film direction control lever on the left to move films one by one. For the remaining view (view 2), hold down the small film direction control lever on the right and turn film speed dial clockwise. Following this procedure, wind films directly from reel-to-reel to the approximate time of the earthquake to be digitized. For example, if the earthquake you wanted to digitize were at 1600 hours, you would wind films until about one-third of the film went onto the takeup reel.

The constant tension on the film spindles when the film is stationary makes threading films difficult, so it is a good idea to turn power to the transport assembly off to thread films.

c. THREADING FILMS

To thread each film, pull down on the film approximately halfway between the reels to create some slack. Place loop of film on glass aperture plate and align film with rollers, as shown in Figure 7a. First carefully lower the small clamp, then lower and lock the large clamp. Do this with all films, then lower lens gate and lock gate into place. (See Figure 7b).

d. FRAMING FILMS

To frame the onset of the earthquake in the "window" on the table, switch power to film transport back on. Depress film lamp buttons to turn on desired views. With film speed switch in vari position, slowly wind films individually until first P-arrival on projected image of each film is one or two centimeters to the right of the left side of the active digitizing area on the table. All other P- and S-arrivals have to be visible on the table at this point in the process or else they must be timed manually.

2. INITIALIZING DIGITIZER AND COMPUTER

Flip up power switch on main power panel of control console to ON position. See Figure 2 for location of switches. Orange light marked "AC" on panel should go on. Depress red POWER button on digitizer control panel. Light should go on inside button. Display should light up indicating zeroes. Turn key on computer clockwise past LOCK to the ON position.

To initialize digitizer, first depress CLEAR, then MENU buttons on digitizer control panel. Now you are ready to digitize the menu and establish the origin. The menu allows the operator to select the appropriate digitizing program from among several programs built into the digitizer. To digitize the menu, put the cursor over the "x" drawn in the lower left corner of the table (see Figure 8) and press the button. The display should read "00.04 00.00".

The origin default is the upper left corner. For convenience, we choose to put it in the center of the table. Digitize an origin approximately in the center, where a circle is marked (see Figure 8). Push ORIGIN button on digitizer control panel. The display should read "48.__ 52.__" where the values to the right of the decimal vary with each attempt.

The digitizer is now initialized and you can proceed to digitize points by placing the crosshairs of the cursor directly over the point to be digitized and pressing the button on the cursor. The digitizer control panel displays the x and y coordinates of the point measured in centimeters with respect to the defined origin.

To initialize the computer, insert master disk with controlling programs into slot A in the computer. Insert data disk into slot B. Figure 9 shows the direction in which the disks are inserted. Press RETURN on the keyboard once or twice until a semicolon (";") appears on the video screen. In response to the ";" prompt, type "B<cr>" to boot up the computer. (<cr> is a carriage return). After the computer displays messages for about five or ten seconds, the prompt "A." will appear. This is the executive or monitor level of the operating system to which you can respond with the options to edit a file, run a program, show directory, etc.

3. DIGITIZING AN EARTHQUAKE - WWVFLM

To digitize an earthquake, the operator uses an interactive program called WWVFLM. After executing this process, the operator can choose to locate the earthquake just digitized to check for errors in timing. For this, there is a program called LOCATE. Once the data are determined to be satisfactory, there is a program to transfer data to the data disk. This program is called XFER. These programs all reside along with other files on the master or "A" disk. To run any of these programs on the master disk, the operator types the program name followed by a carriage return to the "A." prompt.

WWVFLM

WWVFLM is organized into three sections in which information is entered relating to: (1) Processing session, (2) earthquake to be digitized, and, within each earthquake, (3) each film view. The first section, the processing session, establishes information about the station lineup, the operator, the date of processing, and the options within the program to be exercised. The second section combines all the information for an individual earthquake digitized from the separate views into one file. The third section is concerned with getting the information from each film into digital form in the computer. The digitized P, S, and magnitude measurements are assimilated in the computer and matched with the appropriate stations.

When the "A." prompt appears, type "WWVFLM<cr>" and wait approximately 40 seconds for the computer to load the program and an additional ten seconds for all the setup data to be printed out on the video monitor. (See Appendix for processing documentation.)

There are two ways to establish station (set-up) data. One is to answer "Y" to the prompt "NEW TRACE SETUP?" This enables the operator to override any previous station entry. The second way is to answer "N" and use the default station list stored in the program WWVFLM. In either case, the setup data are preserved from one session to the next so that the data from the previous session become the default station list.

Answer the questions posed by the prompts by typing a response followed by a carriage return. When you are prompted for fiducials: "ENTER TIME AT LEFT MARK:", start with the upper left-most ten-second mark on the film closest to you as shown in Figure 10. Enter the time for that mark, then digitize that point in response to the prompt "MEAS FID TOP LEFT". Digitize the next point 60 secs to the right and so on to correspond with the prompts from WWVFLM. Primary fiducials, or the first four points digitized on each film define a rectangular sixty-second window. After this window is set up, the program prompts for fiducial marks at ten-second intervals along the top time-code trace. The last prompt in the sequence of set-up steps is "REDO TEN SEC POINTS?". After responding with an "N" (when you are satisfied that the ten-second points are correctly digitized), you enter the measure mode.

When the first prompt of the measure sequence ("ENTER REMARK") appears, the P and S phases within an individual film view can be digitized in any order. A remark is a sequence of four alphanumeric characters describing the character of a wave arrival. By convention, the first character is either "i" or "e" for impulsive or emergent; the second character is either "p" or "s" ; the third character is for the direction of first motion for p arrivals and can be "u", "d", "n", "+", "-", etc. for up, down, no direction, probable up, probable down, etc. The fourth character is the weighting factor: 0 is the highest weight and 9 is the lowest. WWVFLM is set up to process films in order, but not traces. The film order is in the direction from the one nearest to the operator to the one farthest.

While digitizing within an individual film view, you can override any previous measurement on that film by simply entering a new remark and redigitizing the data for the trace. To remeasure a point on a trace on a film with which the operator has already finished, first the earthquake must be completed with the error left in. Then WWVFLM must be typed in again and the option for correcting a previous quake must be exercised (see page 17, section 5).

One feature of the measure sequence is coda-length (F-P) measurement. When WWVFLM prompts with "MEAS Q", you digitize the coda cutoff point for the trace on which you just measured the P-arrival. To proceed from view to view (after you have digitized all the data on that film), press "return" to the "ENTER REMARK:" prompt.

If the F-P intervals are greater than the length of the table, wait until you have digitized all of the data which fall within the active area. Only then can you move the necessary films to measure the long coda points. You type in WWVFLM again (to the A. prompt) and answer "Y" to the prompt "ADD Q INFO TO PREVIOUS QUAKE?". WWVFLM prompts you for the information it requires. After all of the relevant views have been digitized, the computer stores the data in a file called FORT08.DAT.

4. LOCATING AN EARTHQUAKE - LOCATE

After digitizing an entire event, type "LOCATE<cr> to the "A." prompt. (See Appendix A). A wait of about 45 seconds allows the computer to load the LOCATE program. When the prompt "ZTR=20., EDIT OR RETURN:" appears, the operator must decide whether the earthquake is likely to be shallow or deep so an appropriate trial depth can be entered. The choice of trial depth for the USGS southern Alaska Network is based primarily on three criteria:

(1) the area within the network in which the event occurred

(2) the character of the waveform arrival and whether or not refracted arrivals can be seen

(3) operator intuition and previous experience

By convention, we have decided to use 25 or 75 km for trial depths for earthquakes east and west, respectively, of a NW-SE line drawn on a map through the Cook Inlet. Once the operator types a value for the trial depth, followed by a carriage return, the program goes through up to eight iterations to determine a hypocenter. When the program achieves a solution, based on minimizing, in a least-squares sense, the travel time residuals at the stations recording the event, it prints out the location and a list of all phases picked with their statistics. These statistics are not saved by the program, but the operator can assess the reliability of the picked P- and S-arrivals by briefly studying the solution.

5. REDIGITIZING/CORRECTING ERRORS

If the operator entered an incorrect date or time (for start of measurement window), or needs to add or remeasure an arrival time after digitizing an earthquake, there is an option in the program WWVFLM to make corrections. To exercise this option, the operator must finish an entire earthquake and wait until the picked data has been written into the master disk file FORT08.DAT. Then the operator types WWVFLM again to the "A." prompt, followed by a carriage return. When the prompt "CORRECT PREVIOUS QUAKE?" appears, the operator types "Y<cr>" after which more questions are posed. (See Appendix). WWVFLM prompts the operator to type in responses and to redigitize as necessary. When corrections on one film are finished, a "return" is required to proceed to the next view, just as in the first measurement routine. When all corrections are finished, type "return" to the prompt "ENTER STATION NAME YOU WANT TO REMEAS:" and the program will make adjustments in the FORT08.DAT file on the master disk and return you to the "A." prompt.

6. FINISHING/SHUTTING DOWN

The operator has to decide when a solution is adequate at the time of processing on this system. When a solution reaches this point, the operator uses the program XFER (see Appendix) to transfer the data from the earthquake (in the file FORT08.DAT) to the B-disk (or data disk). Each time a new earthquake is processed, FORT08.DAT is overwritten, so this last step is absolutely essential to save the data. Each file on the B-disk contains data from one earthquake. The operator assigns each file a unique name based on the date and time of the event. When the operator has digitized and stored all of the processed events and is ready to shut the system down, the order is:

(1) Rewind and remove films

(2) Film lamps off

(3) Power off for transport assembly

(4) Take disks out of computer

(5) Computer off

(6) Digitizer off

(7) Main power switch off

E. MAINTENANCE PROCEDURES

REPLACING LIGHT BULBS - First, turn off power to film transport. Quartz lamps are kept in bottom drawer beneath table. To replace burned out bulb, lift up flap of projector box. Reach in and slowly push down bulb release lever on left of bracket with right hand, and at the same time cradle the light bulb in the fingers of your left hand. When bulb slides out to the left, push bulb release lever all the way back up. After throwing the old bulb away, put the new bulb in your left hand, cradling it gently, and making sure not to touch the reflective surface. Slide bulb into the bracket from left to right until snugly in place. Replace flap on projector box.

CLEANING GLASS PLATES - Periodically wipe the bottom surface of the glass apertures with a rag and an all-purpose or glass spray cleaner. The transport assembly causes the films to leave dust particles and film shreds on the glass which obscure the projections.

CLEANING FILM DRIVE COILS - Clean these with power off. Occasionally the copper coils will get dirty, causing the power to the film drives to be sluggish. Open up the black box near the spindle of the affected film drive. This requires removing one screw and pivoting the cover on the other screw. Take an ordinary pencil eraser and erase the entire coil surface. Replace the cover.

F. PROBLEMS

All optical-mechanical and electrical problems to date have been eliminated by fairly simple equipment modifications. The only outstanding computational problems are three associated with the LOCATE program.

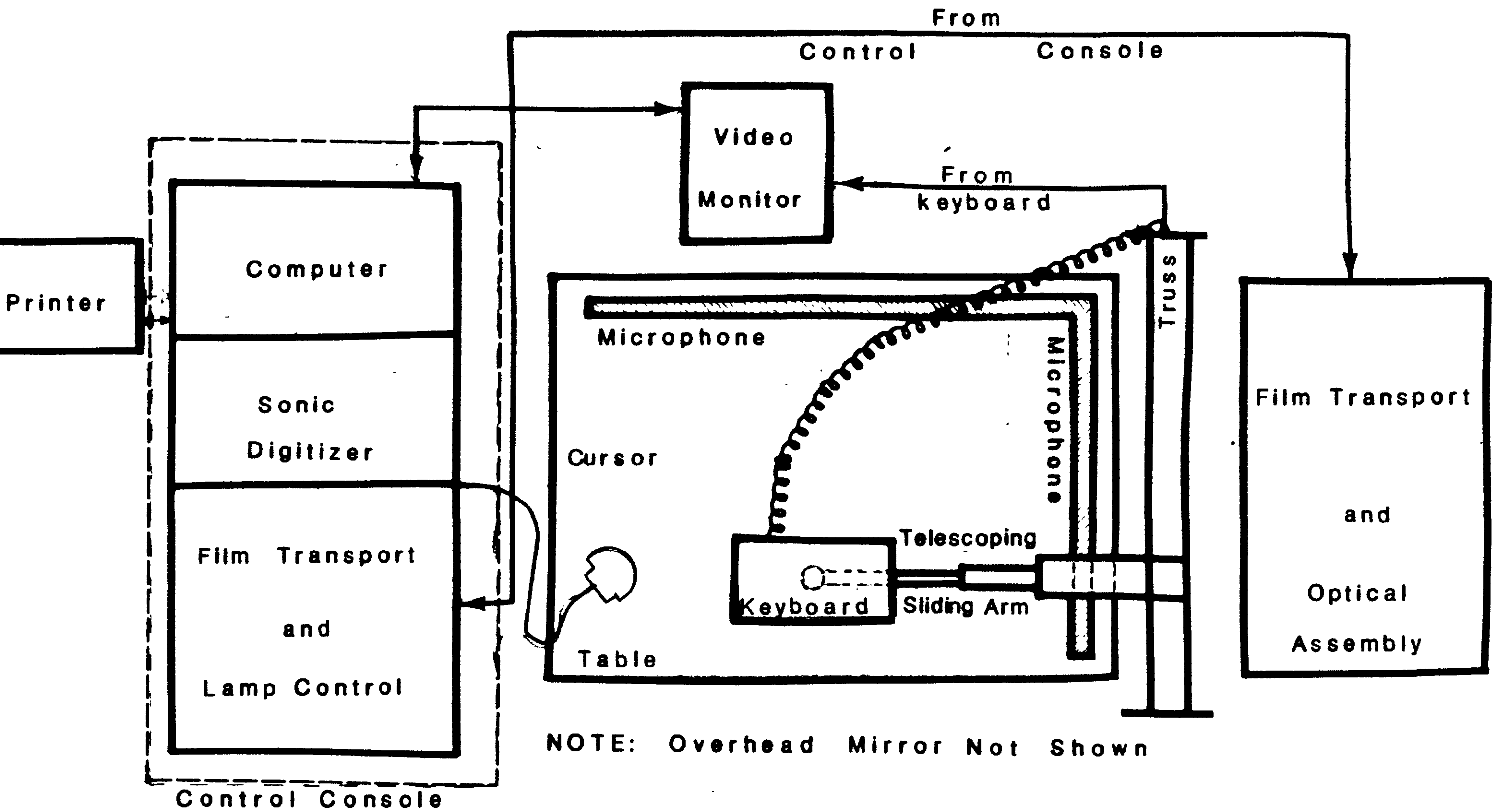
The first problem is that any digitized earthquake in which the S-wave arrival falls into the next hour from the P-wave arrival on the same trace causes a fatal error condition upon location with the LOCATE program. This cannot be compensated for when setting up the traces because the program WWVFLM checks for valid window times, so it must be accomplished through the editor. Any S-wave arrival with a time after the hour should be changed to the previous hour, adding 60 minutes to the minute measurement. For example, 02 hours 00 minutes (0200) would be changed to 01 hours 60 minutes (0160). See Appendix.

The second problem is that no more than 39 P- or S-wave arrivals can be used by LOCATE. If more are picked and the operator attempts to use the LOCATE program, a fatal error condition results. If, within one earthquake, more than 39 P- or S-wave arrivals have been recorded, the operator must delete some data temporarily to use the LOCATE program. Usually, the far-away stations, or those arrivals which are very emergent will be the best to delete. This is done through the editor. When the operator alters a file in the editor, the original file is automatically stored in a backup file called FORT08.BAK. If after trimming the file FORT08.DAT to 39 entries, no corrections need to be made and no codas need to be added, then the operator transfers the backup file (the original file) instead of FORT08.DAT (the altered file) to the B-disk. If the operator decides to make alterations to the large data file, they must be made in the large file, and not in the file that was trimmed in order to use LOCATE. To do this, after using LOCATE with the edited file, and after deciding to make corrections, rename the backup file (the original file) to FORT08.DAT in the editor and then make the necessary changes. If the operator is still interested in using LOCATE to check the new modifications, then this process can be repeated, beginning with re-editing the FORT08.DAT file, cutting it down to 39 P- and S-wave arrivals, etc. It is also necessary to locate the earthquake and make corrections to the readings, if needed, before moving the films to add the coda-length measurements.

The third remaining problem is that although LOCATE gives reasonable hypocenter and origin-time solutions for earthquakes recorded with a good azimuthal distribution of stations, experience has shown that a poor azimuthal distribution of stations (gap > 180^{0}) may lead to computational difficulties and fatal error conditions. At this time we feel that a more sophisticated earthquake location program, using a singular value decomposition technique should be developed and a more powerful computer should be used.

ACKNOWLEDGEMENTS

We wish to thank the late Vaughn S. Davidson for setting up the system software, including writing the program WWVFLM. We are also grateful to Arthur H. (Buck) Rogers for setting up and maintaining the mechanical and electrical aspects of the digitizing system. We also thank George Rothbart for developing the computer hardware. Finally, we would like to thank Roy Tam and Kent Fogleman for their critical reviews of the manual.



SEISMIC PROCESSING SYSTEM II SCHEMATIC - July '82

Fig. 1

CONTROL CONSOLE

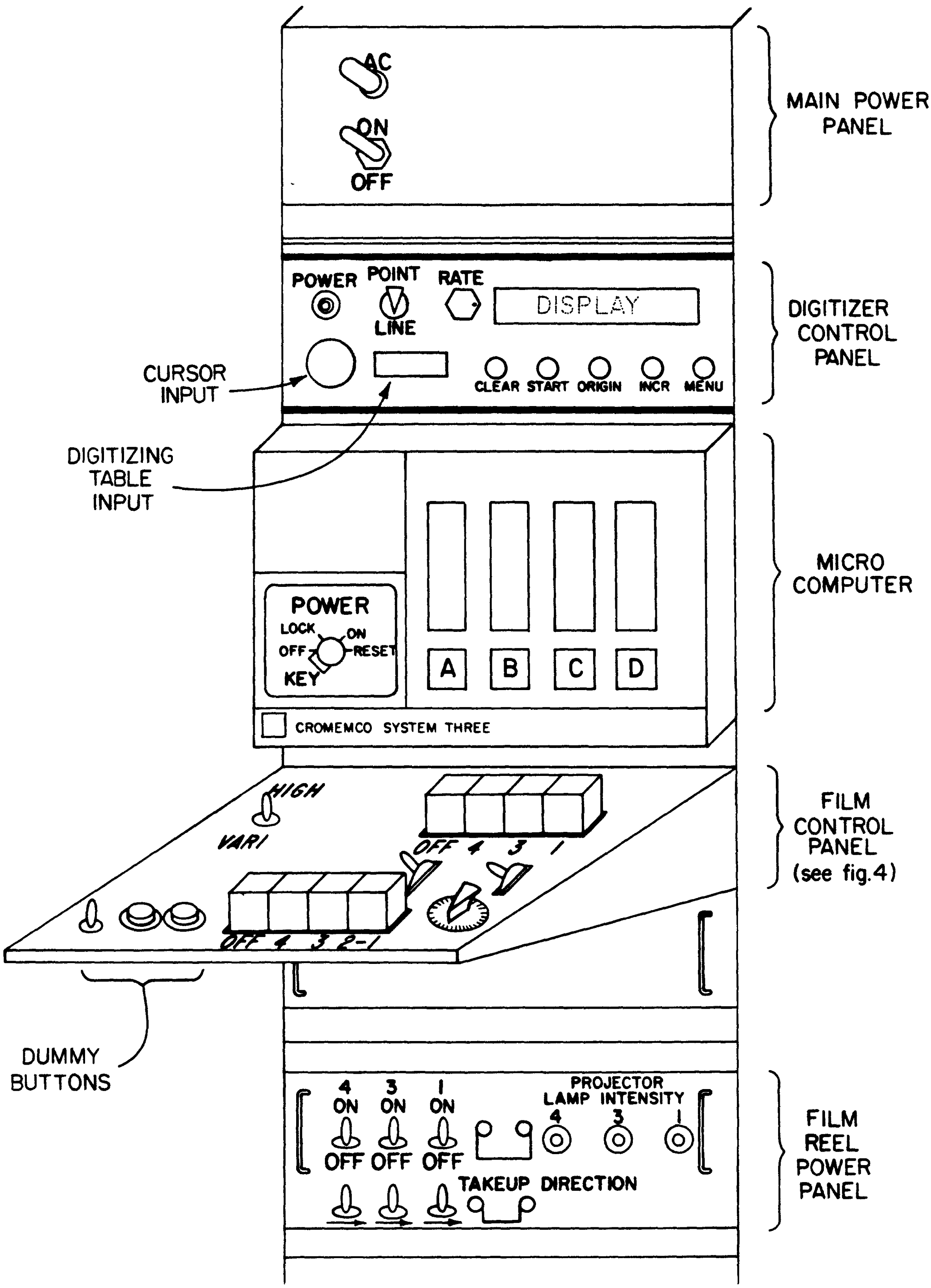


Fig. 2

FILM LAYOUT

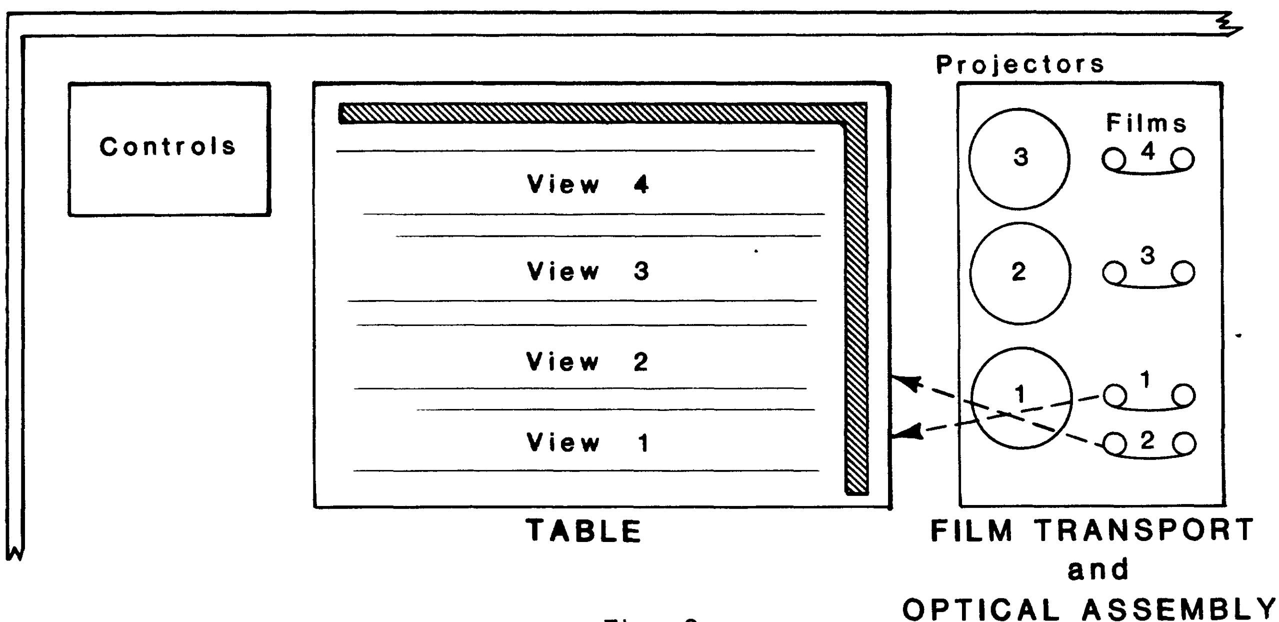


Fig. 3

FILM CONTROL PANEL

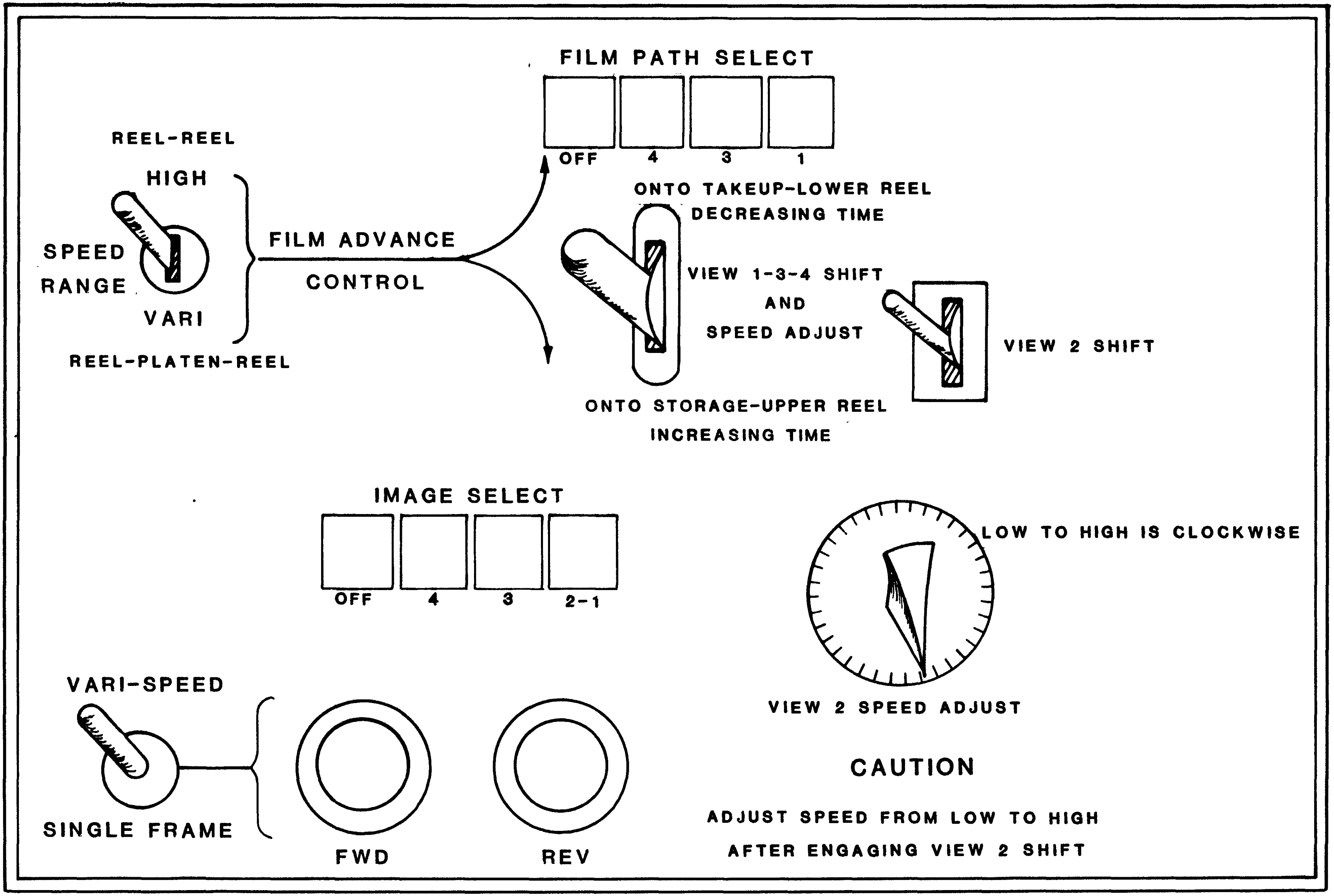


Fig. 4

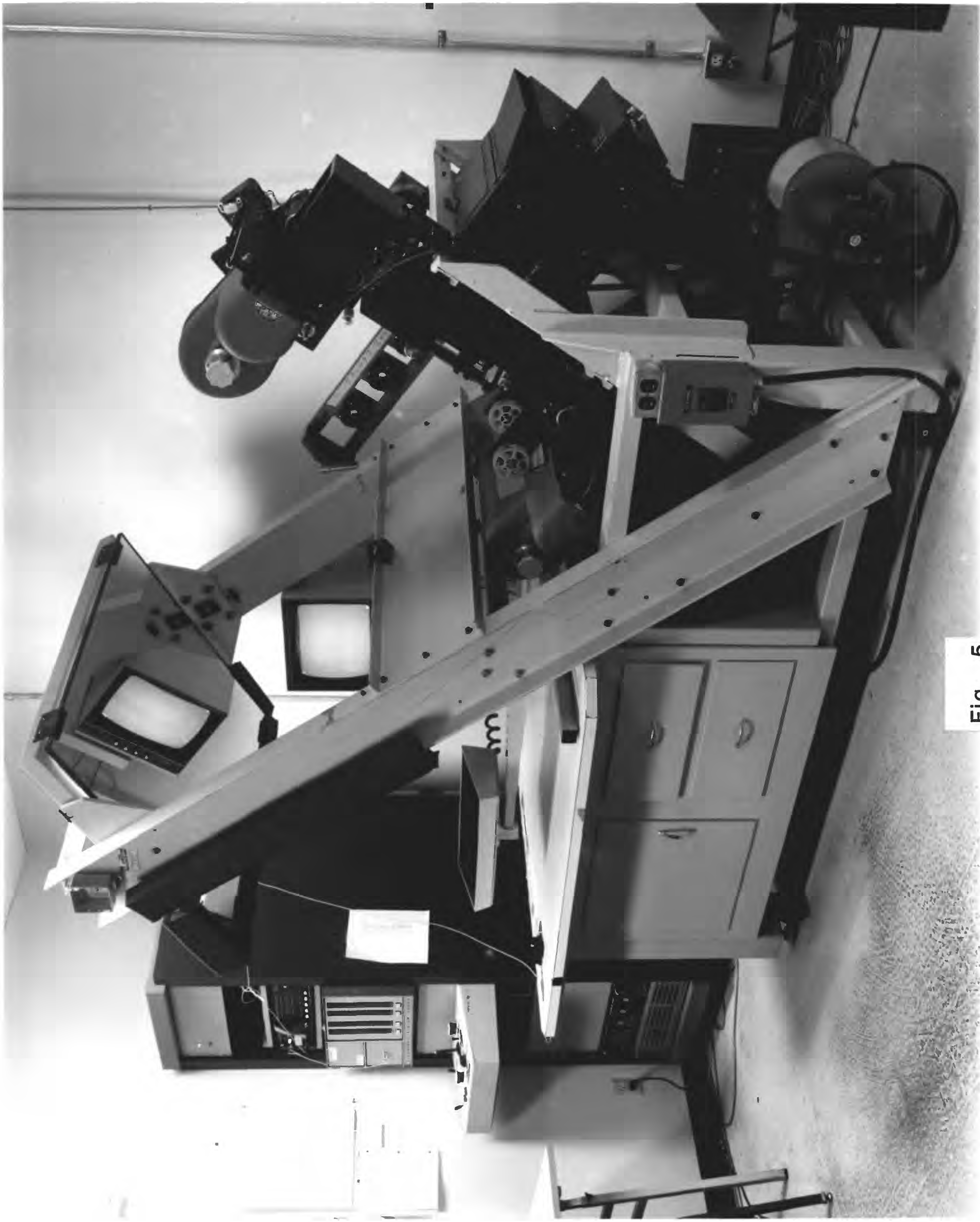


Fig. 5

Photograph of film transport and optical assembly

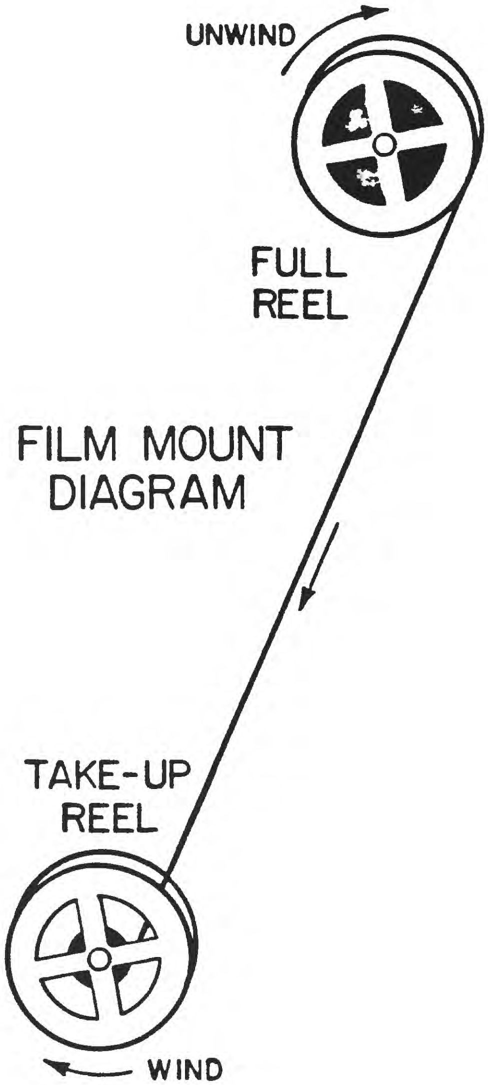


Fig. 6

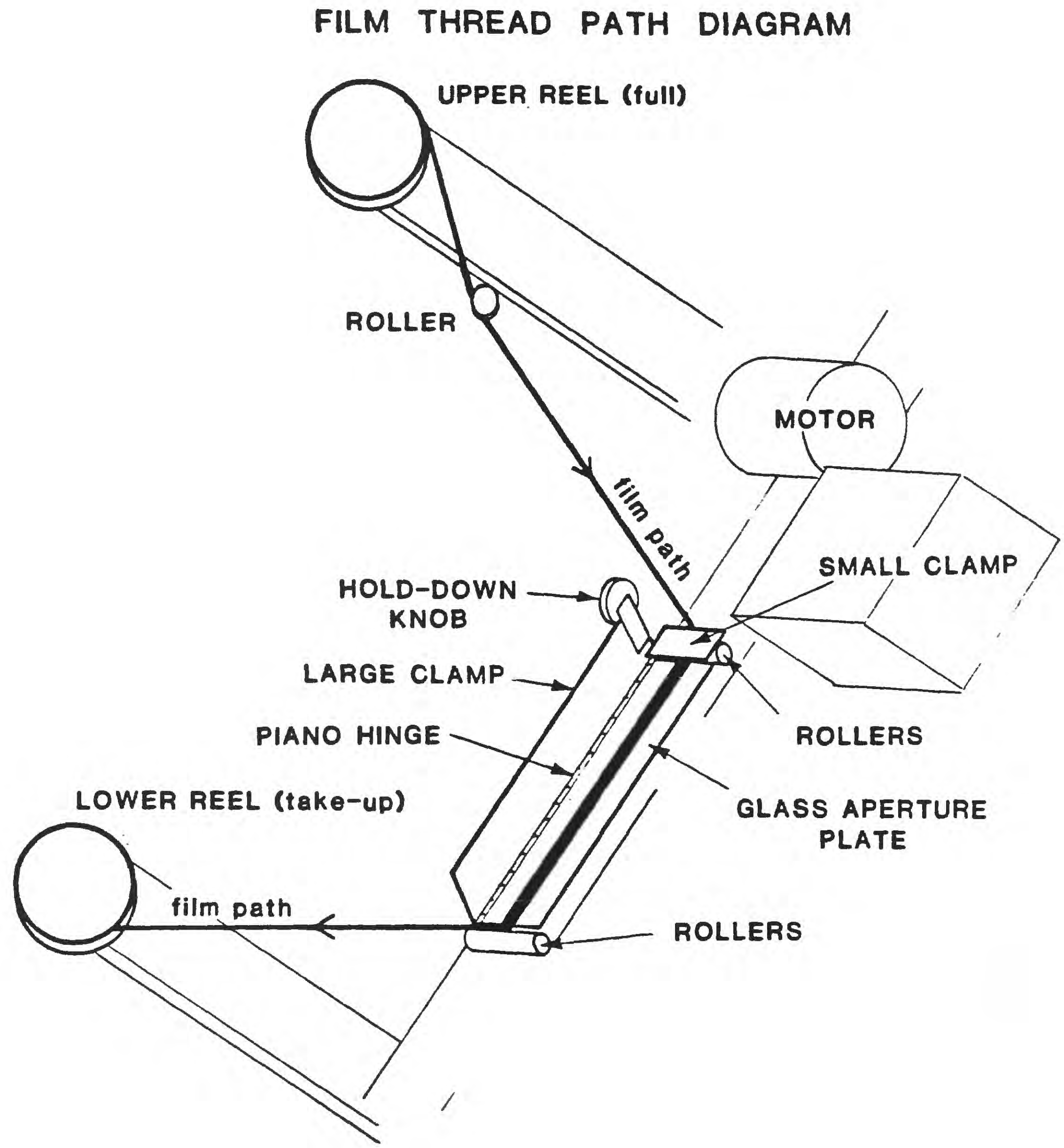

FILM THREAD PATH DIAGRAM
UPPER REEL (full)
ROLLER
MOTOR
film path
SMALL CLAMP
HOLD-DOWN
KNOB
LARGE CLAMP
ROLLERS
PIANO HINGE
GLASS APERTURE
PLATE
LOWER REEL (take-up)
film path
ROLLERS

Fig. 7a

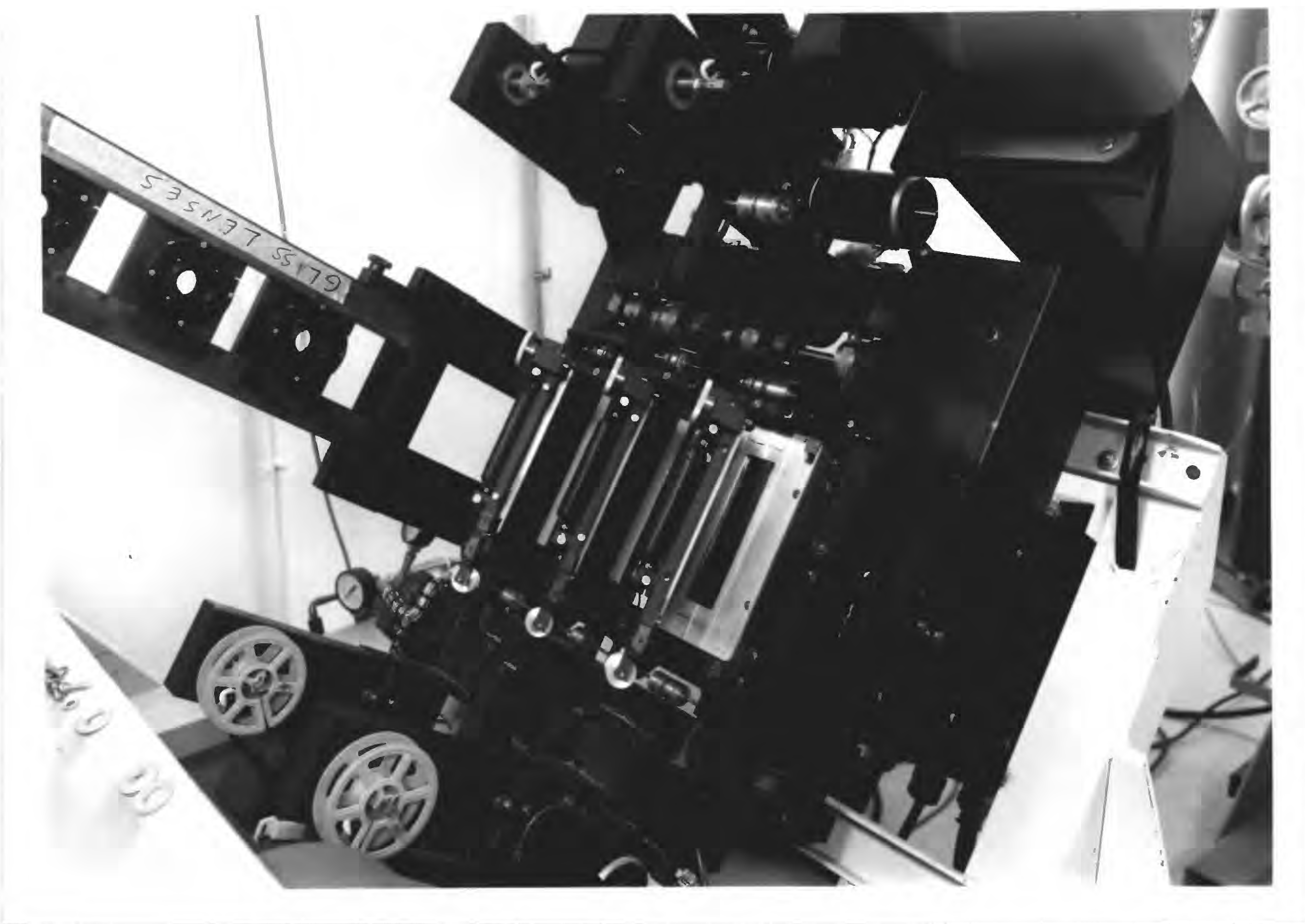


Fig. 7b

Photograph of film capstans and apertures

DIGITIZING TABLE ACTIVE AREA

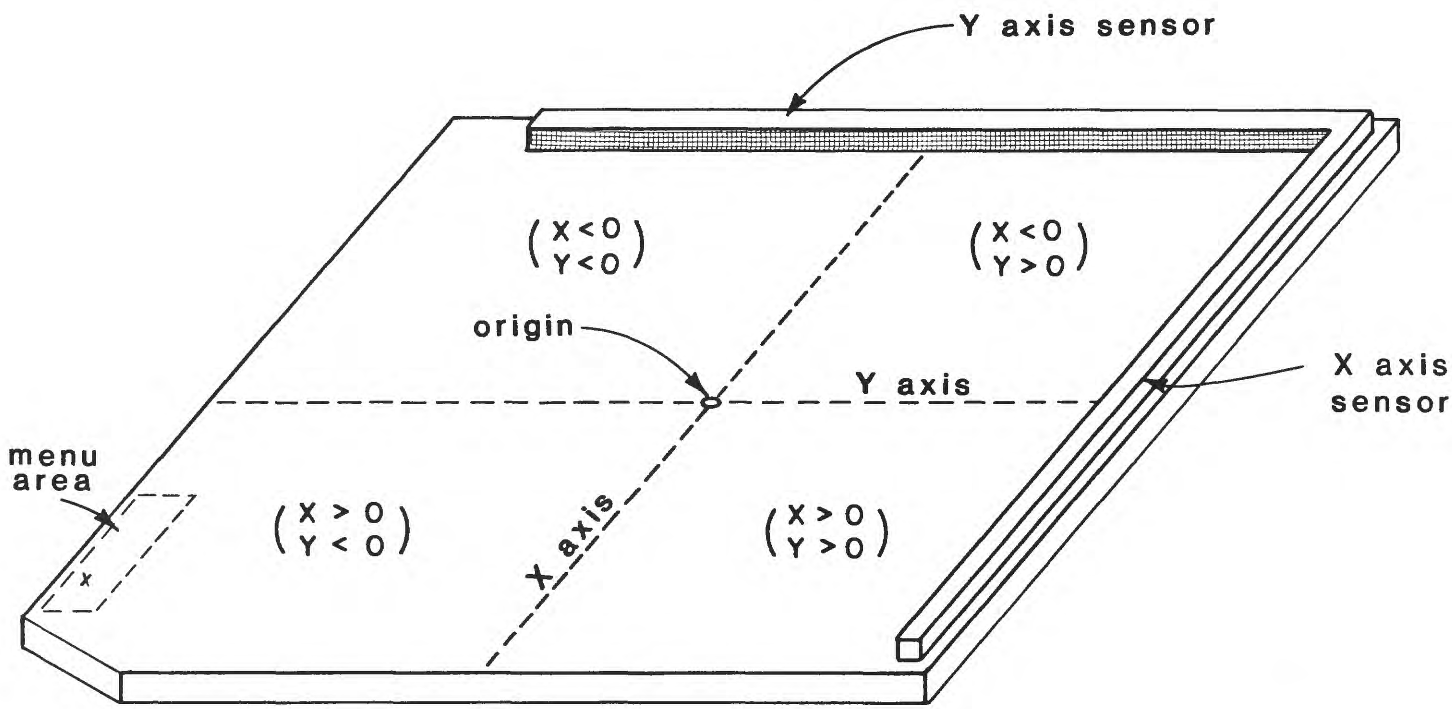


Fig. 8

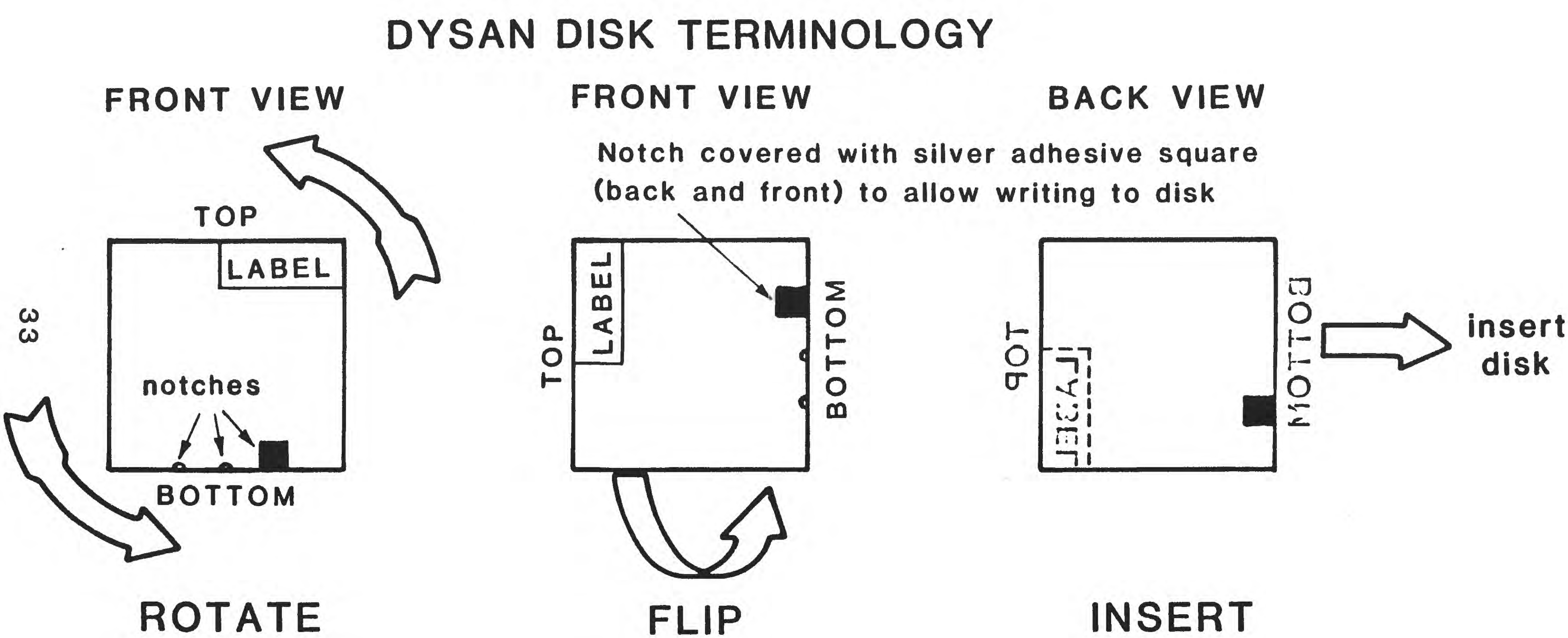
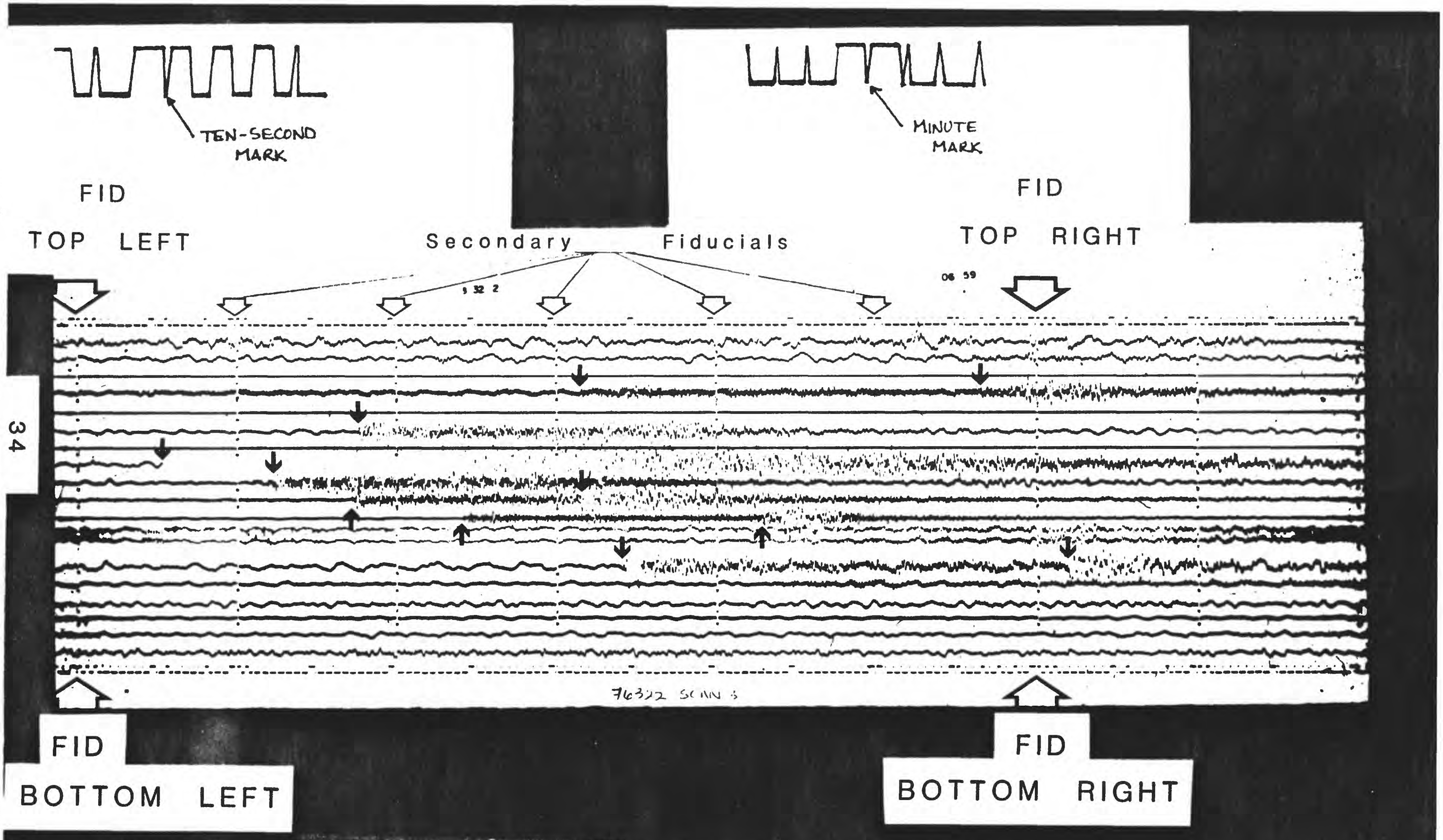

DYSAN DISK TERMINOLOGY
FRONT VIEW
FRONT VIEW
BACK VIEW
Notch covered with silver adhesive square
(back and front) to allow writing to disk
TOP
LABEL
notches
BOTTOM
TOP
LABEL
BOTTOM
insert
disk
ROTATE
FLIP
INSERT

Fig. 9



Develocorder film showing an earthquake and digitizing criteria

Fig. 10

Appendix

PROCESSING DOCUMENTATION

```
WWVFLM

WWVFLM VERSION 04/26/81
READING PREVIOUS SETUP DATA FROM DISK
OPR ID=MCA
LAST USAGE DATE (YYMMDD) 82 8 5
FILM RECORD ID  EACH VIEW: 76336S3 76336E1 76336C4 76336W5
REFERENCE TIME  EACH VIEW:  1211 0   4 830  1211 0   62250
NUMBER OF TRACES PER VIEW:      18       18       18      18

 1  HQN   SIT   GIL   SCT
 2  PIN   PNLZ  BLR   SCF
 3  YKG   PNLN  PAX   PWA
 4  BAL   PNLE  TOA   PMS
 5  RGD   BCS   VLZZ  SKNZ
 6  CVA   MLS   VLZN  SKNN
 7  MTG   CHX   VLZE  SKNE
 8  KLU   RIU   VZW   NKA
 9  GLC   GYO   FID   SKL
10  KNK   WRG   SGA   NNL
11  PRG   YAH   HIN   RDTZ
12  SWD   SSP   MID   RDTN
13  SSN   WAX   SCM   RDTE
14  SPU   SUK   SAW   TTA
15  ILM   KYK   PMR   SVW
16  SLV   GLBZ  CFI   AUW
17  CKK   GLBN  PWL   SHU
18  BIG   GLBE  MSP   KDC
VERBOSE COMMENTS? (Y/N)  N
ENTER OPR ID (A3): MCA
ENTER TODAY'S DATE (YYMMDD): 821007
EDIT FILM RECORD ID'S? (Y/N)  Y
DEFAULT: 76336S3 VIEW 1 ENTER ID (A7): 76337S3
DEFAULT: 76336E1 VIEW 2 ENTER ID (A7): 76337E1
DEFAULT: 76336C4 VIEW 3 ENTER ID (A7):
DEFAULT: 76336W5 VIEW 4 ENTER ID (A7):
CORRECT PREVIOUS QUAKE? (Y/N)  N
ADD Q INFO TO PREVIOUS QUAKE? (Y/N)  N
ENTER QUAKE DATE (YYMMDD):  761202
NEW TRACE SETUP? (Y/N)  Y
DOING VIEW 1
SKIP THIS VIEW? (Y/N)  Y
DOING VIEW 2
SKIP THIS VIEW? (Y/N)  N
ENTER NUMBER OF TRACES (I2): 18
 MEAS FID TOP LEFT +02.77  -42.74
 REDO FID +02.80  -42.80
 MEAS FID TOP RIGHT +02.33  +09.97
 MEAS FID BOTTOM LEFT +20.67  -42.45
 MEAS FID BOTTOM RIGHT +20.23  +10.35   etc.
MEAS A PT ON EACH TRACE, START TOP.
 DO TRACE  1  SIT
 DO TRACE  2  PNLZ
 DO TRACE  3  PNLN
 DO TRACE  4  PNLE
 DO TRACE  5  BCS
 DO TRACE  6  MLS
 DO TRACE  7  CHX
 DO TRACE  8  RIU
 DO TRACE  9  GYO
 DO TRACE 10  WRG
```

```
 DO TRACE 11  YAH
 DO TRACE 12  SSP
 DO TRACE 13  WAX
 DO TRACE 14  SUK
 DO TRACE 15  KYK
 DO TRACE 16  GLBZ
 DO TRACE 17  GLBN
 DO TRACE 18  GLBE
EDIT STATION NAMES? (Y/N) Y
 1  SIT
 2  PNLZ
 3  PNLN
 4  PNLE
 5  BCS
 6  MLS
 7  CHX
 8  RIU
 9  GYO
10  WRG  SSP
11  YAH
12  SSP  WRG
13  WAX
14  SUK
15  KYK
16  GLBZ
17  GLBN
18  GLBE
EDIT STATION NAMES? (Y/N)  Y
 1  SIT
 2  PNLZ
 3  PNLN
 4  PNLE
 5  BCS
 6  MLS
 7  CHX
 8  RIU
 9  GYO
10  SSP
11  YAH
12  WRG
13  WAX
14  SUK
15  KYK
16  GLBZ
17  GLBN
18  GLBE
EDIT STATION NAMES? (Y/N)  N
DOING VIEW 3
SKIP THIS VIEW? (Y/N) Y
DOING VIEW 4
SKIP THIS VIEW? (Y/N) Y
BEGINNING NEW QUAKE.
DOING VIEW 1
SKIP THIS VIEW? (Y/N) N
ENTER TIME AT LEFT MARK (HHMMSS):
ENTER TIME AT LEFT MARK (HHMMSS): 015950
 MEAS FID TOP LEFT
 MEAS FID TOP RIGHT
 MEAS FID BOTTOM LEFT
 MEAS FID BOTTOM RIGHT
BAD FIDUCIALS, REMEAS ALL OF THEM
 MEAS FID TOP LEFT
 MEAS FID TOP RIGHT
 MEAS FID BOTTOM LEFT
 MEAS FID BOTTOM RIGHT
MEAS TOP LEFT MARK+10 SECS
```

```
MEAS TOP LEFT MARK+20 SECS
MEAS TOP LEFT MARK+30 SECS
MEAS TOP LEFT MARK+40 SECS
MEAS TOP LEFT MARK+50 SECS
REDO TEN SEC POINTS? (Y/N) N
STARTING MEASURE MODE.
ENTER REMARK (A4): IPUO
(RE)MEAS P
MEAS Q
MEAS LEFT PEAK POINT
TRACE  2 PIN  IPUO  P= 5.05  FMP= 24
ENTER REMARK (A4): IP 2
(RE)MEAS P
MEAS Q
MEAS LEFT PEAK POINT
TRACE  1 HQN  IP 2  P=  .36  FMP= 22
ENTER REMARK (A4): IS 2
(RE)MEAS S
TRACE  2 PIN  IS 2  S=15.25
ENTER REMARK (A4): IS 1
(RE)MEAS S
TRACE  1 HQN  IS 1  S= 6.84
ENTER REMARK (A4):
DOING VIEW 2
SKIP THIS VIEW? (Y/N)
SKIP THIS VIEW? (Y/N) N
DEFAULT TIME: HHMMSS= 15950
ENTER TIME AT LEFT MARK (HHMMSS):
 MEAS FID TOP LEFT
 MEAS FID TOP RIGHT
 MEAS FID BOTTOM LEFT
 MEAS FID BOTTOM RIGHT
MEAS TOP LEFT MARK+10 SECS
MEAS TOP LEFT MARK+20 SECS
MEAS TOP LEFT MARK+30 SECS
MEAS TOP LEFT MARK+40 SECS
MEAS TOP LEFT MARK+50 SECS
REDO TEN SEC POINTS? (Y/N) N
STARTING MEASURE MODE.
ENTER REMARK (A4): IP-0
(RE)MEAS P
MEAS Q
MEAS LEFT PEAK POINT
TRACE  2 PNLZ IP-0  P=59.81  FMP= 26
ENTER REMARK (A4): IS 2
(RE)MEAS S
TRACE  2 PNLZ IS 2  S= 6.62
ENTER REMARK (A4):
ENTER REMARK (A4): EP 1
(RE)MEAS P
MEAS Q
MEAS LEFT PEAK POINT
MEAS RIGHT PEAK POINT
TRACE  9 GYO  EP 1  P= 9.81  FMP= 21
ENTER REMARK (A4): ES 2
(RE)MEAS S
TRACE  9 GYO  ES 2  S=25.12
ENTER REMARK (A4):
DOING VIEW 3
SKIP THIS VIEW? (Y/N)
DOING VIEW 4
SKIP THIS VIEW? (Y/N)
WRITING DATA TO DISK
ALL DONE
TYPE "LOCATE" TO LOCATE QUAKE. STOP
```

TRANSFERRING A FILE

```
A.XFER/V B:DC027601.DAT=FORT08.DAT
XFER (Transfer) version 01.03
B:DC027601.DAT compared OK
    1K-bytes read

A.
```

LOCATING AN EARTHQUAKE

```
TYPE FORT08.DAT
MCA 8210 7
HON  IP  2  7612 2  160   .36   22.  11 76337S3  0.00  0.00
HON  IS  1  7612 2  160  6.84    0.  11 76337S3
PIN  IP U0  7612 2  160  5.05   24.  21 76337S3  0.00  0.00
PIN  IS  2  7612 2  160 15.25    0.  21 76337S3
PNLZ IP -0  7612 2  159 59.81   26.  22 76337E1  0.00  0.00
PNLZ IS  2  7612 2  160  6.62    0.  22 76337E1
GYO  EP  1  7612 2  160  9.81   21.  92 76337E1   .09 27.95
GYO  ES  2  7612 2  160 25.12    0.  92 76337E1

A.LOCATE

ZTR= 20., EDIT OR RETURN: 25.

I   ORIG DEPTH GAP DM  RMS     DT   DLAT   DLON     DZ
1 53.81 25.00 175  0 1.19 -2.60  17.91 -22.69  26.72

I   ORIG DEPTH GAP DM  RMS     DT   DLAT   DLON     DZ
**FW**

**FW**

1 53.81 25.00 175  0 1.19  1.11 131.16 115*05   0.00
**FW**

**FW**

2 54.92 25.00 31817325.41 -4.99  44.11*121*80*323.50
**FW**

**FW**
```

```
2 54.92 25.00 31817325.41 -4.12 127*08  69.17   0.00
**FW**

**FW**

2 54.92 25.00 31817325.41 -4.12 127*08  69.17   0.00

   ORIGIN     LAT N     LONG W     DEPTH NO GAP DM  RMS   ERH   ERZ
  159 54.92 60-50.79 137-21.44   25.00  8 31817325.41 37.7   0.0 PAUSE


 STN  PRMK    KDATE HRMN T-SEC T-RES T-WT INFO  DELTA AZM AIN   FMP FMAG
PNLZ IS  2   761202  160  6.62-35.23  .58 1.00 173.22 221  53
PNLZ IP -0   761202  159 59.81-22.24 1.56 1.00 173.22 221  53    26  2.6
HON  IP  2   761202  160   .36-22.07  .78 1.00 176.86 209  53    22  2.4
HON  IS  1   761202  160  6.84-35.67  .85 1.00 176.86 209  53
PIN  IS  2   761202  160 15.25-28.30  .69 1.00 180.04 242  53
PIN  IP U0   761202  160  5.05-17.98 1.67 1.00 180.04 242  53    24  2.5
GYO  EP  1   761202  160  9.81-20.35 1.21 1.00 239.21 251  53    21  2.6
GYO  ES  2   761202  160 25.12-30.76  .65 1.00 239.21 251  53

A.LOCATE

ZTR= 20., EDIT OR RETURN: 60.


I   ORIG DEPTH GAP DM  RMS    DT   DLAT   DLON     DZ
1 46.81 60.00 175  0 3.42  2.86 -38.68  17.83   2.96*

I   ORIG DEPTH GAP DM  RMS    DT   DLAT   DLON     DZ
1 46.81 60.00 175  0 3.42  3.24 -46.48  24.00   0.00
2 50.05 60.00 249 52 2.51  -.45* 10.34  -4.04*-11.76*
2 50.05 60.00 249 52 2.51 -1.43    6.82  -5.71   0.00
3 48.62 60.00 241 44  .12   .14  -2.16   2.61  -5.05
4 48.76 54.95 244 47  .06  -.01*   .08*   .05*  -.29*

   ORIGIN     LAT N     LONG W     DEPTH NO GAP DM  RMS   ERH   ERZ
  159 48.76 59-17.64 139-46.21   54.95  5 244 47  .06   .8   .9 PAUSE


 STN  PRMK    KDATE HRMN T-SEC T-RES T-WT INFO  DELTA AZM AIN   FMP FMAG
PNLZ IS  2   761202  160  6.62 -1.30 0.00 1.00  46.69  27 132
PNLZ IP -0   761202  159 59.81  -.03 2.15 1.00  46.69  27 132    26  2.1
HON  IP  2   761202  160   .36  -.08 1.04 1.00  53.73  71 127    22  2.0
HON  IS  1   761202  160  6.84 -2.13 0.00 1.00  53.73  71 127
PIN  IS  2   761202  160 15.25 -1.75 0.00 1.00  93.53 343 108
PIN  IP U0   761202  160  5.05  -.04 2.14 1.00  93.53 343 108    24  2.2
GYO  EP  1   761202  160  9.81  -.01 1.62 1.00 134.85 315 101    21  2.2
GYO  ES  2   761202  160 25.12  -.08 1.05 1.00 134.85 315 101

A.
```

EXAMPLE OF HOUR-CHANGE PROBLEM

```
A.LOCATE

ZTR= 20., EDIT OR RETURN: 25.

**FW**


I  ORIG DEPTH GAP DM  RMS    DT   DLAT   DLON     DZ
1 54.36 25.00 200  0 7.77 -6.46  57.08 -33.27  44.51

I  ORIG DEPTH GAP DM  RMS    DT   DLAT   DLON     DZ
1 54.36 25.00 200  0 7.77  2.95 -18.40* 92.61*  0.00
**FW**

**FW**

**FW**

**FW**

**FW**

**FW**

**FW**

**FW**

**FW**

**FW**

2 57.31 25.00 252 76318*8435*66*5211*6*4788*2*340*38*

   ORIGIN     LAT N     LONG W     DEPTH NO GAP DM  RMS  ERH  ERZ
**FW**

**FW**

**FW**

**FW**

**FW**

**FW**

  159 57.31 59-17.29 140-30.68  25.00  8 252 76318*8398*7124*8 PAUSE

 STN  PRMK   KDATE HRMN T-SEC T-RES T-WT INFO  DELTA AZM AIN  FMP FMAG
**FW**

**FW**

PNLZ IS  2  761202  2 0  6.62361*31  .69 1.00  76.00  56 108
PNLZ IP -0  761202  159 59.81-10.50 1.76 1.00  76.00  56 108   26  2.2
**FW**
```