PART I:

AUTOMATIC DIGITIZATION USING PC AND SCANNER

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*I*1 The Automatic Digitization System

*I*1.1 Introduction

The need for availability and efficient dissemination of digitized strong motion accelerograph data is recognized by engineers, seismologists, and geologists throughout the world. Analysis and interpretations of this data are found in the works of earthquake engineers concerned with the development of earthquake resistant structural design, of geophysicists and seismologists dealing with the understanding of earthquake source mechanism, and of social scientists and public officials responsible for public safety and disaster response and mitigation.

A study made for the Office of Science and Technology of the Executive Office of the President of the United States concludes that:

> "... effort must be devoted to ... the collection of records after destructive earthquakes, analyzing the motions to derive various engineering characteristics, and making the original data and analyses available shortly after the earthquake. The fundamental aspect of all dynamic research in earthquake engineering is the ground motion to which the structure is subjected in a major earthquake..."

Some twenty years ago, the only digitization process available was the manual, hand digitization (Trifunac and Lee, 1973). Before digitizing, the film record, or its enlargement, had to be placed on the digitizing table with the horizontal axis lined up by eye to an estimated zero axis. Each line was then digitized by placing the crosshair manually on successive points of the trace. The digitizer converted the coordinates to numbers which were directly punched on cards or recorded on tape. A set of computer programs were then used to read and to plot the data to the same scale as that of the original digitized record. This plot was then checked against the digitized record. Any errors found had to be corrected manually. Any portion that was digitized improperly had to be redigitized and rechecked until the final plot agreed well with the digitized record. The raw data was then ready for routine computer processing (Trifunac and Lee, 1973).

*I*1.2 The Original Automatic Digitization System

Digitization of a record by the old manual method and data verification and preparation, took up to several days to complete one record. With the development of image processing techniques in the 60's and 70's, Trifunac and Lee (1979) developed an automatic digitization system for strong-motion accelerograms. Under this system, up to four 10 inch-sections of the accelerogram record could be reproduced on a 10 inch $\times$ 10 inch negative film, which was then put into the drum of the photodensitometar for scanning. A scanning program, 'FILM' available for the NOVA-3 Data General mini-computer, was used to control the densitometer and to store the data read by it onto a disk. A filtering program, 'TRACE', was used to read through the raw data and to locate the coordinates of all the traces found. The user then ran the editing program, 'TV' to read the traces,

display them graphically on the Tektronix terminal, and perform editing and correcting operations on the traces. Finally, the edited traces were plotted on a plotter and written onto a disk file by the output program 'SCRIBE'.

In contrast to the manual systems, of the late 1960's and the early 1970's, the automatic system on NOVA-3 computer took only two to three hours to digitize a typical record and to get it ready for data processing. Another important difference between the manual and the automatic digitization was in the average number of digitized points per second of the record. The old manual digitizing method resulted in at most 30 to 50 digitized points per second, as compared to 200 and more points per second for the automatic digitization method.

In the 70's, several manufacturers of strong-motion recording instruments also developed digital instruments for a commercial sale. The advantage of these digital instruments, when compared to their analog counterparts, is that the analog-to-digital conversion is built-in, so that data is available in digital form, thus eliminating the need for digitization. It might have been expected by some that in the 80's, these digital instruments would outsell and gradually replace the analog instruments. This decade came and passed by, but analog instruments continue to be available and are still used at most recording stations. In fact, the majority of the recordings of the 1987 Whittier-Narrows Earthquake and of the 1989 Loma Prieta Earthquake in California are on analog records. This may be due to the fact that (1) many of the existing instruments still in use are analog instruments, (2) the purchase price of new digital accelerographs is still high compared to the analog ones, and (3) the electronic chips used in digital instruments are outdated rapidly with the ongoing development in solid state physics, so that it is not clear what might be their useful life. It is, of course, expected that digital instruments will eventually replace the analog ones. But it is also clear that the analog instruments and, hence, digitization of their records, is here to stay for a long time.

*I*1.3 The New Automatic Digitization System

With new developments in personal computer hardware, the automatic digitization systems of 15 years ago (Trifunac and Lee, 1979), can now be modernized. The digitization system which we developed in 1975 employed a photodensitometer which at that time had a value of over $30,000. It had to be interfaced with a minicomputer, which was costly to acquire ($150,000) and expensive to maintain ($15,000 per year in 1976 and $7,000 per year in 1989). It used the Tektronix terminal ($12,000 in 1975), which used to be one of the best high-resolution Graphics terminals some 10 years ago.

The development of inexpensive high-speed personal computers (PC's) interfaced with desktop digital scanners in the 80's now enables the automatic digitization system to be available to users at an affordable price. This report illustrates such new capabilities via a Hewlett-Packard digital Scanjet, interfaced with an IBM or compatible PC, with 286, 386 or 486 Intel processor. Our new and updated software package, consisting of the programs SCAN, FILM, TRACE, TV, and SCRIBE, now runs on a PC interfaced with an

enhanced graphics (EGA or VGA) terminal, and can perform the same functions of the digitization process as before. With the development of better scanners, these programs will continuously be updated and improved.

We note that the hardware and software presented in this report are in no way limited to digitization and time series analysis operations on strong motion earthquake accelerograms only. We will present all aspects of digitization and processing of accelerograms, because this is in the area of our specialty, and because that subject has motivated us so far to develop systems for the required data analysis. From the material in this work, it should be clear that our programs are able to analyze virtually any analog trace, a contour map or a line chart, directly or after only minor modifications.

$I1.4$ Hardware Components

The elements of the new automatic digitization system are shown schematically in Figure $I1-1$. The reading of an 8.5×11 inch film positive is performed by the Hewlett-Packard HP9195A (or HP9190A) Desktop digital Scanner, also called "Scanjet Plus". It is interfaced with the IBM PC or compatible, with 286, 386 or 486 Intel processor, via the HP88295A (or HP88290A) interface card. The PC is equipped with a 100 (a minimum of 40 Mb) hard disc, a 1.2 Mb $5\frac{1}{4}''$, or a 1.5 Mb $3\frac{1}{2}''$, floppy disk drive, and with 640K (RAM) memory. The automatic digitization system will require the disk operating system "DOS" version 3.0 or higher. (At present, it is running on DOS 5.0). A VGA (or EGA) graphics display terminal is interfaced with the PC via Enhanced Graphics Adapter (EGA) card. An HP Laserjet Series III (or II, IIp, and IIIp) laser printer with graphics data memory of at least 512K (preferably 1.5 Mbyte) is also recommended to be connected to the PC.

A typical strong-motion accelerogram record usually lasts for tens of seconds. Sometimes, if the complete length of useful recording is considered, many such records may approach the duration of a minute or even longer. Then, considering a typical SMA-1 70 mm wide film record, one would have to digitize a rectangular area of 70 mm (2.75 in) wide and up to, say, 80 sec (80 cm, 31.5 in) long. The Scanjet is designed to scan a regular size paper 8.5×11 inches. It is thus useful to expand and augment a 2.75×31.5 inch rectangular area into a 8.5×11 inch area, to avoid wasting information, without creating undue complications in the software required to reconstruct the original record.

Figure $I1-2$ shows the solution which we developed in 1976 for use with Optronics densitometer. It can be adopted again, at present, using a photocopy machine, to produce the resolution comparable with that of the Optronics scanner (300 dpi or higher). In this approach, a transparency with fiducial marks (as shown Figure $I1-2a$) is used with the original accelerograph record. This is a profile with three pairs of fiducial marks corresponding to three consecutive sections (zones) of the 70mm record. By carefully positioning the first portion (zone 1) of the record with the top pair of fiducial marks (step 1 of Figure $I1-2b$), it can be photocopied onto an 8.5×11 inch paper. This paper is then put back into the auto feeder of the photocopying machine and the next portion (zone 2) of the record is positioned with the middle pair of fiducial marks (step 2 of Figure $I1-2b$).

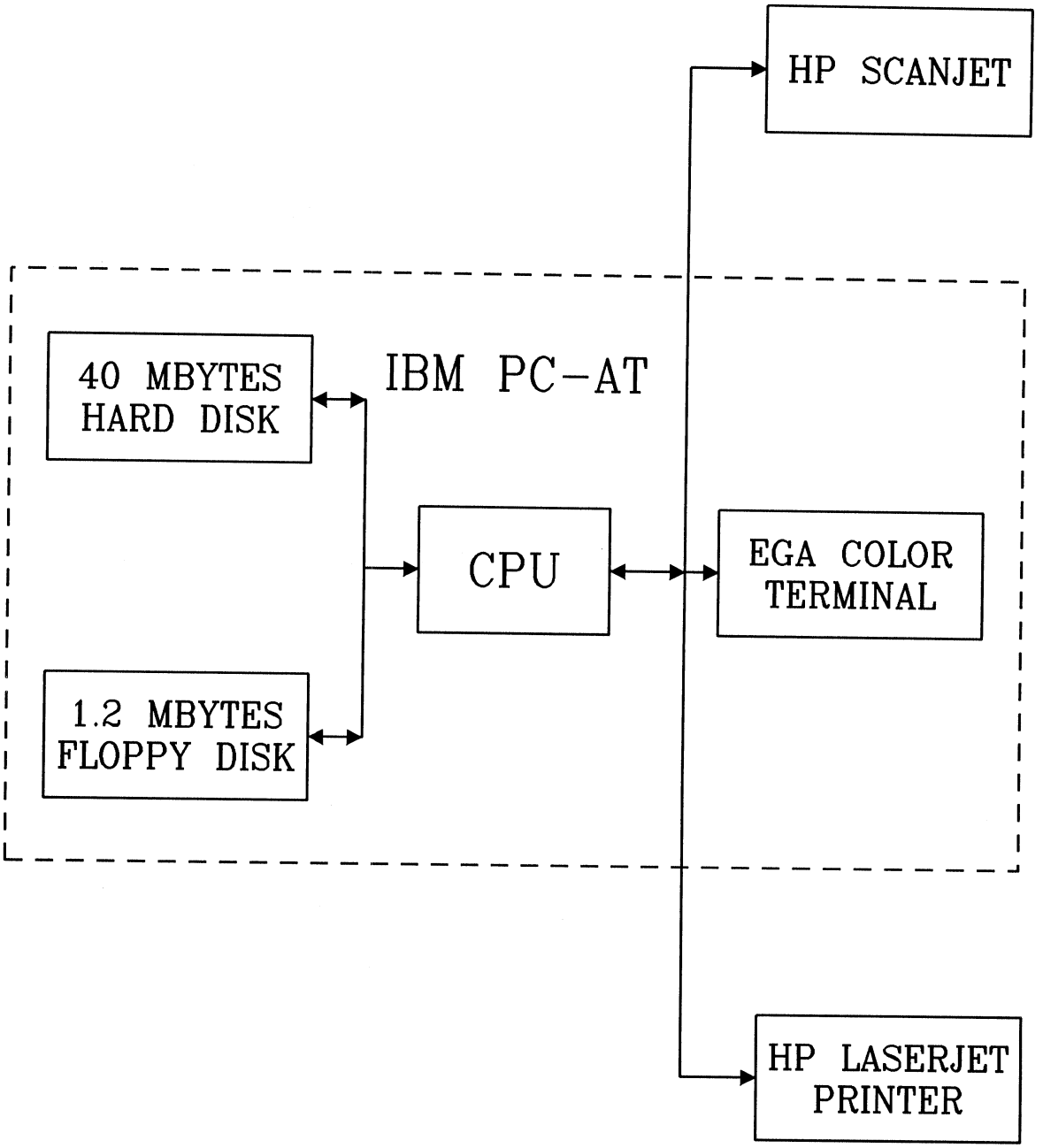
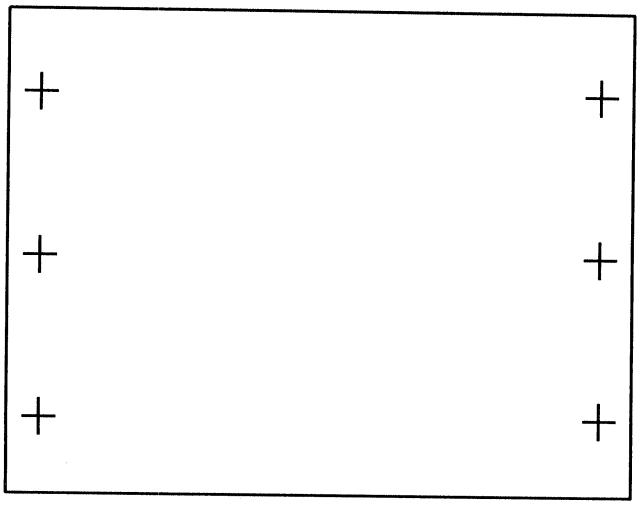


Figure I1 - 1 Hardware components of the automatic digitization and data processing system.

(a) Transparency



(b) Film Duplication onto Transparency

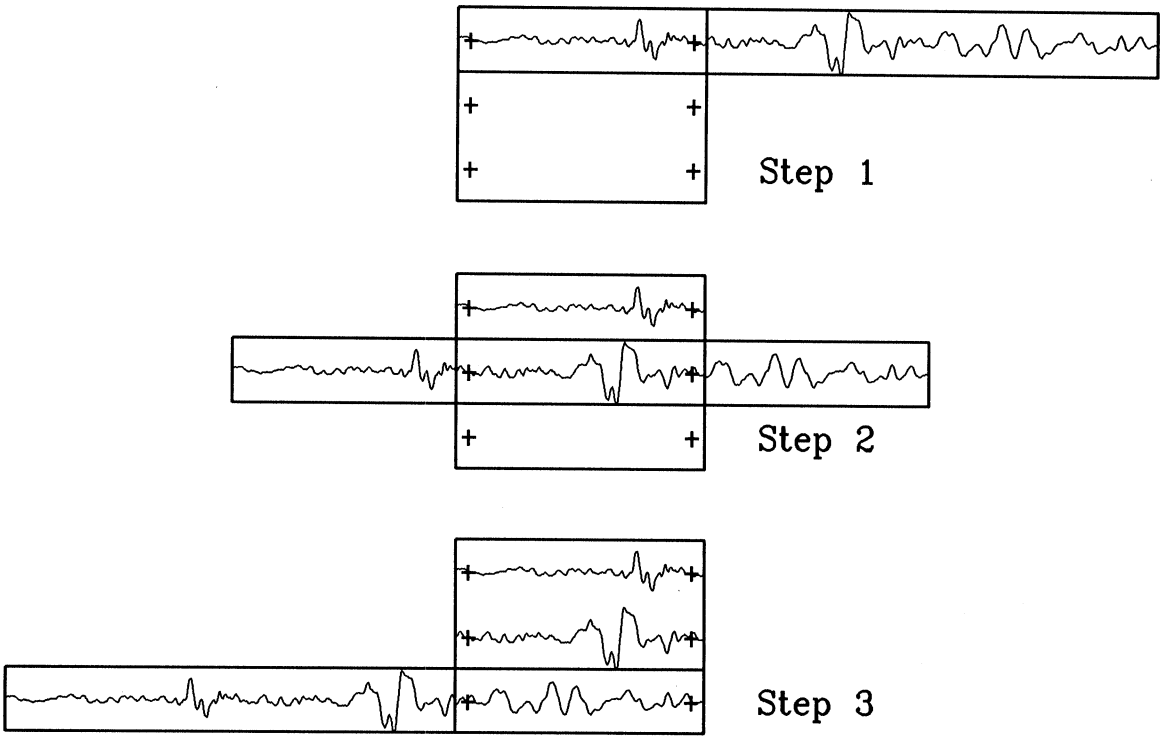


Figure I1 - 2

This process may be repeated for the third portion (zone 3) of the record with the bottom pair of fiducial marks (steps 3 of Figure $I1-2b$). Care must be taken that the left fiducial mark of the current zone is at the same point of the record as the right fiducial mark of the previous zone. The end result is that three consecutive sections of the original record, one below another, are photocopied onto an 8.5×11 inch paper, with consecutive sections marked with corresponding fiducial marks to facilitate subsequent software reconstruction of the original records.

In some cases, when the half-second timing marks are present in both the top and in bottom portions of the 70mm record (and only one of them is needed), only 50mm of the 70mm width of the record may be photocopied. Four consecutive portions of the record, totalling over 100 seconds, can be photocopied onto the single 8.5×11 inch paper.

In another simpler approach, instead of photocopying, consecutive portions of a record, together with the pairs of fiducial marks on a transparency, only one segment can be scanned by the scanjet and written onto the successive disk files. A program can then read all the successive files and assemble them into one continuous disk file. This file will correspond to the one from scanning the photocopy with consecutive sections of the original record, one below another, all with the corresponding fiducial marks. It is seen that this procedure enables one to digitize very long accelerograph records essentially without any limitations on the record duration. The HP Scanjet can also scan metric size paper (A4 format). The above procedures of photocopying the record and all the subsequent digitization programs can also be run for digitization using A4 paper, without any major changes. Alternatively, a 12-in record (wide film with 13 or more components of accelertion) can also be scanned from top to bottom (instead of from left to wright). A program can then switch the data back to be from left to right.

$I1.5$ Noise Characteristics of the New System

The Response and Fourier amplitude spectra of digitization noise, representing the overall automatic digitization process, are next evaluated. This will describe the amplitude and frequency range in which the digitized accelerograms will provide accurate representation of the recorded motions. In general, the amplitude of this noise may depend on the resolution of the scanner, but for this, as for the optical scanner we described in 1979, it will depend mostly on the thickness of the acceleration trace on the film, and on the length of the record. With the old digitization methods, in comparing the recordings on acceleration and displacement tranducers (Trifunac and Lee, 1974), it was found that typical digitization noise may result in "ground displacement" amplitudes of up to several centimeters.

In dealing with semi-automatic hand digitization (Trifunac and Lee, 1973), the resolution (in terms of the number of digitized points per physical length on the record) of digitization plays an important role in the noise characteristics of the system. In automatic digitization this physical resolution of the system (in pixels per mm) can be chosen sufficiently small not to affect the noise amplitudes. For the automatic digitization system

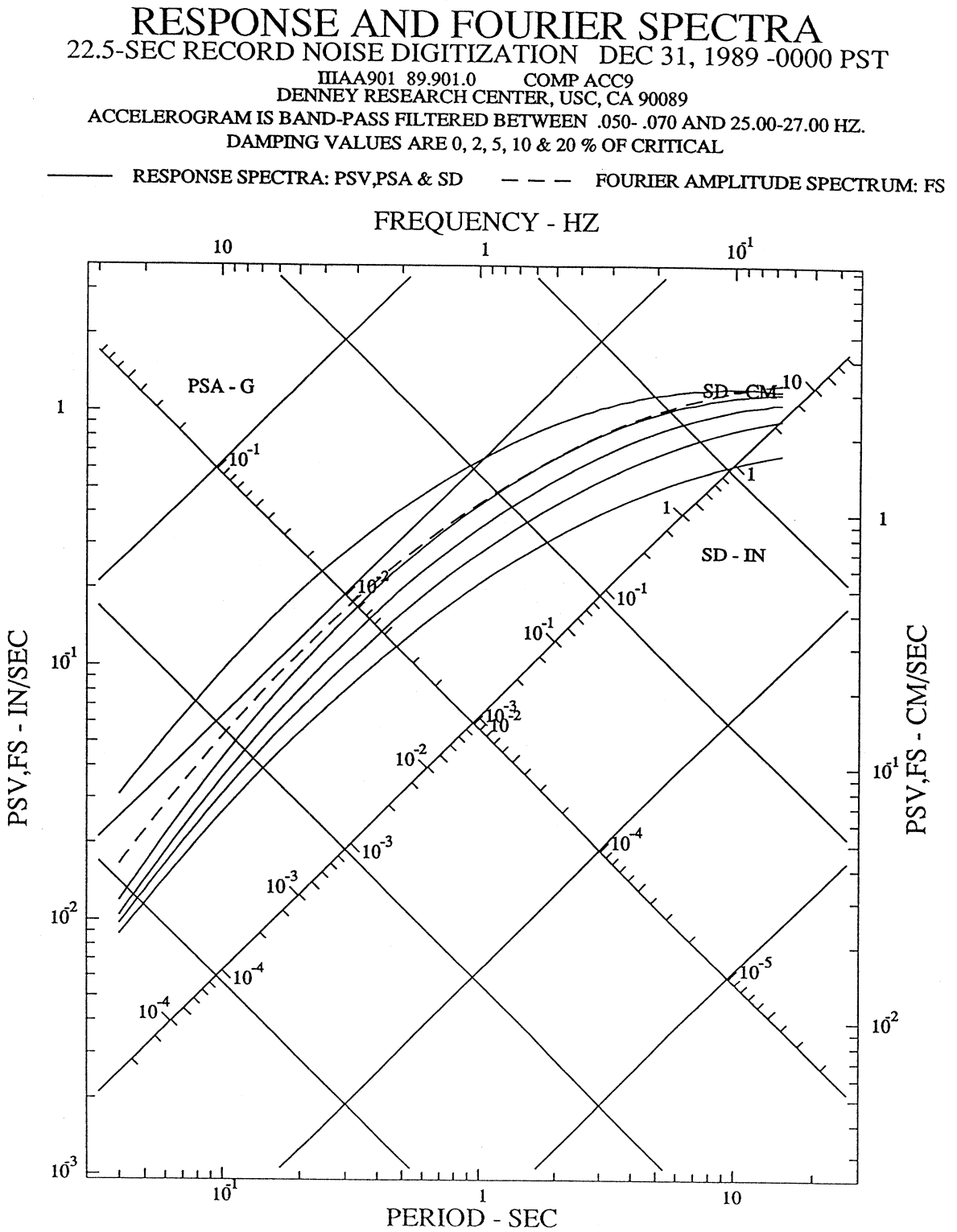


Figure I1 - 3 Noise spectra of a 22.5-sec. record.

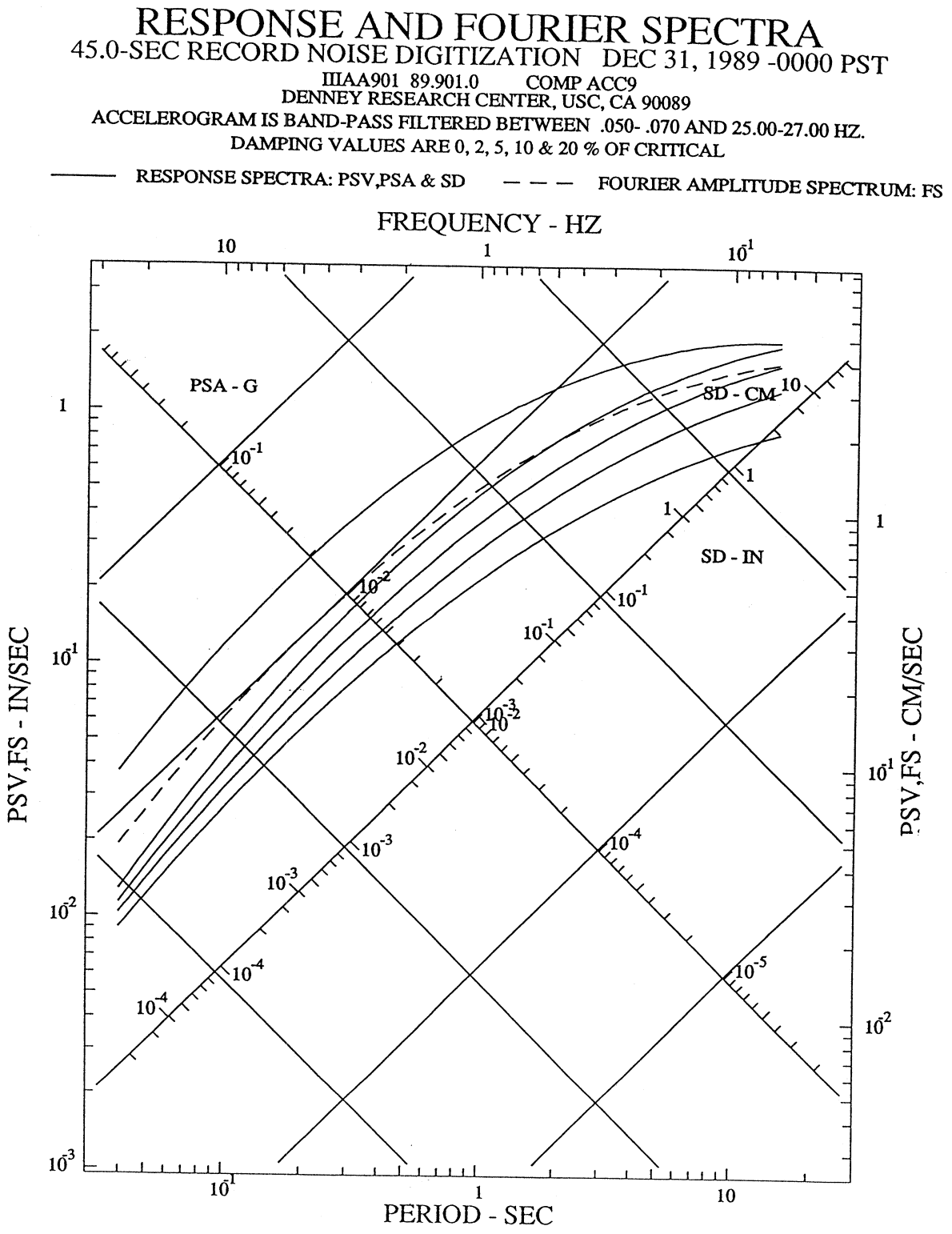


Figure I1 - 4 Noise spectra of a 45.0-sec. record.

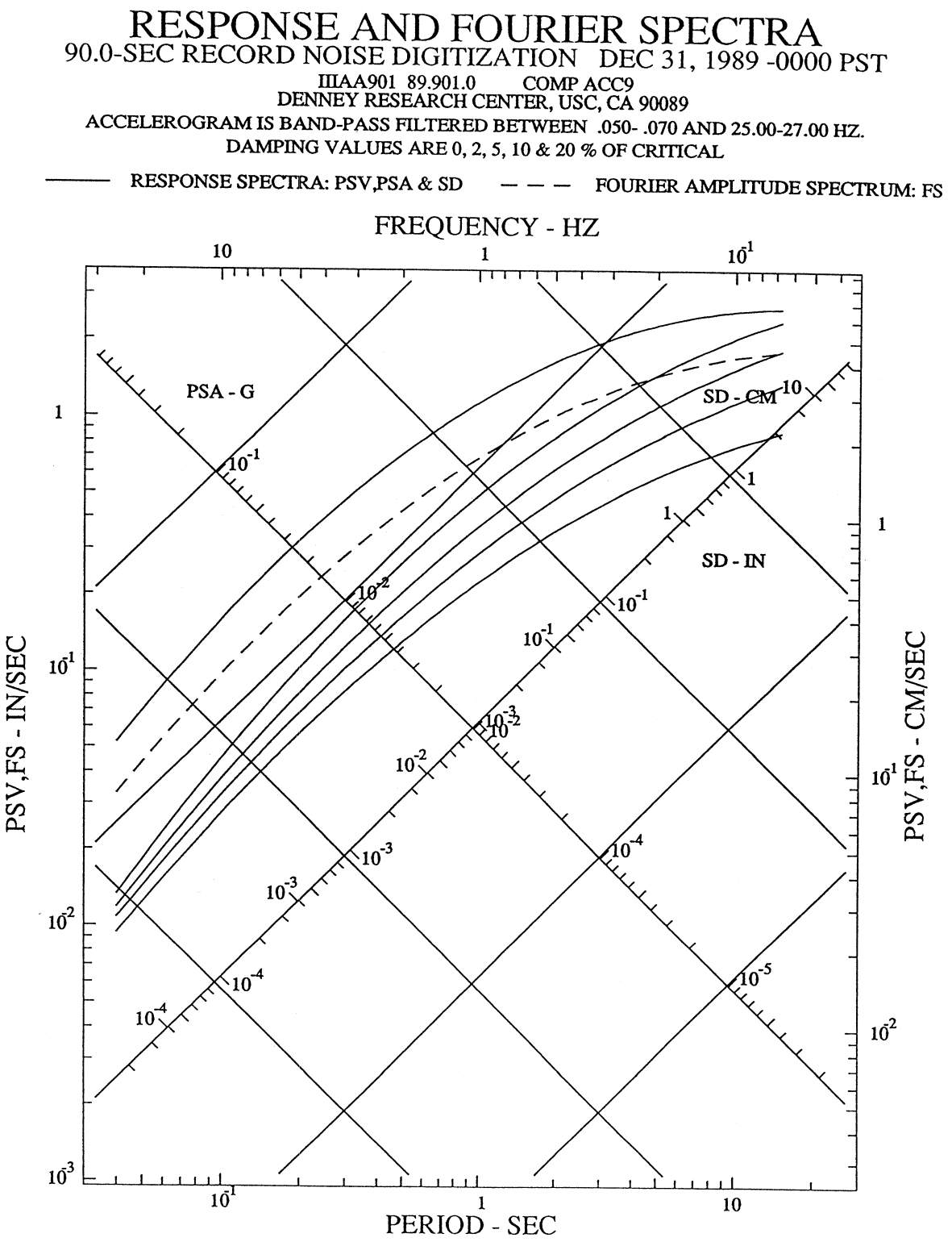


Figure I1 - 5 Noise spectra of a 90.0-sec. record.

using photodensitometer (Trifunac and Lee, 1979), a resolution of 200 points/cm is sufficient (pixels $50\mu \times 50\mu$). The noise amplitudes, then, are dependent more on the thickness of the traces of the record to be scanned. In the new automatic digitization system, a typical resolution is 600 points/inch (dpi). For a record with a time scale of 1 cm/sec, 600 dpi corresponds to 236 points/sec and, hence, to a Nyquist frequency of 118 Hz, which is more than sufficient.

To create "noise acceleration traces," several SMA-1 accelerograms were selected. For each record, the pair of baselines was then digitized, one as a "zero" acceleration trace and the other as a zero baseline. Together with the time trace, all were scaled, and instrument and baseline corrected. The final acceleration data were band pass filtered in the frequency range from .07 to 25 Hz. Response and Fourier amplitude spectra were then calculated. Figures $I1-3$ through $I1-5$ show the smoothed average spectral amplitudes for records 22.5, 45 and 90 seconds long respectively. It can be concluded from these figures that the overall spectrum amplitudes are similar to those for the automatic digitization system on NOVA-3 computer (Trifunac and Lee, 1979), with the present long period noise amplitudes lower than before.

$I1.6$ Use of Numeric Keys for Crosshair Cursor Control

It is assumed here that the user is familiar with the functions of the numeric keys on the right-hand side of the typical keyboard. Figure $I1-6$ shows a diagram of these keys. The Num-Lock key can be pressed to have the Num-Lock light either on or off. When the crosshair cursor appears on the screen, it can be moved in all eight directions, as illustrated by the arrows in the numeric keys 1-9 in this figure. Thus, to go to the right ($\rightarrow$), the user should press the key 6. The crosshair cursor will advance to the right for one small step. The user may keep the right ($\rightarrow$) key down to continue moving the crosshair further to the right, until it gets to the desired position. Each time the user wants to change direction, the corresponding key should be pressed, keeping it down continuously, as desired. To define a point on the screen occupied by the crosshair curser, the user should press the enter key or, if the Num-lock light is on, either the OK[5] or the enter key. The (+) and (-) keys are used for changing the size of the crosshair cursor.

The next four chapters will describe the programs used for automatic digitization of accelerograms: SCAN, FILM, TRACE, TV, and SCRIBE. Old versions of these programs have been discussed in some detail, and the overall process of automatic digitization was presented in our first report on this subject (Trifunac and Lee, 1979). Many ideas, procedures and operator tasks have changed little or not at all in this transition to a personal computer hardware. Numerous new software and algorithm improvements will not be obvious to a new–comer to this subject. Also, many steps and procedures have evolved from our experience in working with the old automatic accelerogram digitization system. For brevity we will not explain or justify all such steps and inovations here, but suggest that the interested reader peruse our 1973 and 1979 reports. At the time when this report is going into print, new options and other updated version of the programs are continuously

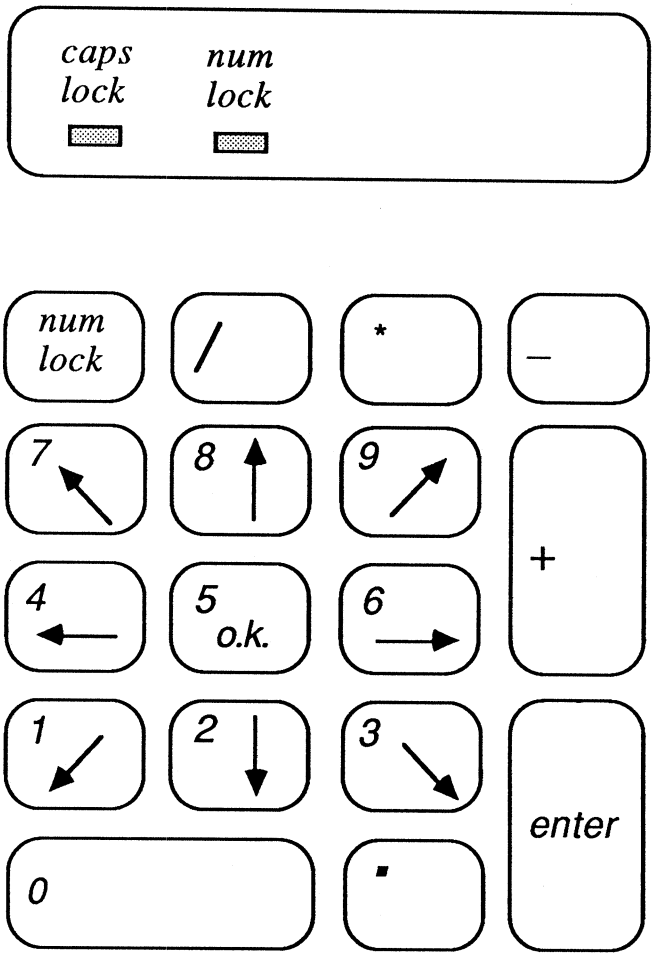


Figure I1 - 6 Numeric keypads used for crosshair cursor control.

being developed. Therefore the following chapters will describe the most recent (current) version of these programs.

*I*2 SCAN and FILM

*I*2.1 Introduction

Instructions on connecting the scanner with the PC by the HP 88290A (or HP88295A) interface card are well documented in the Hewlett-Packard User's Guide and will not be repeated here. It is assumed that the user can read this guide and is familiar with the manual before proceeding. Once the 8.5 × 11 inch positive or paper copy of the film is made, it is placed face down onto the Scanner's flat surface, so that the beginning of the record is at the lower edge of the scanner.

The program SCAN will be used to scan the record image and store it onto a disk file. Under normal circumstances, the record will be scanned at normal intensity without shades of Gray/Color at a resolution of 600 dpi, or for thick traces with low recorded frequencies with 300 dpi. In all cases, 100% of the paper (8.5 inch by 11 inch) will be scanned. With the 300 dpi option, the image file will consist of just over one Mbytes and can be stored onto a high density floppy disk.

The scanning process, will take several minutes. The program FILM will next be used to define the reference points and the lines of the record. There are 3 types of reference lines: "Time-Hacks", "Half-second" lines and "Baselines". Reference points include fiducials, common edges between adjacent sections of the record, and upper and lower limits. All these points and lines, if present, have to be defined (Trifunac and Lee, 1979).

It is important to identify correctly the reference lines. If the trace identification program (TRACE) misses or never receives information on the starting points for a baseline (the solid straight line), this line will be considered as an acceleration trace and the program's ability to deal with intersections between acceleration traces and baselines will be reduced. If a dashed reference line (time-hacks or half-second marks) is missed, each separate dash will be stored on disk as a separate line segment. The user will have to concatenate them, one by one, by the editor program, TV. There can be as many as 75 such broken segments, resulting in considerable and unnecessary work.

As program TRACE (next chapter) reads through the raw data file, it announces on screen how many of the reference lines remained to be identified. If it fails to identify all, the user should stop the program TRACE and go back to FILM to find out why. It is probably so because the reference coordinate was not defined correctly. It might also be because a fiducial mark or common-edge was misidentified as being a reference line, for example.

*I*2.2 Program Flow of FILM

*I*2.2.1 Initialization

The user has just scanned the record using the program SCAN, and is ready to run the program FILM. A special reference file, REFS.DAT, will be created and updated during 'FILM'. When FILM starts, it will first inquire if the user desires to (1) create a new REFS.DAT file for a NEW SCAN, or (2) edit the old REFS.DAT file of an OLD SCAN. Option 1 is for a user who has just scanned a record and is running FILM for that record for the first time. Option 2 is for one who wants to change and edit a previously defined REFS.DAT file from previous runs of FILM.

FILM will clear the screen and the raw data of the beginning portion of the record will begin to appear.

*I*2.2.2 Options (Figure *I*2 – 1)

FILM then gives the user the following options:

MORE ^"R"AW Data
"Q"UIT, ^"B"LOWUP
OR "M"EASURE?

"R" (Raw data) will activate the crosshairs, expecting the coordinates of two opposite corners of a rectangular region to be defined. FILM will then display the RAW DATA within the rectangle outlined by the user. "^R" will result in the RAW DATA in the whole screen window to be displayed.

"Q" (Quit) will allow the user to exit from FILM after the reference points have been defined. The file REFS.DAT will contain the coordinates and types of all reference points or lines defined.

"B" (Blow-up) will activate the crosshairs, expecting the coordinates of two opposite (diagonal) corners of a smaller rectangular window to be defined by the user. FILM software will then reset and rescale the screen, and the region defined will now be enlarged to fill the whole graphic screen with the raw data of the window just defined above.

"^B" will result in the screen cleared and an initial portion of the raw data in the screen replotted at the same scale.

"M" (measure) allows the user to define coordinates of seven types of reference points or lines:

(1) "B"ASELINE: beginning of a solid "zero" baseline.

(2) "H"ALF-SECONDS: beginning of dashed or square-wave half-second ticks.

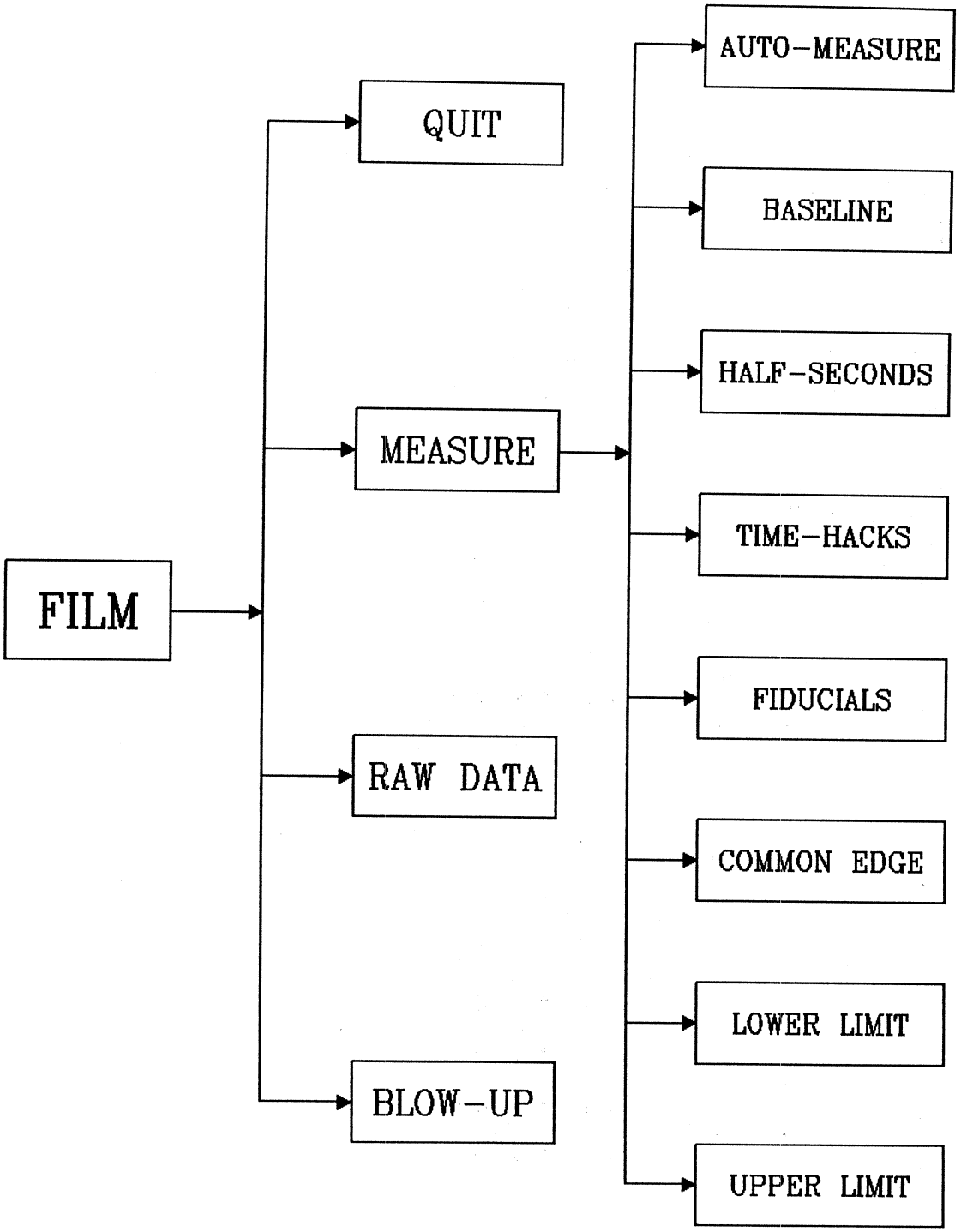


Figure I2 - 1 Flow-chart of program FILM.

(3) "T"IME-HACKS: beginning of a dashed line of a clock time-hacks.

(4) "F"IDUCIALS: the fiducial reference points of different sections.

(5) "C"OMMON edge: a point or a horizontal line marking the common edge between neighboring sections.

(6) "L"OWER edge: lower limit in Y to be considered by program TRACE.

(7) "U"PPER edge: upper limit in Y to be considered by program TRACE.

The option "A" for auto-measurement will allow all the above baseline, half-seconds, time hacks and fiducials (respectively "types" 1 to 4) in a given vertical section to be measured. A vertical crosshair line will first come on. Using keypad keys, the crosshair line can be moved to an appropriate cross-section and the point can be defined.

FILM then indicates on the screen

TYPE n: 0-4, 0 to
IGNORE, -n to DEL

All the raw data traces that intersect the vertical crosshair will be marked and a request made for type # identification:

TYPE #:

acceleration traces are of "type 0" and are ignored. A previously defined point of type n can also be deleted by typing in -n, with n the corresponding type number of the previously defined point.

*I*2.2.3 Methods of "Measurement"

Having specified "M", as explained in the previous section, FILM responds with:

AUTO-MEASURE = (1) "B"ASELINE (2) "H"ALF-SEC (3) "T"IME- HACK
(4) "F"IDUCIAL "C"OMMON-EDGE "U"PPER or "L"OWER LIMITS?
"B", "H", "T", "F",
"C", "U", "L", OR
"A"UTO MEASURE?

"B", "H", "T", "F","C", "U", and "L" will correspond to one of the seven types of reference points or lines described above. Picking any one of these (except "A", which has been described) will result in a little crosshair '+' appearing in the middle of the screen. Using keypad keys, the crosshair can be moved to the desired location and a point defined. FILM will then reply with the question:

"A"DD, "D"EL OR "I"GNORE

"A" will "accept" the measurement, and FILM will then draw an arrow labeled with the corresponding letter identifying its type. "D" is used to delete an earlier measurement. To delete an earlier measurement, the user can call "M"EASURE, center onto a previously defined point, at the tip of the arrow, define the "new" point where the earlier measurement was made, and when the message "A"DD, "D"EL or "I"GNORE? : comes on, type D. The previous measurement will then be deleted as indicated by a box enclosing the coordinate being drawn. Answering "I" will simply ignore the current measurement made.

*I*2.3 Sample Session

In what follows, the user has a record photocopied in sections onto an 8.5 × 11 in paper which is to be scanned by the HP Scanner with resolution of 300 dpi (points/inch). The scanner image file, with this resolution, will be ~ 1 Mbytes and the user may store it onto a high density floppy disk in drive A.

In this sample session:

[Brackets indicate computer activity]
(Explanations are given in parenthesis)
User keyboard entries are underlined.
↩ denotes carriage return or ENTER

*I*2.3.1 Task 1 : Scanning

Step # Transaction/Explanation

1. A:↩
   (User inserts an empty formatted high-density floppy disk into drive A)

2. C: SCAN ↩
   (User runs the program SCAN in drive C to scan the page of a record; the scanner should be on with the record page facing down, and the beginning of the record at the bottom edge of the scanner).

3. (SCAN will first ask the user for the scan image filename, and under normal circumstances, will scan the full page at 300 dpi. The whole process will take about 10 to 15 minutes.)

*I*2.3.2 Task 2: running FILM

Step# Transaction/Explanation

1. FILM ↩
   (To execute the program FILM)

2. [Screen erase]

```
************
*  FILM    *
************
```

FILM VERSION 3.0

3. Filename of Scan Image (A20) [____ .RAW]: A:IMAGE.RAW ↩
   (User inputs scan filename)

4. (1) CREATE NEW REFS.DAT FILE FOR NEW SCAN, OR
   (2) EDIT OLD REFS.DAT FILE OF OLD SCAN? (1/2): 1 ↩

   (User is to define the file REFS.DAT from scratch for the image file of the record just scanned).

5. Starting Graphics Mode of the EGA Terminal,...
   PAUSE
   Hit return to continue... ↩

   (reminds user to check that the Num-Lock and Caps-Lock keys are on).

6. SCANNER UNITS USED, PTS/IN, DPI[300]: 300 ↩

   (300 dpi is the resolution used in this example of scanning the record).

7. [Screen is erased; after a few seconds, raw data of the beginning portion of the record will begin to appear on screen].
   MORE ^"R"AW DATA
   "Q"UIT, ^"B"LOWUP
   or "M"EASURE? B

   (User wants to blowup an area to be defined using the crosshairs).

   [crosshairs come on]

   (Using keypad keys, user enters the coordinates at 2 opposite corners of a rectangular area).

[defined rectangle is drawn on screen]

CONFIRM, Y/N: Y

(User confirms it)

[Screen erased; raw data of the beginning portion within the window are displayed in a scale such that the window area now takes up the whole screen].

8. MORE ^"R"AW data
"Q"UIT, ^"B"LOWUP
or "M"EASURE? M

(User wishes to perform reference measurement routine)

AUTO-MEASURE: (1) "B"ASELINE, (2) "H"ALF–SEC (3) "T"IME- HACK
(4) "FIDUCIAL "C"OMMON-EDGE "U"PPER or "L"OWER LIMITS?
"B", "H", "T", "F",
"C", "U", "L", or
"A"UTO MEASURE: A

(User requests FILM to perform automatic reference measurements).

[Vertical crosshair line comes on]

(Using keypad keys, user can move the crosshair line to an appropriate x-value and press ENTER)

TYPE n:0-4, 0 TO
IGNORE, -n TO DEL
(All raw data that intersect the vertical crosshair will be marked and the type number will be requested from the user)

TYPE # :3

(The first raw data marked is a time-hack trace (type 3); other traces that may be marked are half-second (type 2), baseline (type 1) or acceleration (type 0) traces; this question will be repeated until all raw data of the section are marked.)

9. "B", "H", "T", "F"
"C", "U", "L", or
"A" UTO MEASURE F

(User now wants to define a fiducial mark directly; a little crosshair will appear in the middle of the screen; using keypad keys, user will move the crosshair to the center of the fiducial mark and press ENTER.)

"A"DD "D"EL or
"I"GNORE? A

(User types "A" to add this point to the list of reference points defined; an arrow with initial F is drawn, marking that the coordinate is taken.)

10. "B", "H", "T", "F"
"C", "U", "L", or
"A"UTO MEASURE:↵

(User is ready to rap up after defining all the reference points.)

MORE ^"R"AW DATA
"Q"UIT, ^"B"LOWUP
OR "M"EASURE? Q

(User orders FILM to Quit.)
[screen erased]

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[Program Stops]

(All reference points and lines have been defined and storted in the file REFS.DAT. User is now ready for the next program: TRACE.)

*I*3 TRACE

*I*3.1 Introduction

Program TRACE reads through the RAW DATA file "IMAGE.RAW" locating groups of 'shades of gray' (black dots) along the y-axis that may represent the cross-section of a trace on the film. Initially, a trace segment is begun with every group of gray levels it encounters, and, subsequently, as TRACE moves along the x-axis, further groups of gray in the y-direction are associated with earlier groups, if they are 'close enough' according to certain empirically chosen criteria. In this way, continuous segments are built up, while scratchy segments caused by various imperfactions in the image are discarded if they do not accumulate a required minimum number of 'points'.

Eventually, ambiguous situations are encountered. When this happens, TRACE will examine the problem in greater detail, trying to resolve any confusion resulting from the intersection of segments, or from the presence of scratch marks among the segments. In general, properly identified reference lines will always be pulled through, and intersections with them of the adjacent acceleration traces, if at a sufficiently steep angle, will be resolved correctly. Difficulties arise when traces merge over a substantial length, when traces disappear (gaps), or when two or more traces simultaneously intersect a reference line. When TRACE cannot resolve a problem, the new "pulse" will be used to create a new segment, and earlier disjointed segments will eventually be closed out. Note that TRACE does not 'look ahead'. It deals only with the "pulses" currently in buffer, and attempts to associate them with segments already in existence, the building ends of which lie in the immediate vicinty of the pulses.

As segements are built up, they are each stored on disk as a y-coordinte file SCxxx.DAT, where xxx is a numerical suffix, from 001, 002, 003,... All other information on the segment is stored on a corresponding record in the parameter file PARAMS.

*I*3.2 Program Flow of TRACE (Figure *I*3 – 1)

*I*3.2.1 Initialization

When TRACE begins, it initializes the various parameters created by the previous run of FILM. It then requests the user to provide the leftmost and the rightmost limits, in x scanner units, to begin and to end the scan. For an 8.5×11 inch paper scanned by FILM with a resolution of 300 dpi, the scanner units in the x-direction will range from 5 to 3300. The user may set the leftmost beginning x to some scanner unit ≥ 5, but which is less than the minimum x-coordinate of any of the traces on the paper. One may set the rightmost ending x-value to anything beyond 3300. TRACE will then read the file 'REFS.DAT', created by FILM, containing the coordinates and types of the reference lines and points defined earlier.

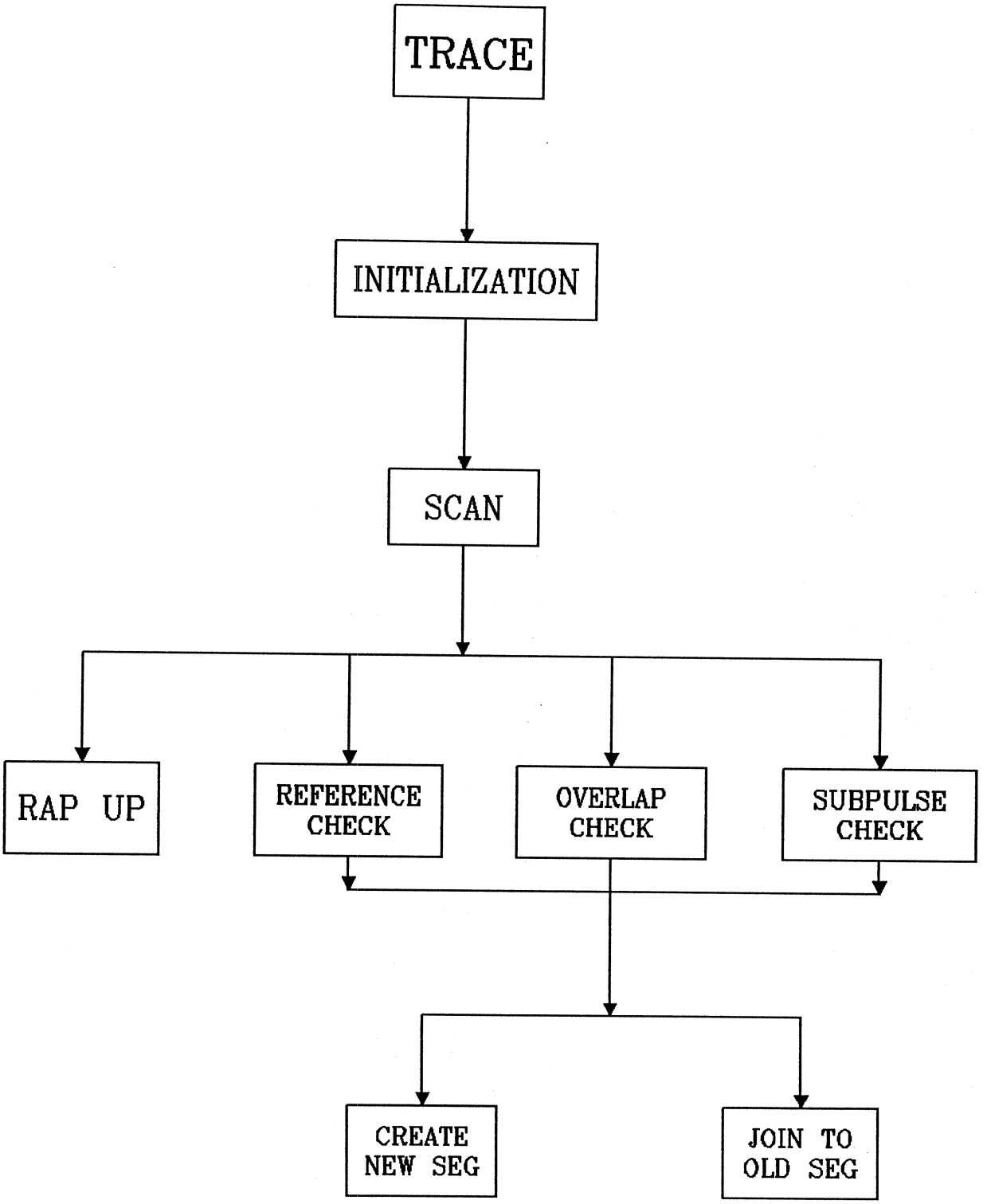

Figure I3 - 1 Flow-chart of program TRACE.

*I*3.2.2 Scanning

With initialization complete, TRACE begins to read the digitized RAW DATA file 'IMAGE.RAW', skipping through the blank area at the beginning, until the starting x-values of one or more traces are encountered. TRACE will then loop through the input buffer looking for distinct groups of densities in the y-direction. Each such grouping, which might represent the cross-section of a trace, is put into a pulse buffer in memory, consisting of a group of densities contiguous in y, together with the pulse width and the bottom y-coordinate.

*I*3.2.3 Reference-Line Check

First, TRACE checks to see if the pulse found is part of any existing reference line segment. The required condition is to be sure that the y-coordinate of the center of the pulse matches closely with the center of the end of any of the reference lines in memory. If this criterion is met, the pulse is associated with the corresponding reference line segment.

*I*3.2.4 Overlap check

If it fails the above reference test, but follows consecutively after the last pulse of other existing segment, with the pulse's center lying within the expected projected direction the given segment is 'pointing', and if there is no overlap with any other segment, the pulse is associated with that segment. If more than one segment overlap the pulse, the pulse will be looked at in a greater detail.

*I*3.2.5 Subpulse check.

TRACE examines the pulse for 'subpulse' that can occur when two or more segments are intersecting. TRACE will try to create subpulses that can be associated with the overlapping segments according to an empirically adopted scoring system.

*I*3.2.6 Creating a New Segment

Any pulse that fails to be associated with any existing segment will eventually be defined as a new segment. When a segment is created, a new segment number is assigned and all known and necessary information about the segment will be stored and updated periodically in an array in the memory. Up to a maximum of 50 segments are in active memory. When there is no room, segments whose ends were left far behind, and whose lengths are insufficient to warrant keeping, are removed and destroyed. Segments that are long enough, but which are now too far away in the x-direction to consider, will be closed and written onto the disc to make room in memory for new segments.

*I*3.2.7 Adding to an Existing Segment

The center y-coordinate of each pulse that can be associated with an existing segment is put into an array in memory. Each array has room for 64 coordinates for up to 128 segments. When they are full, they are written to the SCxxx.DAT file of each corresponding segment, where xxx ranges from 001 to 999.

*I*3.2.8 RAPUP

Once the entire image file has been read, the segments in core are written onto disk and closed. A summary file, 'SUMUP.DAT' is written, containing the maximum x- and y-values found in the segments, and the total number of segments found. The user is now ready to run the next program, TV.

*I*4 TV

*I*4.1 Introduction

Once the program, TRACE, has finished, the trace segments created are stored in disk files. The file PARAMS.DAT contains stored information on each segment, including the file name suffix where the y-coordinates can be found, the first x-coordinate, file type (0, 1, 2 or 3), etc.. The y-coordinate files are named SCxxx.DAT, suffixed with xxx a 3-digit number, 001, 002, 003,..., 999. The total number of such files for each record digitized will vary, depending on its size and quality.

With TV, the next program, the user can access the segments, display them on the screen, and perform required editing functions. It is important to note that the SC-files and the file PARAMS are not altered after any editing session. Any editing performed is stored by means of a map file MPxx.DAT which is created by TV. The suffix of the files MPxx.DAT can range from 01, 02, 03, to 99, thus allowing a total of up to 99 editing sessions, which is probably more than enough. As the editing progresses, the operator, through editing, will create single traces running continuously from the left side of the scanned image to the right.

A typical editing session involves examining the segments in each zone section by section. Initially, the operator may request all segments of all zones to be displayed on the screen, so as to be able to mark down all those segment numbers starting from the left margin that do not go all the way to the right margin. Then, using the crosshair cursor, the trouble spots may, one by one, be blown-up to a higher resolution for editing.

The editing involves truncation, splitting, filling-in, deleting and creating of segments. All these changes are recorded on the map file MPxx.DAT. The final phase of the digitizing process, performed by the program SCRIBE, will then read the map file to plot and write onto disk the full-length traces.

The first editing session, after running TRACE, begins by creating the map file from scratch. TV does this by reading the PARAMS.DAT file and the SCxxx.DAT files and puts the information onto the map file MP00.DAT. This is the original, uneditted version that should be retained for possible reference. The user should instruct TV to record all subsequent editing changes on other map files, say MP01, MP02,..., up to MP99.

*I*4.2 Program Flow of TV (Figure *I*4 – 1)

*I*4.2.1 Initialization

When TV starts, it initializes the various parameters of each segment created earlier by TRACE. It then reads the file 'REFS.DAT', consisting of coordinates of the reference points and traces defined by FILM. TV will next request from the user the map file suffix MPxx, where the serial number and filename SCxxx of the traces are available. A zone

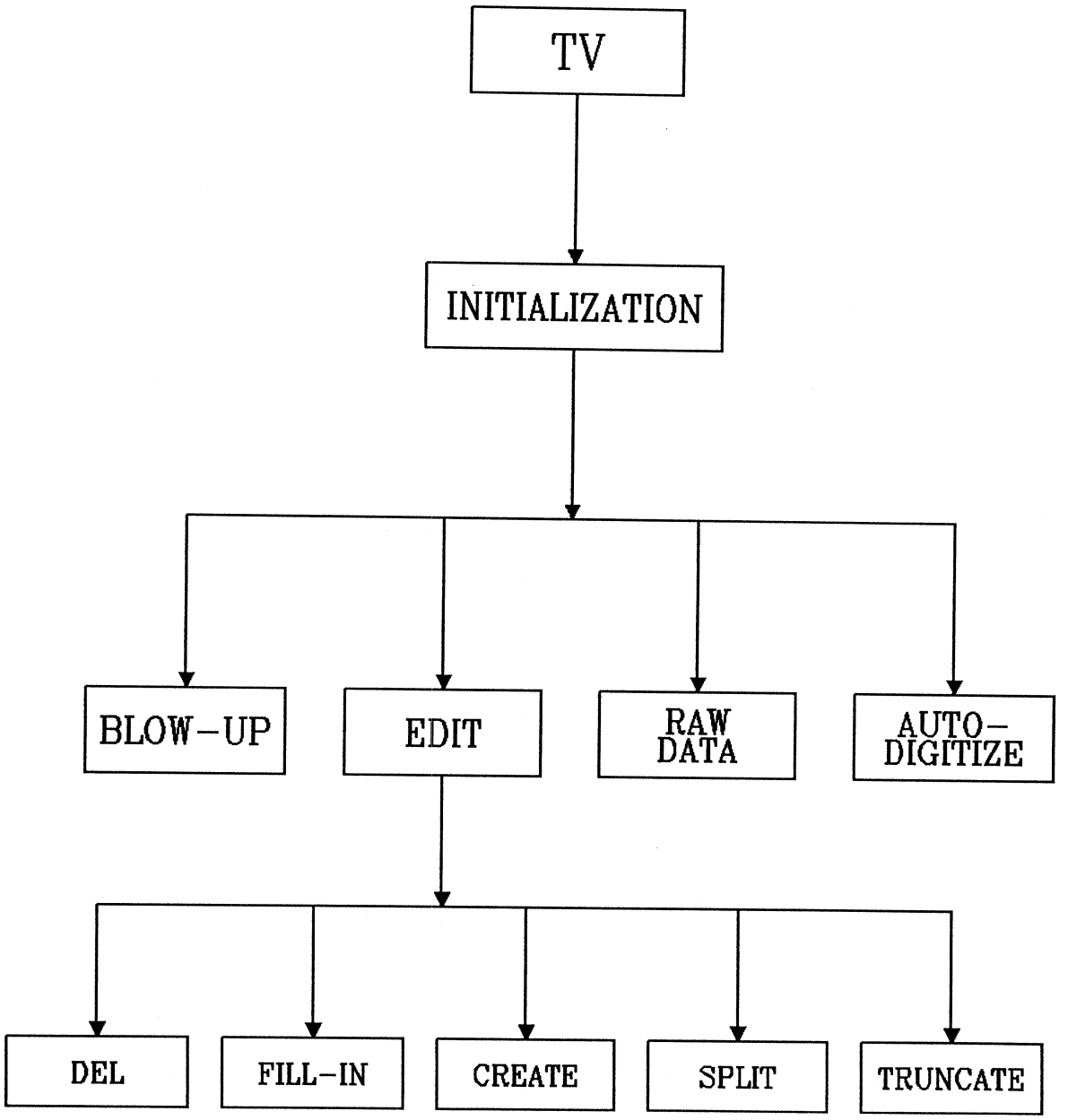

Figure I4 - 1 Flow-chart of program TV.

(film section) number is also assigned to each segment of the traces. This is to speed up the searches of segments when they are to be displayed on the screen. The screen is then reset and cleared. The coordinates of the reference points and traces are displayed as arrows, labelled with their corresponding types on the screen.

*I*4.2.2 Plot Request

TV then requests from the user information on whether to display all or some of the segments, to go on to the next step, or to quit and exit from TV:

"Q"UIT, OR PLOT
"N"ONE, "S"OME
OR "A"LL SEG?

A response of "A" (all segments) will be followed by another question:

```
ZONE: 0     1     2     3
        4     5     6
              7 :
```

Zones 0 though 3 correspond respectively to the bottom through top zones of the film. Zone 4 corresponds to zones 0 and 1, 5 corresponds to 1 and 2, 6 to 2 and 3, and 7 corresponds to all the zones.

A response of "S" (some segments) will result in the question from TV:

SEG:

where the 3-digit serial numbers of up to 5 segments are to be input by the user. If less than 5 segments are to be input, the user can simply hit carriage return (or the enter key) once after the last serial number. A response of "N" will instruct TV to go on to the next step of the program. A "no" response (carriage return) will set TV to get ready to quit.

*I*4.2.3 Menu

With the response of "A" or "S" in the above step, TV will display the requested segments on the graphic screen. Only those segments that are within the current screen window will be plotted. Each segment is labelled with its serial number. If the end of the segment is also within the window, the end will be shown by a small triangle.

After the segments are all displayed on the screen, TV requests from the user directions for the next step with the following list of MENU:

"A"UTO DIGITIZE
^"B"LOWUP "E"DIT

OR ^"R"AW DATA?

"B"(blowup) will activate the crosshair, expecting the coordinates of two diagonally opposite corners of a (smaller) region to be defined by the user. TV will then reset and rescale the screen and the region defined will now be enlarged to fill the whole screen with all the segments in that region displayed.

^"B" will result in all the segments in the current screen windows to be replotted in the same scale.

"E" (Edit) will result in sending the control to the editing routine.

"R" (Raw data) will also activate the crosshairs, expecting the coordinates of two diagonally opposite corners of a rectangular region to be defined. TV will then display the RAW DATA within the rectangle outlined by the user. Note that the size and scale of the current window is unchanged.

^"R" will result in the RAW DATA in the whole screen to be displayed.

"A" (Auto digitize) will again activate the crosshairs, expecting the coordinates of two opposite corners of a rectangular region to be defined. TV will then digitize the RAW DATA within the region resulting in defining a new segment.

A no response (↵) will clear, reset and rescale the screen to the area of the full size record and will then go back to step 4.2.2 above.

*I*4.2.4 Edit

This is the step in TV that controls the editing functions. TV responds with the following list of options.

"D"EL "F"ILL-IN
"C"REATE "S"PLIT
"T"RUNCATE:

"D" (Del) is used to delete (up to a maximum of five) segments. It will result in the question from TV:

SEG :

where the 3-digit serial numbers of up to 5 segments are to be input by the user. Each of the segments input will be deleted one by one on the screen and confirmation for each segment requested:

CONFIRM,(Y/N):

If confirmation is "Y" (Yes), the segment will be deleted from the list of active segments on the map file. If it is "N" (No), the segment will be redrawn on the screen and its deletion is cancelled.

"F" (Fill-in) is to "fill in" a sequence of (up to five) segments. TV will request the user to input from two to as many as five serial numbers. The segments must be entered in the same order as they appear on the screen from left to right. The last point of a preceding segment must be at least one scanner x-unit less than the first point of the next segment following in the list. If this condition is satisfied, TV will connect them with a straight line joining the end points. The joining line will be a solid line if the end points are exactly one x-unit apart, otherwise it will appear as a dotted line on the screen. TV will then request confirmation from the user. If it is confirmed, the two segments will become one with the serial number same as that of the preceding segment, while the serial number of the right segment will disappear from the screen. This process will be repeated for the current segment and for the next segment on the input list.

"C" (Create) is to create a segment manually by the user. TV will activate the little crosshair, expecting up to 20 coordinates to be entered, with the last coordinates entered by pressing the key with period "." instead of Enter (or OK [5]) (see section I1.6). With all the points entered, TV will first rearrange the points in increasing values of x. For each integer value of x (in scanner units) between the first (leftmost) and last (rightmost) points defined, TV will calculate the corresponding values of y, using straight line interpolation between successive points entered by the user. A segment is then defined and displayed on the screen with a serial number assigned by the program.

"S" (split) is to split a segment. TV will request from the user a serial number:

SEG:

The user responds with a three-digit serial number, corresponding to that of the segment to be split followed by two carriage returns. Next TV activates a vertical crosshair, expecting the user to locate the appropriate x-coordinate of the point on the segment to be split. After this, a small crosshair will appear at the chosen point on the segment and the following request will appear:

OK? OR ELSE MOVE
↑ OR ↓ THE SEG?

The user can use the numeric keypad keys to further move the crosshair left or right along the segment and then press Enter or 'OK'. The segment will be split in two, resulting in a new segment with a new serial number to appear left of the point chosen. The original segment will end at the chosen point.

"T" (Truncate) is to truncate the tail (right) end of a segment. This proceeds the same way as the option "S" (SPLIT) above, with the exception that, at the end, no new

segment to the right of the point will be created, but will be deleted, after confirmation from the user.

*I*4.3 Sample Session

[Brackets indicate computer activity]
(Explanations are given in parentheses)
User keyboard entries are underlined.

Step # Transaction/Explanation

1. TV ↩
   (To execute the program TV)

2. [Screen erase]

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3. FILENAME OF SCAN IMAGE (A20) [___ .RAW]: A:IMAGE.RAW ↩
   (User inputs the scan filename)

4. Starting Graphics Mode of the EGA Terminal,...
   PAUSE
   Hit return to continue... ↩
   (reminds user to check that the Num-Lock and Caps-Lock keys are on)

5. [Screen erased]

```
**********
*   TV   *
**********
```

   MP##: MP ↩
   (User wants a new map file.)
   [computer process for 5 to 10 seconds]

6. [screen erased]
   [reference coordinates are displayed by arrows on white background]

7. PLOT "N"O, "S"OME
   OR "A"LL SEG A

   ZONE: 0 1 2 3
   4 5 6
   7: 7
   (User wants all segments of all zones to be plotted)

[segments of all zones and their labels come on to the screen]

8. "A"UTO-DIGITIZE
^"B"LOWUP "E"DIT
or ^"R"AW DATA: B

(User wants to examine in detail an area to be defined using the crosshairs)

[crosshairs come on]

(Using keypad keys, the user enters the coordinates at two diagonally opposite corners of the rectangular area of interest)

[the rectangle defined is drawn on the screen]

CONFIRM, Y/N:Y

(User confirms it)

9. [Screen erased]

[All segments within the window are displayed in the full screen; they are labeled at their beginning and/or where they enter the window; their ends are marked with a small triangle, but not where they exit to the right end of the window (Figure $I4-2$)]

10. "A"UTO - DIGITIZE
^"B"LOWUP "E"DIT
OR ^"R"AW DATA: R

(User wants to see the raw data in an area to be specified)

[crosshair's come on]

[rectangle defined drawn on screen]

(As in step #8, a rectangular area is defined and confirmed by the user. The user wants to analyse an area surrounding a discontinuity of trace 002. After inspection of the original acceleration traces, the user will perform the following steps to split, old segments, create new segments, delete segments which are not required and, finally, to merge the remaining sements into continuous traces.)

CONFIRM, Y/N: Y:

[Raw data comes on within the rectangle (Figure $I4-3$)]

11. "A"UTO - DIGITIZE
^"B"LOWUP "E"DIT
OR ^"R"AW DATA: E

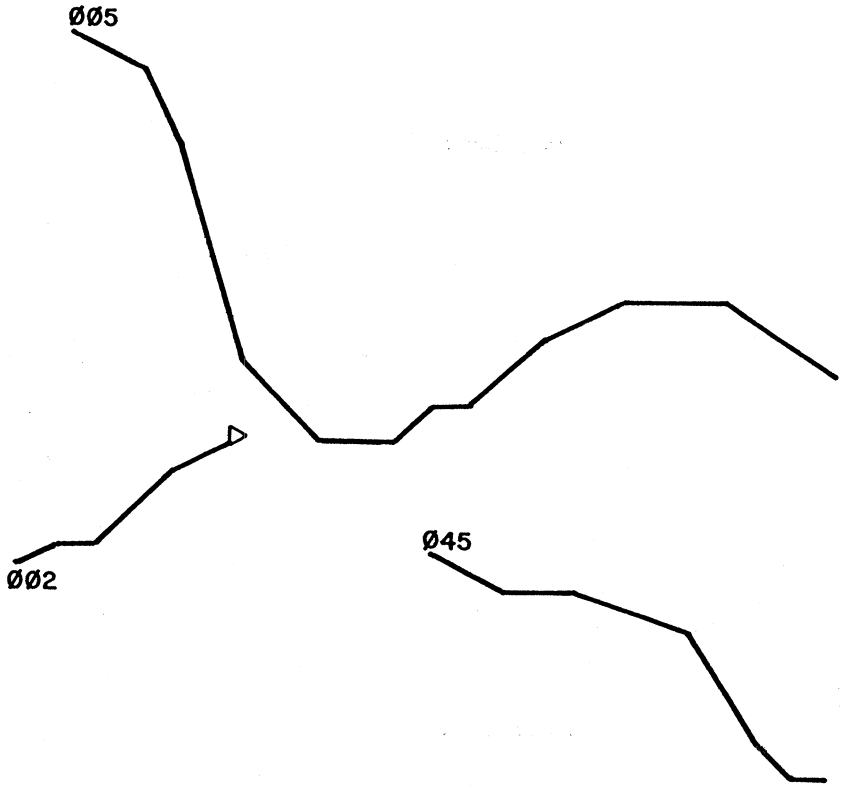

Figure I4 - 2 Screen as it appears after the execution of step 9. Only segment 002 actually ends within the window.

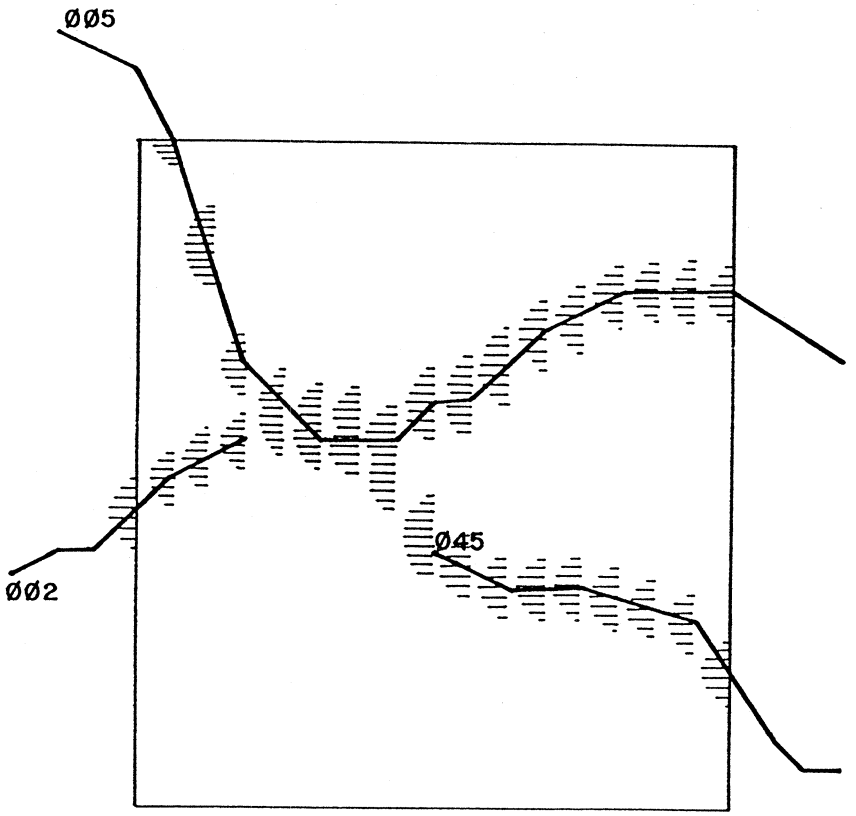

Figure I4 - 3 Screen as it appears after the execution of step 10, and when 16 or 256 density levels have been employed. With only two density levels all data points would be shown with lines of constant lenght.

(User wants to perform some editing on the segments now on screen)

12. "D"EL "F"ILL-IN
    "C"REATE "S"PLIT
    "T"RUNCATE: S

    (User wants to split a segment in two)

    SEG:005
    SEG: ↩

    (User enters the serial number of the segment to be split. User could have entered a new number if 005 was wrong; there was no error, so user hits ↩)

13. [Vertical line comes on] (Figure $I4-4$)
    (User moves the vertical crosshair to the vicinity of x where split is desired and hits return. A small '+' will appear at a point on the segment where the vertical crosshair intersects)

14. OK? OR ELSE MOVE
    ↑OR ↓ THE SEG?

    (User can now use the keypad keys to move the '+' crosshair up and down the segment to the precise point to split and hit OK [5 ↩]; SEG 005 is now split in two and a new serial number, e.g. 254, is created for the right half of the segment).

15. "D"EL "F"ILL-IN
    "C"REATE "S"PLIT
    "T"RUNCATE: C

    (User wishes to create a segment manually)

    [The '+' (crosshair) comes on.]

    (With the keypad keys, the user defines each point, entering the last point with ↩; if only one point is entered, a 1-point segment is defined; if more than one point is entered, a segment is defined with straight lines connecting the points.) (Figure $I4-5$)

    SEG 255 CREATED.

16. "D"EL "F"ILL-IN
    "C"REATE "S"PLIT
    "T"RUNCATE : F

    (User wants to connect (fill-in) segment 005, the newly created segment 255 and segment 045.)

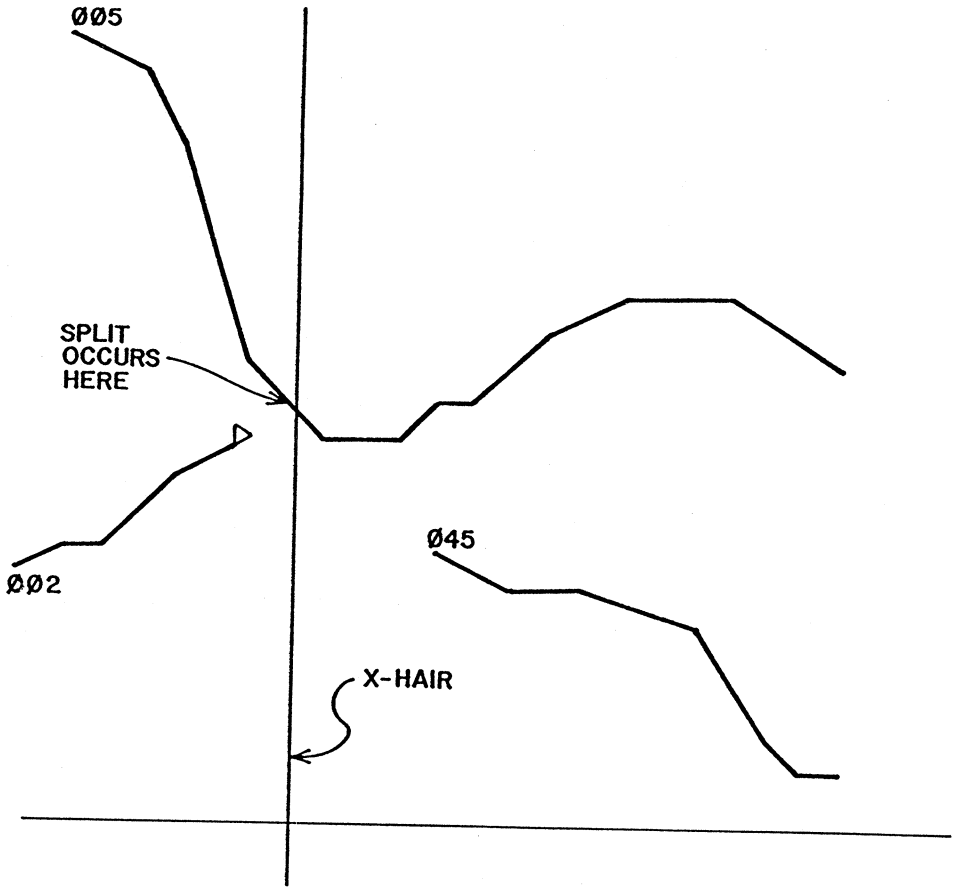

Figure I4 - 4 Appearance of the screen during the execution of step 13. The vertical crosshair is used to define the cutoff. The raw data amplitudes, shown in Figure I4-3 have been omitted here.

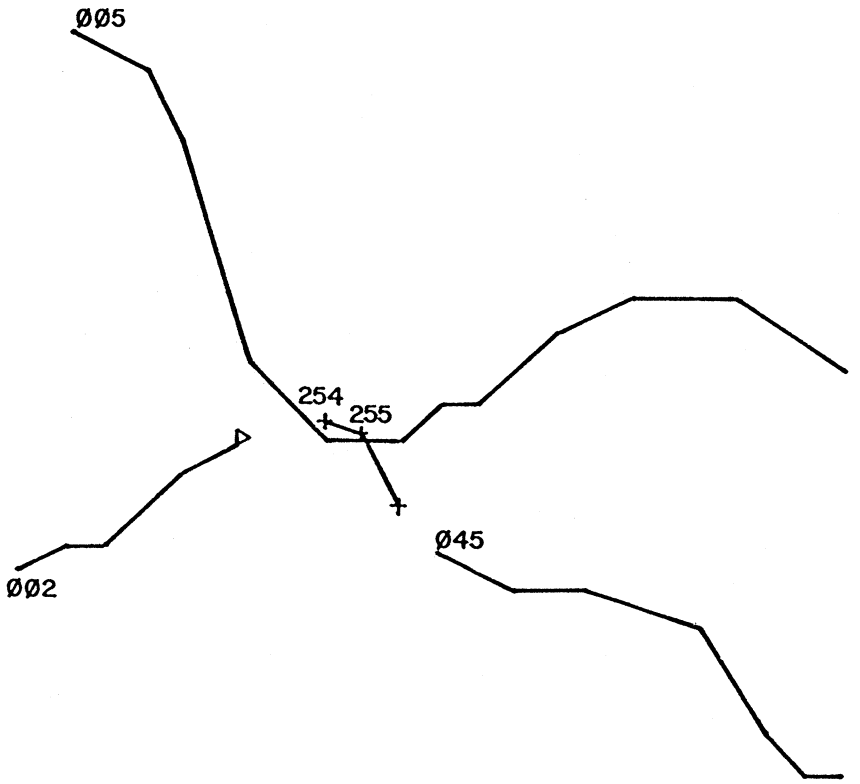

Figure I4 - 5 The segments as they appear just prior to performing "F" ILL-IN in step 15. As in Figure I4-4, the raw data amplitudes shown in Figure I4-3 have been omitted here.

SEG : 005
SEG : 255
SEG : 045
SEG : ↩

(A line will be drawn from the end of segment 255 to the beginning of segment 045)

CONFIRM, Y/N:Y

(User again confirms it; the label 045 will disappear as segment 045 is now part of segment 255; a line will next connect segments 005 and 255);

CONFIRM, (Y/N): Y

(User again confirms it; the label 255 will disappear and it is now a part of segment 005 (Figure $I4-6$).)

17. "D"EL "F"ILL-IN
"C"REATE "S"PLIT
"T"RUNCATE: F

(User now wants to fill-in segments 002 and 254)

SEG : 002
SEG : 254
SEG : ↩

[segments 002 and 254 are connected]

CONFIRM, (Y/N):Y

(User conforms it; the label 254 disappears as this trace is now a part of segment 002 (Figure $I4-7$)).

18. "D"EL "F"ILL-IN
"C"REATE "S"PLIT
"T"RUNCATE:↩

(User is now done with editing in this window)

"A"UTO - DIGITIZE
^"B"LOWUP "E"DIT
OR ^"R"AW DATA? R

(User wants to see on the screen raw data in another area of missing segments to be outlined with crosshairs)

[same as step 10]

(A rectangular area is defined and confirmed by the user, Figure $I4-8$.)

19. "A"UTO - DIGITIZE

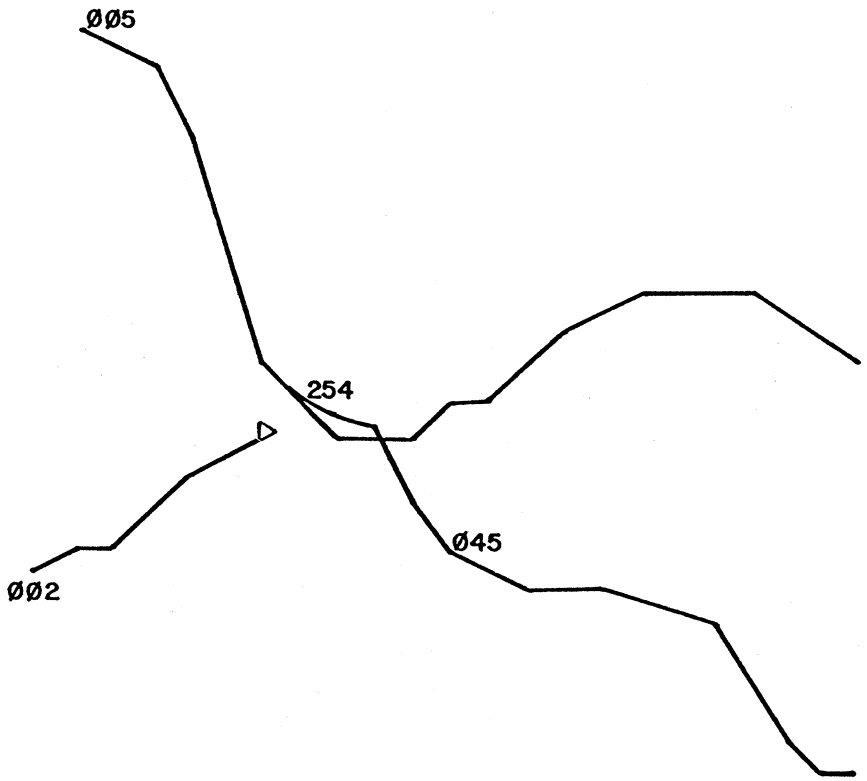

Figure I4 - 6 The segments as they appear after performing FILL-IN in step 15. Note that seg # 254 refers to the segment created earlier by the splitting of seg # 005.

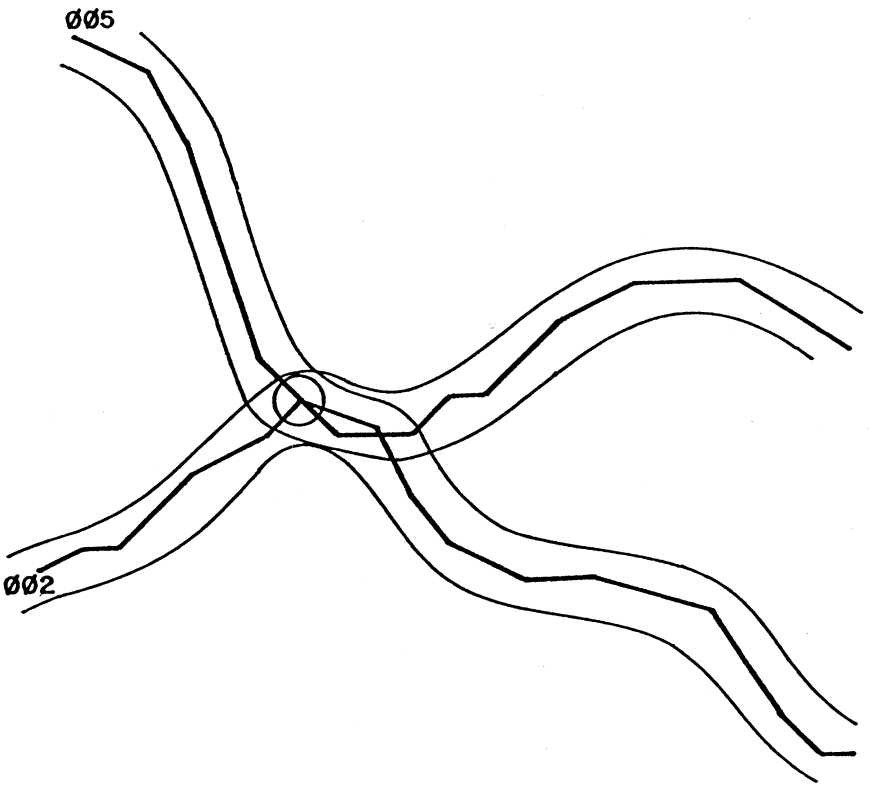

Figure I4 - 7 After editing, one may erase the screen and replot the same window. This is how the edited segments would appear (heavy, piecewise straight, lines). Note that the point circled is shared by the 2 segments. Light smooth lines outline the areas corresponding to the traces and filled with raw data.

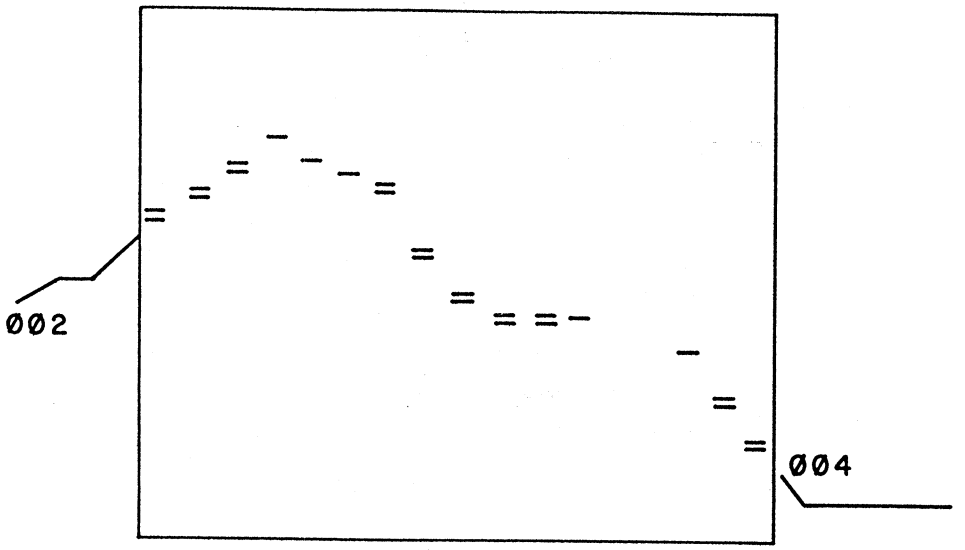

Figure I4 - 8

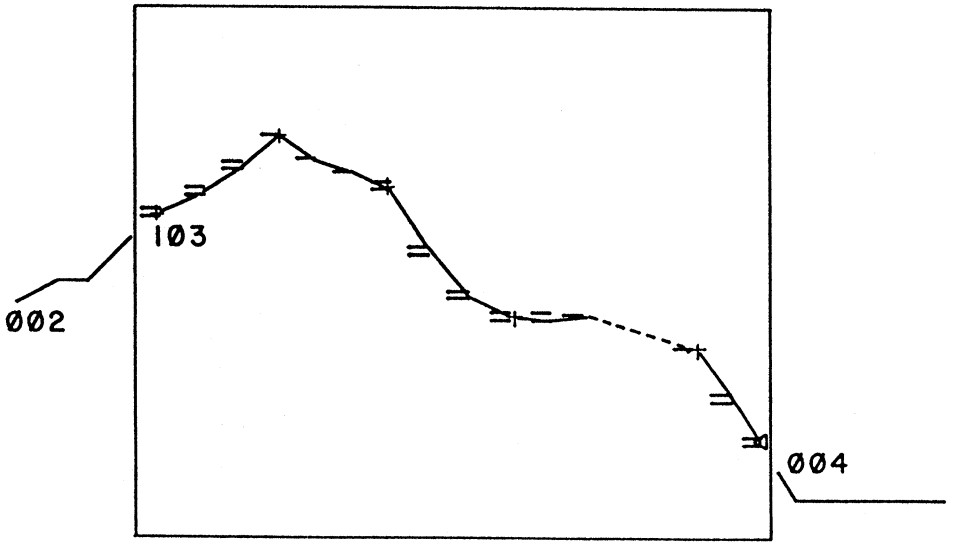

Figure I4 - 9

^"B"LOWUP "E"DIT
or ^"R"AW DATA? ↩

(User wants the program TV to automatically digitize a segment of the raw data displayed)

[crosshairs come on]

(As in step #8, a rectangular area is defined and confirmed by the user)

CONFIRM, Y/N: Y

[a '+' (crosshair) will move along the digitized path. Depending on the total number of points digitized, one or more segments are defined and eventually connected together as one segment. The assigned serial number, e.g. 103, will then appear, Figure $I4-9$)

20. "A"UTO - DIGITIZE
^"B" LOWUP "EDIT
or ^"R"AW DATA? ↩

(User is ready to finish)

[screen erased, and rescaled to that of the full record on the screen; reference coordinates are displayed by arrows]

"Q"UIT, OR PLOT
"N"ONE, "S"OME
OR "A"LL SEG? Q
MP##: MP01

(User saves the current map in file MP01.DAT; other files written will be SC901.DAT containing the coordinates of the segments that were created, and TPFD01.DAT, with information for the next phase of the system (SCRIBE))

[screen erased]

```
**********
*   TV   *
**********
```

"C"ONTINUE OR "Q"UIT: Q

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[Program stops].

*I*5 SCRIBE

*I*5.1 Introduction

With editing completed, the trace segments are ready to be plotted and/or written onto a disk file. Initially, SCRIBE requests for options to plot, write onto disk or both:

"P"LOT, "D"ISK, or "B"OTH:

Next, the output file name is requested (if disk file is to be created):

FILENAME FOR OUTPUT RAW DATA ON DISK (A2O): V0X0001.DAT ↩

SCRIBE then asks for the mapfile suffix created by TV:

ENTER MAPFILE SUFFIX: MP01 ↩

The map file MP01.DAT is open, and its first record read. SCRIBE is now ready to plot and/or write onto disk all types of curves found. Recall that the curve types are defined as follow:

Type	Description
3	time-clock marks
2	half-second time marks
1	fixed traces (baselines)
0	acceleration traces

SCRIBE has one additional question:

INCLUDE REFERENCE LINES? (Y/N): Y ↩

Here reference lines include lines of type 1, 2 and 3. For each type, starting with type 3, SCRIBE goes through an inner loop searching for a segment of that type in zone 1 (top zone). The serial and type numbers of any such segment found are written onto the screen with a question:

THIS SEGMENT TO BE PLOTTED? (Y/N):

If the segment is to be plotted, SCRIBE will proceed to read the points from the disk files and plot them and/or write them onto the disk. When the end of the segment in the top zone is reached, and if there are more zones, SCRIBE will first identify the matching segment in the next zone. It then proceeds to plot and/or write data to disk, after making the necessary corrections to each coordinate to recreate the original, a continuous curve out of the corresponding segments in two or more zones. SCRIBE will repeat this for each segment until all the zones are read.

If dashed reference lines are present (type 3 radio clock time-hack traces, type 2 crystal clock time or half-second traces), they are written to file in two formats: an all point version followed by the 'abbreviated', dash end-points-only version.

*I*5.2 Transformation Correction

When more than 1 zone (sections) of the record are included, as consecutive sections, one below the other, all photocopied onto the 8.5×11 inch paper, these sections need to be assembled together to recreate the original continuous record. Each zone has an associated pair of fiducials at the left and right ends. The points in each zone will be rotated so that the resulting fiducial pairs are perfectly horizontal. They are then translated so that the left fiducial of the zone will correspond to the right fiducial of the previous zone. This is summarized in the following set of transformation equations (Figure $I5-1$):

For Section i, let

$$
\begin{aligned}
(XL_i, YL_i) &= \text{Coordinate of the left fiducial in zone i,} \\
(XR_i, YR_i) &= \text{Coordinate of the right fiducial in zone i,} \\
D_i &= \text{Distance between the left and right fiducials in zone i} \\
D_i &= \sqrt{(XR_i - XL_i)^2 + (YR_i - YL_i)^2} \qquad \text{(I5.1)} \\
\alpha_i &= \text{angle in zone i to be rotated so that the} \\
&\qquad \text{fiducial pair is horizontal} \\
\alpha_i &= \tan^{-1}\left(\frac{YR_i - YL_i}{XR_i - XL_i}\right) \qquad \text{(I5.2)}
\end{aligned}
$$

Then, for (X,Y) the coordinates of a point in zone i, the rotation by an angle α_i results in

$$
\begin{aligned}
\text{Rotated } X &= (X - XL_i)\cos\alpha_i + (Y - YL_i)\sin\alpha_i \\
\text{Rotated } Y &= (Y - YL_i)\cos\alpha_i - (X - XL_i)\sin\alpha_i \ . \qquad (I5.3)
\end{aligned}
$$

Let

(XT_i, YT_i)= translated coordinates for points in zone i, then

$$
\begin{aligned}
XT_i &= XT_{i-1} + D_{i-1} \\
YT_i &= YT_{i-1} \quad (YT_1 = YL_1) \qquad (I5.4)
\end{aligned}
$$

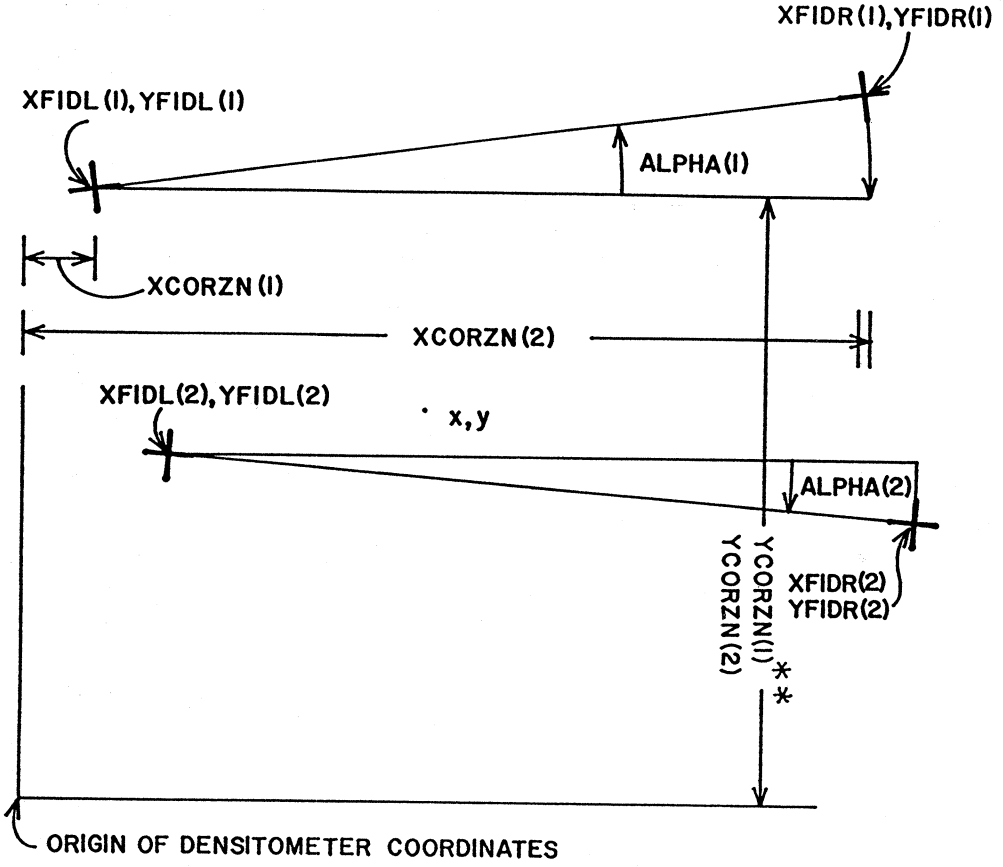

Figure I5 - 1 Correction constants.

so that

$$
\begin{aligned}
CORRECTED\ X &= XT_i + \text{Rotated } X \\
&= XT_i + (X - XL_i)\cos\alpha_i + (Y - YL_i)\sin\alpha_i \\
CORRECTED\ Y &= YT_i + \text{Rotated } Y \\
&= YT_i + (Y - YL_i)\cos\alpha_i - (X - XL_i)\sin\alpha_i\ . \qquad (I5.5)
\end{aligned}
$$

Such transformation correction is applied by SCRIBE to every point of every segment in every zone and will result in the recreation of the original record.

$I5.3$ Program Flow of SCRIBE (Figure $I5-2$)

Steps # ACTIVITY

1. Initialization
   SCRIBE initially asks for the map file suffix, opens the file MPxx.DAT, where xx is the suffix input by the user. SCRIBE reads the first record of the map file. It then opens the corresponding file, TPFDxx.DAT and reads the whole file containing information on the fiducial coordinates, on the serial number, type, initial y-coordinate and zone numbers of the segments.

2. Correction Constants
   SCRIBE calculates from the fiducial coordinates the transformation correction constants used later to transform the coordinates of every point of every segment in every zone, so as to recreate the original record.

3. LOOP
   SCRIBE begins looping on the curve types, starting from type 3 (Time Hack), followed by types 2 (Half-second), 1 (baselines) and 0 (acceleration). For each type, an inner loop searches for a segment of that type in zone 1.

4. Segment Address
   SCRIBE finds the segment serial number in the map file and identifies the file name suffixes of the SCxxx.DAT file containing the y-coordinates of the segment, the beginning and ending addresses within the SCxxx.DAT files, and the first x-coordinate of each piece of the segment. SCRIBE reads in blocks of y-coordinates, and computes the corresponding x-coordinate for each y.

5. Transformation Correction
   SCRIBE "rotates" the points around the left fiducial of the zone containing the point to eliminate the fiducial skew (equation $I5.3$), and the "rotated" coordinates are then added to the translational terms (equation $I5.5$) to recreate the original continuous curve.

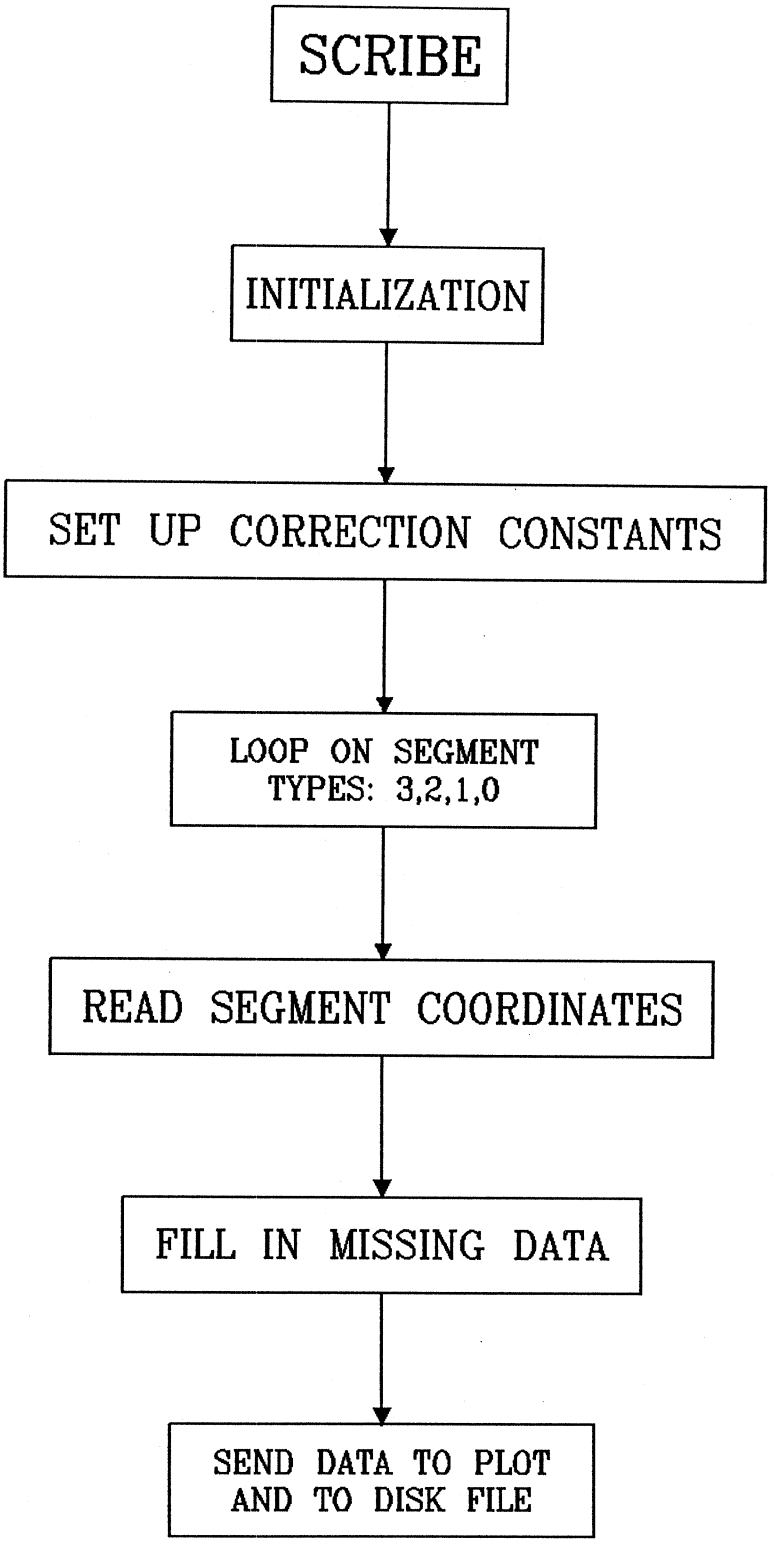

Figure I5 - 2 Flow-chart of program SCRIBE.

6. Fill-in Missing Data
   'Missing' data is defined as empty gaps lying between two successive points of the segment. Those are stored as 0 y-coordinates in the data files. They exist in segments at area of missing raw data or are created by 'FILLIN' during TV editing. SCRIBE assumes that the curve is a straight line joining the two points to the left and right of the missing data.

7. Output: to Plot and to File
   When the points of a segment are transformed, they are sent by SCRIBE to the plotter and/or the disk file. The disk file will now be called the file of unscaled RAW DATA.

*I*5.4 Input/Output files from Digitization

The following is a summary of the list of all files created during digitizations, starting from SCAN, through FILM, TRACE, TV and SCRIBE.

1. IMAGE.RAW This is the file created by the scanning program SCAN. It is the image file resulting from scanning the 8.5×11 inch paper containing the record to be digitized.

2. REFS.DAT This file is created by FILM containing the coordinates and types of the reference lines and points. It is read by TRACE and TV.

3. PARMS.DAT This file is written by TRACE, containing parameters associated with each record of the segments written on to disk. It contains information on the filename SCxxx.DAT of the record, segment type, zone number and the first x-value of the segment, etc.

4. SCxxx.DAT Files of this name are written by TRACE. Each such file contains the y-coordinates of the segments. xxx ranges from 001 to 999. Files SC001.DAT to SC899.DAT are created by TRACE to be read by TV and SCRIBE. The more complicated is the record, more of these will be used. Files SC900.DAT to SC999.DAT are created by TV during editing, to be read by SCRIBE.

5. SUMUP.DAT This file is written by TRACE. It contains the maximum x and y scanner units found for the segments and the total number of segments found.

6. TPFDxx.DAT Files of this name are written by TV. Those contain a list of the segment serial numbers, the y-coordinates of their first point, segment type and film zone. Those files also contain the fiducial coordinates in descending order. TPFDxx.DAT is created at the end of editing TV. The number xx corresponds to the map file MPxx.DAT, where xx ranges from 00 to 99. This file is to be read by SCRIBE.

7. MPxx.DAT Files of this type are written by TV. The map file contains information on all given segments created or edited by TV. A segment, after editing, might consist

of points stored in several different SCxxx.DAT files, or in different parts of a single SCxxx.DAT file. Information on the address of each group of these points are contained in the map file MPxx.DAT, created at the end of editing version number xx by TV, where xx ranges from 00 to 99. This file is to be read by SCRIBE.

8. Unscaled RAW DATA FILE: V0X0001.DAT This is the final file written by SCRIBE containing the unscaled coordinates of the Raw Data of the digitized record.

Having completed the digitization of an accelerogram record, with the unscaled RAW DATA file V0X0001.DAT, part II of this report will describe the data processing of the strong-motion record.