Manual 6D

Ultrasound Assessment: Distensibility Reading Procedures

The National Heart, Lung, and Blood Institute
of the National Institutes of Health

ATHEROSCLEROSIS RISK IN COMMUNITIES STUDY PROTOCOL

MANUAL 6D

ULTRASOUND ASSESSMENT: DISTENSIBILITY READING PROCEDURES

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1. INTRODUCTION

Arterial distensibility information is acquired on every ARIC participant by the field center sonographers as part of the ultrasound examination. A separate protocol, Manual 6.C, describes in detail the procedure to acquire arterial distensibility data.

The field center sends distensibility data on a floppy diskette weekly along with ultrasound tapes to the Ultrasound Reading Center (URC). Distensibility data for each participant includes distensibility strip charts and four files containing demographic information, blood pressure data, digitized distensibility data and a note log with sonographer comments. Participant strip charts are kept on file at the URC and serve as reference material for distensibility readers. The participant's distensibility floppy disk files are logged in and transferred from the transcription station to a file in the central database. When the distensibility data are to be read, the chief distensibility reader transfers the distensibility files to the computer at the distensibility reading station. A computer algorithm randomly assigns one week's distensibility studies and inter- and intra-reader quality control readings to distensibility readers. The chief reader performs a visual check to verify that all distensibility studies recorded on the log sheet is assigned. (There are four log sheets per week.)

In each distensibility reading, the reader views the digitized data and identifies and confirms the valid cardiac cycles. Measurements of diastolic and systolic diameter of the common carotid artery are based on the data selected by the reader. The diameter measurements and blood pressure data are used by the distensibility reading program to calculate several arterial parameters which quantitate mechanical properties of the arteries.

After each distensibility study is read, results are stored in the distensibility database as the distensibility studies are read. A backup tape of the distensibility database is performed daily.

This manual describes the step-by-step reading process for arterial distensibility data. Supplemental information is included in three appendices: Appendix A contains examples of valid and invalid arterial waveforms; Appendix B contains the definitions of Arterial Stiffness Parameters, and Appendix C cites certain instances when values for the arterial parameters cannot be calculated and cases which require additional reading instructions.

2. READER TRAINING AND MONITORING

Distensibility reader training includes extensive review of the following topics: the distensibility reading protocol; the meaning of arterial distensibility, including the quantities used in defining arterial elasticity, the parameters used to calculate these measurements, and knowledge of how the quantity values are derived; characteristics of valid arterial waveforms, and the operation of work station and reading program.

After observing the chief reader perform distensibility readings, the trainee reads randomly selected studies which have been read by a certified reader. Inter-observer statistics are developed to determine reliable and acceptable

criteria for certification. When performance reaches a satisfactory level, in terms of proficiency and efficiency, the reader is certified.

Inter- and intra-observer measurements are reviewed monthly to monitor the performance of readers. Any trend suggesting deterioration in performance levels is promptly discussed with the individual and/or group.

3. READER WORKSTATION INSTRUMENTATION

The distensibility workstation (Figure 1) consists of a 16 MHz computer with 2 Mb memory, 5 1/4 inch 1.2 Mb floppy disk drive and 70 Mb hard disk. It also has a math co-processor and EGA color graphics adaptor with an EGA color monitor. The Omega dual cartridge Model A220H Bernoulli box provides needed memory for backup.

4. BEGINNING THE DISTENSIBILITY READING PROGRAM

When a week's distensibility data are received from the field centers, a weekly assignment sheet is printed by the chief distensibility reader from the computer's algorithm program, which randomly assigns studies to be done by the distensibility readers. The assignment sheet is reconciled with the participant files received and number of participant studies assigned.

A program developed by ARIC Ultrasound Reading Center is used to read distensibility data. To start the reading program, first the Bernoulli box, then the computer are turned on. The command DISTEN1 or DISTEN2 (to distinguish between the participant's first or second visit) is entered at the D>: prompt using upper or lower case letters. For example:

D>:DISTEN1 <Enter>

This results in the name of the program being displayed on the monitor. (Figure 2a). The reader presses the <enter> key to continue.

The program instructs the reader to enter the assigned reader's two digit identification number (Figure 2b). The <enter> key is pressed to continue.

The program then instructs the reader to enter the participant ID as listed on the assignment sheet (Figure 2c). If the reader enters an invalid participant ID, (the distensibility software is preprogrammed to recognize valid participant IDs by field center), the error is detected, the computer responds with an audible beep and allows the reader to re-enter the ID. When the correct ID has been entered and accepted, the computer begins acquiring the data for that particular participant from the hard disk. If the correct participant ID number is entered and the beep still occurs, the chief distensibility reader is notified.

5. VIEWING THE PARTICIPANT'S WAVEFORM

After the required data files have been accessed, a graphical representation of the participant's distensibility data is displayed on the computer screen by two different waveforms. Each waveform in this preliminary display plots every 8th point in the DC and AC waveforms. (Subsequent cardiac cycle screens plot every or every other data point.) This display is used to identify the start and stop points and to assess the overall quality of the data.

Figure 1. The Distensibility Workstation

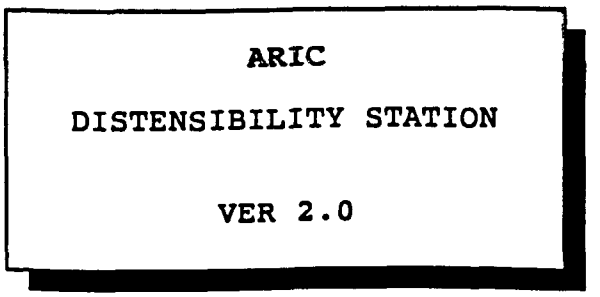

Figure 2 a

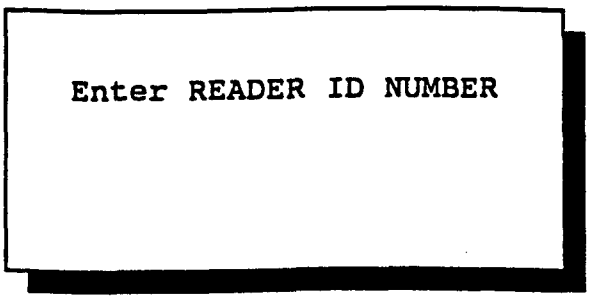

Figure 2 b

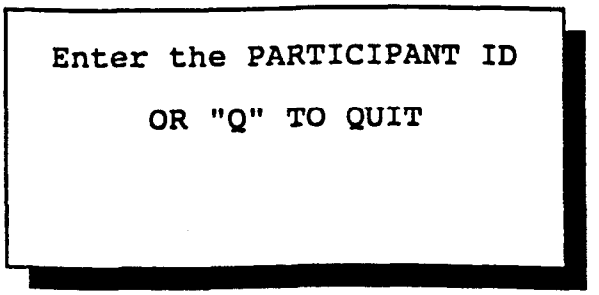

Figure 2 c

Figure 2 (a-c). Distensibility Reader Station Computer Screens

The top waveform is referred to as the DC (blue scale) waveform. The vertical scale for this waveform is 0 to 10 mm from the bottom of the screen to the top. The bottom waveform is referred to as the AC (pink scale) waveform. The vertical scale for the AC waveform is 0 to 1 mm from the bottom of the screen to the top, and it displays the time varying portion of the DC waveform magnified ten times. The horizontal scale for both the DC and the AC waveforms from the left edge of the screen to the right represents a time of 10 seconds. An example is shown in Figure 3.

The participant's heart rate, at the time the distensibility is acquired, determines the number of cardiac cycles displayed. The data displayed may contain anywhere from 6 to 15 cardiac cycles. The scale for the data points is at the bottom of the screen.

At this time the reader reviews the data displayed on the screen, verifying that both the DC (blue) and the AC (pink) waveforms are within the limits of the scale. Refer to Appendix C for reading instructions when they are not.

6. ENTERING START AND STOP POINTS

The start and stop point values are obtained from the numbers on the bottom of the first graph that appears on the screen. In Figure 3, the values range from 0-620. The start point is the number at which the first diastole appears. In Figure 3, this value is 45. The stop point is the last complete systolic value. In Figure 3, the value is 600. When these values are entered, the computer generates pictures of individual cycles and calculates how many cycles are to be read.

7. VIEWING INDIVIDUAL CYCLES

The first cycle from diastole to diastole appears on the screen (Figure 4a). The reader views the individual cycle and decides whether or not it is acceptable for analysis. (Waveform acceptability criteria are defined below.) "Y" is pressed to accept the waveform and "N" is pressed when it is not acceptable. The next diastole-to-diastole waveform is displayed on the screen. This is repeated until all the waveforms within the start and stop range have been viewed.

If the participant's heartrate is $\geq$ 65/min, each cycle's data extends across almost the entire screen. The time division Factor M, appearing in the upper right hand corner of the screen, is equal to one (Figure 4a). If the heartrate is less than 65 beats/min, a cycle has more than 640 data points. In this case, every second data point is displayed, and the time division factor is changed to M=2 (Figure 4b).

7.1 Characteristics of Valid Waveforms

In determining whether cycles are valid for distensibility analysis, the reader keeps in mind the following characteristics of valid arterial waveforms:

1. Relatively fast systolic upstroke;
2. relatively slow diastolic downstroke;
3. dicrotic notch, seen in most cases;
4. relative consistency in the shape of consecutive cycles;
5. complete cycles with no jumps or discontinuity in the data.

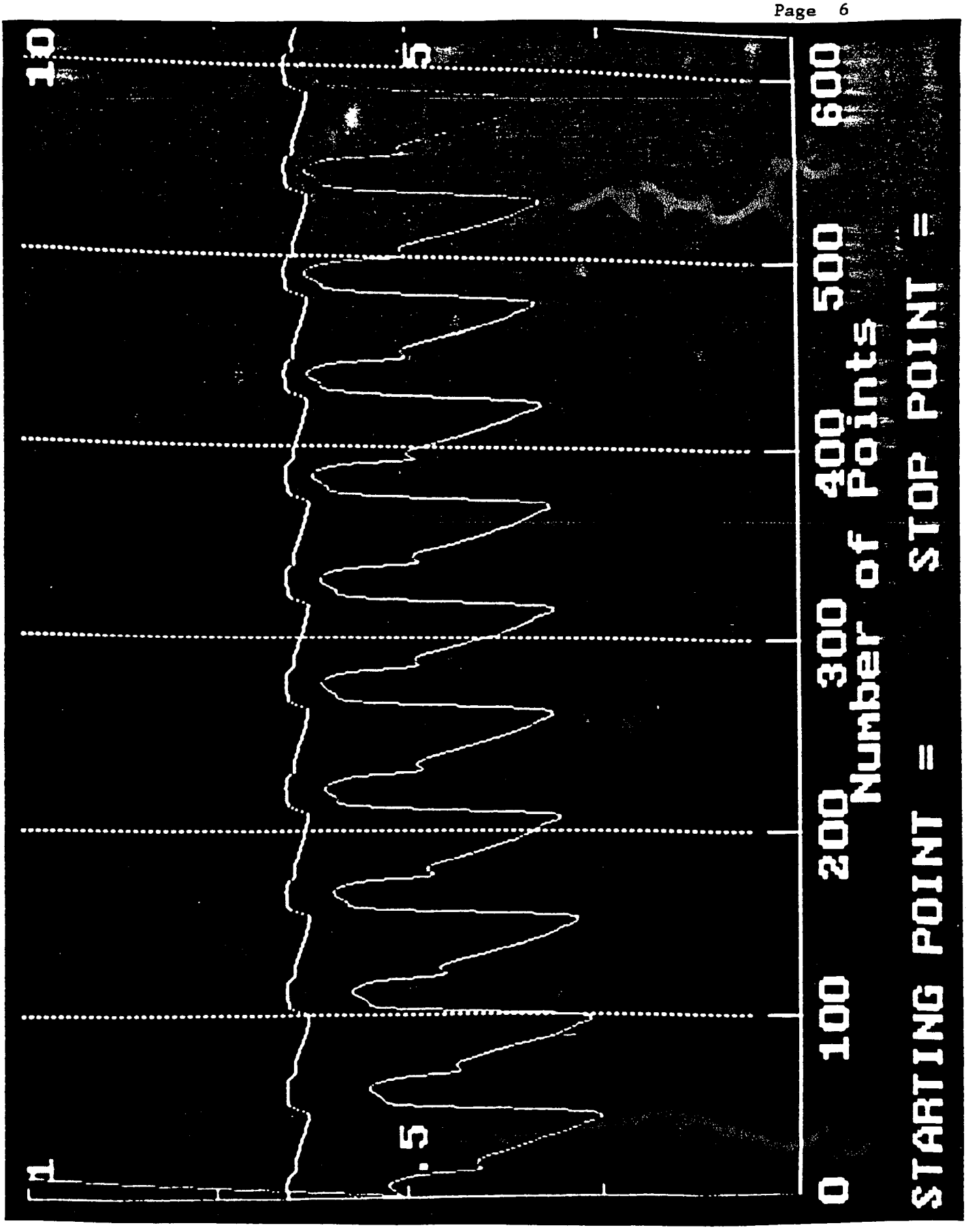

Figure 3. Distensibility Data Graph

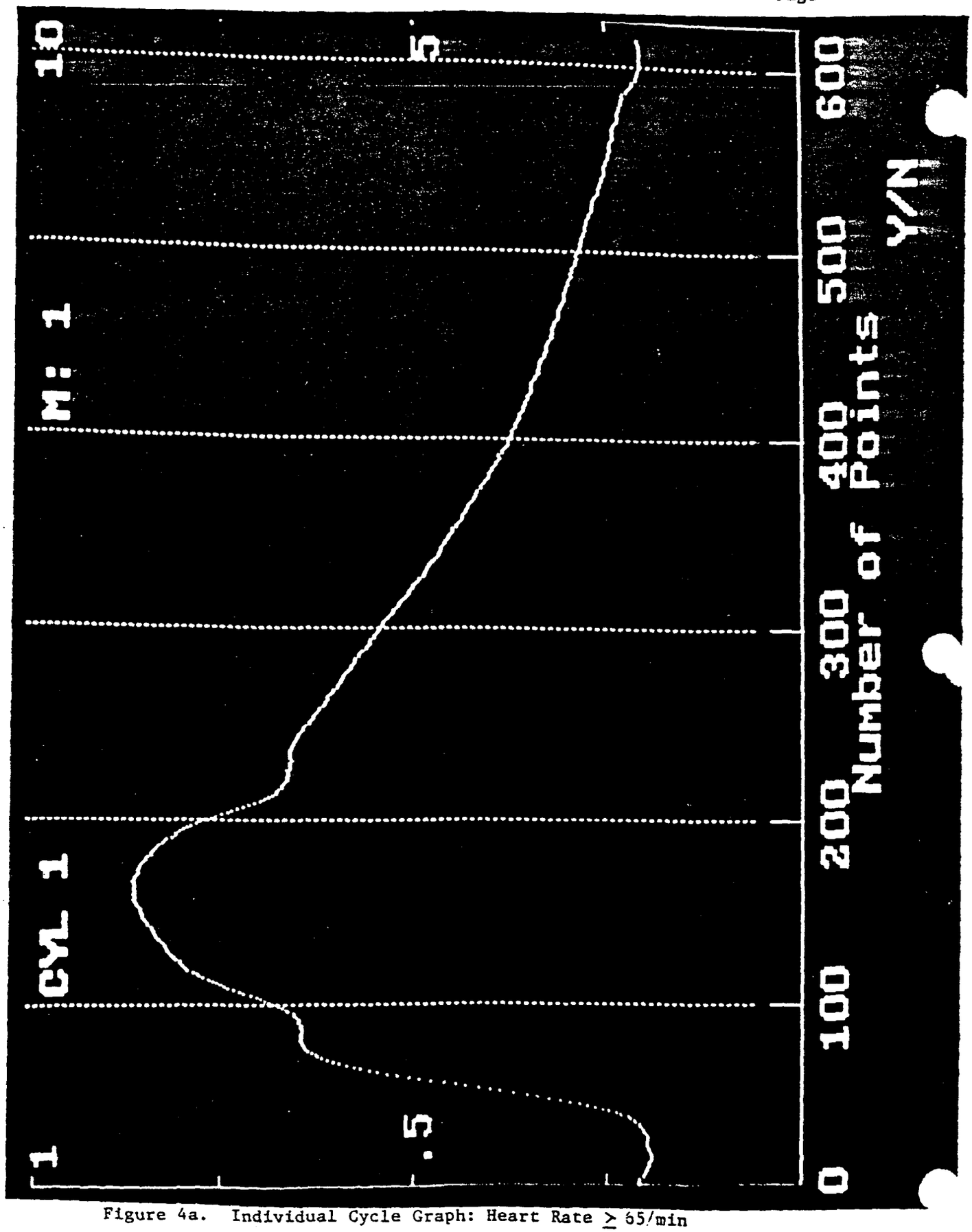

Figure 4a. Individual Cycle Graph: Heart Rate $\geq$ 65/min

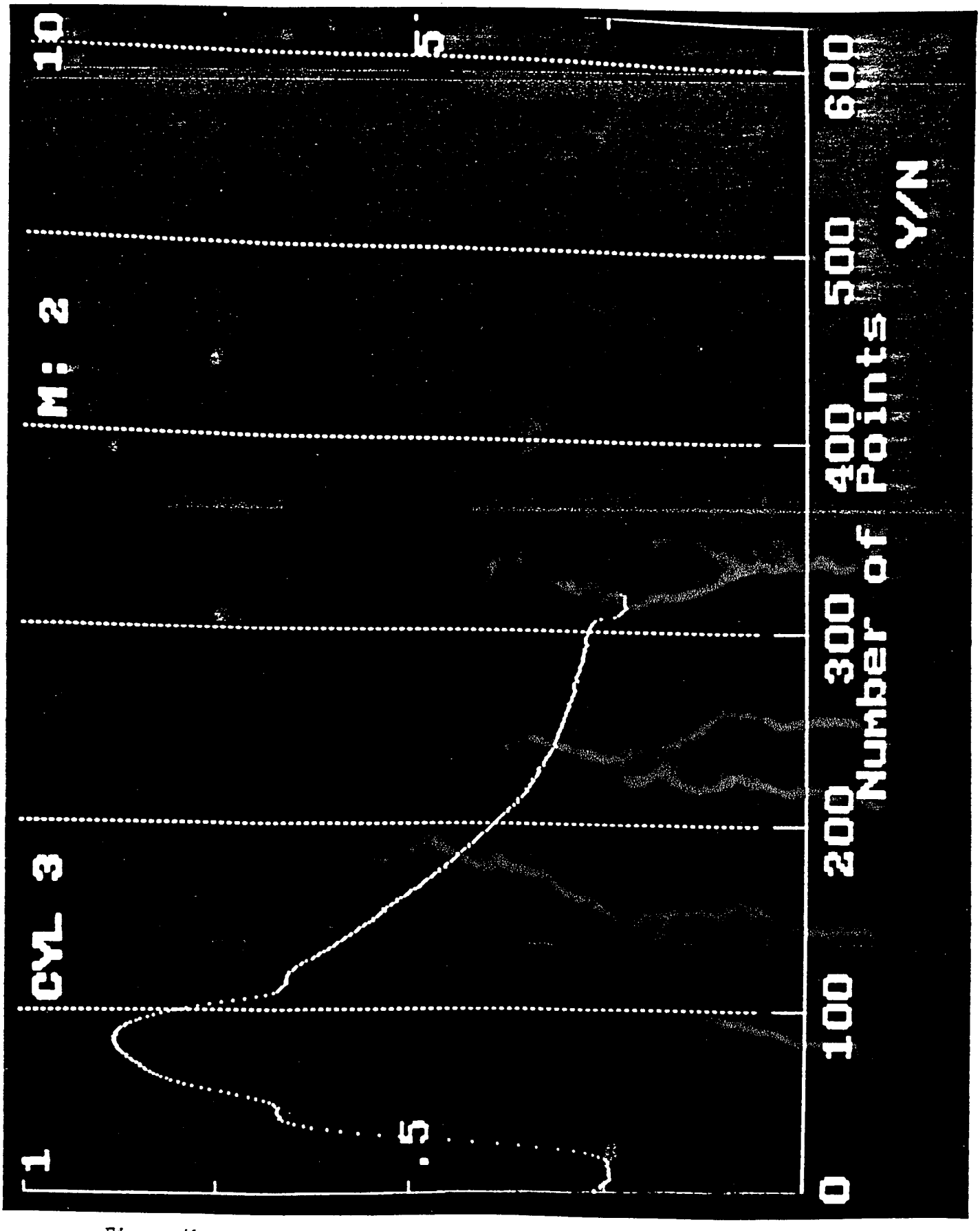

Figure 4b. Individual Cycle Graph: Heart Rate < 65/min

Examples of valid and invalid arterial waveforms are presented in Appendix A.

When the reader is uncertain about whether a particular cardiac cycle is valid the chief distensibility reader is consulted.

8. THE DATA SCREEN

When the last waveform has been evaluated, the data screen appears on the monitor (Figure 5a). For every cycle accepted as valid, the following seven columns of information are displayed on the screen:

1. The cycle number of valid waveforms selected from the range of cycles between the start and stop points.
2. Diastolic diameter calculated from the DC waveform.
3. Systolic diameter calculated from the DC waveform.
4. Diameter change from the DC waveform.
5. Systolic diameter from the AC waveform.
6. AC diameter change .
7. Heartrate.

The mean value for each column is displayed at the foot of that column. Below the columnar data are three values for systolic and diastolic blood pressure. For each type of measurement, the first value was recorded before the distensibility exam; the second, recorded after the exam, and the third is the mean of the two readings.

Below the blood pressure information are the calculated measurements of pressure strain elastic modulus (Ep), arterial distensibility (DISTENSIBILITY), circumferential arterial strain (STRAIN), and arterial compliance (COMPLIANCE). Definitions of these arterial parameters are in Appendix B.

The reader performs a visual edit of the data shown on the data screen. All the DC diastolic diameters appearing in the first column should be very similar. Further, all of the numbers in any one column should fall within a narrow numeric range (within a few 100ths of one millimeter). The reader should pay particular attention to the data in the DC columns, as the distensibility reading program uses this scale to calculate the results. The reader also verifies that the blood pressure and the measurements for Ep and Strain are within a pre-specified range. Examples of typical and plausible measurements are displayed in Appendix B.

9. COMPLETING THE STUDY

When the data screen has been carefully reviewed by the reader, the Enter key is pressed, and the question appears on the screen, "Save Results?" (Figure 5b). If the reader is satisfied that the study is acceptable and ready to be stored, "Y" is entered, and the statement "Enter Visit Number" appears on the screen (Figure 5c). The reader enters a "1" or "2", depending on whether it is the first or second visit of the participant, and presses <Enter>. Then the question appears on the screen "Add to Database?" (Figure 5d). When "Y" is typed and <Enter> is pressed, the program containing the results from the reading process is stored on the hard disk of the personal computer in the distensibility database (Figure 6), and the participant ID screen (Figure 2b).

Figure 5 a
Data Screen

CYL #	DC DIASTOLIC DIAMETER	DC SYSTOLIC DIAMETER	DC DIAMETER CHANGE	AC SYSTOLIC DIAMETER	AC DIAMETER CHANGE	DC HEART RATE
1	6.20	6.49	0.29	6.50	0.30	81.1
2	6.19	6.49	0.30	6.50	0.31	78.6
3	6.18	6.49	0.31	6.50	0.32	79.3
4	6.19	6.49	0.30	6.49	0.30	83.0
5	6.19	6.49	0.29	6.49	0.30	80.4
6	6.19	6.48	0.30	6.49	0.30	80.4
7	6.18	6.49	0.30	6.49	0.31	81.7
8	6.19	6.49	0.30	6.50	0.31	81.7
9	6.20	6.50	0.30	6.50	0.30	78.0
10	6.20	6.50	0.30	6.50	0.31	83.4
MEAN	6.19	6.49	0.30	6.50	0.31	80.8

		MEAN	
SBP	114	120	117.0
DBP	71	70	70.5

EP = 127.2 kPa
DISTENSIBILITY = 1.6 % / kPa

STRAIN = 4.8 %
COMPLIANCE = 4.8 CUBIC MM / kPa

Figure 5 b
Data Screen

CYL #	DIASTOLIC DIAMETER	SYSTOLIC DIAMETER	DIAMETER CHANGE	SYSTOLIC DIAMETER	DIAMETER CHANGE	HEART RATE
1	6.20	6.49	0.29	6.50	0.30	81.1
2	6.19	6.49	0.30	6.50	0.31	78.6
3	6.18	6.49	0.31	6.50	0.32	79.3
4	6.19	6.49	0.30	6.49	0.30	83.0
5	6.19	6.49	0.29	6.49	0.30	80.4
6	6.19	6.48	0.30	6.49	0.30	80.4
7	6.18	6.49	0.30	6.49	0.31	81.7
8	6.19	6.49	0.30	6.50	0.31	81.7
9	6.20	6.50	0.30	6.50	0.30	78.0
10	6.20	6.50	0.30	6.50	0.31	83.4
MEAN	6.19	6.49	0.30	6.50	0.31	80.8

		MEAN	
SBP	114	120	117.0
DBP	71	70	70.5

SAVE RESULTS?

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Figure 5 (a-b). Distensibility and Save Results Data Screens

Figure 5 c
Data Screen

CYL #	DIASTOLIC DIAMETER	SYSTOLIC DIAMETER	DIAMETER CHANGE	SYSTOLIC DIAMETER	DIAMETER CHANGE	HEART RATE
1	6.20	6.49	0.29	6.50	0.30	81.1
2	6.19	6.49	0.30	6.50	0.31	78.6
3	6.18	6.49	0.31	6.50	0.32	79.3
4	6.19	6.49	0.30	6.49	0.30	83.0
5	6.19	6.49	0.29	6.49	0.30	80.4
6	6.19	6.48	0.30	6.49	0.30	80.4
7	6.18	6.49	0.30	6.49	0.31	81.7
8	6.19	6.49	0.30	6.50	0.31	81.7
9	6.20	6.50	0.30	6.50	0.30	78.0
10	6.20	6.50	0.30	6.50	0.31	83.4
MEAN	6.19	6.49	0.30	6.50	0.31	80.8

		MEAN	
SBP	114	120	117.0
DBP	71	70	70.5

SAVE RESULTS? y F101381

ENTER VISIT NUMBER

Figure 5 d
Data Screen

CYL #	DIASTOLIC DIAMETER	SYSTOLIC DIAMETER	DIAMETER CHANGE	SYSTOLIC DIAMETER	DIAMETER CHANGE	HEART RATE
1	6.20	6.49	0.29	6.50	0.30	81.1
2	6.19	6.49	0.30	6.50	0.31	78.6
3	6.18	6.49	0.31	6.50	0.32	79.3
4	6.19	6.49	0.30	6.49	0.30	83.0
5	6.19	6.49	0.29	6.49	0.30	80.4
6	6.19	6.48	0.30	6.49	0.30	80.4
7	6.18	6.49	0.30	6.49	0.31	81.7
8	6.19	6.49	0.30	6.50	0.31	81.7
9	6.20	6.50	0.30	6.50	0.30	78.0
10	6.20	6.50	0.30	6.50	0.31	83.4
MEAN	6.19	6.49	0.30	6.50	0.31	80.8

		MEAN	
SBP	114	120	117.0
DBP	71	70	70.5

ADD TO DATA BASE?

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Figure 5 (c-d). Entering Visit Number and Add to Data Base Data Screens

[reading] VISIT 2 DISTENSIBILITY 20 MAR 1990 - 15:01
[I]NQUIRE Distensibility Reading Record
Subject id: 101381 Visit: 2 Reading:1 Reading Date: 03/20/90 Edit: 03/20/90
Reader no: 20 Retrieval date: **/**/** Update level: 0 Delete:0
Retrieval time: 00.00 retrieved: 0
cyl: 13 # cyl accept: 10 Start point: 193 Stop point: 4793 1 Min: 347
Ep: 127.2 Strain: 4.8 Disten: 1.6 Compliance: 4.8 Circumfer: 0.0

Cy #	DDDC	SDDC	DCDC	SDAC	DCAC	IHRT
1	6.20	6.49	0.29	6.50	0.30	81.1
2	6.19	6.49	0.30	6.50	0.31	78.6
3	6.18	6.49	0.31	6.50	0.32	79.3
4	6.19	6.49	0.30	6.49	0.30	83.0
5	6.19	6.49	0.29	6.49	0.30	80.4
6	6.19	6.48	0.30	6.49	0.30	80.4
7	6.18	6.49	0.30	6.49	0.31	81.7
8	6.19	6.49	0.30	6.50	0.31	81.7
9	6.20	6.50	0.30	6.50	0.30	78.0
10	6.20	6.50	0.30	6.50	0.31	83.4
0	0.00	0.00	0.00	0.00	0.00	0.0
0	0.00	0.00	0.00	0.00	0.00	0.0

DDCM: 6.19 SDDCM: 6.49 DCDCM: 0.30 SDACM: 6.50 DCACM: 0.31 MHRT: 80.8
[N]EXT, [P]REVIOUS, [S]TOP

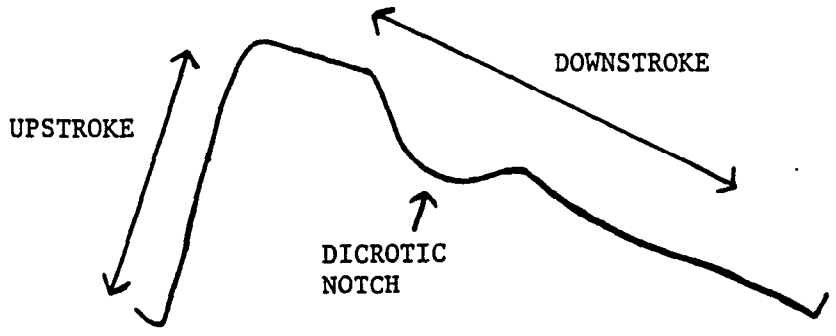
Figure 6. Stored Distensibility Data

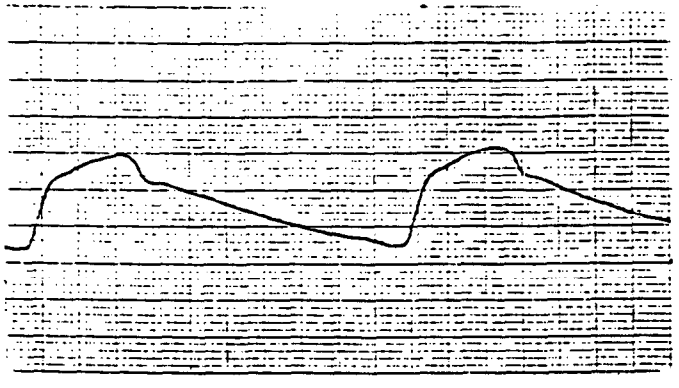
If the reader is not satisfied with the data from a study, an "N" is typed in response to the "Save Results" question, and the program returns to the distensibility reading program menu. The reader may choose to re-read the study indicating different cycles for the computer to analyze, or not to read that study because of invalid or insufficient data.

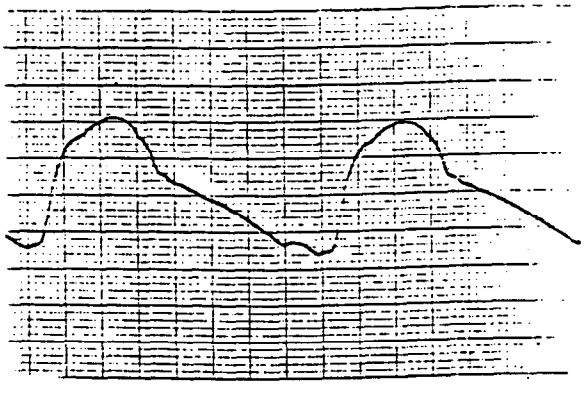
When all the studies to be read have been completed and/or stored, the reader exits the reading program by entering "Q" (quit) at the reading program menu, which returns the screen to the D>: prompt.

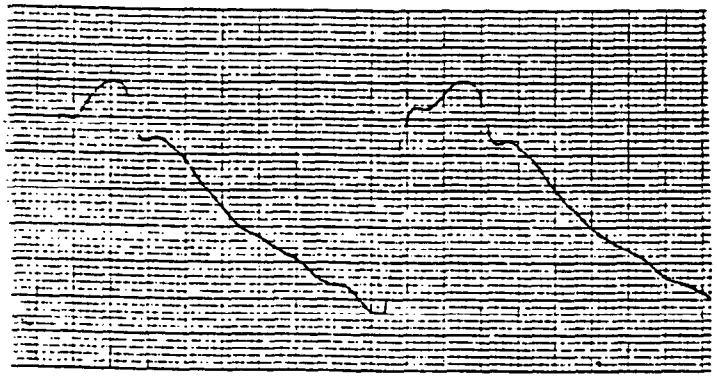
Appendix A. Charts of Valid and Invalid Waveforms

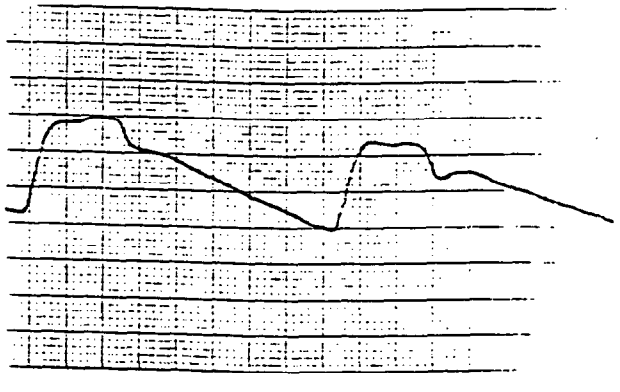
Appendix A provides examples of valid arterial waveforms, invalid waveforms (vein tracking), and invalid waveforms (venous-arterial wall tracking).



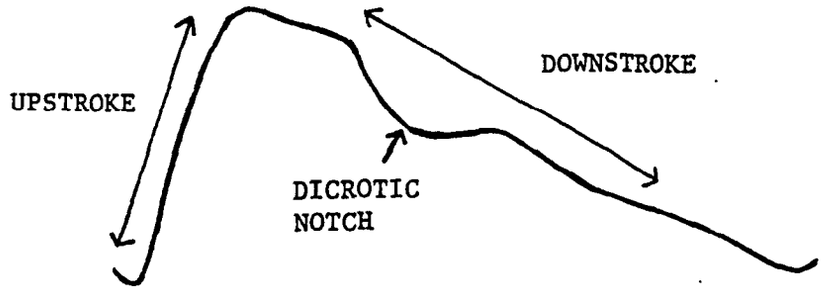


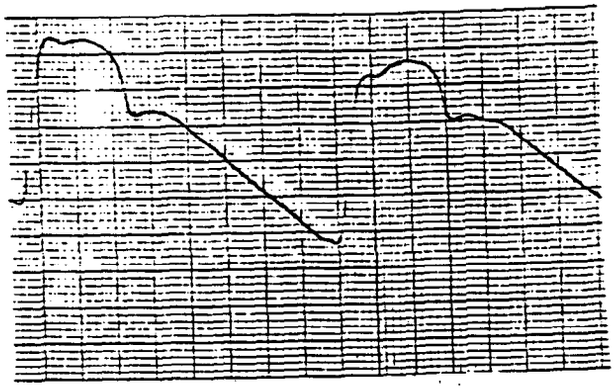


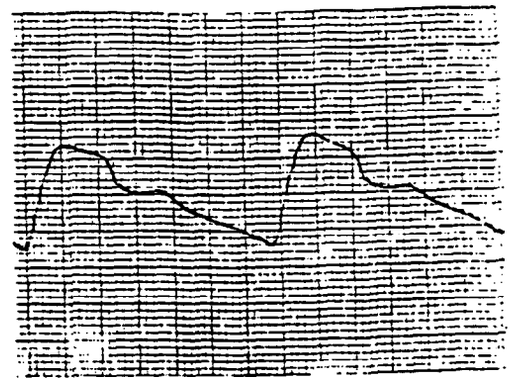


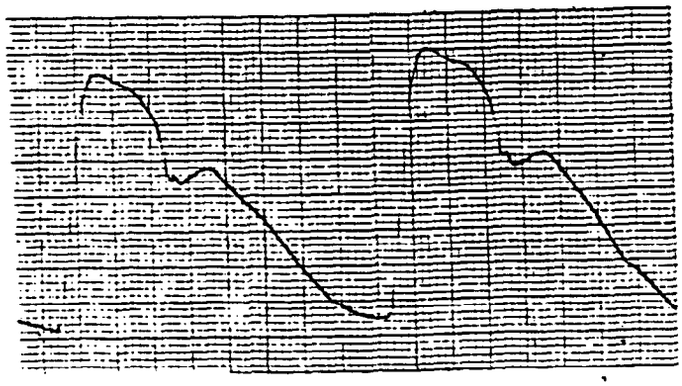


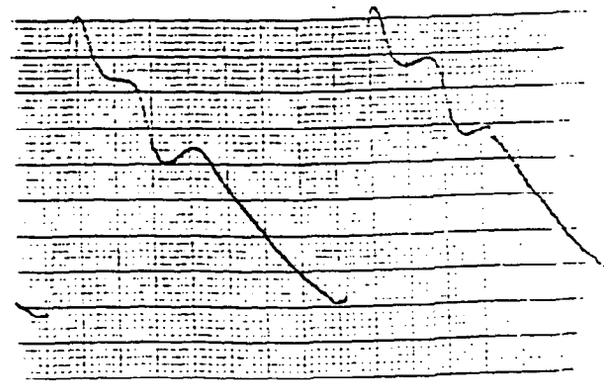
Appendix A. Examples of Valid Arterial Waveforms (Set 1)



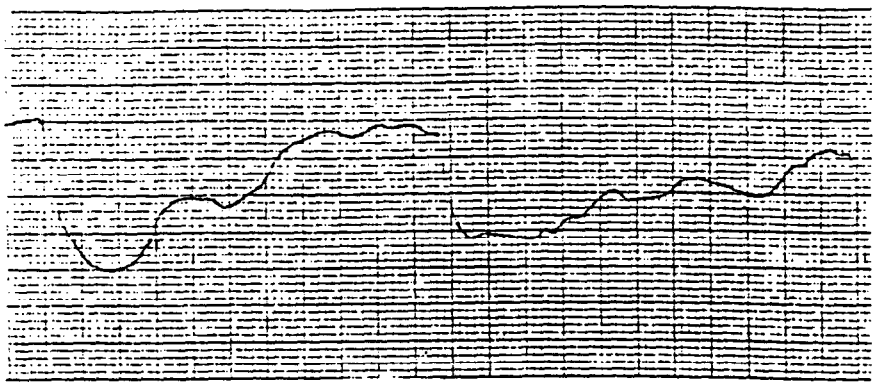


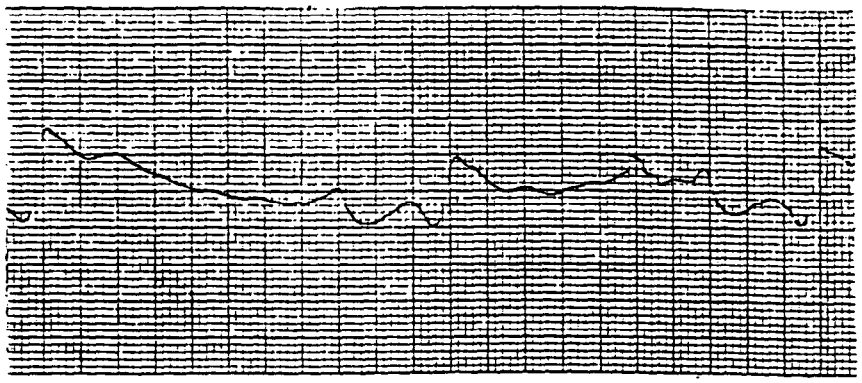


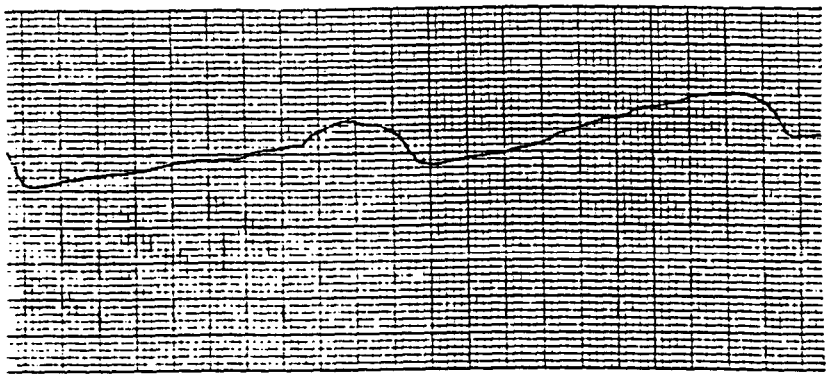




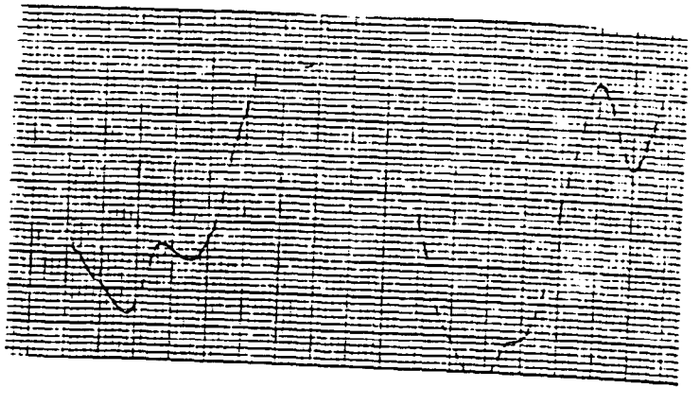
Appendix A. Examples of Valid Arterial Waveforms (Set 2)

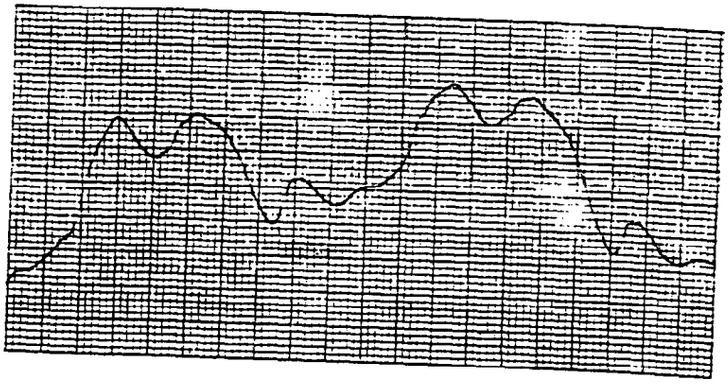


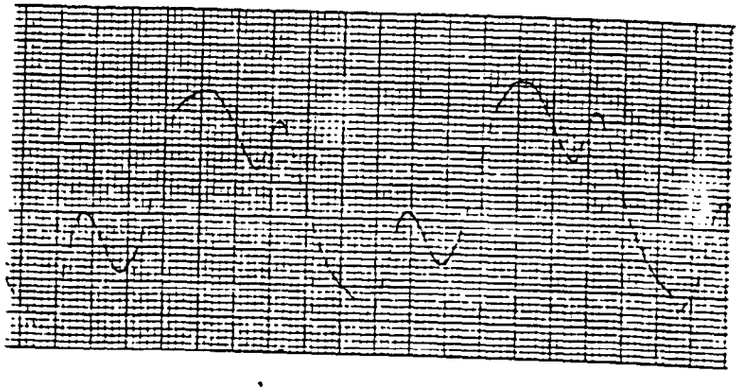




Appendix A. Examples of Invalid Waveform (Vein Tracking)







Appendix A. Examples of Invalid Waveforms (Venous-Arterial Wall Tracking)

Appendix B. Definitions of Arterial Parameters

Arterial distensibility (AD) is defined as the percent volume increase occurring within an arterial segment during the cardiac cycle divided by the arterial pulse pressure. For the simple model of an artery consisting of a thin walled cylindrical tube, having systolic and diastolic diameters equal to D(S) and D(D), respectively, and systolic and diastolic blood pressures equal to P(S) and P(D) respectively, the arterial distensibility is defined as:

$$AD = 100 \times (D(S)^2 - D(D)^2) / [D(D)^2 (P(S) - P(D))]$$

Arterial distensibility defined in this way is independent of the length of the arterial segment. The unit of measurement is %/kPa where 1 kPa = 7.6 mmHg.

Arterial compliance (AC) is defined as the absolute volume increase occurring within an arterial segment during the cardiac cycle divided by the arterial pulse pressure. The arterial compliance per unit length (1 mm) for our simple model is:

$$AC = \pi (D(S)^2 - D(D)^2) / [4 (P(S) - P(D))]$$

It is measured in units of mm^3/kPa. The artery is assumed to lengthen minimally during the cardiac cycle.

The pressure-strain elastic modulus (Ep) is defined as the arterial pulse pressure divided by the circumferential arterial strain (CAS) imposed on the artery during the cardiac cycle. This gives:

$$Ep = (P(S) - P(D)) / CAS \quad \text{where} \quad CAS = [(D(S) - D(D)] / D(D)$$

or, in other terms, the fractional increase in arterial diameter during the cardiac cycle. Ep is measured in kPa.

The stiffness index (SI) which was found to be less dependent on arterial blood pressure within individuals (2) is defined as the natural logarithm of the ratio of systolic blood pressure to diastolic blood pressure divided by the CAS. This gives:

$$SI = \ln[P(s)/P(D)]/CAS$$

and SI is a unitless quantity.(2)

As an artery becomes stiffer, the distensibility and compliance decrease while the pressure-strain elastic modulus and stiffness index increase.

(1) Riley, WA. Ultrasonic evaluation of arterial wall dynamics in Pathology of the Human Atherosclerotic Plaque. Glayov S, Newman WP and Schaffer SA (eds). Springer-Verlag; New York; 687-696, 1990.

(2) Hirai T, Sasayama S, Kawasaki T and Yagi S. Stiffness of Systemic arteries in patients with myocardial infarction. Circulation 80(1):78-86,1989.

Appendix C. Cases from which Arterial Parameters cannot be Calculated

There are certain instances when one to all of the waveforms in a study should not be accepted. Reasons for not accepting waveforms and instructions for finishing the study are listed below.

1.1 Poor Tracking

Waveforms which have "jumps" in them due to poor tracking (Figure 7) are unacceptable because the "jumps" would be measured along with the valid data, making the results inaccurate. Poor tracking (i.e., jumps) may occur in some or all of the cardiac cycles in any one study. At the beginning of each new study, the reader starts at point 1, stops at point 600, and answers no to each individual cycle which contains jumps. Studies with intermittent poor tracking (i.e., some acceptable cycles and some with jumps) are stored and saved on the database following standard procedures. However, the distensibility reading program calculates arterial parameters using only the data from the acceptable cardiac cycles. Studies with all unacceptable cycles are also stored and saved on the database as having been read, but none of the arterial parameters are calculated.

1.2 Invalid Waveforms

When one or more cycles do not have valid arterial waveforms (Appendix A), all cycles are unacceptable and none of the parameters are calculated. The study, however, is read and stored.

1.3 Only One Blood Pressure

In the situation when the reader observes that only one blood pressure is recorded on the data screen <u>after</u> one or more cardiac cycles have been read and accepted, an "N" is entered at the SAVE RESULTS? query at the end of the study. This permits the reader to reread the study, indicating that although the cycle data might be acceptable, there is insufficient blood pressure data from which the reading program can calculate the arterial parameters. The distensibility program does not calculate arterial parameters when only one blood pressure was recorded.

1.4 Absence of Waveforms

In the absence of any waveforms, the blue DC line and the pink AC line are straight across the scale (Figure 8). The reader enters a "1" for the start point and a "2" for the stop point. When the next screen appears for viewing individual cycles, it will have no waveforms. If one cycle has no waveforms, they will be missing from all the cycles. The reader enters "N", saves the study and stores it on the database in the usual manner.

1.5 Interference

Occasionally, the entire screen displaying the distensibility data will be a series of spikes from top to bottom, and no waveform is visible. An example is shown in Figure 9. This is due to electrical interference, and the study is finished in the same manner as in Absence of Waveforms (1.4 above). Interference generally affects the entire study.

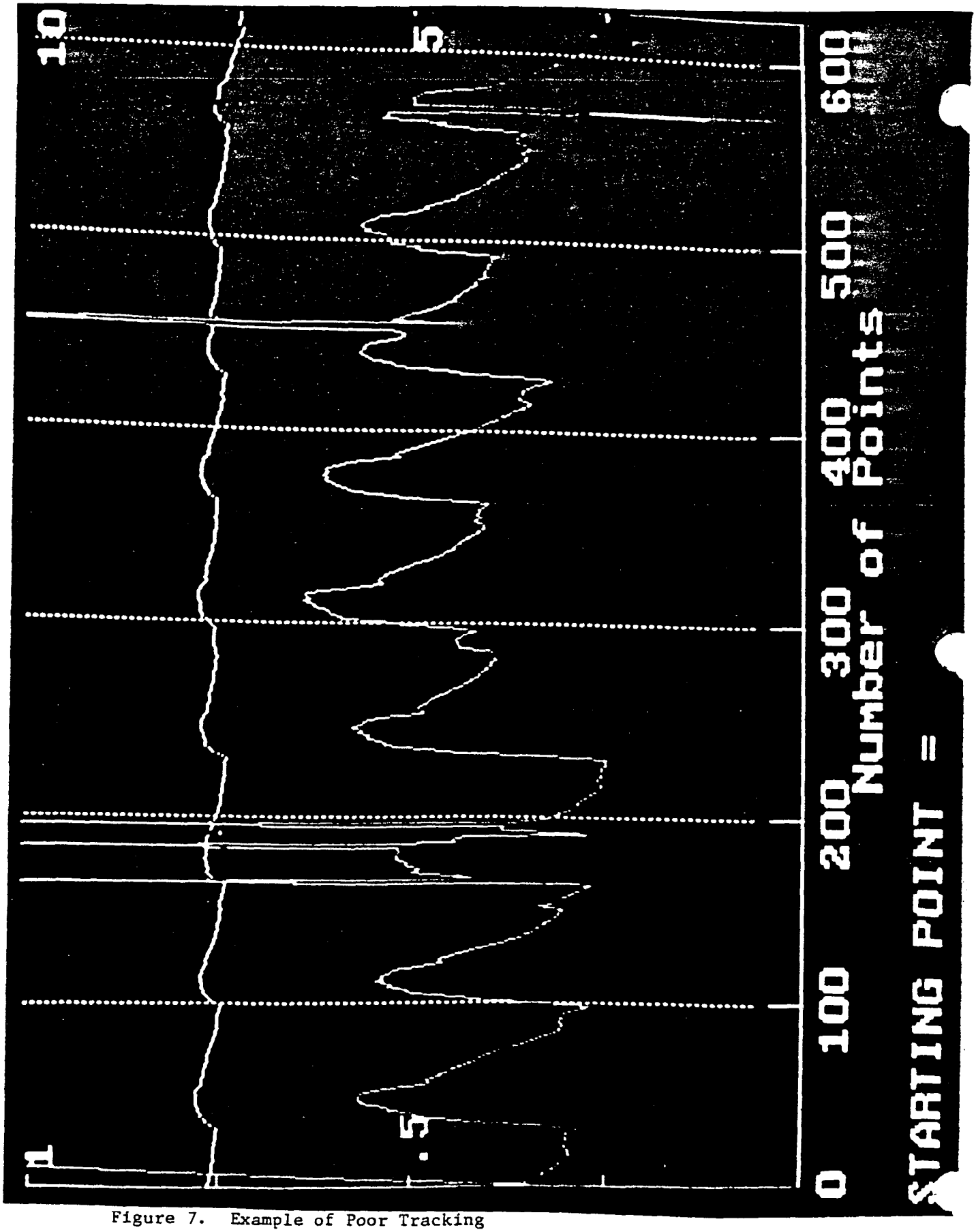


Figure 7. Example of Poor Tracking

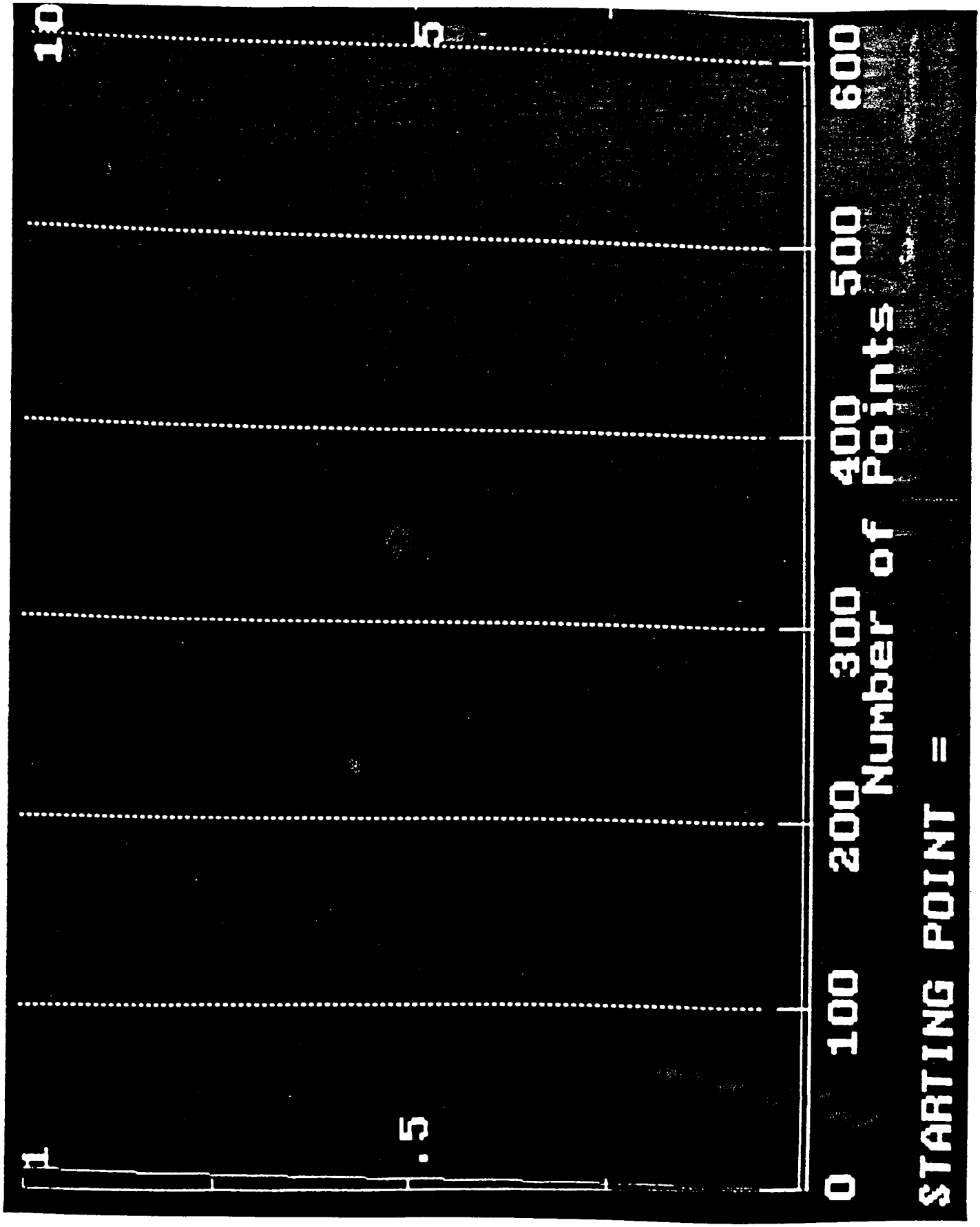


Figure 8. Example of No Waveforms

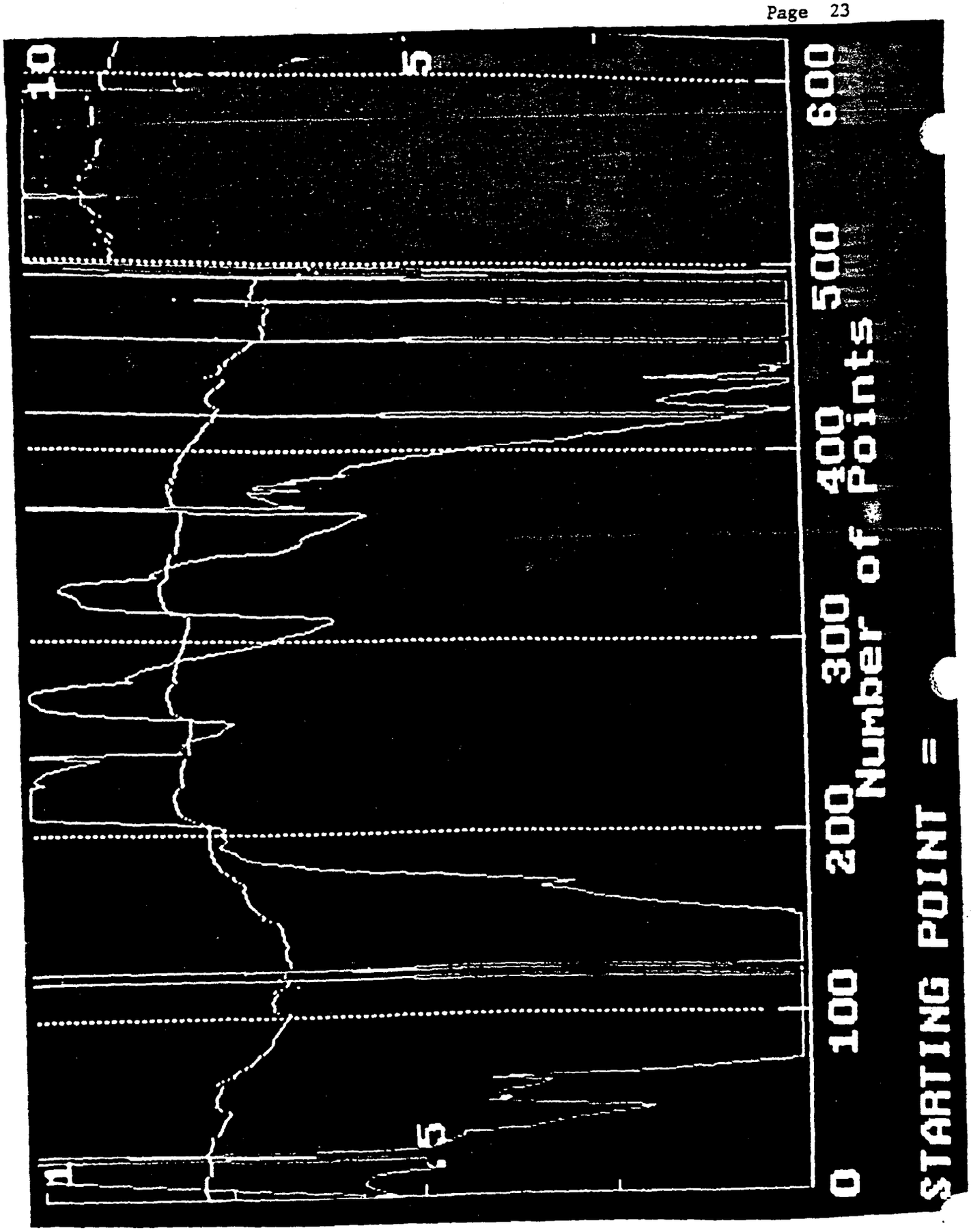


Figure 9. Example of Interference

Appendix C. Cases Requiring Additional Reading Instructions

2.1 Arterial Movement

When there is arterial movement or the artery drifts with respiration, the graphical representation of the data will display a few waveforms very high on the scale followed by a few very low on the scale, and the next few will again be very high (Figure 10). All the waveforms may be acceptable, but the reader should only choose one group, i.e., one set of high waveforms or one set of low waveforms. The goal is to select the "group" with the most acceptable cycles, and this may take several trial readings. Once the reader has found the best "group", the start and stop points that include these cycles are entered, and the study is completed.

2.2 DC Diastolic and Systolic Diameters Off Scale

When both the diastolic and systolic diameters of the DC (blue) waveform are off scale, the waveform appears as a straight line at the very top of the graphical representation (Figure 11). When this occurs, the reader reviews the distensibility strip chart to verify that the waveform does exceed the 10 mm limit. These studies are read following the protocol for poor tracking with no acceptable cycles (Appendix C, Section 1.1), resulting in no arterial parameters being calculated. DC diastolic and systolic diameters are calculated as 10.00 on the data screen (Figure 12) when they do exceed the scale limit. This identifies the study as one with both diameters off scale.

If the systolic diameter is off scale and the diastolic diameter is within the 10 mm scale (again verified by the strip chart), the study is read in the normal manner. In this instance, the reading program uses the DC diastolic diameter and the AC diameter change to obtain the systolic diameter for calculation of results. Therefore, particular attention should be paid to the AC diameter change column when viewing the data screen i.e., the values fall within a narrow numeric range (Figure 13).

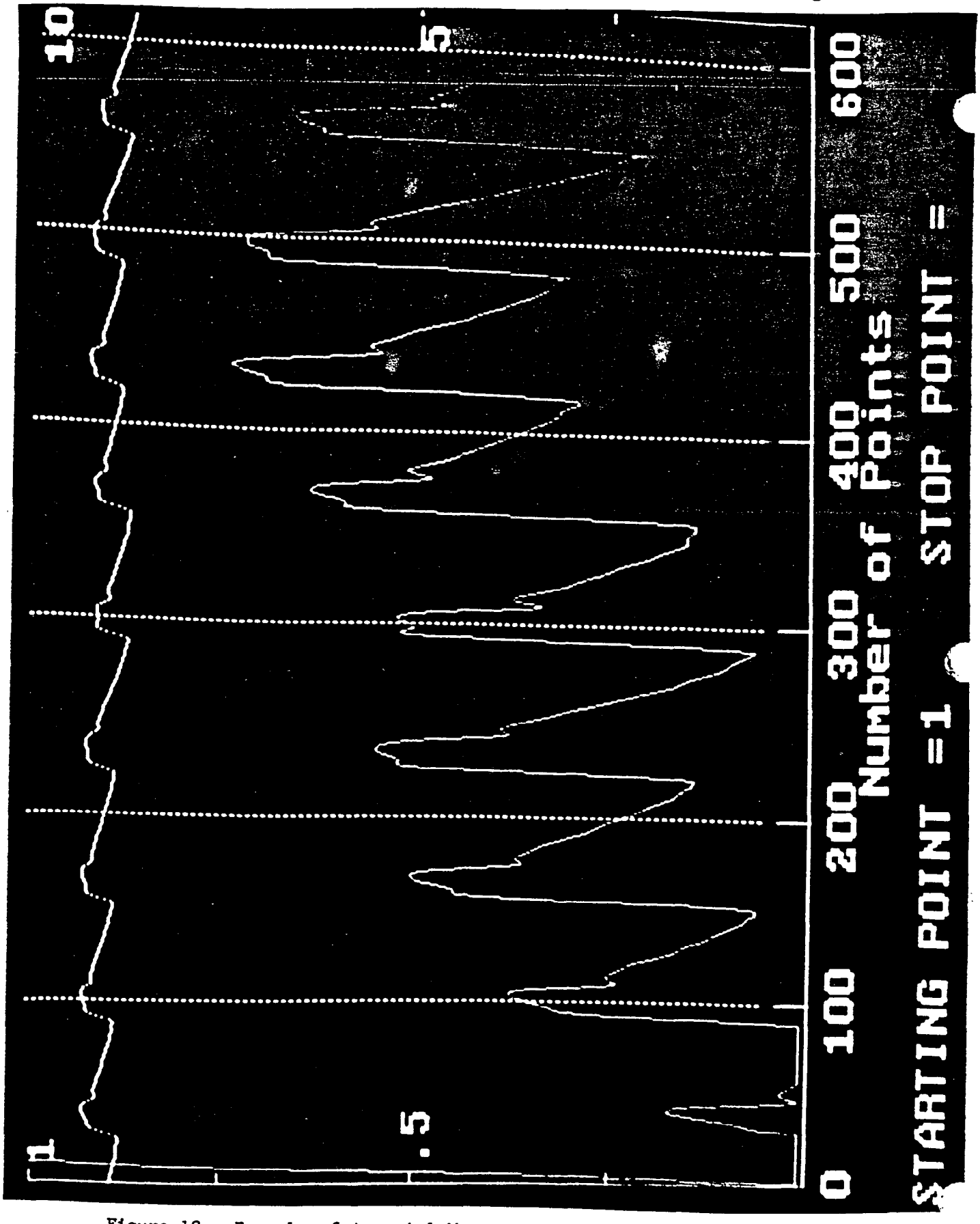


Figure 10. Example of Arterial Movement

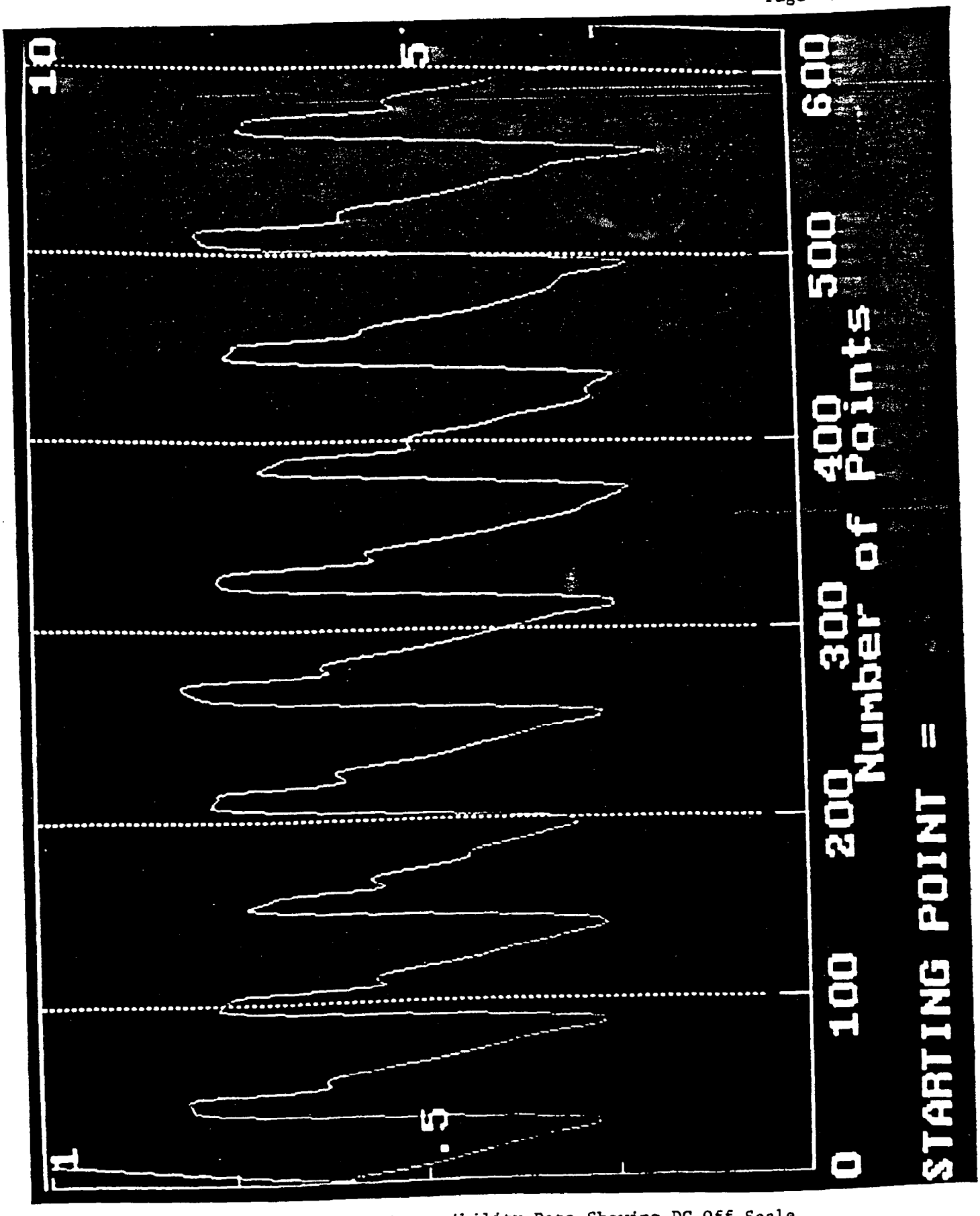


Figure 11. Example of Distensibility Data Showing DC Off Scale

CYL #	DC DIASTOLIC DIAMETER	DC SYSTOLIC DIAMETER	DC DIAMETER CHANGE	AC SYSTOLIC DIAMETER	AC DIAMETER CHANGE	DC HEART RATE
1	10.00	10.00	0.00	10.21	0.45	65.3
2	10.00	10.00	0.00	10.15	0.38	63.4
3	10.00	10.00	0.00	10.17	0.41	63.8
7	10.00	10.00	0.00	10.16	0.38	65.3
MEAN	10.00	10.00	0.00	10.17	0.41	64.5

		MEAN	
SBP	104	121	112.5
DBP	57	62	59.5

EP = 167.6 kPa
DISTENSIBILITY = 1.2 % / kPa

STRAIN = 4.2 %
COMPLIANCE = 9.1 CUBIC MM / kPa

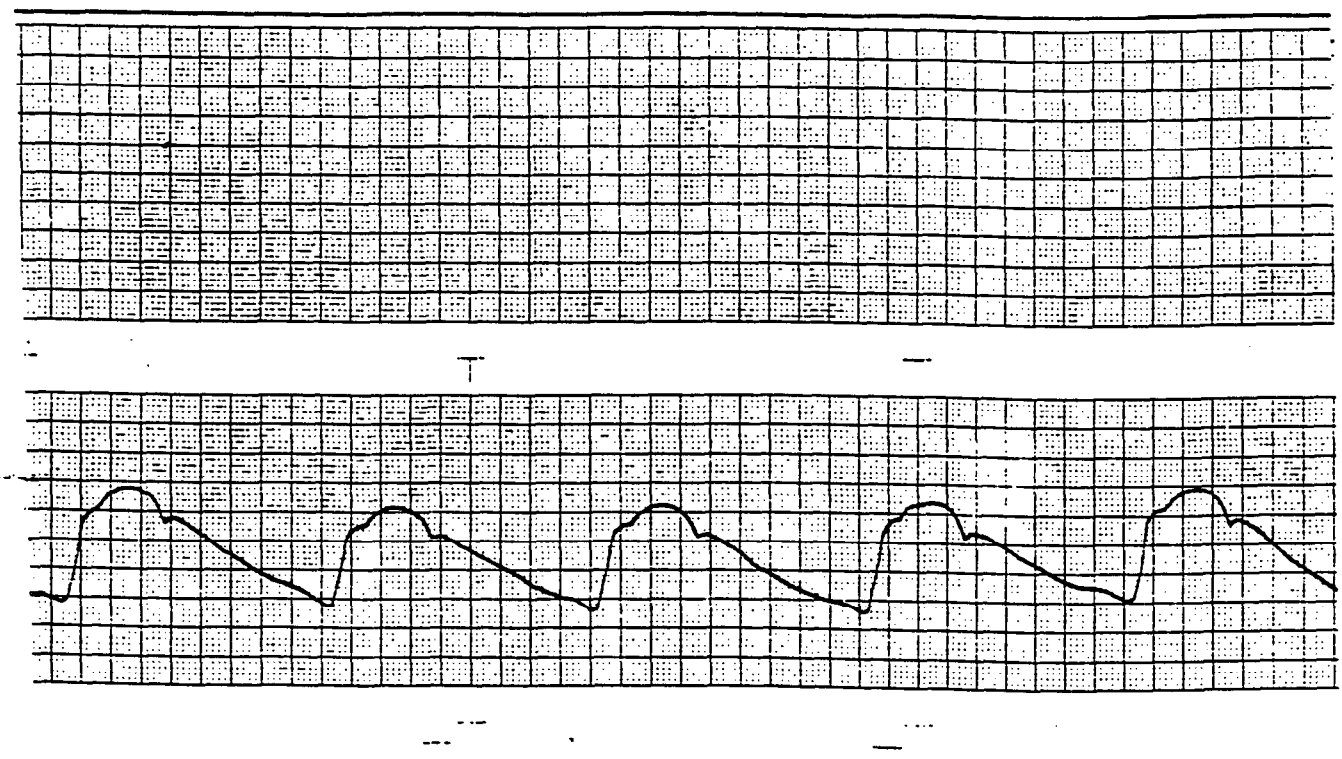


Figure 12. Data Screen - Both DC Diameters Off Scale

CYL #	DC DIASTOLIC DIAMETER	DC SYSTOLIC DIAMETER	DC DIAMETER CHANGE	AC SYSTOLIC DIAMETER	AC DIAMETER CHANGE	DC HEART RATE
1	9.46	10.00	0.54	10.12	0.67	59.5
2	9.46	10.00	0.54	10.15	0.69	61.9
3	9.49	10.00	0.51	10.13	0.64	57.0
4	9.47	10.00	0.53	10.16	0.68	59.9
5	9.51	10.00	0.49	10.14	0.63	59.2
6	9.50	10.00	0.50	10.15	0.65	58.5
7	9.47	10.00	0.53	10.13	0.66	61.9
8	9.48	10.00	0.52	10.15	0.67	61.9
MEAN	9.48	10.00	0.52	10.14	0.66	60.0

			MEAN
SBP	131	129	130.0
DBP	73	69	71.0

EP = 111.0 kPa
DISTENSIBILITY = 1.9 % / kPa

STRAIN = 7.0 %
COMPLIANCE = 13.2 CUBIC MM / kPa

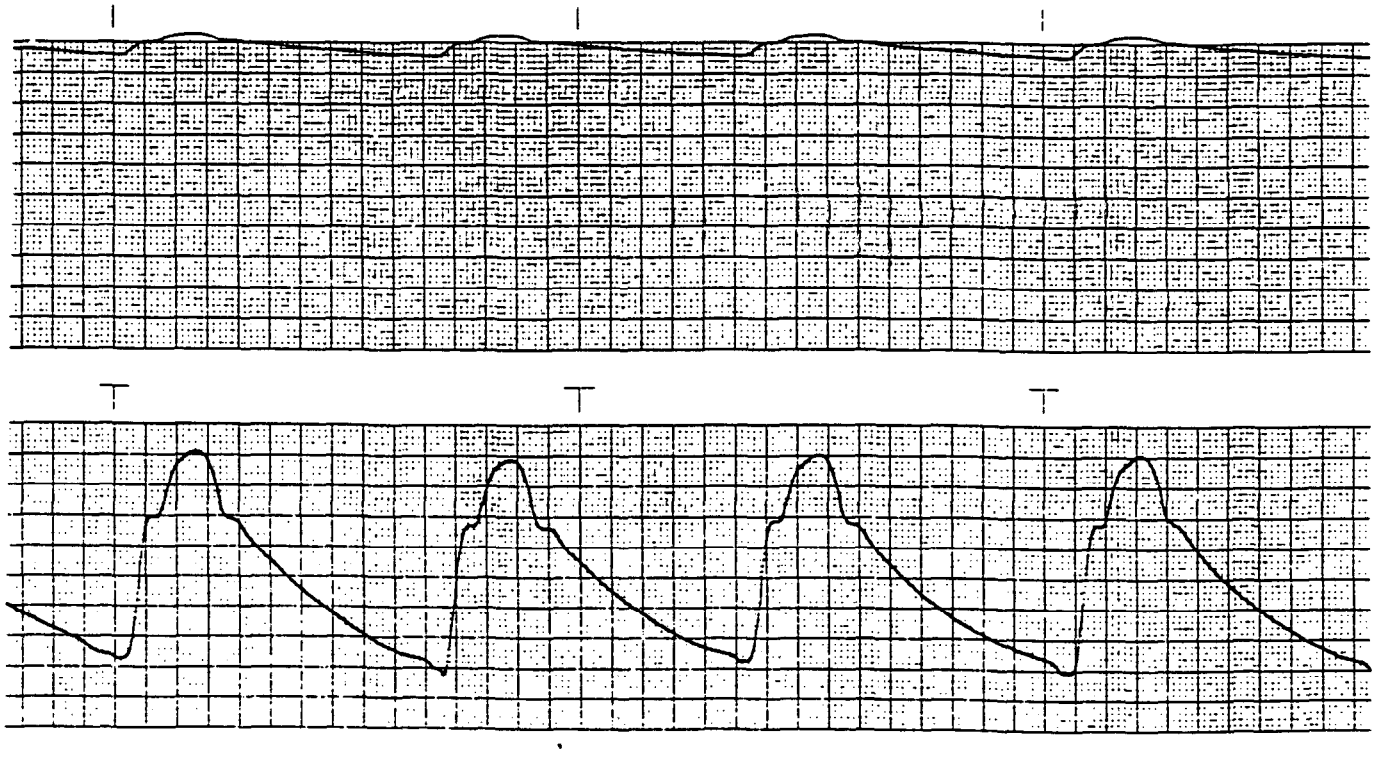


Figure 13. Data Screen - Only DC Systolic Off Scale