N69-31943

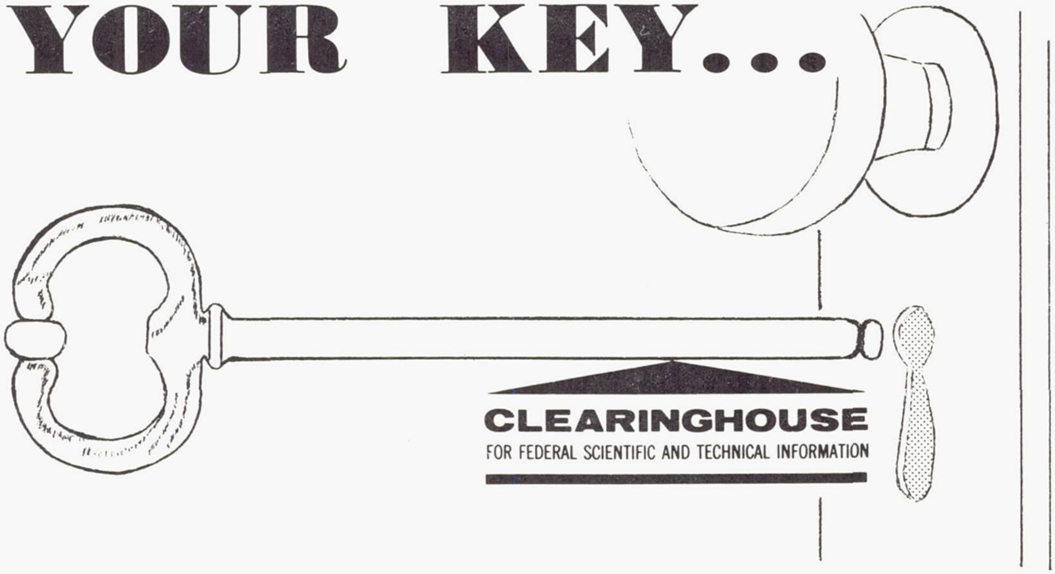
PERIPHERAL VOLUME MEASUREMENTS AS INDICES OF PERIPHERAL CIRCULATORY FACTORS IN THE CARDIOVASCULAR ORTHOSTATIC RESPONSE

Loren D. Carlson, et al

DISTRIBUTED BY: CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION

U. S. DEPARTMENT OF COMMERCE / NATIONAL BUREAU OF STANDARDS

YOUR KEY...



to scientific and technical advancement

Mr. Scientist. . .Engineer. . .Businessman. . .the Clearinghouse for Scientific and Technical Information can serve as your key to progress in research and development. Each year, some 40,000 unclassified documents from more than 125 Government agencies enter our collection. The Clearinghouse announces, reproduces and sells these reports to the public at a nominal cost. To make this wealth of scientific and technical information readily available, we have tailored our services to meet the needs of the highly selective customer as well as the general user. Some of these services are listed below.

U.S. GOVERNMENT RESEARCH AND DEVELOPMENT REPORTS (USGRDR). This semimonthly journal abstracts approximately 40,000 new Government-sponsored reports and translations annually. Features a quick-scan format, cross references, edge index to subject fields, and a report locator list.

U. S. GOVERNMENT RESEARCH AND DEVELOPMENT REPORTS INDEX (USGRDR-I). Published concurrently with the USGRDR to index each issue by subject, personal author, corporate source, contract number and accession/report number. Quarterly Indexes and an Annual Cumulative also are available.

CLEARINGHOUSE ANNOUNCEMENTS IN SCIENCE AND TECHNOLOGY. A semimonthly current awareness announcement service in 46 separate categories representing complete coverage of all documents announced by the Clearinghouse. Highlights special interest reports.

FAST ANNOUNCEMENT SERVICE (FAS). Selective announcement service emphasizing commercial applications of report information. Covers approximately 10 percent of Clearinghouse document input. Compiled and mailed in 57 categories.

SELECTIVE DISSEMINATION OF MICROFICHE (SDM). Automatic distribution twice monthly of Government research and development reports on microfiche. Economical and highly selective. Several hundred categories from which to choose.

ADDITIONAL INFORMATION concerning these and other Clearinghouse services is available by writing to:

Customer Services
Clearinghouse
U.S. Department of Commerce
Springfield, Virginia 22151

☆ U. S. GOVERNMENT PRINTING OFFICE : 1969 O - 360-245

NOTICE TO USERS

Portions of this document have been judged by the Clearinghouse to be of poor reproduction quality and not fully legible. However, in an effort to make as much information as possible available to the public, the Clearinghouse sells this document with the understanding that if the user is not satisfied, the document may be returned for refund.

If you return this document, please include this notice together with the IBM order card (label) to:

Clearinghouse
Attn: 152.12
Springfield, Va. 22151

NASA CR 101812

PERIPHERAL VOLUME MEASUREMENTS AS INDICES OF PERIPHERAL CIRCULATORY FACTORS IN THE CARDIOVASCULAR ORTHOSTATIC RESPONSE

Contract NGR 05-004-036

University of California Account No. 3-444530-23209

Loren D. Carlson, Ph.D. - Principal Investigator
Richard F. Walters, Ph.D. - Computer Analyst
Stephen J. Bartok, M.S. - Technical Assistant
Steven M. Weinberg, B.E. - Electronics Engineer
Dennis C. Lindberg - Technical Assistant
Masahiro Kaneko, M.Ed - Technical Assistant

Office of Contracts and Grants
Code SC
National Aeronautics and Space Administration
Washington, D. C. 20546

GENERAL INTRODUCTION

Classical bedrest studies[1], immobility and water immersion, and results of orbital space flight give rise to a set of clinical signs and symptoms which characterize a "deconditioning" of the cardiovascular system. The principal measurements related to the description are the change in heart rate and blood pressure during passive tilt to a 70° from horizontal position. Vogt has proposed a number of different measures and derivatives of measures (a total of 32) to characterize the response but finds heart rate to be the best single indicator.

An alternative provocative test is the application of negative pressure to the lower portions of the body.[2]

There are a number of mechanisms which may give rise to the response. Among these are a change in blood volume or a change in venous pooling during the tilt.

Each of these tests provides many data on a variety of parameters in time. These data are relevant to a quantitation of the response, to an assessment of mechanism, and to an evaluation of remedial measures.

This report is concerned with an evaluation of techniques of measuring changes in limb volume (Part I) and an evaluation of this measure in assessing the deconditioning occasioned by bedrest (Part II).

---

[1] Extensive bedrest literature is reviewed in NASA CR-171, "The effect of bedrest on various parameters of physiological function," C. Vallbona, F. B. Vogt, D. Cardus, W. A. Spencer and M. Walters, 1965. See also Lamb, L. E., "Status of knowledge of weightlessness, 1965" Appendix 5. pp. 531-54?, Space Research, Directions for the Future, NAS-NRC Publ. 1403.

[2] The principal references are given in "Cumulative effects of venesection & lower body negative pressure," Raymond H. Murray, M.D., John Krog, Ph.D., Loren D. Carlson, Ph.D., and John A. Bowers, M.D., Aerospace Medicine, Volume 38, March 1967 (SEE REFERENCES ATTACHED)

ATTACHMENT - references

Junod, V.T. Recherches Physiologique et Therapeutique sur les Effet de la Compression et de la Rarefaction de Lair tant sur le Corps que sur les Membres Isoles. Revue Med. franc. et etranc., 1834 Vol. III.

Bier, A. Hyperemia as a Therapeutic Agent. (Translated by Blech, G.M.) Chicago, A. Robertson 1905.

Junod, V.T. Traite Theoretique et Pratique de l'Hemospasie. Paris, G. Masson, 1875.

Yamada, S. and Burton, A.C.: Effects of Reduced Tissue Pressure on Blood Flow of the Fingers; the Venovasomotor Reflex. J Appl. Physiol., 6 501-505, 1954.

Coles, D. R., Kidd, B.S.L. and Patterson, G.C. The Reactions of the Blood Vessels of the Human Calf to Increases in Transmural Pressure. J. Physiol., 134 665-674, 1956.

Greenfield, A.C.M. and Patterson, G.C. Reactions of the Blood Vessels of the Human Forearm to Increases in Transmural Pressure. J. Physiol. (London) 125: 508-524, 1954.

Greenfield, A.D.M. and Patterson, G.C.: On the Capacity and Distensibility of the Blood Vessels of the Human Forearm. J. Physiol. (London) 131. 290-306, 1956.

Greenfield, A.D.M., Brown, E., Goei, J.S. and Plassaras, G.C. Circulatory Responses to Abrupt Release of Blood Accumulated in the Legs. The Physiologist, 6 191, 1963.

Brown, E., Goei, J.S., Greenfield, A.D.M. and Plassaras, G.: Circulatory Responses to a Large but Brief Increase in Venous Return in Man. J. Physiol., 170: 21P, 1963.

Greenfield, A.D.M. Blood Flow Through the Human Forearm and Digits as Influenced by Subatmospheric Pressure and Venous Pressure. Circulation Research, Supp. 1, 14 and 15. 1-70, 1964.

Plassaras, G.C., Brown, E., Goei, J.S. and Greenfield, A.D.M.: Effects of Simulated Postural Blood Shifts on the Capacity Function of the Limb Vessels. The Physiologist, 6 255, 1963.

FIGURE DESCRIPTIONS - PART I

PART I

Introduction

Non-invasive techniques for the measurement of blood flow by venous occlusion plethysmography involve direct or indirect measures of volume change of the extremity measured. In this study, three techniques were investigated: 1) limb circumference changes by a resistance transducer; 2) limb volume change by capacitance measurement; and 3) limb volume change by impedance measurement.

The resistance transducer for volume change, a circumference measurement, was introduced by R. J. Whitney (1953). The applications of the gauge have been described in detail by Fagan (1961) and the validation of the method documented by Burger, et al (1959 a,b) and by Clarke and Fellon (1957). The gauge, as described by Whitney, has a low resistance (0.1 to 8 ohms). A high impedance application has been devised by Waggoner (1965) introducing electrode paste in substitution for the mercury.

The physics of the strain gauge and the calculations for the gauge have been compiled by Fagan (1961). The fundamental considerations from that article are reproduced below.

Abbreviations

"The symbols which will be used are listed below. Values applicable to a specific finger gauge, and to a typical finger, are given in square brackets, for some parameters.

- L = length of active portion of gauge (cm). [45 mm when T = 10 g]
- r = radius of the bore of the tubing (cm). [ID = 0.35 mm]
- a = cross-sectional area of mercury column (cm^2)
- v = volume of mercury in the gauge (units not required).
- R = resistance of the mercury column (ohm). [ca. 0.45 ohms]
- t = temperature of the mercury (°C).
- T = tension in the gauge tubing (g). [10 g]
- P = pressure exerted radially by gauge upon the finger (mm Hg).
- Ts = longitudinal tension in finger skin required to support P (g).

C = circumference of finger (cm). [50 mm]

A = cross-sectional area of finger under the gauge (units not required).

V = volume of finger (units not required).

↔ = symbol used in logic, meaning "is equivalent to."

Standard values that are used have been taken from the <u>Handbook of Chemistry and Physics</u> (37th ed.).

<u>Terminology</u>

The volume (V) of the finger is the dependent variable in plethysmography. It is percentage change in volume (%ΔV), either per unit time or following the application of some procedure, which is most useful to physiologists. To convert this to the terminology commonly used in plethysmography:

$$n\%\ \Delta V \leftrightarrow n \text{ cc/100 cc of tissue,}$$

(n = any number).

<u>Resistance of Gauge</u>

Resistivity (ρ) of mercury = 95.78 microhm-cm, at 20° C.

Resistance (R) of a mercury column = $\frac{(9.578 \times 10^{-5} \text{ ohm-cm})\ (\text{cm})}{\text{cm}^2}$

$$= \frac{\rho L}{a}.$$

If ID = 0.35 mm, r = 0.175 mm = 1.75×10^{-2} cm, and

$a = \pi r^2 = 3.14(1.75 \times 10^{-2})^2$

$= 9.6 \times 10^{-4}$ cm^2.

$R = \frac{9.578 \times 10^{-5}}{9.6 \times 10^{-4}} = 0.10$ ohms/cm*. (meaning "ohms per cm of length")

Hence, for the gauge described (L = 45 mm), R = 0.45 ohms. (The measured resistance will be slightly greater since ID was measured with the tubing unstretched; under 10 g T, the area (a) is slightly less than the figure calculated above.)

*Lawton and Collins (1959) have used rubber tubing of 0.5 mm ID, which works out to R = 0.05 ohm/cm. Yet, they report "a resistance of about 0.23 ohm/cm" - a surprising discrepancy!

<u>Change in Resistance with Length</u>

The volume of mercury in a column = L · a = v

$$R = \frac{\rho L}{a}$$

$$= \frac{\rho L^2}{v} \text{ (top and bottom multiplied by L).}$$

Differentiating, $\frac{dR}{dL} = \frac{2\rho L}{v}$ (since ρ and v are constants),

$$= \frac{2R}{L} \quad (\text{Since } \frac{\rho L}{a} = R).$$

From this, it follows that:

$$1\%\ \Delta L \leftrightarrow 2\%\ \Delta R.$$

However, this is only approximately correct. The exact general relationship is given by:

$$n\%\ \Delta L = 2n\%\ \Delta R + \frac{n^2}{100}\ \%\ \Delta R.$$

<u>Temperature Coefficient of Resistance</u>

The temperature coefficient of resistivity (α) of mercury = 0.00089, at 20° C, or at 20° C, $\Delta R/°C = 8.9 \times 10^{-4} \times R$.

The $\%\ \Delta R/°C = \frac{8.9 \times 10^{-4} \times R}{R} \times 100$

$= 8.9 \times 10^{-2}\%$.

Now 1% ΔL ↔ 2% ΔR. The temperature change (Δt) required to cause 2% ΔR = $\frac{2}{8.9 \times 10^{-2}}$

= 22.5° C

Hence, 1% ΔL ↔ 22.5° C Δt.

<u>Change in Tension with Length</u>

"A gauge was suspended with 10-g tension (T) on it. The length (L) of the active portion was 45 mm. An additional 5-g tension was applied which stretched the gauge by 1.6 mm, as determined by the method of precise calibration (Eagan, 1961) which was being done concurrently.

Hence, $5\ g\ \Delta T \leftrightarrow \frac{1.6}{45} \times 100 = 3.3\%\ \Delta L.$

Then $1\%\ \Delta L \leftrightarrow \frac{5}{3.3} = 1.5\ g\ \Delta T.$

(The relationship between L and T will vary according to the OD of the particular sample of tubing. ID is quite regular.)

<u>Change in Volume of a Cylinder Related to Change in Circumference</u>

'The first section which follows is excerpted from Clarke and Hellon (1957). 'Consider a cylinder of radius r. Let the cylinder expand slightly in a radial direction only, so that the radius increases from r to r + dr.

$$\text{The change in area} = \pi(r + dr)^2 - \pi r^2$$
$$= 2\pi r\ dr, \text{ if } dr^2 \text{ is small,}$$
$$\text{Percentage change in area} = \frac{2\pi r\ dr}{\pi r^2} \cdot 100$$
$$= \frac{2\ dr}{r} \cdot 100$$
$$\text{The change in circumference} = 2\pi(r + dr) - 2\pi r$$
$$= 2\pi dr$$
$$\text{Percentage change in circumference} = \frac{2\pi dr}{2\pi r} \cdot 100$$
$$= \frac{dr}{r} \cdot 100$$

'Thus, the percentage change, or rate of change, of limb (<u>or digital</u>) circumference will be half the percentage change, or rate of change, of cross-sectional area (or volume).'

Using the symbols we have applied for the finger:

$$1\%\ \Delta C \leftrightarrow 2\%\ \Delta A$$
$$\leftrightarrow 2\%\ \Delta V.$$

'This simple relationship is only approximately correct, but it will be shown that the error involved in using it is too slight to be of practical importance in plethysmography.

"The exact relationship between C and V is usually given by the formula:

$$\%\ \Delta V = \frac{2C \cdot \Delta C + (\Delta C)^2}{C^2} \cdot 100$$

"The use of this formula will give the appearance of slightly greater accuracy, though the extra work of calculation is usually unwarranted by reason of other possible errors in the plethysmographic method. If one is measuring blood flow in the finger, and following venous occlusion obtains 1% Δ C/sec, then blood flow calculated by the formula becomes 2.01% Δ V/sec + 120.6% Δ V/min. However, there is a pitfall for the unwary plethysmographer who hopes for greater accuracy by using the formula, but who makes the assumption that it is C which changes linearly with time. This error can be fallen into by assuming that 1% Δ C/sec = 60% Δ C/min. Then, using the formula, blood flow would work out to 156% Δ V/min — a considerable error!

"It must be remembered that Δ V is closer to the changing physiological parameter than is Δ C. For instance, the actual progression of events relevant to venous occlusion plethysmography would be as follows: venous occlusion → Δ V → Δ C → Δ L → Δ P → stylus deflection, from which is calculated the rate of blood flow. The general progression of measurement is in the reverse, with error being possible at each transition.

"A simple formula which exactly delineates the relationship between % Δ C and % Δ V is:

$$n\%\ \Delta C = 2\ n\%\ \Delta V + \frac{n^2}{100}\ \%\ \Delta V$$

In finger plethysmography, n will usually equal approximately 1% and will seldom be greater than 2%. Using this figure, 2% Δ C = 4.04% Δ V. With cognizance of the possible errors in all of the other steps in the progression of measurement mentioned above, it is evident that the 0.04% portion could be safely disregarded. Hence, in finger plethysmography, it can be assumed that 1% Δ C ↔ 2% Δ V.

"All of the previous calculations have been based on the cylinder and this shape is presupposed for the finger. Whitney (1953) has shown that there is negligible error in this assumption unless there is a very great deviation from the circular shape.

Relationship Between Δ V and Δ R

It has been stated previously that:

$$n\%\ \Delta L = 2\ n\%\ \Delta R + \frac{n^2}{100}\ \%\ \Delta R,$$

and,

$$n\%\ \Delta C = 2\ n\%\ \Delta V + \frac{n^2}{100}\ \%\ \Delta V.$$

Now the relationship between Δ L and Δ C is one of exact linearity* (since C and L are constants in any one experiment),

viz. $n\%\ \Delta C = \frac{C}{L}\ n\%\ \Delta L.$

Hence, $n\%\ \Delta V = \frac{C}{L}\ n\%\ \Delta R.$

"Thus, in practice, all of the previous minor reservations that have been made concerning the use of the short mathematical form in describing the relationship between % Δ C, on the one hand, and % Δ V and % Δ R, on the other, may be ignored entirely. The dependent variable is % Δ V, and % Δ R is what is measured. Their relationship is one of exact linearity in the case where L and C are equal. It has been shown that even on the assumption of a linear relationship betweem Δ C and Δ R, the error in using the equation, n% Δ C = 2 n% Δ V, was slight. It is now apparent that this relationship is exactly true when L = C, and so close to being correct when L makes up the greater part of C, that no error is involved in using it. (For example, if % Δ C = 2.0, L = 45 mm, and C = 50 mm, then % Δ V = 3.996, rather than the 4.0 which would derive from the simple equation.)

Thus, through a fortuity of nature, in the calibration of the mercury finger gauge, and in its use for plethysmography of the finger, it may be considered that:

$$n\%\ \Delta C = 2\ n\%\ \Delta V$$

---

*This is true with the assumption that: (a) the length of the gauge changes with change in circumference without causing variation in the degree of deformation of the skin under the gauge; (b) changes in the thickness of the wall of the tubing between the mercury column and the skin are negligible.

Radial Pressure Exerted by the Gauge

"Gauge tension (T) = 10 g = 9800 dynes. Since OD of the gauge tubing is about 1.25 mm, the pressure exerted by the gauge will be on a circular strip of the finger approximately 1 mm wide. Hence, T = 9800 dynes/mm = 98,000 dynes/cm.
C of finger = 50 mm, so that the radius (r) = 0.80 cm. From the formula, $P = \frac{T}{r}$ (where P is in dynes/cm², T in dynes/cm, and r in cm) the radial pressure, $P = \frac{98.000}{0.80} = 122,500$ dynes/cm². Since 1 mm Hg = 1330 dynes/cm², then $P = \frac{122,500}{1330} = 92$ mm Hg. Since 1% Δ C ↔ 1.7 g Δ T, then T_1 = 11.7 g and P_1 = 108 mm Hg. Hence, 1% Δ C ↔ 16 mm Hg Δ P.

Support of the Gauge Pressure

"The gauge may be supported by tension in the skin (T_s) acting longitudinally. From inspection, it was estimated that the radius of the "circle" of deformation of the skin = 1 mm, approximately. Since P = 92 mm Hg = 122,500 dynes/cm², then

$$T = P\ r = 122,500 \times 0.1 = 12,250 \text{ dynes/cm}$$
$$= \frac{12,250}{980} = 12.5 \text{ g/cm.}$$

Total longitudinal tension in the skin (T_s) of the finger of 5.0 cm C = 5 x 12.5 = 62.5 g. If 1% increase in C occurs, T_1 = 11.7 g and T_{s_1} = 73 g, in order to support P_1. Hence 1% Δ C ↔ 10.5 g Δ T_s. These are maximum figures for both T_s and Δ T_s; the gauge P may be supported in part by tissues directly under the gauge.

"An experiment was done to assess the relative importance of T_s. A light, latex rubber finger cot was sealed to the tip of the finger, circumferentially, 2 or 3 mm distal to the mercury gauge attached as described in NAL-TN-60-15 (Eagan, 1961). The finger was held with the tip downwards. When 50 g was hung from the free end of the cot, an apparent increase in circumference of the finger equal to 0.25% Δ C was measured (average value). A 100-g weight gave an average of 0.5% Δ C. Hence, 1% Δ C ↔ 200 g of externally applied tension.

Tension applied externally to the surface of the skin at a few millimeter's distance from the gauge is not numerically comparable to that which exists in the skin (Rothman, 1954) and which could increase due to deformation caused by the radial pressure (P) exerted by the gauge. The fact that increasing the tension in the skin causes an apparent increase in C of the finger suggests that the gauge is supported at least in part by T_s. The remaining part would be supported by diffusion of the pressure gradient radially and laterally into the underlying tissue. The failure of any slow decrease in apparent C to occur in the finger, after the gauge under 10-g tension is attached, suggests that T_s is the important factor.

<u>Calibration Equivalents</u>

Static calibration of the finger gauge has been discussed in AAL-TN-60-15 (Fagan, 1961). A typical value obtained is 20.0-mm deflection on the record, with an ATTENUATOR setting of X 100 (on the carrier preamplifier of the Sanborn 150 system), for 2.00-mm extension of the gauge. It follows that:

$$1\%\ \Delta C \leftrightarrow 5.0\text{-mm deflection, on X 100}$$
$$\leftrightarrow 50\text{-mm} \qquad \text{X 10}$$

At the limit of resolution, a Δ C of 1 micron = 0.002% Δ C $\leftrightarrow$ 1 mm of stylus deflection, on X 1.

A dynamic calibration of the gauge has been done by Lawton and Collins (1959) using a variable-frequency, variable-amplitude vibrator. Since this work cannot readily be summarized, the reader is referred to the original. The frequency response characteristics of the gauge are such that they impose no limitations on its use in ordinary plethysmography.

<u>Resistance Transducers for Volume Change</u>

Mercury and rubber gauge or Whitney gauge, as used in these experiments, is shown in Figure I-1. It consists of a double loop of 0.045" OD and 0.015" ID silastic tubing fixed to silver wires after being filled with mercury. Silver wire ends are fastened with the lead wires in a plastic block approximately 1 cm apart. The loop is carried around the leg and fastened on the semicircular plastic block and adjusted on the phosphobronze strip of metal until the tension is equal to the 20 g tension used in calibration. Calibration stand is shown in Figure I-2 and gauge as mounted on the leg is shown in Figure I-3.

The gauges are stable. Tests over a sixty-minute period gave changes randomly distributed about zero and within the range -0.122% Δ V to +0.04% Δ V.

Improvements for the gauge design are shown in the fabrication drawing with a materials list in Figure I-4, I-5.

<u>The Question of Artifact and Error in the Use of the Whitney Gauge</u>

The comparison of conventional methods and the strain gauge technique has been made by Clarke and Hellon in 1957. This discussion of artifact and error will not negate the close correspondence of strain gauge method and conventional volume plethysmography but will indicate the pitfalls of the method when it is extended beyond the standard use in which it can be compared with a water- or air-filled plethysmograph. That is to say, the Whitney gauge can be installed and worn during exercise and during tilt procedures and in these conditions it cannot be compared with water-filled apparatus.

Temperature induced errors in uncompensated gauges, such as have been used, will not be great under the conditions of the tilt table experiment. If room temperature is maintained so the subject is warm so as to have a reasonable skin blood flow without sweating, the errors in temperature will be minimal. Measurements of the temperature of the leg do indicate slight shifts in temperature and an ideal gauge would include the temperature compensation circuit which was devised by Whitney and has been demonstrated to be functional over a temperature range from 0° to 37° C by Fonda (1962).

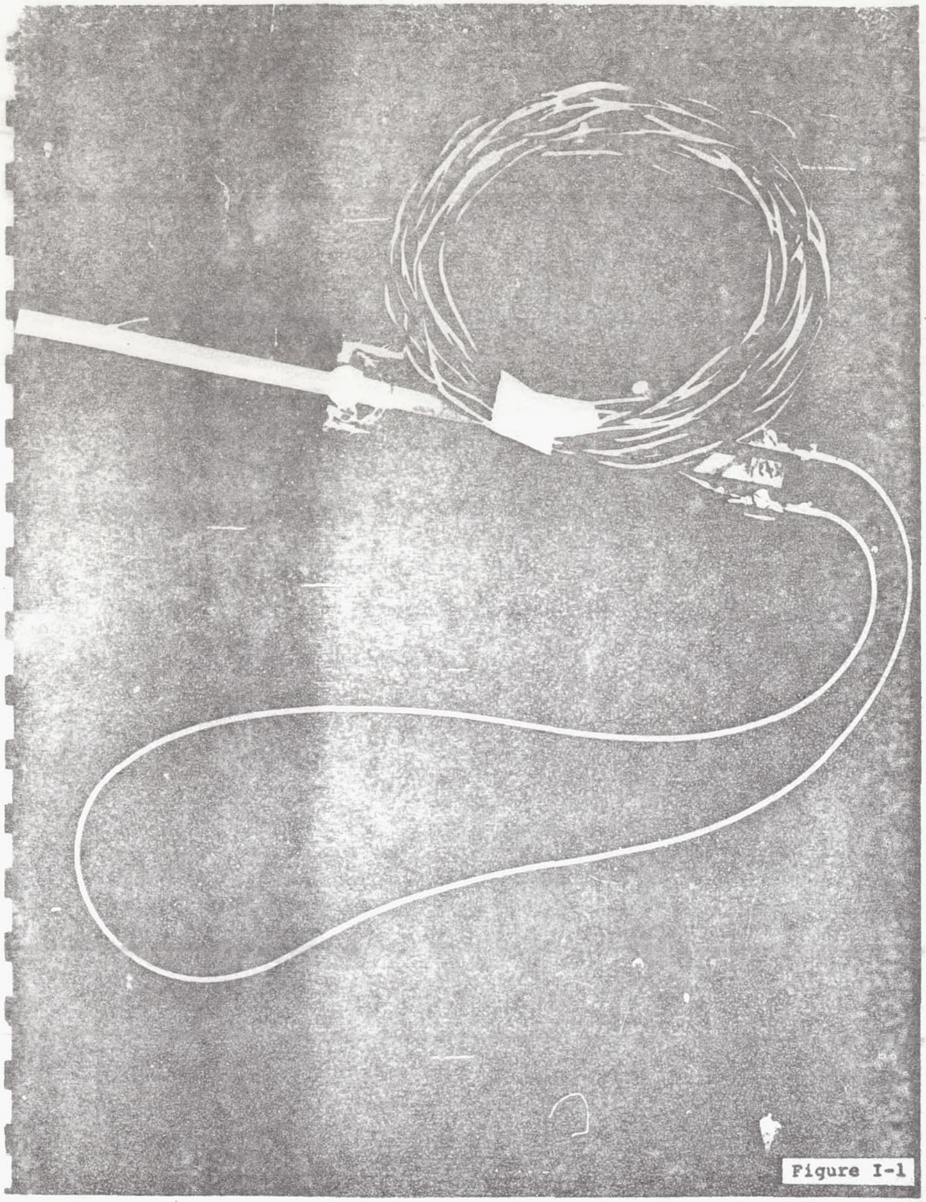


Figure I-1

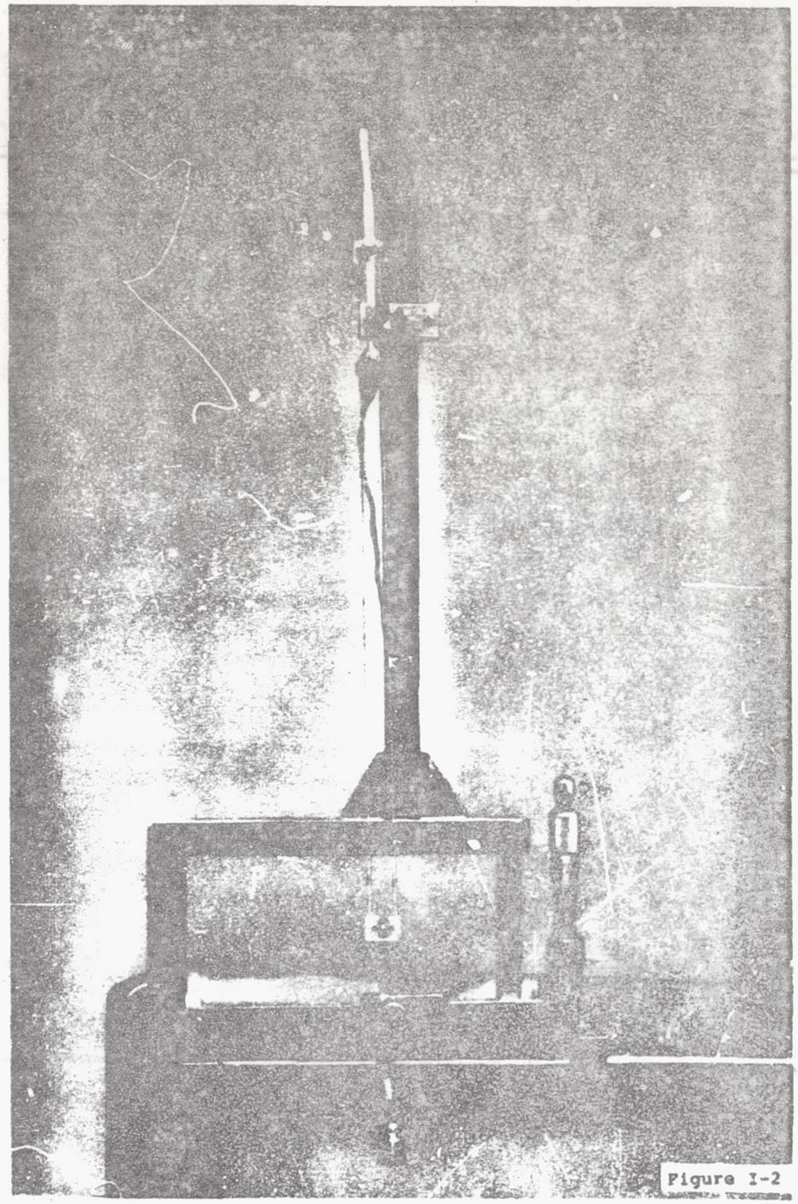


Figure I-2

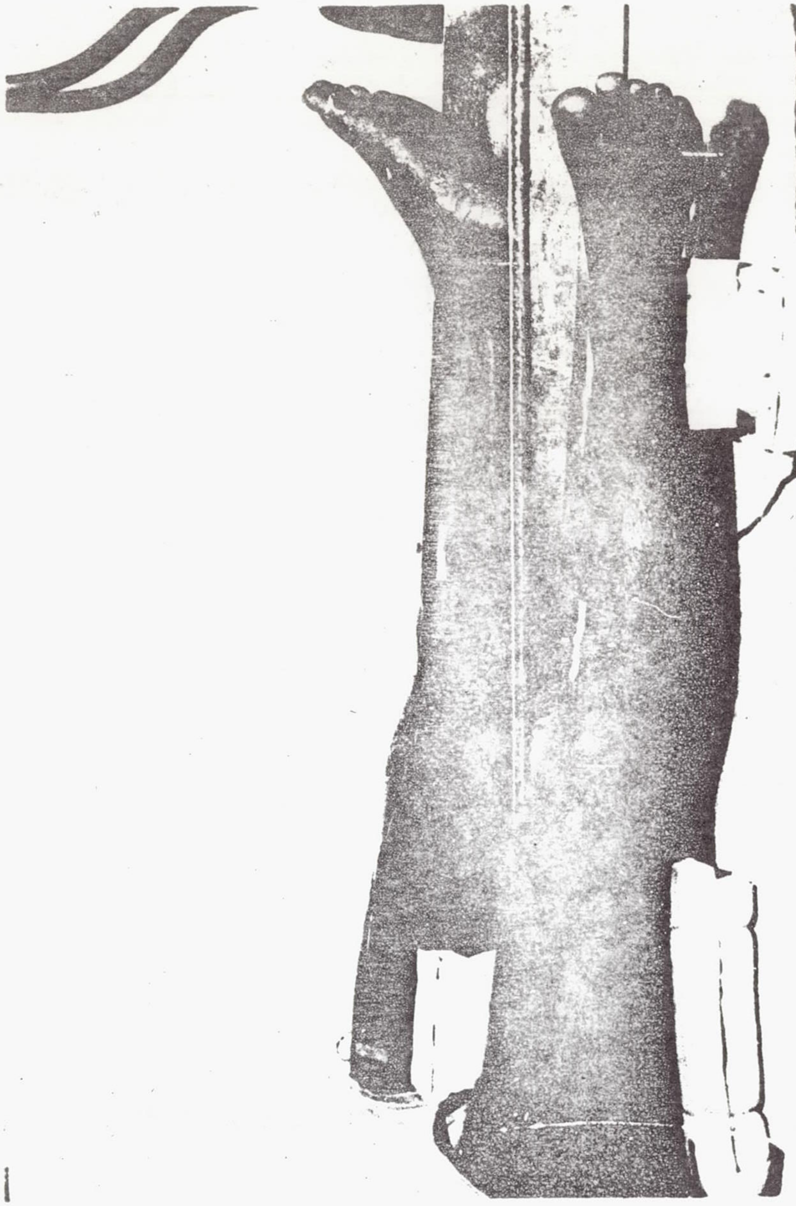


Figure I-3

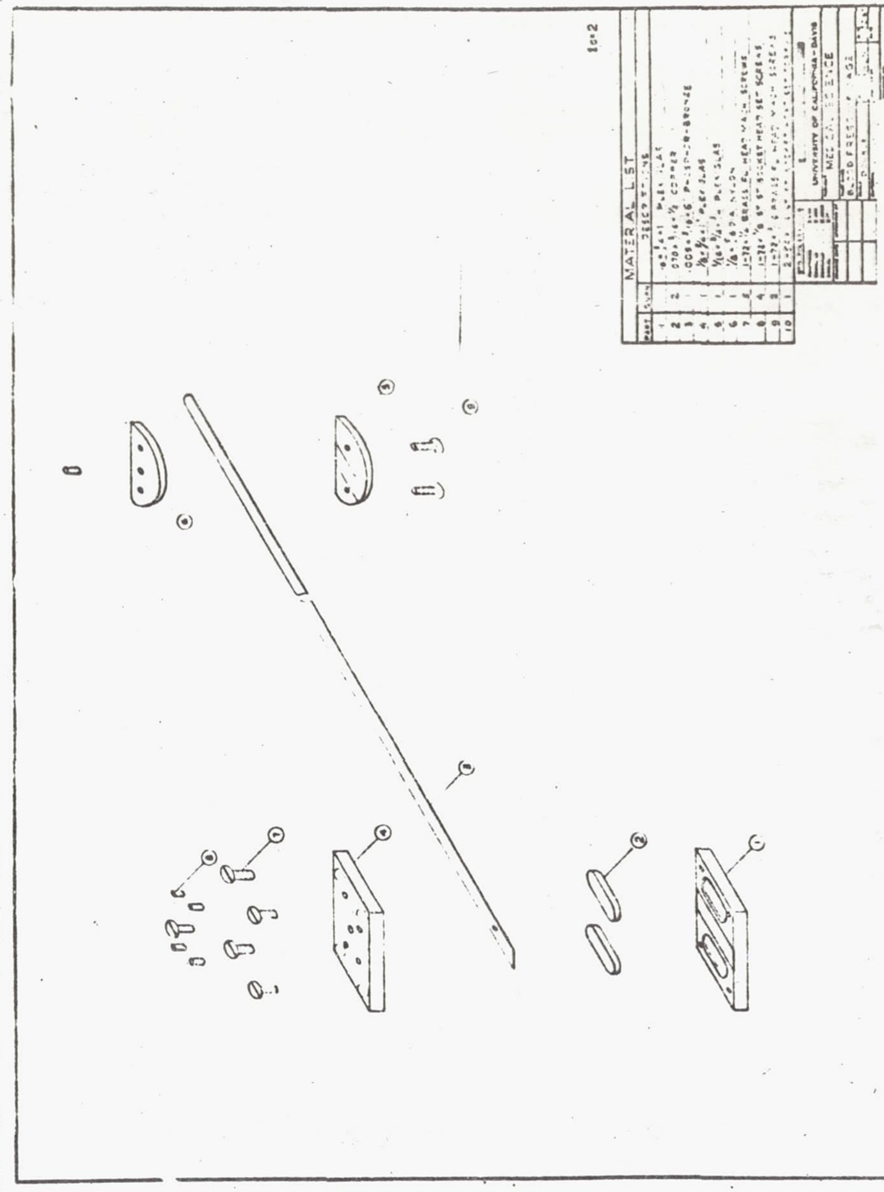


Figure I-4

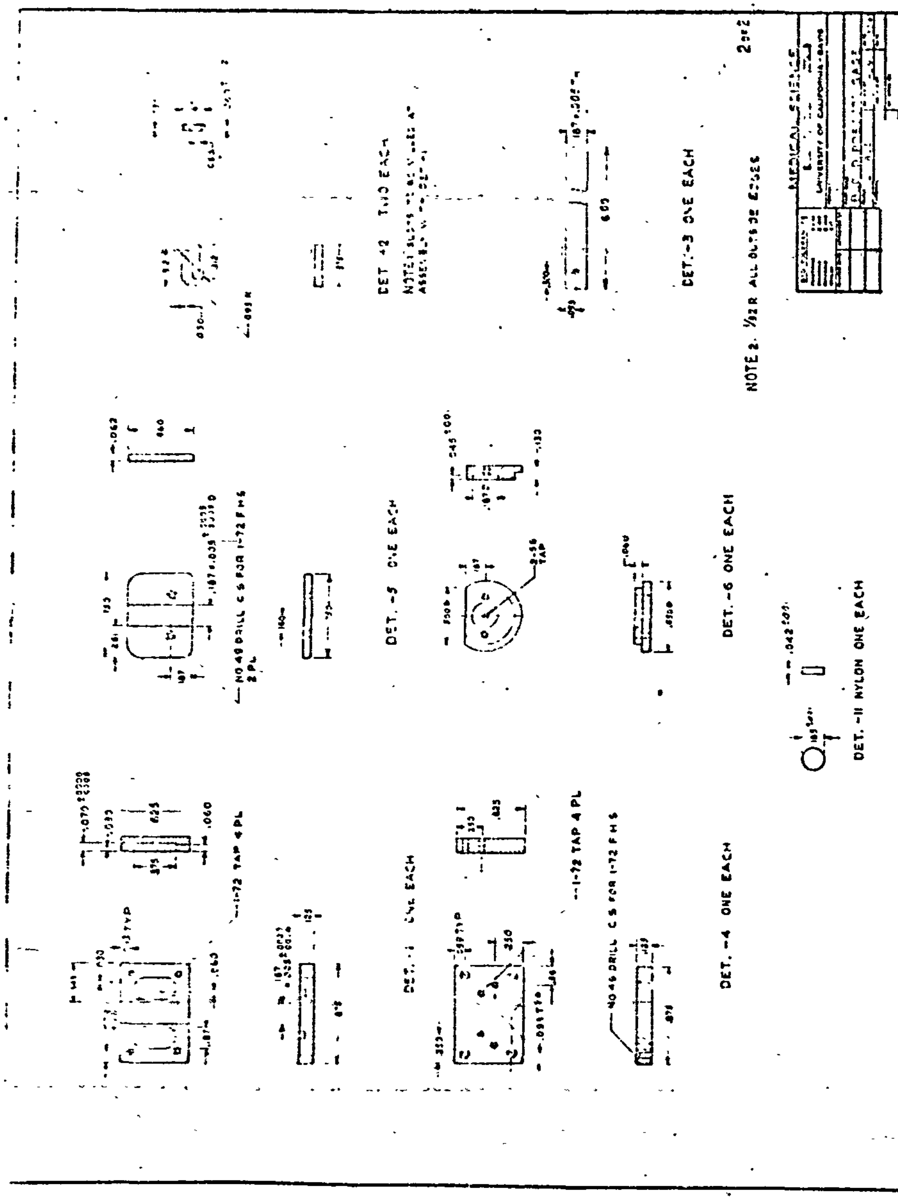


Figure I-5

Motion and Position Artifact

In these experiments, the gauges were carefully positioned around the maximum circumference of the calf of the leg. The double-stranded gauge was carefully positioned to cover this circumference. We have tested possible artifacts both in tilt and during negative pressure by positioning gauges proximal and distal to the gauge at maximum circumference in such a position so that the gauges are one centimeter shorter than the maximal circumference gauge. A series of tilt experiments are shown in the accompanying figures to show the correspondence of these gauges and the tilt procedure. A standard tilt (Figure I-6) and a measure of blood flow with venous occlusion (Figure I-7) show the correspondence. To test for artifact, an arterial occlusion cuff was placed on the thigh and inflated to 200 mm of mercury. The tilt was then repeated. An inspection of these records show that there is some leakage into the limb with the cuff on, seen by a rise in the baseline. The most marked differences are between the upper or proximal gauge and its counterparts more distal during tilt (Figure I-8). With venous occlusion, the gauges also lack correspondence (Figure I-9). There are two possible interpretations of this volume change. One is a slight shift in the muscle mass under the gauges - the second is the possibility of redistribution of blood in the columns of the veins. Slight changes in the tilt table, as well as maneuvers which cause slight changes in position of the leg, such as pushing on the knee or pulling at the ankle, give similar but much smaller changes in the gauge electrical output (Figure I-10). Experimental maneuvers which cause the knee to be fixed in position during the tilt do not eliminate the artifact shown in the initial figures (Figures I-11 and I-12).

An experiment was devised to determine if this artifact exists with the application of negative pressure to the leg. There is a clear difference in the three gauges - again showing a change during arterial occlusion which might be interpreted as a shift in blood from the upper part of the leg to the lower (Figures I-13, I-14, I-15). Redistribution of blood rather than muscle shift seems a better explanation for the discrepancies based on these experiments.

These tests bring into serious question the use of the gauge as an index of leg volume change in the tilt table tests. They do not invalidate the data such as were obtained in the bedrest study, but they seriously constrain the interpretations which may be made. It appears that error is minimal, or at least compensatory, when the gauge is placed at maximal leg circumference.

Capacitance Transducer for Volume Change

Capacitance methods for plethysmographic measurements have been presented by Hyman, et al (1963) [in adaptation of an earlier method proposed by Figar (1959)] and Fewings and Whelan (1966). The physics of the capacitance system and its application to plethysmography has been described by Fewings and Whelan (unpublished) and is presented here.

The capacitance method for recording volume changes in a limb consists in passing a constant current at a fixed frequency across a capacitor formed by the surface of the limb and the plethysmograph plate which surrounds it. These two 'plates' are separated by a uniform distance. Changes in volume induced by venous occlusion alter the distance between the two plates and thus produce changes in electrical capacity which can be detected as voltage changes. Capacity (c), volume (v) and voltage (c) can be related by the following equation:

$$C = \frac{K_1 A}{d}$$

where A = mean surface area, d = mean distance between arm surface and plethysmograph plate.

$$V = K_2 A d$$

where V = volume of the space between the arm surface and the plethysmograph plate

$$E = \frac{I}{jwc}$$

where I = current, j is constant and w = frequency. If I and w are constant, then

$$E = \frac{K_3}{c}$$

By substitution it is found that $V = \frac{1}{c}$ and $V = E$ for a fixed frequency constant current system. In such a system, however, two types of errors must be considered

(1) Those due to imperfect correlation between volume and capacity for a constant spacing between the plethysmograph and arm. In practice this type of error can be kept below 1% if the ratio of the plethysmograph 'plate' circumference to arm circumference is less than 1.4.

(2) Those due to a non-uniform spacing between the plethysmograph and arm which must occur because a small range of plethysmographs is used for all arms and the expansion of the forearm during periods of venous occlusion is not necessarily uniform. This type of error can be kept below 5% by using a spacing of 1.25 ± 0.25 cm between the plethysmograph and the forearm. This spacing also permits a linear relationship between capacity and volume.

As the plethysmograph actually measures the volume of the space between the plethysmograph and the surface of the forearm, i.e. the volume between the plates, it is necessary to relate the capacity and volume of this annular space. The capacity between the plethysmograph and arm surface is given by the equation

$$C_T = \sqrt{\frac{\overline{P}_1 \cdot \overline{P}_2}{4\pi d}} \cdot L \text{ cm units} \qquad \ldots\ldots\ldots\ldots 1$$

where C_t = total capacity between plethysmograph and arm

$\overline{P}_1$ = mean arm circumference

$\overline{P}_2$ = mean plethysmograph circumference

d = mean distance between plethysmograph and arm

L = effective length of plethysmograph.

The total volume between the plethysmograph and arm (V_T) is given by

$$V_T = \frac{P_1 + P_2}{2} \cdot d \cdot L \text{ ml} \qquad \ldots\ldots\ldots\ldots 2$$

Substituting in equation (2) for d obtained from equation (1)

$$V_T = \frac{(P_1 + P_2)}{2} \cdot \sqrt{\frac{P_1 \cdot P_2}{4\pi C_T}} \cdot L^2 \text{ ml}$$

In practice C_T is measured from a variable capacitor calibrated in picofarads (pF) and 1 pF = 0.9 cm.

$$\therefore \quad V_T = \sqrt{\frac{\bar{P}_1 \cdot \bar{P}_2}{3.6 \pi C_T}} \cdot 1/2 \, (P_1 + P_2) \cdot L^2 \text{ ml} \qquad \ldots\ldots\ldots\ldots\ldots 3$$

In practice with the specified spacing and ratio between $\bar{P}_1$ and $\bar{P}_2$ equation (3) becomes

$$V_T = \frac{A^2}{3.6 \pi C_T} \text{ ml} \qquad \ldots\ldots\ldots\ldots\ldots 4$$

where A = 1/2 (area forearm + area plethysmograph plate) sq.cm.

The volume of the arm (V_a) can therefore be calculated from equation (5)

$$V_a = V_p - V_t \text{ ml} \qquad \ldots\ldots\ldots\ldots\ldots 5$$

where V_p = volume of plethysmograph.

The theory of operation is based on the fringing field between plethysmograph and arm being entirely tuned out with no arm in place and volume and capacity being measured in the space between the plethysmograph and arm with normal planes limiting both the volume and the electrostatic field within the capacitor. In practice this is not possible but by shaping the end screen the same effect is achieved at the expense of the loss of 0.5 cm of plethysmograph length at each end.

The relationship between volume change (ΔV) and capacity change (ΔC) is linear at a spacing of 1.25 $\pm$ 0.25 cm and is given by the equation (6)

$$V = \frac{A_a^2 \cdot \Delta C}{4 \pi C_T^2} \qquad \ldots\ldots\ldots\ldots\ldots 6$$

where A_a = area of arm surface.

This equation holds true for wide variations in ΔV provided the spacing between the plethysmograph and arm is within the prescribed limits. Equation (6) applies to the situation in which the volume change is distributed equally over the entire forearm. In the unlikely event that all the volume change is located in 20% of the forearm, the error involved is $<$ 1.0%.

Calibration. The most practical way to calibrate the capacitance plethysmograph electrically is to introduce an inductance in series with a capacity equivalent to the capacity between the plethysmograph and arm to give a voltage change of the same order as the changes produced by resting blood flow measurements.

If a substantially constant current of 1 amp be sent through a capacity C_T at a constant frequency w. then using volt, amp and farad units with w in radians/sec, the voltage drop across the condenser is given by

$$E = \frac{1}{w \, C_T} \text{ volts}$$

$$E = \Delta E = \frac{1}{w(C_T + \Delta C)} \text{ volts}$$

$$\therefore \quad E \quad \frac{I \, \Delta C}{w \, C_T^2} \text{ Volts} \qquad \ldots\ldots\ldots\ldots\ldots 7$$

Substituting in equation for ΔC obtained from equation 7 and putting 1 farad = 9 x 10^{11} cm

$$V = \frac{w \, A_a^2}{36 \pi 10^{11}} \cdot \frac{\Delta E}{I} \text{ ml} \qquad \ldots\ldots\ldots\ldots\ldots 8$$

$$\text{But} \quad \frac{\Delta E}{I} = w \, L_c \qquad \ldots\ldots\ldots\ldots\ldots 9$$

where L_c = inductance in Henries

therefore, substituting in equarion (8) for $\frac{\Delta E}{I}$ obtained from equation (9)

$$\Delta V = \frac{w^2 \cdot A_a^2 \cdot L_c}{36 \pi 10^{11}} \text{ ml} \qquad \ldots\ldots\ldots\ldots\ldots 10$$

The surface area of the arm is the only variable in equation (10) as a value can be chosen for L_c (a circuit constant) so that the volume increment is of any desired value. (In this particular case with a circuit frequency of 6.59 Mc/sec an inductance of 0.27 gives a volume increment of the order of 4.0 ml). The actual calibration of the plethysmograph is effected by introducing the calibration inductance in series with a capacity equal to that between the plethysmograph and arm. This causes a deflection of the pen recorder equivalent to the known volume increment. From this step, the displacement caused by a volume increment of 1.0 ml is readily calculated.'

Figure I-16, I-17 shows the wire net which was used as capacitance device. It is a double-wire netting which was knit from 26 gauge, 7 strand, 34 gauge wire plastic covered on a No. 10-1/2 knitting needle. The outer dark netting served as a shielding ground and was connected to the arm with a small silver plate. The inner lighter-colored netting served as the capacitor plate which was referenced to the arm. The electrodes were supplied from a Biocom Model 560 Capacitance Plethysmograph. This is an 20 kc generator capable of handling 200 to 1000 pF with an output voltage of 5 Mv/pF.

Calibration was accomplished with a flat balloon into which saline is injected.

Figure I-18 is the record from an experiment comparing the capacitance gauge and strain gauge during application of negative pressure to the arm (upper) and during venous occlusion (lower). A record during the tilt procedure is shown in Figure I-19, I-20. These records are qualitatively similar. The small quantitative differences are related to the amplitude of the expression of artifacts such as limb movement.

Impedance

If the length of a cylinder is constant and the volume is changed by a change in cross-section, the change in resistance is proportional to the change in volume.

$$\Delta R = R_1 - R_2 = \rho L^2 \left(\frac{1}{V_1} - \frac{1}{V_2}\right)$$

where ρ is specific resistivity.

The fractional change is

$$\frac{\Delta R}{R} = -\frac{\Delta V}{V}$$

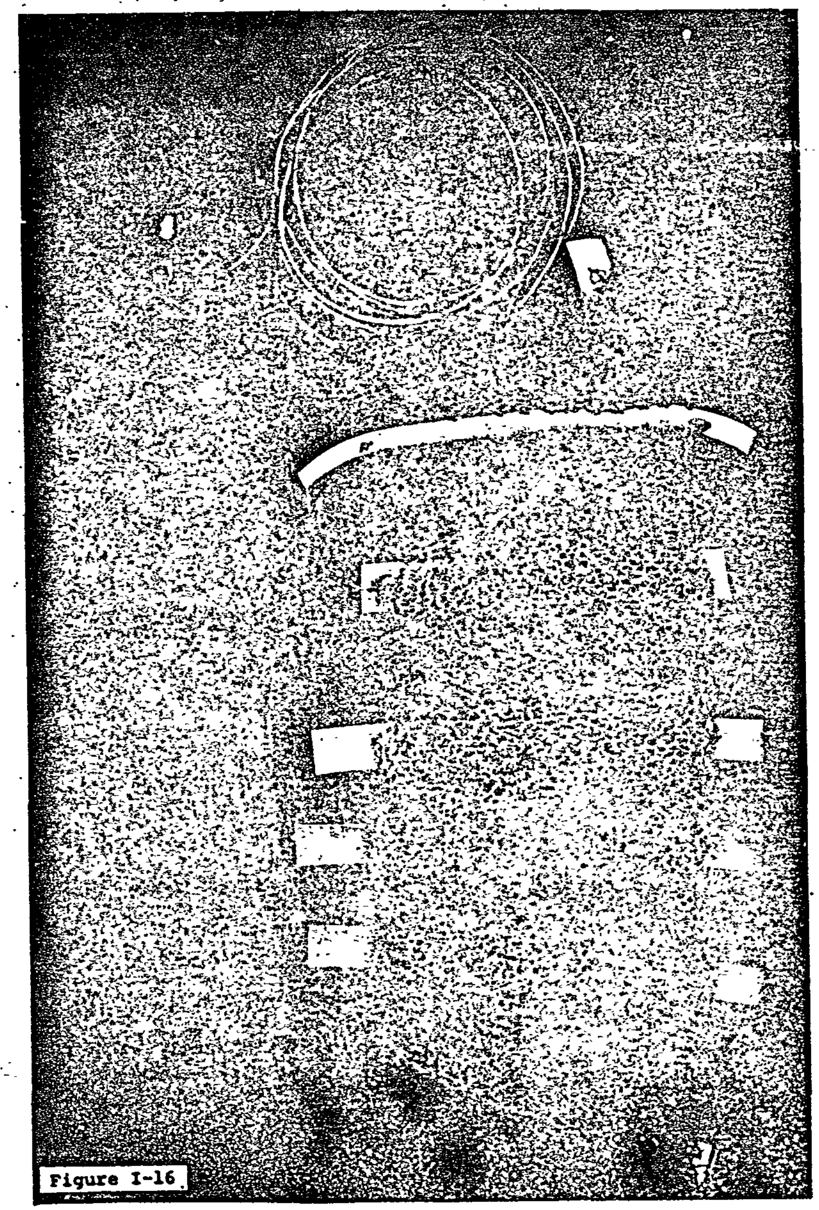


Figure I-16

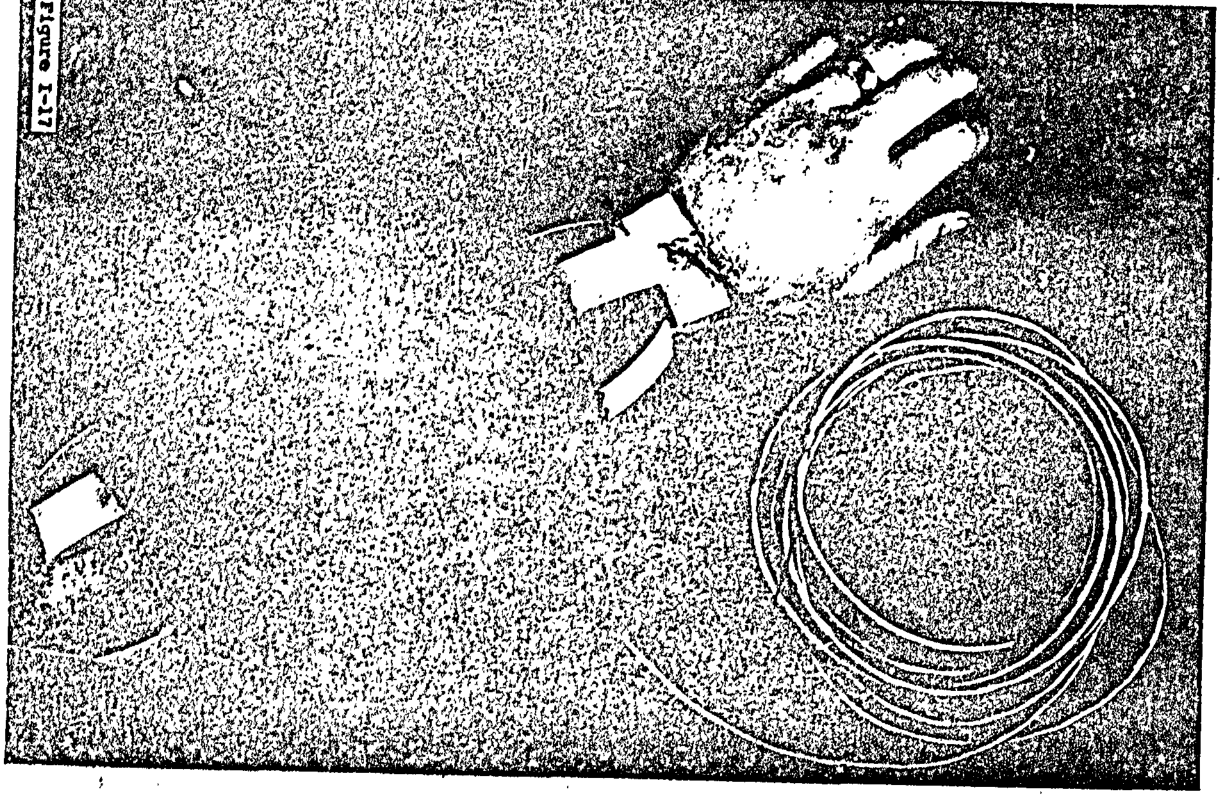
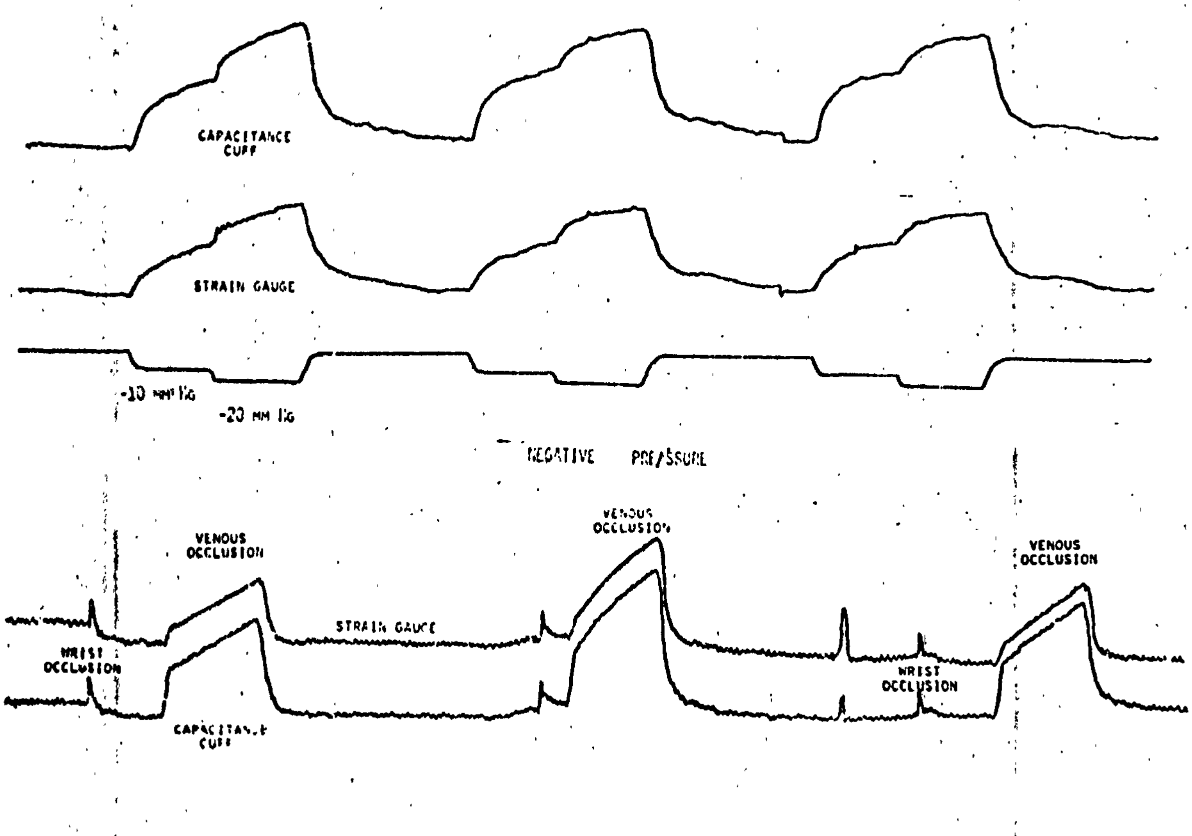


Figure I-17



VENOUS OCCLUSION

Figure I-18

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

and $\Delta V = -\frac{\Delta R}{R} V$

Since this method depends on the resistance of the tissues, the change in volume (if entirely in the blood compartment) is in series with a tissue component, and

$$V_R = \Delta B \cdot \frac{\Delta^2}{R_S}$$

The physical basis of impedance changes related to volume change are thoroughly discussed by Nyboer (1959).

In these tests two techniques were used - a two-electrode technique similar to the Nyboer technique with two 1 cm electrodes supplied from a Biocom Model 991 impedance transducer, 50 KH activation, and a four-electrode technique described by Allison (1967) supplied from a Tagno Electrical Impedance Plethysmograph Model 102 (50 KH activation).

Comparison of the impedance technique with the Whitney gauge were made. The ratio of change was used as an indication of conformity. Plots of the ratio of the response of the impedance change to that of the resistance change show the lack of correspondence between the output of the two systems (Figure I-21).

Direct Flow Measurements

The application of a transcutaneous Doppler (described by Rushmer, et al, 1966) would permit recording of transient changes in volume flow. This method has been used by Strandness (1966).

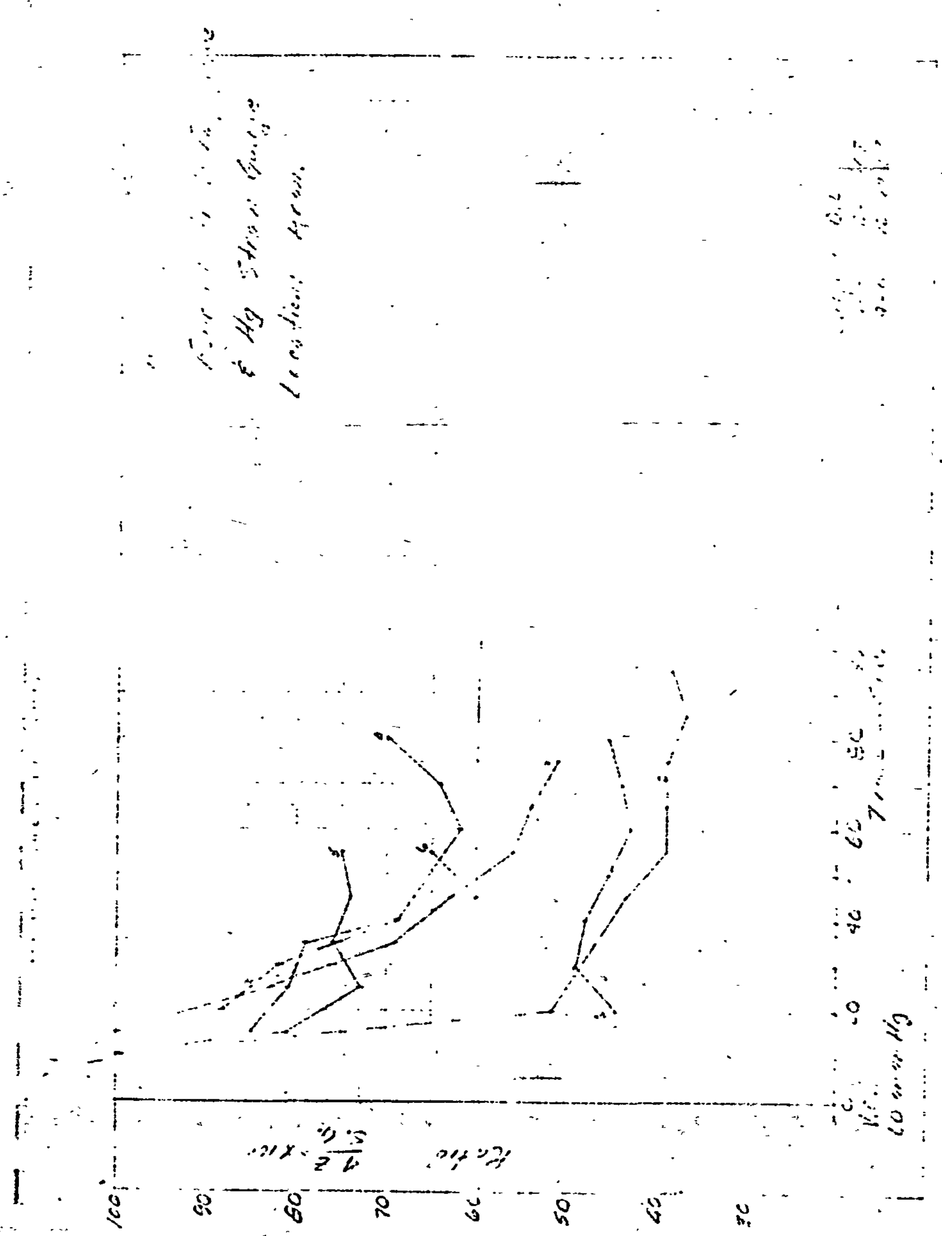


Figure I-21

Technique	Principle	Remarks on use
Water or air plethysmograph	Direct volume displacement. Basic reference: Hewlett and Zwaluwenburg (1909)	Not readily adaptable to tilt table or to negative pressure devices. Water plethysmograph has been used in lab by S. Musgrave, F. Zechman and R. Mains. Artifacts of motion and muscle mass shift likely.
Mercury in silastic gauge	Change in length = change in resistance. Length = circumference converted to volume. Basic reference: Whitney (1953)	Can be used on tilt table but there are demonstrated artifacts. Three double strand gauges may provide better records. Similar comment applies to negative pressure. The artifacts are position, and possible fluid or muscle mass shifts.
Capacitance	With the limb as one plate held at ground potential and a second shielded plate, changes in capacitance measure a change in volume between the plates. Empirically calibrated. Basic reference: Pyman et al (195[illegible])	Motion free attachment to arm or leg difficult. Motion artifacts.
Impedance 2-electrode	A change in distance between electrodes is reflected in the impedance change. Basic reference: Nyboer (195[illegible])	Stability. Calibration. } difficult to achieve
4-electrode	A signal is introduced by separate electrodes and the field is monitored by two other electrodes. Changes in the monitored signal reflect changed distance between electrodes or change in size of field. Basic reference: Allison (1967)	Lack of correspondence to silastic gauge.

Conclusion

None of the systems tested seem qualified for in flight use. Each must be used with great care in carefully controlled laboratory experiments. Interpretation of data obtained from tilt table or negative pressure must be regarded as tentative due to the possibilities of artifact.

FIGURE DESCRIPTIONS – PART II

Figure	
II-1	Schematic record showing time sequence of tests and measurements (see text).
II-2	Test set up. Tilt-table in foreground, table for leg negative pressure test adjacent. Clocks, electronic equipment and polygraph were in view of subject during tilt.
II-3	Scaled drawing of negative pressure application device.
II-4	View of the negative pressure application device assembled.
II-5	Opened negative pressure application device.
II-6	End view showing inserts to provide for seal at leg.
II-7 to II-35	Graphic presentation of tilt test. Systolic, diastolic and mean blood pressure in upper traces. Heart rate in lower trace. Set number description in Table II-3.
II-36 to II-69	Graphic presentation of leg volume change during first three minutes of tilt. Values on ordinate are to be multiplied by 2.5 to obtain per cent change in volume. Set number description in Table II-3.

PART II

Introduction

The bedrest study under the direction of Dr. F. Bernauer and supported by NASA NGR 05-004-021 included measurements of metabolic balance, basal metabolism, work metabolism, fluid spaces, body composition, strength tests, renal function, blood and urine composition. A total of 10 subjects (Table II-1) were used. Eight were confined to bed on the calendar schedule shown in Table II-2. Four of the bedrest subjects exercised daily (1 hour at 50% of maximum capacity)

The studies reported here were concerned with an evaluation of cardiovascular function following bedrest. Heart rate and blood pressure served as reference and comparative values for other tests.

Procedure

In orientation sessions during the two weeks prior to the study, each subject provided a pertinent medical history, received a full explanation of the procedure and underwent a complete tilt table and negative pressure (NP) run (infra vide).

During the study, each subject was run before and after bedrest according to the calendar of experimentation (Table II-2). Initially, a.m. and p.m. duplicate runs were conducted at 12-hour intervals until sufficient data were accumulated regarding circardian variation. On the morning of the conclusion of bedrest, the subjects were transferred to the tilt table without rising from horizontal, and the first post-BR was performed. Following 2-1/2 hours of standardized activity, the subjects were run again. The evening of the same day, 12 hours post-BR, a third run was performed. The following morning, 24 hours post-BR, and the mornings of days 3, 5, 7 post-BR, additional runs were made. In addition to the regular tilt table and NP runs, a measurement of lower leg blood flow by venous occlusion plethysmography was made before and after bedrest as detailed in the calendar of experimentation.

The protocol (Figure II-1) for each run commenced with an equilibration period on the horizontal tilt table for a minimum of 15 minutes. In the first 10 minutes, the necessary instrumentation was accomplished and the subjects were briefly tilted to 70° following

Table II-1

[illegible] SUBJECTS SUMMER '67

No.	Name	Height	Weight	Age
1	[illegible]	5'9	1[illegible]0 lbs.	1[illegible] yrs.
2	[illegible]. C.	5'10"	150 lbs.	1[illegible] yrs.
3	[illegible]. G.	5'6"	142 lbs.	20 yrs.
[illegible]	J. V.	5'8"	155 lbs.	20 yrs.
[illegible]	G. J.	5'9-1/2"	155 lbs.	19 yrs.
[illegible]	D. S.	5'8"	137 lbs.	19 yrs.
7	[illegible] L.	6'2	157 lbs.	21 yrs.
[illegible]	[illegible]	5'10"	1[illegible]0 lbs.	1[illegible] yrs.
[illegible]	[illegible]	5'9"	1[illegible]4 lbs.	19 yrs.
[illegible]	[illegible]	5'10-1/2"	171 lbs.	19 yrs.

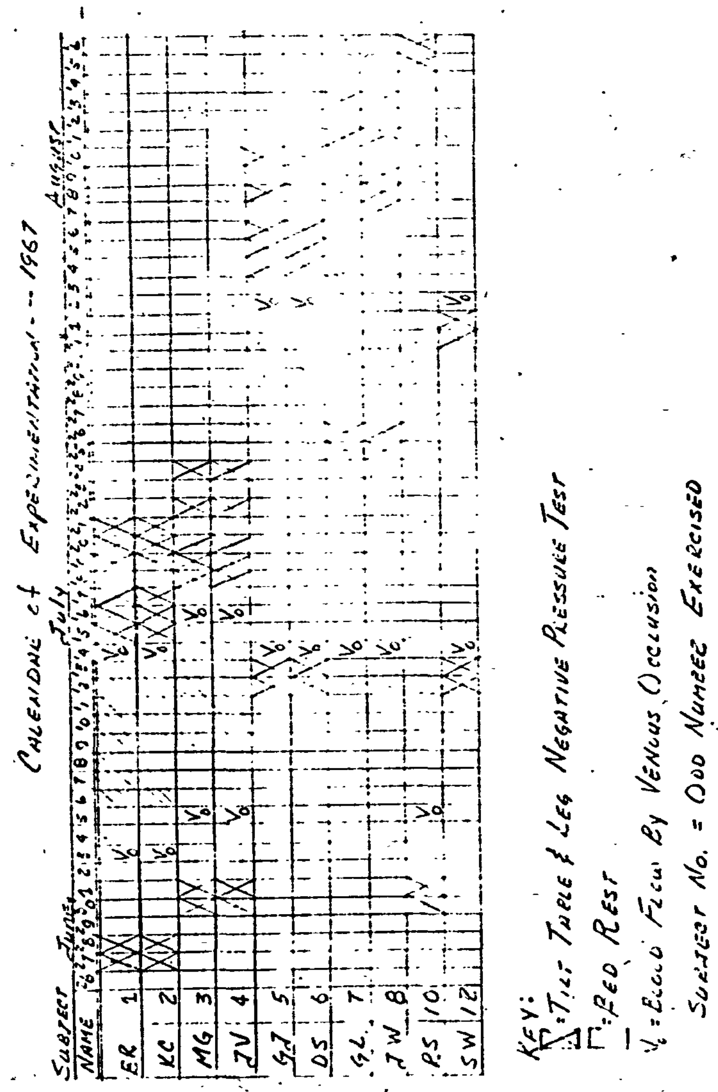


Table II-2

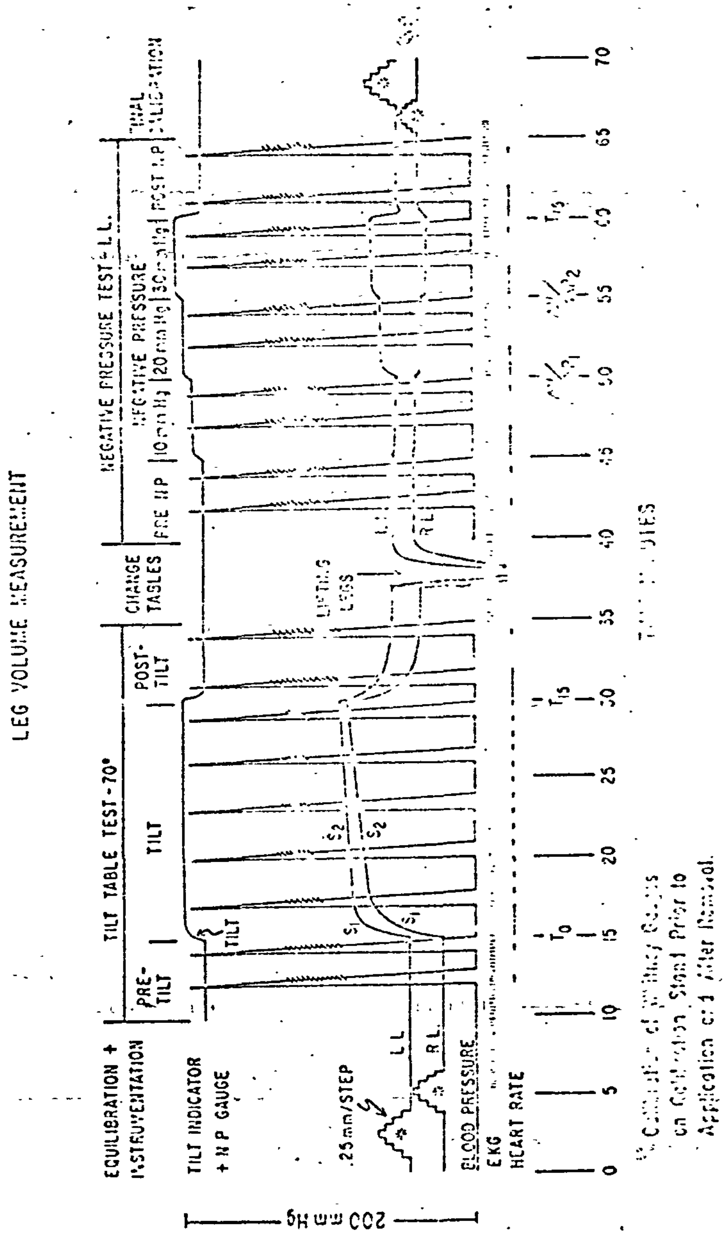


Figure II-1

instrumentation to minimize body movement during the subsequent tilt procedure. In the first five minutes of measurement, the EKG and leg circumference measurement ran continuously and the blood pressure was recorded at minute 12 and 14. At minute 5, tilt to 70° was accomplished manually over a 15-second period. Tilt was maintained for 15 minutes or until clinical signs of presyncopy were manifest. Electrocardiogram and leg circumference were recorded continuously. Blood pressure was measured at minutes 17, 20, 23, 26, 29. At minute 30, the subject was returned to the supine position over a 15-second period. During minute 30 to 35, EKG and leg circumference were recorded continuously and the blood pressure measured at minute 31 and 34. At minute 35, the subject was then transferred from the tilt table to a flat table for application of the NP device. Measurements of EKG and leg circumference were recorded continuously during transfer. After 5 minutes, during which EKG and leg circumference were measured continuously and two blood pressure measurements were made, 30 mm Hg negative pressure was applied to the left leg in 3 steps of 10 mm Hg for 5 minutes each. Each step of 10 mm Hg was accomplished in about 5 seconds. Data were recorded for 5 minutes following release of NP. EKG and leg volume of both legs were recorded continuously during the negative pressure test and blood pressure at the second and fourth minute of each period. The total run, including instrumentation, averaged about 70 minutes per subject.

The overall experimental setup for use in tests before and after bedrest study are shown in Figure II-2. The tilt table was obtained from the Manned Spacecraft Center and modified with the foot supports to hold the legs and feet from movement during tilt. Small potentiometer was mounted on the table in a battery-supplied Wheatstone bridge so that the angle of the table could be recorded. The subject was moved from the tilt table to the large table so that negative pressure could be applied to the left leg in the can shown in the Figure. A shop vacuum cleaner provided the suction for the can which was adjusted and read from a mercury manometer. The two small panels contained the instrumentation to activate and record from the gauges as well as record blood pressure and heart rate. Cuffs for blood pressure were inflated from preset tank pressure. The Whitney gauges were activated from a Parks Model 270 bridge and the output of

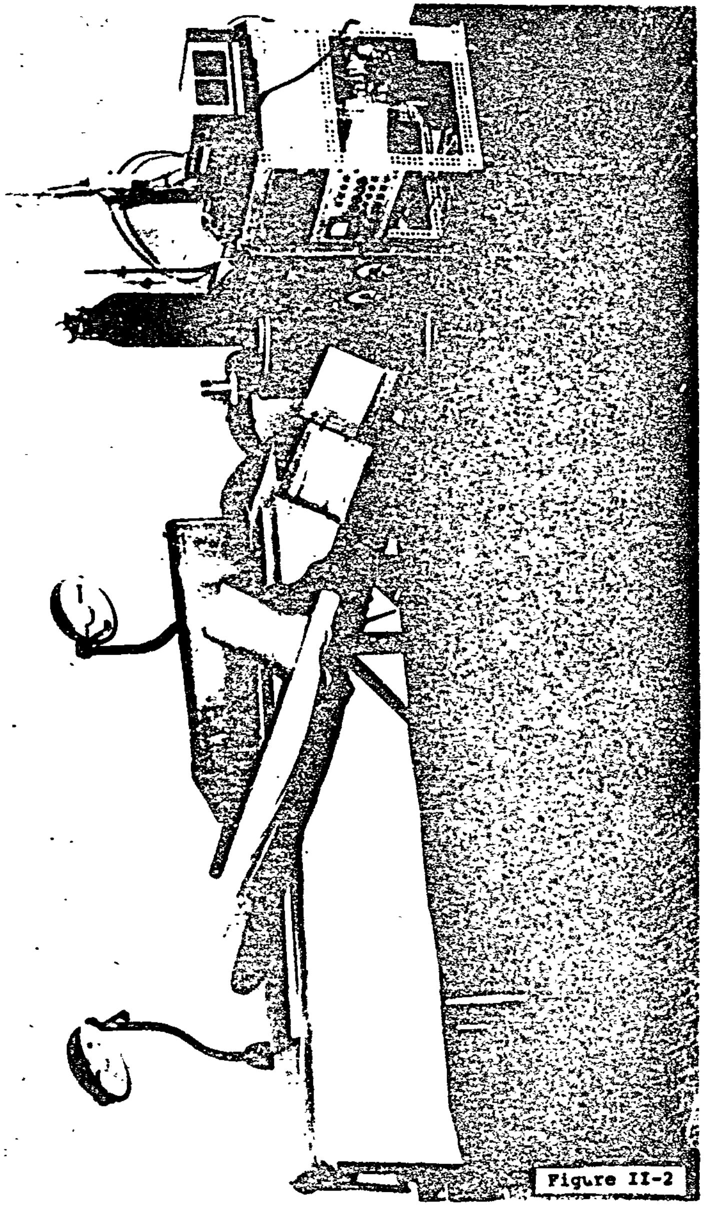


Figure II-2

the bridge fed through the CEC Model 1-155 amplifiers into the optical recorder. The EKG was fed through the CEC amplifiers to the recorder. Blood pressure was recorded with an E & M Electrosphygmograph Mark IV system. The strain gauge recorded the pressure in the negative pressure tank.

The negative pressure can, or clam-can as it came to be known, was built specifically for these tests and was used in preference to lower body negative pressure, since the object of the measurement was change in volume of the leg and problems involved with respect to shifts of blood distribution and, when the lower body is involved include more than muscle and skin in the leg. The can is shown in prospective in Figure II 3 and in three views of the device in Figures II-4, II-5 II-6. As shown in the final figure of the can, inserts were made approximately to fit the leg to prevent the sealing rubber apron from being sucked into the can.

Equipment and Methodology

All data was recorded on a CEC Recording Oscillograph 5-124 using a paper speed of 4"/minute.

Tilt

A standard tilt table with a pneumatic saddle was used (Figure II-2). The slope of the tilt and recline was recorded using a battery powered 5 K potentiometer inserted at the axis pin and plugged directly to a light galvonometer on the oscillograph. An event marker was wired into this system.

N. P.

A commercial vacuum cleaner supplied NP to a galvanized clam-can (Figure II-2) sealed around the upper left thigh of the subject. Can pressure was monitored by a mercury manometer inserted in a T-line with a Statham differential pressure transducer whose signal was amplified by a CEC Carrier AMP 1-118 and recorded on the oscillograph.

Heart Rate

Heart rates were calculated by 15-second intervals taken from continuous EKG recording, detected by chest leads and using CEC DC AMP Type 1-155.

NEGATIVE PR_SSURE CAN
"CLAM TYPE"

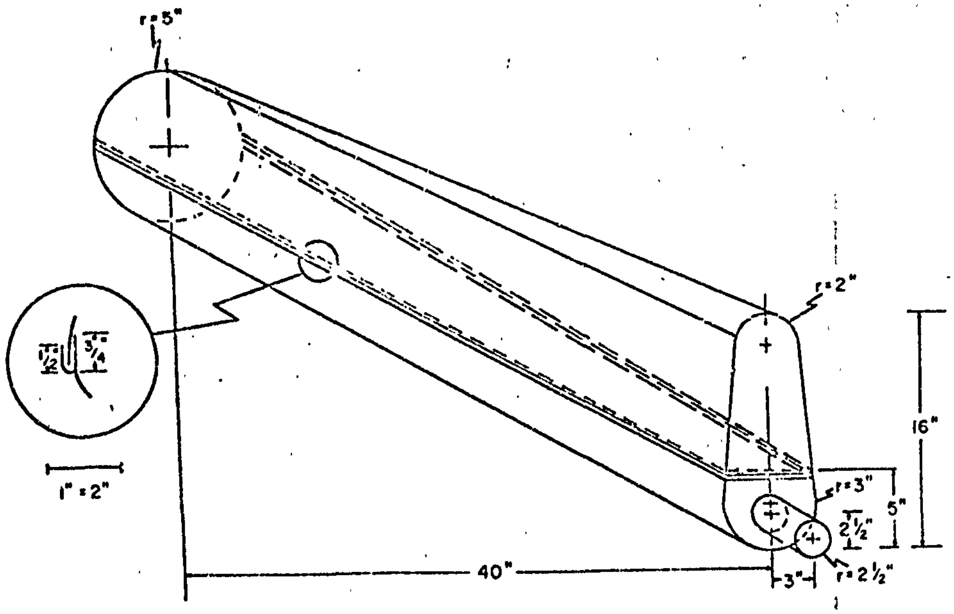


Figure II-3 Scale: 1" = 5"

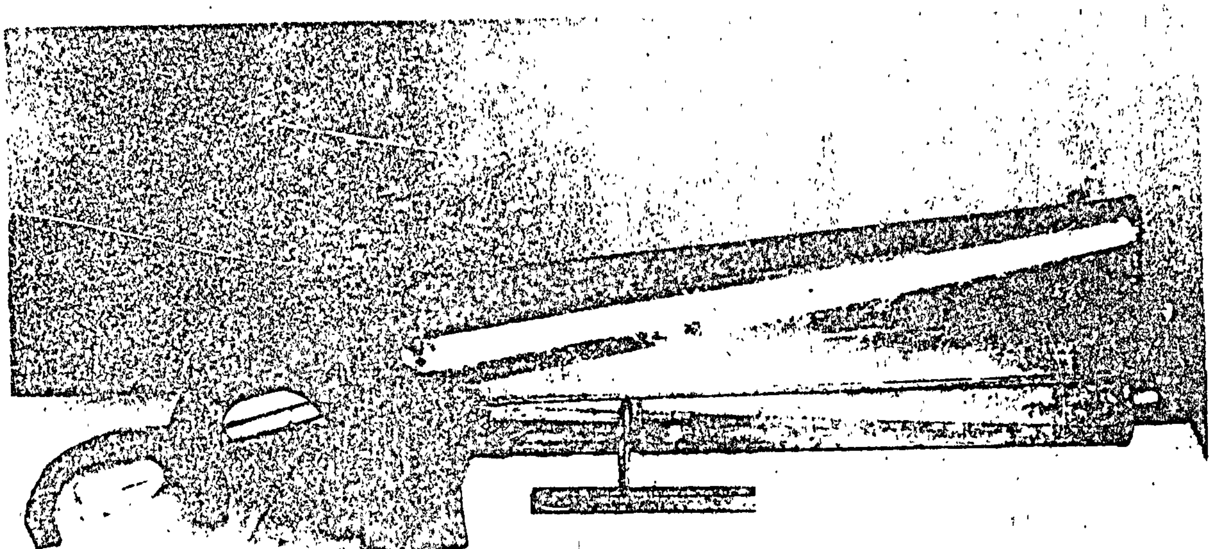


Figure II-4

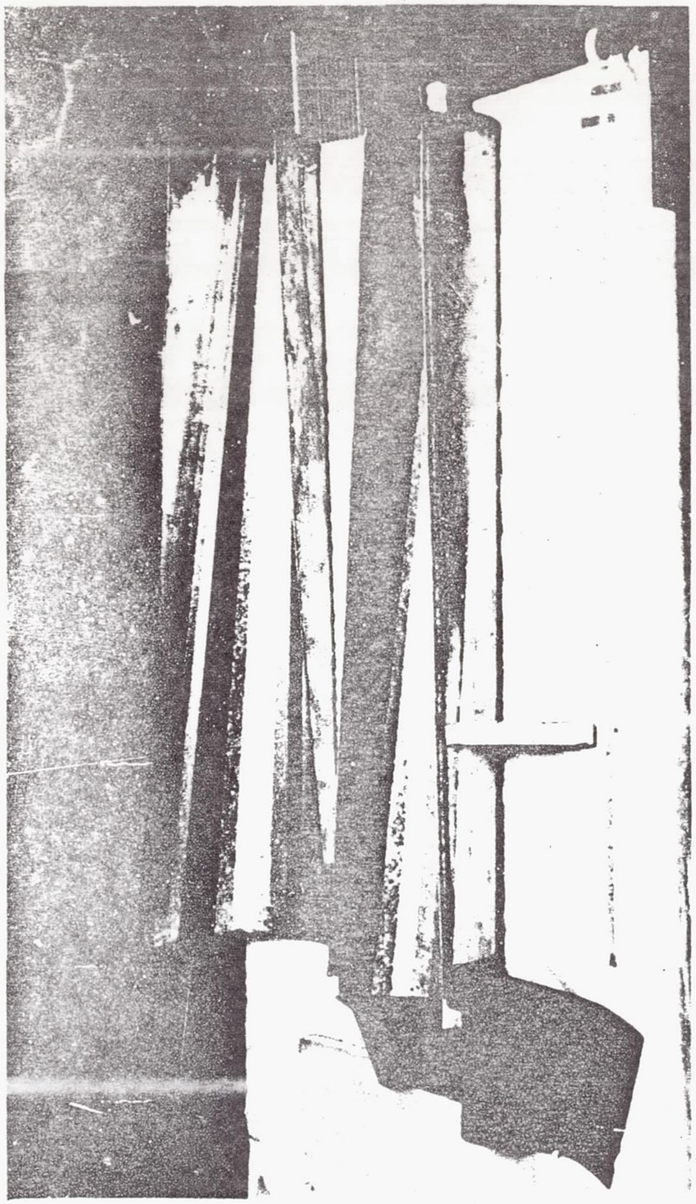


Figure II-5

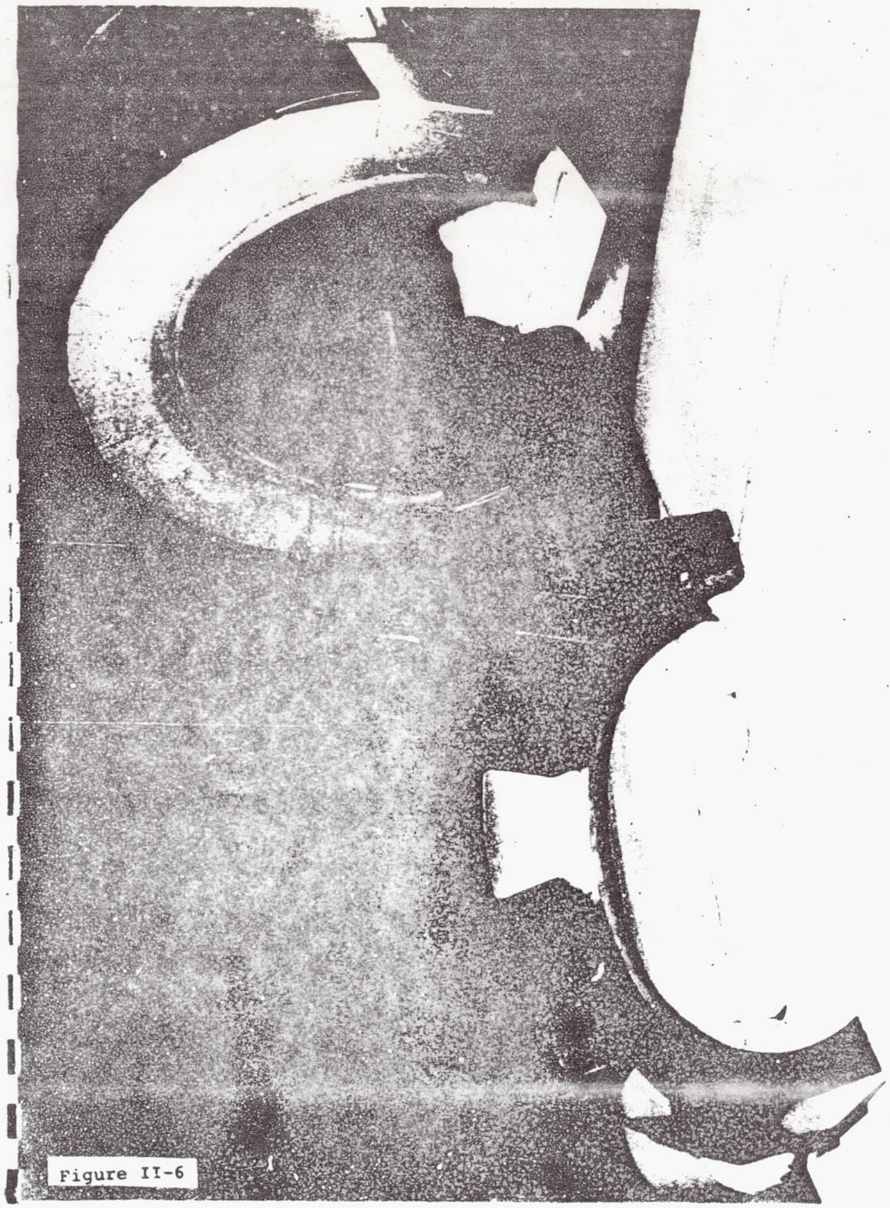


Figure II-6

Blood Pressure

Blood pressure was measured at 2-3 minute intervals using a rapid inflation, microphone equipped 15 cm occlusion cuff on the left arm. The E & M Electrosphygmograph SM IV signal was amplified by an E & M Physiograph MK VII and pressure tracings recorded on the oscillograph. The peak pressure was held at 200 mm Hg on the Electrosphygmograph gauge for 1 second and then allowed to decrease through an orifice over a 30-second period. The first distinct sound was taken as systolic pressure and the last distinct sound taken as diastolic pressure. [illegible] the average 30-second bleedoff.

Leg Volume

A double-stranded, [illegible] mercury-filled silastic (.015 ID) Whitney strain gauge was applied to the measured maximum circumference of each calf following stand calibration. Gauge tension was [illegible] gms during pre and post run calibrations and this was closely approximated on application of the gauge to the leg. Parks Model 270 Plethysmograph D.C. outlet signal was amplified by CEC 1-155 DC AMP and recorded on the oscillograph. The change in volume was calculated from the circumference change with the approximations noted in Part I.

Results[1] - Tilt Table

The data have been assembled in sets which represent the individual and group treatments in time in Table II-3.

Heart Rate and Blood Pressure Responses

While these data serve primarily as a reference for comparison with other studies, a number of mean values and derivatives are presented in Table II-4.

The time course of changes in systolic and diastolic blood pressure and in heart rate are shown in Figures II-7 to II-35 inclusive.

Leg Volume Changes

The leg volume change was analyzed with respect to several features of the time course of change. The initial slope is termed

1. complete set of data on computer stationery is appended to the first copy of this report.

Table II-3 Description of Data Assembly System

		Pre Bed Rest		Post Bed Rest [illegible]								*		
				0	2.5	12	2.	48	[illegible]	[illegible]	[illegible]			
Condition	Ind.#	AM	PM	AM	AM	PM	AM	AM	AM	AM	AM	[illegible]	**/leg	***
Exercised	1	1,3	2,4	5	6	7	8	9	10	1	12		11 R	5
	3	1,3	2.4	5	6	7	8	9	10		11		9 R	-
	5	1,3	2,4	5	6	7	8	9	10		11		6 R	6
	7	1,2	-	3	4	5	6	7	8		9		2 L 3 R	-
(a) Sub-Total COMPUTER SET NO.		1	2	3	4	5	6	7	8	9	10			
Non-exercised	2	1,3	2,4	5	6	7	8	9	10	11	12		11 R	-
	4	1,3	2,4	5	6	7	8	9	10		11		-- -	-
	6	1,3	2,4	5	6	7		9	10		11		5 R	-
	8	1,2	-	3	4	5	6	7	8		9		2 R 3 R	-
(b) Sub-Total COMPUTER SET NO.		11	12	13	14	15	16	17	18	19	20			
Ext. Control	10	1,3	2,4									5,6	-- -	1
	12	1,3	2,4									5,6	-- -	-
Ext.Cont. Total COMPUTER SET NO.		21	22									23		
(a)+(b) Total COMPUTER SET NO.		24	25	26	27	28	29	30	31	32	33			

* External Control
** Ankle Occlusion
*** Short Tilt Due to Pre Syncopy

Table II-4

Condition Time in Min.	0	.075	.175	.25	1.00	2.00	2.96
Set 1	-0.000 -0.0000	0.151 0.0982	0.563 0.1564	0.862 0.1906	1.661 0.1945	2.255 0.2168	2.562 0.2591
Set 2	-0.000 -0.0000	0.291 0.0523	0.673 0.2426	0.936 0.3202	1.868 0.2689	2.271 0.1988	2.499 0.2090
Set 3	-0.000 -0.0000	0.105 0.1255	0.049 0.5484	0.098 0.5564	0.932 0.7742	1.442 0.9492	1.835 1.0716
Set 4	-0.000 -0.0000	0.059 0.0669	0.001 0.2670	0.286 0.3411	0.857 0.4813	1.364 0.5061	1.942 0.4952
Set 5	-0.000 -0.0000	0.162 0.0446	0.555 0.2969	0.789 0.3701	1.594 0.3842	2.079 0.2630	1.954 0.8183
Set 6	-0.000 -0.0000	0.234 0.0553	0.549 0.2319	0.661 0.3603	1.192 0.3578	1.735 0.4253	1.885 0.6851
Set 7	-0.000 -0.0000	0.249 0.0960	0.693 0.1771	0.993 0.2174	1.784 0.1980	2.295 0.2373	2.540 0.3157
Set 8	-0.000 -0.0000	0.235 0.0989	0.628 0.3398	0.922 0.3162	1.596 0.2720	2.074 0.2560	2.047 0.7027
Set 9	-0.000 -0.0000	0.310 -0.0000	0.650 -0.0000	1.041 -0.0000	1.731 -0.0000	1.888 -0.0000	2.098 -0.0000
Set 10	-0.000 -0.0000	0.235 0.1599	0.500 0.5663	1.171 0.6454	2.010 0.8849	2.493 0.8272	2.135 1.5547
Set 11	-0.000 -0.0000	0.204 0.0551	0.657 0.1153	0.957 0.1205	1.829 0.2458	2.224 0.2592	2.268 0.4242
Set 12	-0.000 -0.0000	0.347 0.0489	1.001 0.1323	1.372 0.1871	2.215 0.3914	2.559 0.3696	2.362 0.8206
Set 13	-0.000 -0.0000	0.147 0.1210	0.377 0.1731	0.744 0.2313	1.685 0.5664	2.132 0.5316	1.776 1.3403
Set 14	-0.000 -0.0000	0.245 0.1285	0.584 0.1845	0.850 0.2261	1.564 0.2732	2.079 0.3086	2.064 0.7620
Set 15	-0.000 -0.0000	0.0225 0.1006	0.1631 0.2303	0.901 0.2493	1.951 0.3807	2.387 0.5127	2.637 0.5102
Set 16	-0.000 -0.0000	0.174 0.1739	0.534 0.2145	0.770 0.2488	1.415 0.3506	1.950 0.3987	1.339 1.2450

Condition Time in Min.	0	.075	.175	.25	1.00	2.00	2.96
Set 17	-0.000 -0.0000	0.234 0.0898	0.834 0.2896	1.123 0.3967	1.946 0.4016	2.363 0.3486	2.166 0.8275
Set 18	-0.000 -0.0000	0.253 0.0668	0.738 0.1597	1.043 0.1995	1.820 0.3131	2.176 0.3288	1.698 0.8268
Set 19	-0.000 -0.0000	0.173 -0.0000	0.421 -0.0000	0.573 -0.0000	0.938 -0.0000	1.329 -0.0000	1.690 -0.0000
Set 20	-0.000 -0.0000	0.205 0.0534	0.681 0.1097	0.905 0.1284	1.588 0.2546	2.031 0.2321	2.013 0.6512
Set 21	-0.000 -0.0000	0.272 0.1135	0.733 0.1840	1.014 0.3156	1.810 0.4927	2.097 0.5817	1.523 1.2243
Set 22	-0.00 -0.0000	0.214 0.0424	0.773 0.0546	1.147 0.0620	1.908 0.2691	2.131 0.2791	0.437 1.2442
Set 23	-0.000 -0.0000	0.325 0.1033	0.759 0.2292	0.942 0.2518	1.381 0.2960	1.624 0.3040	0.686 0.8253
Set 24	-0.000 -0.0000	0.179 0.0529	0.612 0.0922	0.911 0.1060	1.748 0.1520	2.239 0.1611	2.410 0.2440
Set 25	-0.000 -0.0000	0.318 0.0349	0.829 0.1456	1.144 0.1947	2.033 0.2249	2.408 0.1956	2.434 0.3721
Set 26	-0.000 -0.0000	0.128 0.0738	0.183 0.2466	0.450 0.2939	1.343 0.4424	1.818 0.4685	1.803 0.7405
Set 27	-0.000 -0.0000	0.165 0.0830	0.334 0.1956	0.609 0.2174	1.261 0.2812	1.773 0.2973	2.012 0.4327
Set 28	-0.000 -0.0000	0.195 0.0511	0.609 0.1690	0.845 0.2002	1.773 0.2538	2.233 0.2657	2.296 0.4559
Set 29	-0.000 -0.0000	0.208 0.0699	0.543 0.1423	0.708 0.2081	1.287 0.2299	1.827 0.2671	1.651 0.5840
Set 30	-0.000 -0.0000	0.241 0.0581	0.768 0.1595	1.062 0.2115	1.870 0.2117	2.331 0.1932	2.340 0.4252
Set 31	-0.000 -0.0000	0.244 0.0533	0.683 0.1688	0.982 0.1685	1.708 0.1913	2.125 0.1868	1.872 0.4891
Set 32	-0.000 -0.0000	0.242 0.4341	0.536 0.7225	0.807 1.4779	1.334 2.5004	1.608 1.7654	1.894 1.2899
Set 33	-0.000 -0.0000	0.219 0.0701	0.737 0.2373	1.029 0.2761	1.785 0.3918	2.246 0.3697	2.070 0.7041

S1 and is assumed to describe the venous filling. The second slope (S2) is assumed to be related to capillary filtration. The final point in time on slope 2 is designated T15 and is the maximum filling. Extrapolation of S2 to T0 gives a value of available initial filling capacity. The values appear in Table II-4.

Post-bedrest leg volume changes with tilt at 0 and 2.5 hours deviated so dramatically from pre-bed values that these curves were digitized over the first three minutes (Figures II-35 to II-63 inclusive). The filling patterns at 10 seconds, 30 seconds and three minutes were significantly ($p < .05$) lower at 0, 2.5 and 12 hours post-bedrest than pre-bedrest. At 3, 5 and 7 days post-bedrest the filling curves were significantly lower at 3 minutes after tilt, but were significantly higher at 5, 10 and 30 seconds after tilt. The four students who were exercised during bedrest showed greater changes in the filling curve than the four who did not exercise. The values at seven time intervals are assembled in Table II-5 with their standard deviations.

These data are assembled in Table II-6 to give the material for calculation of an integrated score according to the system suggested by Benjamin, et al, (unpublished).

Leg Negative Pressure Test

Heart rate and blood pressure. Application of negative pressure to the left leg at increments of 10 mm Hg up to 30 mm Hg caused the heart rate to increase (Table II-4).

The change in volume with change in pressure (dV/dP) or compliance was altered following bedrest indicating a decrease in compliance.

Table II-5

Values for the calf filling curves at selected intervals to give standard deviations (under each value). These values should be multiplied by 2.54 to give percent change in volume. Set designations as shown in Table II-3.

Table II-5

TILT TABLE TESTS Values and standard deviation

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Heart Rate					
Avg Pre-Tilt	60.250 2.25	66.667 15.93	53.000 3.46	54.500 9.57	71.000 9.59
Avg During Tilt	86.770 9.98	89.619 13.77	83.708 9.35	87.117 12.31	99.221 8.20
Max During Tilt	95.500 11.80	96.000 13.15	103.000 11.49	101.000 15.45	109.000 8.25
Delta Hr Avg	26.520 9.04	22.952 8.03	30.708 10.05	32.617 11.18	28.221 5.33
Delta Hr Max	35.250 10.79	29.333 7.45	50.000 13.56	46.500 13.30	38.000 7.83
Pct Delta Hr Max	158.363 17.00	146.861 17.31	195.569 31.19	189.308 35.90	154.993 16.81
Delta Hr Return	-6.000 4.00	-7.333 4.32	-5.500 6.19	-4.500 1.91	-9.500 6.19
Pct Delta Hr Return	90.089 6.54	88.626 6.51	89.104 12.97	91.435 4.50	85.658 11.51

TILT TABLE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Heart Rate					
Avg Pre-Tilt	59.000 7.75	58.500 8.85	56.500 3.42	48.000 0.00	52.500 3.42
Avg During Tilt	91.151 13.09	81.936 9.66	84.231 11.05	73.800 0.00	75.013 5.56
Max During Tilt	105.000 15.45	92.000 11.78	93.000 13.61	80.000 0.00	81.000 6.83
Delta Hr Avg	32.151 10.51	23.436 4.14	27.731 9.51	25.800 0.00	22.513 4.35
Delta Hr Max	16.000 10.71	33.500 6.40	36.500 11.59	32.000 0.00	28.500 4.12
Pct Delta Hr Max	178.331 16.47	158.105 13.48	164.342 18.41	166.667 0.00	154.202 6.12
Delta Hr Return	-0.000 8.00	-6.000 4.32	-3.500 6.19	-26.000 0.00	-4.000 2.31
Pct Delta Hr Return	99.789 13.51	89.090 9.37	93.399 11.81	15.833 0.00	92.309 4.58

TILT TABLE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Heart Rate					
Avg Pre-Tilt	62.500 8.05	69.167 7.11	64.000 6.93	63.000 7.75	84.000 8.33
Avg During Tilt	87.213 6.25	90.140 5.17	100.372 13.17	103.000 19.42	110.305 8.06
Max During Tilt	98.500 6.39	97.333 5.47	117.000 16.45	118.000 21.79	122.000 7.66
Delta Hr Avg	24.713 9.05	20.973 5.09	36.372 8.71	40.000 12.35	26.305 2.31
Delta Hr Max	36.000 9.26	28.167 5.00	53.000 12.81	55.000 15.53	38.000 7.30
Pct Delta Hr Max	159.621 21.13	141.481 10.79	182.929 17.93	186.499 18.65	145.939 12.31
Delta Hr Return	-3.750 4.95	-4.833 5.60	-3.000 4.16	-1.000 2.00	-4.500 3.00
Pct Delta Hr Return	94.287 7.85	92.813 8.72	95.709 6.55	98.485 3.03	94.786 3.16

TILT TABLE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Heart Rate					
Avg Pre-Tilt	70.000 11.14	74.500 13.00	68.000 8.49	76.000 0.00	65.500 9.00
Avg During Tilt	98.816 20.23	98.624 18.22	89.714 4.13	105.333 0.00	86.800 11.13
Max During Tilt	109.333 22.03	108.000 19.32	99.000 5.03	120.000 0.00	94.000 9.52
Delta Hr Avg	28.816 9.11	24.124 5.44	21.714 6.95	29.333 0.00	21.300 11.16
Delta Hr Max	39.333 11.37	33.500 7.19	31.000 9.31	44.000 0.00	28.500 10.25
Pct Delta Hr Max	155.575 8.21	144.919 5.43	147.204 19.27	157.895 0.00	144.797 18.64
Delta Hr Return	-4.667 3.06	-7.000 9.45	-2.000 8.64	2.000 0.00	-3.500 5.51
Pct Delta Hr Return	93.164 4.31	92.129 13.26	97.804 12.59	102.632 0.00	94.966 7.73

TILT TABLE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Heart Rate					
Avg Pre-Tilt	65.500 11.70	69.000 16.85	66.000 2.31	61.375 5.83	67.917 11.84
Avg During Tilt	80.989 22.40	80.948 24.00	83.910 7.84	86.992 7.99	89.879 9.92
Max During Tilt	88.000 25.51	87.000 27.01	91.000 11.02	97.000 9.30	96.667 9.62
Delta Hr Avg	15.489 12.71	11.948 7.61	17.910 8.89	25.617 8.79	21.963 6.49
Delta Hr Max	22.500 16.11	18.000 10.71	25.000 11.94	35.625 9.72	28.750 6.08
Pct Delta Hr Max	132.894 21.28	124.643 10.55	138.143 18.89	158.992 18.54	144.171 14.04
Delta Hr Return	-5.500 3.42	-4.500 3.42	-4.500 2.52	-4.875 4.50	-6.083 4.94
Pct Delta Hr Return	91.874 4.65	93.808 4.38	93.214 3.62	92.188 7.31	90.719 7.66

TILT TABLE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Heart Rate					
Avg Pre-Tilt	58.500 7.76	56.750 9.25	77.500 10.84	63.714 10.29	66.500 13.38
Avg During Tilt	92.040 13.82	95.059 17.59	101.763 9.58	94.436 [illegible]	90.280 16.18
Max During Tilt	110.000 15.12	109.500 19.70	115.500 10.13	106.857 16.93	100.000 17.10
Delta Hr Avg	33.540 9.22	36.309 11.60	27.263 3.94	30.721 9.28	23.780 [illegible]
Delta Hr Max	51.500 12.32	50.750 14.14	38.000 7.01	43.143 10.64	33.500 6.30
Pct Delta Hr Max	189.249 24.50	187.403 26.50	150.466 14.47	168.578 17.50	151.512 11.84
Delta Hr Return	-4.250 5.06	-2.750 2.60	-7.000 5.24	-2.000 [illegible]	-6.500 6.82
Pct Delta Hr Return	92.407 10.14	94.960 5.18	90.222 9.21	96.950 10.49	90.609 10.64

TILT TABLE TESTS

Measure Condition	SET 31	SET 32	SET 33
Heart Rate			
Avg Pre-Tilt	62.250 8.58	62.000 19.80	59.000 9.39
Avg During Tilt	86.973 8.26	89.567 22.30	80.907 10.30
Max During Tilt	96.000 10.03	100.000 28.28	87.500 10.35
Delta Hr Avg	24.723 8.36	27.567 2.50	21.907 7.87
Delta Hr Max	33.750 10.17	38.000 6.49	28.500 7.23
Pct Delta Hr Max	155.774 19.71	162.281 6.20	149.500 13.79
Delta Hr Return	-2.750 7.01	-12.000 19.80	-3.750 3.92
Pct Delta Hr Return	95.602 11.55	74.232 40.16	93.638 6.05

2

TILT TABLE TESTS

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Blood Pressure					
Avg Sys Pre-Tilt	110.563 9.65	109.333 10.54	11[illegible].125 12.93	117.500 3.94	121.250 5.42
Avg Dia Pre-Tilt	55.063 11.69	46.083 2.23	65.875 7.70	68.750 7.60	61.250 14.19
Pulse Pre-Tilt	55.500 10.14	63.250 9.36	53.250 5.56	48.750 11.29	60.000 15.56
Mean Pres Pre-Tilt	73.562 9.96	67.167 4.66	83.625 9.10	85.000 3.92	81.250 9.50
Avg Tilt Sys	116.825 7.56	117.467 10.51	122.050 12.13	116.525 6.34	122.350 5.57
Min Tilt Sys	111.125 9.66	111.667 8.33	116.000 10.68	105.000 11.75	116.000 3.65
Avg Tilt Dia	71.525 7.44	71.267 4.00	82.567 6.00	81.100 10.10	78.500 8.59
Max Tilt Dia	77.125 6.49	76.333 3.56	88.250 6.13	88.250 12.31	85.000 5.89
Avg Tilt Pulse	45.300 8.28	46.200 13.63	39.483 6.20	36.287 14.70	43.850 11.66
Min Tilt Pulse	37.375 10.60	36.167 11.09	29.000 6.68	25.750 15.31	33.000 7.87
Avg Tilt Mean	86.625 6.38	86.667 2.50	95.728 8.03	93.196 5.74	93.117 5.41
Min Tilt Mean	82.792 7.24	84.056 2.82	91.750 7.39	82.583 17.20	87.583 7.43
Avg Sys Post-Tilt	113.875 11.13	111.250 6.86	122.750 15.18	118.250 4.50	122.000 7.04
Avg Dia Post-Tilt	52.375 11.42	46.250 3.71	63.750 8.63	61.000 6.48	60.375 17.57
Delta Dia Avg	16.462 8.55	25.183 5.33	16.692 1.76	12.350 6.79	17.250 8.64
Delta Dia Max	22.063 10.26	30.250 4.98	22.375 3.71	19.500 5.34	23.750 9.35

TILT TABLE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Blood Pressure					
Delta Pulse Avg	11.975 14.58	13.075 16.96	10.313 3.34	-3.800 0.00	15.675 9.61
Delta Pulse Max	22.125 14.14	23.125 18.67	24.875 14.77	8.000 0.00	28.125 15.91
Pct Delta Pulse	60.948 23.79	63.959 25.40	52.262 34.91	78.947 0.00	46.434 31.46
Delta Mean Avg	11.458 3.35	13.567 4.81	8.200 4.98	11.367 0.00	13.550 9.66
Delta Mean Pres	6.042 2.92	9.667 4.22	-16.375 41.06	8.167 0.00	7.333 6.59
Pct Return Pulse	111.842 22.39	101.905 13.08	116.063 7.58	60.526 0.00	111.162 11.77
Pct Return Mean	101.482 2.75	97.815 4.48	96.725 3.49	46.407 0.00	100.685 9.77

TILT TABLE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Blood Pressure					
Avg Sys Pre-Tilt	111.063 10.89	107.750 4.27	125.375 4.19	121.625 4.39	128.000 4.24
Avg Dia Pre-Tilt	57.313 11.30	55.417 5.39	75.250 6.38	67.125 4.31	67.500 8.11
Pulse Pre-Tilt	53.750 11.54	52.333 6.31	50.125 6.17	54.500 6.94	60.500 5.61
Mean Pres Pre-Tilt	75.229 9.75	72.861 4.08	91.958 4.96	85.292 2.84	87.667 6.55
Avg Tilt Sys	113.175 7.19	116.100 2.44	125.050 7.29	118.200 7.28	126.812 8.62
Min Tilt Sys	107.000 9.17	109.500 4.04	120.000 8.21	110.250 9.29	120.750 8.42
Avg Tilt Dia	74.175 8.54	71.800 5.11	86.700 8.94	86.500 6.23	85.825 8.90
Max Tilt Dia	79.750 8.08	76.500 5.82	93.750 8.66	95.250 8.66	90.000 7.07
Avg Tilt Pulse	39.000 8.62	44.300 6.06	38.350 10.55	31.700 8.20	40.987 5.68
Min Tilt Pulse	30.000 8.75	35.000 7.62	29.750 12.18	20.500 10.08	31.750 5.74
Avg Tilt Mean	87.175 7.02	86.567 3.35	99.483 6.80	97.067 5.34	99.487 8.39
Min Tilt Mean	81.625 7.28	83.444 4.53	94.667 8.59	92.917 4.65	95.417 11.21
Avg Sys Post-Tilt	112.250 8.63	112.667 5.31	130.125 4.25	127.500 7.38	128.375 0.95
Avg Dia Post-Tilt	61.313 11.28	57.333 4.45	80.500 7.93	74.625 5.62	68.000 7.33
Delta Dia Avg	16.862 8.89	16.383 7.54	11.450 4.35	19.375 4.10	18.325 8.43
Delta Dia Max	22.438 10.73	21.083 9.17	18.500 4.88	28.125 7.27	22.500 7.11

TILT TABLE TESTS

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Blood Pressure					
Delta Pulse Avg	10.200	17.050	13.767	12.462	16.150
	7.84	11.93	1.83	5.04	9.28
Delta Pulse Max	18.125	27.083	24.250	23.000	27.000
	9.15	9.47	2.06	1.60	14.35
Pct Delta Pulse	67.672	57.048	53.923	49.720	56.666
	17.97	15.22	7.67	[illegible]	16.27
Delta Mean Avg	13.062	19.500	12.103	8.196	11.867
	6.40	4.87	1.52	5.50	6.26
Delta Mean Pres	9.229	16.899	8.125	-2.417	6.333
	6.68	5.46	2.34	19.09	9.05
Pct Return Pulse	113.129	104.127	110.579	119.175	102.858
	26.82	14.28	3.82	17.17	6.22
Pct Return Mean	99.360	101.230	99.619	94.304	99.307
	8.31	4.17	2.50	4.00	5.18

TILT TABLE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Blood Pressure					
Avg Sys Pre-Tilt	116.875	120.250	120.875	106.500	117.500
	6.02	4.43	8.23	0.00	5.61
Avg Dia Pre-Tilt	59.500	57.125	65.750	68.500	64.125
	10.47	4.89	3.07	0.00	3.20
Pulse Pre-Tilt	57.375	63.125	55.125	38.000	53.375
	11.48	8.76	5.68	0.00	3.50
Mean Pres Pre-Tilt	78.625	78.167	84.125	81.167	81.917
	7.48	2.33	4.66	0.00	3.82
Avg Tilt Sys	120.350	125.100	122.200	120.400	120.600
	7.41	6.84	14.15	0.00	5.03
Min Tilt Sys	110.000	117.500	89.250	115.000	110.750
	9.93	9.85	59.85	0.00	10.34
Avg Tilt Dia	74.950	75.050	77.387	78.600	82.900
	5.47	9.99	5.41	0.00	9.28
Max Tilt Dia	79.750	80.500	89.250	85.000	88.750
	8.26	12.07	4.43	0.00	10.78
Avg Tilt Pulse	45.400	50.050	44.812	41.800	37.700
	8.64	16.65	8.87	0.00	11.14
Min Tilt Pulse	35.250	40.000	30.250	30.000	25.250
	14.82	17.15	20.30	0.00	17.80
Avg Tilt Mean	90.083	91.733	92.325	92.533	95.467
	4.65	4.53	8.30	0.00	6.19
Min Tilt Mean	84.667	87.833	67.750	89.333	89.250
	6.62	4.43	45.31	0.00	3.18
Avg Sys Post-Tilt	121.375	119.000	123.750	53.000	121.875
	8.36	6.79	4.73	0.00	1.93
Avg Dia Post-Tilt	59.125	55.125	60.000	30.000	62.375
	9.20	4.01	1.35	0.00	7.41
Delta Dia Avg	15.450	17.925	11.637	10.100	18.775
	6.83	10.18	4.10	0.00	12.40
Delta Dia Max	20.250	23.375	23.500	16.500	24.625
	5.74	12.17	7.45	0.00	13.59

TILT TABLE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Blood Pressure					
Delta Pulse Avg	14.750	9.033	11.775	22.800	19.513
	9.20	8.77	10.71	3.11	4.94
Delta Pulse Max	23.750	17.333	20.375	34.000	28.750
	10.93	12.37	12.35	5.34	6.33
Pct Delta Pulse	56.551	68.426	53.594	36.446	32.547
	15.56	20.21	24.01	15.11	8.84
Delta Mean Avg	11.946	13.706	7.525	13.775	11.821
	6.49	4.98	5.37	3.45	7.28
Delta Mean Pres	6.396	10.583	2.708	7.625	7.750
	6.48	5.55	5.85	3.59	9.71
Pct Return Pulse	97.555	106.375	99.682	97.514	99.564
	20.80	8.20	9.67	8.49	3.33
Pct Return Mean	104.368	104.202	105.476	108.108	100.659
	6.76	7.22	2.21	4.17	3.47

TILT TABLE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Blood Pressure					
Avg Sys Pre-Tilt	119.333	128.500	122.125	116.500	122.000
	3.33	10.61	5.82	0.00	3.29
Avg Dia Pre-Tilt	70.333	66.750	66.875	61.500	75.750
	4.31	9.91	14.08	0.00	3.71
Pulse Pre-Tilt	49.000	61.750	55.250	55.000	46.250
	5.20	10.81	14.12	0.00	3.20
Mean Pres Pre-Tilt	86.667	87.333	85.292	79.833	91.167
	3.18	8.73	9.63	0.00	3.24
Avg Tilt Sys	116.667	128.300	119.800	113.800	119.400
	5.25	8.98	4.16	0.00	3.99
Min Tilt Sys	109.667	117.250	115.750	105.500	114.250
	6.81	12.79	5.91	0.00	3.20
Avg Tilt Dia	84.400	83.200	82.950	78.000	89.350
	5.20	11.69	5.23	0.00	6.81
Max Tilt Dia	90.000	88.750	87.250	82.000	93.500
	4.58	9.36	6.85	0.00	5.07
Avg Tilt Pulse	32.267	45.100	36.850	35.800	30.050
	9.10	10.92	2.74	0.00	7.38
Min Tilt Pulse	23.333	35.000	30.500	24.000	24.750
	14.19	15.25	2.52	0.00	9.54
Avg Tilt Mean	95.156	98.233	95.233	89.933	99.367
	2.97	9.57	4.72	0.00	4.91
Min Tilt Mean	90.778	92.750	91.250	84.333	96.250
	3.37	11.69	4.41	0.00	5.49
Avg Sys Post-Tilt	124.833	127.000	122.875	121.500	127.625
	2.36	9.47	6.05	0.00	2.17
Avg Dia Post-Tilt	75.167	68.625	65.750	68.500	81.750
	4.16	6.68	5.33	0.00	6.71
Delta Dia Avg	14.067	16.450	16.075	16.500	13.600
	3.33	2.63	10.96	0.00	7.08
Delta Dia Max	19.667	22.000	20.375	20.500	17.750
	4.37	2.94	10.85	0.00	6.38

TILT TABLE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Blood Pressure					
Delta Pulse Avg	16.733 5.25	16.650 5.42	18.400 11.92	19.200 0.00	16.200 8.63
Delta Pulse Max	25.667 10.69	26.750 8.46	24.750 11.89	31.000 0.00	21.500 10.49
Pct Delta Pulse	46.456 25.56	55.138 18.62	57.032 9.61	43.636 0.00	53.855 22.25
Delta Mean Avg	8.489 1.58	10.900 1.11	9.942 7.25	10.100 0.00	8.200 4.97
Delta Mean Pres	4.111 0.25	5.417 4.09	5.958 7.44	4.500 0.00	5.083 6.10
Pct Return Pulse	101.627 4.65	94.748 6.16	107.626 24.05	96.364 0.00	99.115 9.97
Pct Return Mean	105.920 5.21	101.132 4.49	99.993 8.47	107.933 0.00	106.547 6.65

TILT TABLE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Blood Pressure					
Avg Sys Pre-Tilt	104.500 3.37	108.250 4.56	116.125 6.68	110.813 9.94	108.542 7.77
Avg Dia Pre-Tilt	61.125 7.65	59.625 9.21	67.000 4.56	56.188 11.17	50.750 6.27
Pulse Pre-Tilt	43.375 9.25	48.625 9.58	49.125 6.71	54.625 10.53	57.792 9.51
Mean Pres Pre-Tilt	75.583 4.88	75.833 6.47	83.375 4.33	74.396 9.56	70.014 5.13
Avg Tilt Sys	105.200 11.27	113.100 6.29	114.750 5.51	115.000 7.38	116.783 7.31
Min Tilt Sys	100.500 8.70	105.500 8.54	105.750 4.27	109.063 9.34	110.583 6.35
Avg Tilt Dia	67.425 13.67	71.050 8.02	75.200 6.39	72.850 7.85	71.533 4.38
Max Tilt Dia	71.500 16.50	76.000 8.04	78.750 6.02	78.438 7.21	76.417 4.60
Avg Tilt Pulse	37.775 5.54	41.250 5.00	39.550 1.54	42.150 8.79	45.250 10.10
Min Tilt Pulse	32.250 8.46	31.500 4.80	29.500 8.19	33.688 10.13	35.583 9.09
Avg Tilt Mean	80.017 12.66	85.600 7.10	88.383 6.07	86.900 6.49	86.617 2.82
Min Tilt Mean	76.250 9.95	81.667 5.96	84.250 5.69	82.208 7.04	83.750 3.62
Avg Sys Post-Tilt	105.625 4.75	111.750 4.21	114.250 3.18	113.063 9.66	111.958 5.89
Avg Dia Post-Tilt	55.750 3.80	57.375 7.72	63.750 6.44	56.844 11.90	51.792 6.98
Delta Dia Avg	6.300 11.10	12.225 2.43	8.200 5.75	16.662 8.43	20.783 7.74
Delta Dia Max	10.375 12.80	16.375 3.47	11.750 6.61	22.250 10.14	25.667 8.51

TILT TABLE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Blood Pressure					
Delta Pulse Avg	5.600 7.68	7.375 8.03	9.575 7.94	12.475 8.59	12.542 11.02
Delta Pulse Max	11.125 8.87	17.125 11.46	19.625 14.90	20.938 10.16	22.208 11.67
Pct Delta Pulse	75.918 19.45	67.092 18.22	62.445 23.44	62.112 17.22	62.737 18.08
Delta Mean Avg	4.433 11.51	9.767 2.53	5.008 3.26	12.504 6.25	16.603 5.59
Delta Mean Pres	0.667 9.69	5.833 2.40	0.875 1.96	7.813 6.52	13.736 6.20
Pct Return Pulse	117.857 19.33	112.665 9.73	102.801 7.12	105.342 24.54	105.251 11.17
Pct Return Mean	95.988 6.43	99.678 2.68	96.717 4.05	101.864 7.76	102.716 5.84

TILT TABLE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Blood Pressure					
Avg Sys Pre-Tilt	122.250 9.50	119.563 4.44	124.625 5.77	117.929 4.85	124.375 8.72
Avg Dia Pre-Tilt	70.563 8.24	67.938 5.78	64.375 11.21	64.143 9.72	61.938 8.88
Pulse Pre-Tilt	51.688 5.69	51.625 9.20	60.250 10.83	53.786 9.74	62.438 9.14
Mean Pres Pre-Tilt	87.792 8.26	85.146 3.17	84.458 8.30	82.071 7.06	82.750 7.70
Avg Tilt Sys	123.550 9.40	117.362 6.38	124.581 7.13	118.771 6.37	126.700 7.58
Min Tilt Sys	118.000 9.07	107.625 10.20	118.375 6.52	109.857 8.05	117.375 10.57
Avg Tilt Dia	84.633 7.39	83.800 8.28	82.162 8.9[illegible]	79.000 7.03	79.125 10.97
Max Tilt Dia	91.000 7.54	91.750 10.54	87.500 6.59	84.143 8.43	84.625 10.93
Avg Tilt Pulse	38.917 8.03	33.994 11.29	42.419 8.62	39.771 10.69	47.575 13.30
Min Tilt Pulse	29.375 9.10	23.125 12.32	32.375 6.41	30.143 14.75	37.500 15.26
Avg Tilt Mean	97.606 7.18	95.131 5.54	96.302 7.37	92.257 4.59	94.983 7.75
Min Tilt Mean	93.208 7.58	87.750 12.91	91.500 9.75	87.286 6.03	90.292 8.60
Avg Sys Post-Tilt	126.438 11.05	122.875 7.52	125.188 5.76	122.857 6.34	123.000 8.75
Avg Dia Post-Tilt	72.125 11.79	67.813 9.20	64.188 13.11	66.000 11.03	61.875 8.83
Delta Dia Avg	14.071 4.16	15.862 6.41	17.787 7.92	14.857 5.25	17.187 6.93
Delta Dia Max	20.438 4.52	23.813 7.49	23.125 7.72	20.000 4.79	22.688 8.23

TILT TABLE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Blood Pressure					
Delta Pulse Avg	12.771 7.19	17.631 6.75	17.831 7.11	14.014 11.04	14.863 11.81
Delta Pulse Max	22.313 8.46	28.500 7.47	27.875 10.31	23.613 11.90	24.938 13.56
Pct Delta Pulse	56.758 16.78	43.084 17.13	54.607 12.32	54.737 23.68	59.548 21.15
Delta Mean Avg	9.814 1.40	9.985 4.66	11.844 6.28	10.186 3.00	12.233 3.53
Delta Mean Pres	5.417 5.05	2.604 13.81	7.042 8.72	5.214 2.31	7.542 4.47
Pct Return Pulse	105.130 8.96	108.345 17.07	101.211 4.95	107.464 16.96	98.326 10.21
Pct Return Mean	102.548 3.82	101.206 8.28	99.983 4.14	103.384 1.29	99.474 4.51

TILT TABLE TESTS

Measure Condition	SET 31	SET 32	SET 33
Blood Pressure			
Avg Sys Pre-Tilt	121.500 5.58	111.500 7.07	119.750 4.89
Avg Dia Pre-Tilt	66.313 9.45	65.000 4.95	69.938 6.99
Pulse Pre-Tilt	55.188 9.96	46.500 12.02	49.813 4.91
Mean Pres Pre-Tilt	84.708 7.03	80.500 0.94	86.542 5.93
Avg Tilt Sys	121.000 9.74	117.100 4.67	120.000 4.25
Min Tilt Sys	102.500 41.84	110.000 7.07	112.500 7.33
Avg Tilt Dia	80.169 5.75	78.300 0.42	86.125 8.29
Max Tilt Dia	88.250 5.44	83.500 2.12	91.125 8.20
Avg Tilt Pulse	40.831 7.42	38.800 4.24	33.875 9.66
Min Tilt Pulse	30.375 13.39	27.000 4.24	25.000 13.22
Avg Tilt Mean	93.779 6.44	91.233 1.84	97.417 5.58
Min Tilt Mean	79.500 32.34	86.833 3.54	92.750 5.59
Avg Sys Post-Tilt	123.313 5.05	87.250 48.44	124.750 3.62
Avg Dia Post-Tilt	62.875 4.73	49.250 27.22	72.063 12.25
Delta Dia Avg	13.856 8.02	13.300 4.53	16.187 9.75
Delta Dia Max	21.938 8.78	18.500 2.83	21.188 10.49

TILT TABLE TESTS

Measure Condition	SET 31	SET 32	SET 33
Blood Pressure			
Delta Pulse Avg	14.356 9.19	7.700 16.26	15.938 8.46
Delta Pulse Max	24.813 12.42	19.500 16.26	24.813 12.97
Pct Delta Pulse	54.647 23.84	61.292 24.97	50.144 25.54
Delta Mean Avg	9.071 5.83	10.733 0.90	10.875 7.67
Delta Mean Pres	-5.208 29.81	6.333 2.59	6.208 6.00
Pct Return Pulse	111.844 17.12	78.445 25.34	105.139 11.97
Pct Return Mean	98.359 6.25	77.170 13.51	103.616 8.34

TILT TABLE TESTS

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Limb Volume					
Left Leg S1	6.045 1.48	5.[illegible]78 1.75	[illegible] 2.59	4.370 1.26	5.287 1.16
Right Leg S1	6.857 0.95	5.472 2.10	3.320 0.00	3.880 0.00	6.667 3.46
Average S1	[illegible].571 3.04	5.446 1.62	2.312 2.99	2.012 2.37	4.482 3.39
Left Leg S2	0.125 0.03	0.152 0.03	0.127 0.04	0.110 0.04	0.110 0.02
Right Leg S2	0.144 0.02	0.144 0.04	0.152 0.03	0.110 0.03	0.125 0.01
Average S2	0.133 0.03	0.151 0.03	0.140 0.03	0.110 0.03	0.117 0.02
Left Leg To	2.236 0.69	2.203 0.60	2.045 1.39	2.217 0.93	2.005 0.47
Right Leg To	2.486 0.41	2.280 0.29	1.867 0.64	2.545 0.43	2.115 0.24
Average To	2.341 0.52	2.177 0.46	1.956 1.01	2.431 0.68	2.060 0.31
Left Leg T15	4.155 0.85	4.243 0.58	3.870 1.29	4.132 0.85	3.960 0.38
Right Leg T15	4.691 0.59	3.984 0.95	4.145 0.65	4.392 0.59	4.015 0.20
Average T15	4.404 0.63	4.126 0.65	4.007 0.97	4.262 0.66	3.987 0.22

TILT TABLE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Limb Volume					
Left Leg S1	5.975 1.23	5.717 0.89	5.75[illegible] 1.3[illegible]	4.050 0.00	5.913 2.90
Right Leg S1	8.830 0.00	7.000 1.41	6.847 3.08	12.190 0.00	8.150 3.45
Average S1	3.231 3.90	4.769 3.22	4.724 3.63	8.075 0.00	5.274 3.58
Left Leg S2	0.145 0.03	0.142 0.02	0.145 0.04	0.190 0.00	0.140 0.01
Right Leg S2	0.152 0.02	0.140 0.04	0.155 0.01	0.190 0.00	0.130 0.04
Average S2	0.149 0.01	0.141 0.03	0.150 0.02	0.190 0.00	0.127 0.03
Left Leg To	2.112 0.46	2.137 0.23	2.050 0.38	1.630 0.00	2.357 0.34
Right Leg To	2.400 0.35	3.042 1.28	2.427 0.30	2.580 0.00	2.777 0.66
Average To	2.256 0.33	2.590 0.55	2.239 0.24	2.155 0.00	2.535 0.61
Left Leg T15	4.195 0.81	4.015 0.36	4.067 0.81	4.410 0.00	1.377 0.57
Right Leg T15	4.675 0.43	4.677 0.89	4.667 0.47	5.920 0.00	4.722 1.00
Average T15	4.435 0.48	4.346 0.53	4.367 0.50	5.165 0.00	4.424 0.77

TILT TABLE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Limb Volume					
Left Leg S1	5.239 2.50	6.308 1.97	1.210 0.00	4.900 2.36	5.933 3.04
Right Leg S1	5.783 2.77	5.788 1.37	[illegible].400 0.23	3.810 0.00	6.963 1.34
Average S1	5.272 2.39	6.048 1.57	1.821 2.23	3.627 3.11	4.836 3.40
Left Leg S2	0.114 0.03	0.115 0.03	0.117 0.06	0.092 0.01	0.110 0.04
Right Leg S2	0.144 0.03	0.117 0.02	0.137 0.05	0.097 0.01	0.127 0.04
Average S2	0.129 0.03	0.116 0.03	0.124 0.05	0.095 0.01	0.119 0.04
Left Leg To	2.174 0.56	2.318 0.23	2.217 0.81	2.537 0.45	2.502 0.87
Right Leg To	2.507 0.77	2.173 0.31	2.692 0.66	2.357 0.44	2.400 0.82
Average To	2.341 0.53	2.246 0.24	2.601 0.77	2.447 0.36	2.451 0.80
Left Leg T15	3.719 0.36	4.075 0.33	4.167 1.08	3.907 0.42	3.975 0.98
Right Leg T15	4.592 0.84	3.852 0.62	4.540 0.91	3.787 0.51	4.050 0.71
Average T15	4.156 0.48	3.963 0.42	4.354 0.87	3.847 0.37	4.012 0.79

TILT TABLE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Limb Volume					
Left Leg S1	4.025 0.19	5.273 1.28	5.897 0.92	3.920 0.00	4.177 0.53
Right Leg S1	6.900 2.76	8.657 1.28	5.602 2.21	5.310 0.00	5.557 1.59
Average S1	6.438 3.01	5.224 3.64	5.550 1.36	4.115 0.00	4.867 0.82
Left Leg S2	0.120 0.02	0.125 0.03	0.127 0.04	0.090 0.00	0.110 0.04
Right Leg S2	0.143 0.02	0.137 0.03	0.140 0.03	0.140 0.00	0.127 0.04
Average S2	0.132 0.02	0.131 0.03	0.133 0.03	0.115 0.00	0.119 0.04
Left Leg To	1.890 0.06	2.282 0.60	2.147 0.19	1.850 0.00	2.082 0.17
Right Leg To	2.593 0.42	2.287 0.26	2.212 0.63	1.970 0.00	2.115 0.45
Average To	2.242 0.24	2.285 0.35	2.180 0.41	1.910 0.00	2.099 0.31
Left Leg T15	3.623 0.34	4.132 1.02	4.000 0.61	2.970 0.00	3.612 0.64
Right Leg T15	4.000 1.40	4.387 0.71	4.292 1.04	4.060 0.00	3.675 1.04
Average T15	3.812 0.84	4.260 0.84	4.146 0.79	3.515 0.00	3.644 0.84

TILT TABLE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Limb Volume					
Left Leg S1	5.112 0.81	4.883 1.61	0.000 96.70	5.584 2.09	5.693 1.83
Right Leg S1	5.850 1.63	5.710 2.27	5.030 0.00	6.141 2.31	5.662 1.59
Average S1	5.180 0.99	3.972 3.08	1.257 2.51	4.921 2.66	5.747 1.55
Left Leg S2	0.160 0.02	0.140 0.02	0.100 0.01	0.119 0.03	0.133 0.04
Right Leg S2	0.167 0.02	0.145 0.02	0.125 0.01	0.144 0.03	0.129 0.03
Average S2	0.164 0.02	0.142 0.02	0.112 0.01	0.131 0.03	0.133 0.03
Left Leg To	1.552 0.67	1.642 0.49	1.267 0.21	2.205 0.61	2.261 0.44
Right Leg To	1.987 0.42	1.982 0.31	2.142 0.24	2.497 0.61	2.222 0.29
Average To	1.770 0.50	1.812 0.38	1.705 0.22	2.341 0.51	2.212 0.35
Left Leg T15	3.873 0.76	3.587 0.90	2.540 0.30	3.937 0.67	4.159 0.46
Right Leg T15	4.565 0.78	4.025 0.49	3.745 0.37	4.639 0.71	3.912 0.75
Average T15	4.219 0.74	3.806 0.68	3.142 0.30	4.280 0.56	4.045 0.53

TILT TABLE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Limb Volume					
Left Leg S1	3.370 2.62	4.688 1.81	5.610 2.09	5.000 1.35	5.495 1.02
Right Leg S1	4.010 0.64	3.860 0.03	6.815 2.35	7.382 2.15	7.828 1.51
Average S1	2.067 2.46	2.820 2.70	4.659 3.19	4.606 3.68	4.996 3.19
Left Leg S2	0.123 0.04	0.101 0.03	0.110 0.03	0.134 0.03	0.134 0.03
Right Leg S2	0.145 0.07	0.104 0.02	0.126 0.03	0.139 0.02	0.139 0.03
Average S2	0.132 0.04	0.102 0.02	0.118 0.03	0.141 0.02	0.136 0.03
Left Leg To	2.119 1.09	2.427 0.69	2.254 0.70	2.017 0.35	2.210 0.43
Right Leg To	2.280 0.75	2.451 0.41	2.257 0.58	2.483 0.36	2.665 0.95
Average To	2.279 0.90	2.439 0.51	2.256 0.60	2.250 0.27	2.437 0.46
Left Leg T15	4.019 1.11	4.020 0.63	3.967 0.69	3.950 0.68	4.074 0.71
Right Leg T15	4.342 0.77	4.090 0.60	4.032 0.49	4.386 0.93	4.532 0.76
Average T15	4.181 0.87	4.055 0.54	4.000 0.54	4.168 0.68	4.303 0.65

TILT TABLE TESTS

Measure Condition	SET 31	SET 32	SET 33
Limb Volume			
Left Leg S1	5.606 1.92	3.485 0.80	4.921 1.95
Right Leg S1	6.136 2.47	8.705 4.80	6.669 2.68
Average S1	5.137 2.57	6.095 2.80	5.071 2.41
Left Leg S2	0.136 0.04	0.140 0.07	0.123 0.03
Right Leg S2	0.147 0.02	0.165 0.04	0.129 0.03
Average S2	0.142 0.03	0.152 0.05	0.123 0.03
Left Leg To	2.099 0.28	1.740 0.16	2.200 0.52
Right Leg To	2.320 0.47	2.325 0.50	2.446 0.63
Average To	2.209 0.31	2.032 0.17	2.317 0.50
Left Leg T15	4.034 0.67	3.690 1.02	3.940 0.69
Right Leg T15	4.480 0.77	4.990 1.32	4.199 1.10
Average T15	4.257 0.62	4.340 1.17	1.034 0.85

NEGATIVE PRESSURE TESTS

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Heart Rate					
Avg Pre-NP	57.250	64.333	52.000	51.500	64.500
	4.40	13.94	7.12	9.98	16.68
Avg Step I NP	54.965	62.046	52.819	50.847	63.569
	2.80	12.55	7.84	7.01	11.41
Avg Step II NP	57.299	65.194	54.532	52.236	66.511
	2.46	13.29	9.37	8.67	11.46
Avg Step III NP	58.431	65.583	58.778	54.931	68.694
	2.28	10.86	6.62	7.52	13.46
Avg Total NP	56.898	64.275	55.380	52.671	66.259
	2.19	12.02	7.92	7.69	12.00
Max Hr NP	64.500	72.000	64.000	60.000	74.000
	3.34	13.62	10.33	8.64	12.44
Avg Post-NP	56.000	66.000	56.000	59.000	71.500
	2.39	12.71	8.16	5.29	16.52
Delta Hr Avg	-0.352	-0.059	3.380	1.171	1.759
	2.80	2.81	1.57	3.91	8.01
Delta Hr Max	7.250	7.667	12.000	8.500	9.500
	4.77	3.14	4.32	1.91	7.90
Pct Delta Hr Max	113.140	112.513	122.914	117.174	117.909
	8.93	6.85	6.47	6.94	17.67
Pct Delta Hr Return	98.071	103.053	107.654	117.194	112.269
	4.25	4.28	5.33	20.34	12.86

NEGATIVE PRESSURE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Heart Rate					
Avg Pre-NP	58.500	54.500	55.000	40.000	49.500
	9.57	17.39	11.14	0.00	4.43
Avg Step I NP	57.917	54.597	55.806	44.000	49.569
	11.30	10.42	9.43	0.00	5.18
Avg Step II NP	61.097	58.042	55.931	45.333	50.472
	5.20	12.35	10.76	0.00	2.86
Avg Step III NP	62.722	57.069	56.431	47.111	52.028
	6.03	10.19	10.02	0.00	4.20
Avg Total NP	60.579	56.569	56.056	45.481	50.690
	7.21	10.95	10.01	0.00	1.02
Max Hr NP	73.000	65.000	65.000	56.000	58.000
	10.52	11.49	12.38	0.00	4.00
Avg Post-NP	63.500	61.500	55.500	48.000	59.000
	10.75	8.23	9.15	0.00	9.31
Delta Hr Avg	2.079	2.069	1.056	5.481	1.190
	5.32	6.60	2.31	0.00	3.45
Delta Hr Max	14.500	10.500	10.000	16.000	8.500
	3.70	6.91	1.63	0.00	1.73
Pct Delta Hr Max	126.016	123.973	118.418	140.000	117.680
	15.92	22.10	2.29	0.00	10.29
Pct Delta Hr Return	108.970	118.286	101.667	120.000	120.526
	10.39	23.86	5.77	0.00	25.44

NEGATIVE PRESSURE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Heart Rate					
Avg Pre-NP	62.000 8.14	67.333 7.97	67.000 7.75	64.000 8.79	78.000 9.52
Avg Step I NP	60.937 6.72	66.296 6.14	66.750 6.84	63.472 7.22	78.000 5.72
Avg Step II NP	61.500 6.13	68.516 5.34	67.944 6.65	70.653 8.42	79.222 5.68
Avg Step III NP	63.604 4.69	70.204 6.06	72.194 7.71	71.986 8.37	80.194 5.74
Avg Total NP	62.014 5.60	68.339 5.74	68.963 6.97	68.704 7.40	79.139 5.55
Max Hr NP	70.000 6.05	76.333 4.46	77.000 8.87	80.000 8.64	85.000 5.03
Avg Post-NP	65.250 4.77	70.667 10.25	69.500 6.40	69.000 7.39	78.000 6.32
Delta Hr Avg	0.011 3.91	1.005 3.25	1.963 2.14	4.704 5.79	1.139 4.79
Delta Hr Max	8.000 6.41	9.000 6.54	10.000 4.32	16.000 7.83	7.000 7.57
Pct Delta Hr Max	113.898 12.24	114.318 11.36	115.052 6.36	125.861 13.26	109.823 10.24
Pct Delta Hr Return	106.031 8.08	105.602 16.21	104.009 4.52	108.480 10.86	100.420 5.33

NEGATIVE PRESSURE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Heart Rate					
Avg Pre-NP	65.333 14.74	70.500 11.82	66.000 8.00	86.000 0.00	63.000 12.70
Avg Step I NP	65.167 11.56	71.347 11.04	66.875 7.60	[illegible] 0.00	63.986 10.90
Avg Step II NP	66.667 11.56	70.625 11.25	64.958 7.97	86.000 0.00	63.417 9.72
Avg Step III NP	73.389 12.14	71.542 10.03	66.079 6.93	86.000 0.00	67.083 10.64
Avg Total NP	68.407 9.96	71.171 10.70	65.971 7.46	85.481 0.00	64.829 10.23
Max Hr NP	80.000 10.58	79.000 13.61	74.000 6.93	92.000 0.00	71.000 11.55
Avg Post-NP	70.000 8.72	75.000 12.70	48.000 32.78	83.000 0.00	65.500 11.12
Delta Hr Avg	3.074 5.27	0.671 3.37	-0.029 1.47	-0.519 0.00	1.829 2.86
Delta Hr Max	14.667 13.01	8.500 3.00	8.000 2.31	6.000 0.00	11.000 7.58
Pct Delta Hr Max	125.011 22.13	112.020 3.55	112.407 4.37	106.977 0.00	118.222 5.95
Pct Delta Hr Return	109.042 15.43	106.406 5.27	71.299 47.55	102.326 0.00	104.656 9.06

NEGATIVE PRESSURE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Heart Rate					
Avg Pre-NP	60.000 10.33	69.000 17.32	63.500 1.00	59.625 6.78	65.833 10.94
Avg Step I NP	60.625 9.28	67.750 16.09	62.681 1.47	57.951 5.85	64.171 9.68
Avg Step II NP	62.167 12.52	68.441 17.10	61.486 2.46	59.399 5.01	66.855 9.81
Avg Step III NP	63.028 12.54	68.778 18.08	65.139 4.33	61.017 4.45	67.894 8.72
Avg Total NP	61.940 11.34	68.324 17.32	63.102 1.69	59.456 4.89	66.307 9.23
Max Hr NP	69.000 14.39	73.000 18.58	73.000 2.00	67.250 5.51	74.167 9.93
Avg Post-NP	67.000 13.71	69.500 18.86	66.000 3.65	60.625 6.01	68.333 11.28
Delta Hr Avg	1.940 1.37	-0.676 1.23	-0.398 2.44	-0.169 3.29	0.473 2.95
Delta Hr Max	9.000 5.03	4.000 1.63	9.500 3.00	7.625 5.48	8.333 5.03
Pct Delta Hr Max	114.633 6.39	105.768 1.84	115.020 5.01	113.519 10.36	113.416 8.99
Pct Delta Hr Return	111.310 5.52	100.351 2.78	104.007 7.10	102.051 7.47	104.327 11.41

NEGATIVE PRESSURE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Heart Rate					
Avg Pre-NP	59.500 10.57	57.750 10.98	71.250 14.50	61.429 11.47	62.500 16.20
Avg Step I NP	59.785 10.09	57.160 9.42	70.785 11.37	61.021 11.06	62.972 13.38
Avg Step II NP	61.243 10.39	61.411 12.63	72.868 10.78	63.484 8.18	64.333 12.84
Avg Step III NP	65.486 9.78	63.458 11.72	74.444 11.38	67.294 9.99	64.306 12.11
Avg Total NP	62.171 10.02	60.687 11.06	72.699 11.06	63.934 8.75	63.870 12.70
Max Hr NP	70.500 11.30	70.000 13.35	79.500 10.57	76.000 10.33	72.000 13.86
Avg Post-NP	62.750 9.91	64.000 8.00	74.750 12.09	66.286 9.76	68.250 12.26
Delta Hr Avg	2.671 1.90	2.937 4.95	1.449 6.12	2.505 4.86	1.370 4.91
Delta Hr Max	11.000 4.14	12.250 6.63	8.250 7.29	14.571 9.71	9.500 4.99
Pct Delta Hr Max	118.983 7.28	121.669 10.78	113.866 14.05	125.585 17.04	117.997 15.99
Pct Delta Hr Return	105.831 4.97	112.837 15.80	106.344 11.10	109.001 11.59	112.346 17.24

NEGATIVE PRESSURE TESTS

Measure Condition	SET 31	SET 32	SET 33
Heart Rate			
Avg Pre-NP	60.500 10.73	63.000 32.53	56.250 11.39
Avg Step I NP	61.3[illegible]0 9.89	6[illegible].222 28.60	56.778 11.04
Avg Step II NP	60.[illegible] 10.0[illegible]	65.667 28.76	56.944 9.59
Avg Step III NP	61.255 9.50	56.556 27.50	59.556 10.99
Avg Total NP	61.013 9.74	65.481 28.28	57.759 10.43
Max Hr NP	69.500 10.46	74.000 25.46	66.000 11.71
Avg Post-NP	51.750 22.64	68.000 28.28	62.250 10.11
Delta Hr Avg	0.513 1.89	2.481 4.24	1.509 2.96
Delta Hr Max	9.000 2.14	11.000 7.07	9.750 3.77
Pct Delta Hr Max	115.412 4.56	123.488 23.35	117.951 7.78
Pct Delta Hr Return	86.483 35.31	111.163 12.50	112.591 19.61

NEGATIVE PRESSURE TESTS

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Blood Pressure					
Avg Sys Pre-NP	107.688 8.51	113.333 7.37	115.625 12.37	116.750 3.66	117.500 8.81
Avg Dia Pre-NP	56.688 10.01	56.333 4.40	69.625 7.66	69.500 6.94	64.875 4.03
Avg Pulse Pre-NP	51 000 9.16	57.000 8.67	46.000 5.55	47.250 [illegible].19	52.625 8.53
Avg Mean Pulse Pre-NP	73.687 8.51	75.333 3.78	84.958 9.13	85.250 5.72	82.417 4.53
Total Sys Steps	108.187 9.24	110.593 7.88	112.792 11.21	114.333 7.50	117.333 9.87
Total Pulse Steps	49.146 10.84	52.556 9.9[illegible]	39.833 5.1[illegible]	42.542 7.02	47.375 8.34
Total Mean Steps	75.424 7.78	75.516 [illegible].48	86.236 10.92	85.972 4.43	85.750 6.39
Sys Post-NP	111.063 11.28	110.917 7.13	112.750 11.87	114.875 4.44	121.375 10.56
Dia Post-NP	57.000 6.81	59.667 8.07	71.250 10.09	71.250 5.55	71.875 14.10
Pulse Post-NP	54.063 11.62	51.250 9.65	41.500 7.58	43.625 6.39	49.500 12.34
Mean Post-NP	75.021 6.58	76.750 6.41	85.083 10.10	85.792 4.24	88.375 11.66
Min Systolic	103.250 8.41	105.167 6.77	109.500 10.63	107.000 12.36	112.750 9.18
Max Diastolic	63.250 10.70	63.333 7.12	79.500 12.97	78.500 5.57	75.000 6.98
Min Pulse	41.750 9.24	45.833 10.83	33.000 5.42	31.000 7.48	39.750 6.29
Min MBP	72.458 7.79	71.667 4.48	81.750 10.31	82.250 5.10	80.917 [illegible].57
Delta Pulse Max	9.250 4.17	11.167 6.65	13.000 7.63	16.250 11.44	12.875 2.93

NEGATIVE PRESSURE TESTS

Measure Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Blood Pressure					
Pct Delta Pulse Max	81.609 8.31	80.170 11.53	72.584 15.21	66.936 21.33	75.629 2.91
Delta BP Mean Avg	1.736 3.41	0.213 3.15	1.278 4.71	0.722 3.53	3.333 2.24
Delta BP Mean Max	-1.229 3.25	-3.667 [illegible].07	-3.208 5.81	-3.000 3.89	-1.500 1.48
Pct Return Pulse	106.928 22.09	90.[illegible]2 1[illegible].35	90.438 13.79	93.164 18.75	94.501 20.44
Pct Return BP Mean	102.132 4.61	101.807 5.39	100.140 5.08	100.916 7.42	106.883 8.55

NEGATIVE PRESSURE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Blood Pressure					
Avg Sys Pre-NP	116.875 7.66	115.750 6.33	116.125 6.34	107.000 0.00	11[illegible].000 [illegible].42
Avg Dia Pre-NP	63.750 6.81	63.375 5.96	65.125 4.53	[illegible]3.000 0.00	68.875 9.63
Avg Pulse Pre-NP	53.125 3.61	52.375 10.37	51.00 9.37	[illegible].000 0.00	[illegible]5.125 11.02
Avg Mean Pulse Pre-NP	81.458 6.90	80.833 3.63	82.125 2.76	77.667 0.00	83.917 6.43
Total Sys Steps	116.042 9.39	116.250 9.97	120.250 8.67	108.667 0.00	11[illegible].417 5.33
Total Pulse Steps	[illegible]7.958 5.12	53.375 12.92	51.208 8.58	[illegible]2.500 0.00	[illegible].792 7.86
Total Mean Steps	84.069 6.67	80.667 1.00	86.111 3.05	80.333 0.00	[illegible].556 3.45
Sys Post-NP	114.750 6.75	113.000 7.11	120.750 8.72	106.500 0.00	117.750 9.73
Dia Post-NP	66.000 [illegible]	62.750 6.12	65.625 4.71	66.000 0.00	72.500 5.79
Pulse Post-NP	[illegible]9.750 7.17	50.250 12.74	55.125 9.56	[illegible]0.500 0.00	[illegible]5.250 [illegible].31
Mean Post-NP	82.250 7.14	79.500 2.38	8[illegible].000 4.41	79.500 0.00	87.583 2.91
Min Systolic	109.750 6.55	110.500 7.00	11[illegible].750 8.02	100.000 0.00	108.250 [illegible].99
Max Diastolic	73.750 6.40	69.250 6.99	76.667 5.51	72.000 0.000	75.750 5.7[illegible]
Min Pulse	40.000 3.83	45.250 13.45	41.000 5.89	37.000 0.00	37.750 9.60
Min MBP	79.083 7.89	76.917 7.18	81.417 3.78	75.333 0.00	79.833 3.11
Delta Pulse Max	13.125 0.25	7.125 3.93	10.000 6.04	7.000 0.00	7.375 [illegible]

NEGATIVE PRESSURE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Blood Pressure					
Pct Delta Pulse Max	75.19[illegible] 2.18	30.3[illegible]1 16.96	81.078 8.31	8[illegible].091 0.00	93.98[illegible] 9.55
Delta BP Mean Avg	2.611 2.60	-0.1[illegible]7 3.39	3.986 4.73	2.667 0.00	0.63[illegible] 3.96
Delta PP Mean Max	-2.375 5.[illegible]3	-3.917 2.98	0.708 5.26	-2.333 0.00	-4.083 [illegible].02
Pct Return Pulse	91.46[illegible] 8.23	95.[illegible]29 7.7[illegible]	108.725 13.77	92.0[illegible]5 0.00	101.182 25.6[illegible]
Pct Return BP Mean	100.965 1.4[illegible]	[illegible].437 3.52	102.[illegible]8 7.88	102.361 0.00	10[illegible].826 3.77

NEGATIVE PRESSURE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Blood Pressure					
Avg Sys Pre-NP	10[illegible].63[illegible] 10.03	110.167 3.82	122.000 [illegible].24	120.625 4.01	120.125 [illegible].25
Avg Dia Pre-NP	[illegible]0.313 6.90	5[illegible].833 3.59	8[illegible].125 6.30	76.375 2.06	68.25[illegible] 7.01
Avg Pulse Pre-NP	[illegible].37[illegible] [illegible].73	51.333 3.53	37.875 5.7[illegible]	[illegible].250 5.19	51.875 7.1[illegible]
Avg Mean Pulse Pre-NP	7[illegible].771 6.65	75.9[illegible] [illegible].27	[illegible].750 3.01	91.125 1.[illegible]	85.542 5.23
Total Sys Steps	110.771 9.71	108.50[illegible] [illegible]	11[illegible].917 [illegible].01	11[illegible].5[illegible] [illegible].1[illegible]	121.417 3.22
Total Pulse Steps	[illegible].333 10.22	[illegible].361 2.[illegible]	39.208 4.71	39.417 5.51	[illegible]8.917 [illegible].65
Total Mean Steps	77.982 5.75	75.[illegible]9[illegible] [illegible].35	92.778 5.05	93.26[illegible] [illegible].20	98.806 [illegible].11
Sys Post-NP	112.[illegible]38 9.77	109.5[illegible] [illegible].7[illegible]	122.250 [illegible].97	122.375 [illegible].70	126.375 [illegible].80
Dia Post-NP	[illegible]0.500 3.32	5[illegible].167 6.37	80.250 8.45	79.700 2.69	72.375 6.01
Pulse Post-NP	51.938 10.07	51.333 [illegible].89	[illegible]2.000 3.53	42.[illegible]75 5.23	5[illegible].000 5.23
Mean Post-NP	77.[illegible]12 4.08	75.278 [illegible]	[illegible].250 7.28	93.79[illegible] 2.[illegible]5	90.375 5.07
Min Systolic	105.375 11.19	10[illegible].933 3.66	11[illegible].250 2.7[illegible]	115.50[illegible] [illegible].51	117.750 [illegible].57
Max Diastolic	6[illegible].333 7.09	6[illegible].600 5.[illegible]	85.000 6.68	85.667 3.79	78.750 [illegible].09
Min Pulse	[illegible].125 11.[illegible]1	43.[illegible]33 5.[illegible]	3[illegible].000 5.83	33.250 6.40	[illegible]3.000 [illegible].0[illegible]
Min MIP	7[illegible].292 5.2[illegible]	72.667 3.82	88.417 [illegible].79	89.250 2.9[illegible]	85.0[illegible]3 5.[illegible]6
Delta Pulse Max	5.250 7.66	7.500 6.89	5.875 6.36	11.000 3.70	8.875 8.61

NEGATIVE PRESSURE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Blood Pressure					
Pct Delta Pulse Max	89.518 14.29	85.913 13.02	85.110 14.37	74.859 8.98	84.017 13.59
Delta BP Mean Avg	1.111 3.39	-0.046 3.79	-3.972 0.69	2.139 1.13	3.264 1.59
Delta BP Mean Max	-2.379 3.58	-3.278 2.92	-8.333 2.33	-1.875 2.42	-0.458 0.88
Pct Return Pulse	106.580 17.20	100.516 14.56	112.109 12.54	96.935 5.07	105.228 15.05
Pct Return BP Mean	101.654 4.58	99.165 6.18	97.330 2.83	102.919 1.56	105.702 3.10

NEGATIVE PRESSURE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Blood Pressure					
Avg Sys Pre-NP	118.667 3.21	122.750 6.51	117.750 3.62	116.000 0.00	117.000 2.56
Avg Dia Pre-NP	75.000 4.00	65.500 6.67	69.625 7.52	64.500 0.00	75.375 4.52
Avg Pulse Pre-NP	43.667 6.81	57.250 8.27	48.125 8.56	51.500 0.00	41.625 5.48
Avg Mean Pulse Pre-NP	89.556 1.95	84.583 5.35	85.667 5.08	81.567 0.00	89.250 3.02
Total Sys Steps	117.111 5.34	122.625 3.60	117.667 3.23	115.167 0.00	119.083 2.13
Total Pulse Steps	42.167 5.53	54.958 5.59	48.167 9.39	50.833 0.00	40.125 7.29
Total Mean Steps	89.000 1.78	85.996 6.43	85.556 6.08	81.278 0.00	92.333 3.55
Sys Post-NP	120.500 4.27	124.375 3.94	117.375 3.82	116.500 0.00	119.375 3.90
Dia Post-NP	76.667 2.75	68.375 7.85	68.000 8.92	64.000 0.00	76.500 7.15
Pulse Post-NP	43.833 2.31	56.000 6.10	49.375 12.36	52.500 0.00	42.875 9.11
Mean Post-NP	91.278 3.15	87.042 6.07	81.458 4.89	81.500 0.00	90.792 4.55
Min Systolic	113.000 4.36	119.250 3.40	114.750 4.35	114.000 0.00	113.500 4.36
Max Diastolic	81.500 2.12	71.000 7.87	74.000 9.38	66.000 0.00	84.00 5.94
Min Pulse	36.667 4.93	49.750 4.03	44.750 8.77	49.000 0.00	32.750 5.74
Min MBP	86.667 2.19	84.317 6.24	82.500 6.02	80.333 0.00	87.833 5.67
Delta Pulse Max	7.000 2.65	7.500 4.95	3.375 2.59	2.50 0.00	8.875 2.56

NEGATIVE PRESSURE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Blood Pressure					
Pct Delta Pulse Max	9[illegible].220	87.6[illegible]7	92.[illegible]31	95.146	78.453
	[illegible].03	7.51	6.10	0.00	7.09
Delta BP Mean Avg	-0.556	1.[illegible]03	-0.111	-0.389	3.083
	3.[illegible]2	2.32	2.01	0.00	1.73
Delta BP Mean Max	-2.889	-0.167	-3.167	-1.333	-1.417
	2.99	[illegible].32	2.22	0.00	3.[illegible]1
Pct Return Pulse	101.782	98.516	101.793	101.942	102.679
	14.15	9.78	10.92	0.00	1[illegible].58
Pct Return BP Mean	101.994	102.913	90.6[illegible]2	99.796	101.71[illegible]
	5.39	3.55	3.53	0.00	3.31

NEGATIVE PRESSURE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Blood Pressure					
Avg Sys Pre-NP	107.375	108.500	109.625	108.688	111.750
	2.90	6.77	2.25	9.05	5.83
Avg Dia Pre-NP	61.125	61.500	65.500	58.500	57.583
	7.77	9.57	8.[illegible]0	8.51	[illegible].0[illegible]
Avg Pulse Pre-NP	46.250	[illegible]7.000	[illegible].125	50.188	5[illegible].167
	8.[illegible]5	6.23	8.[illegible]0	9.16	6.97
Avg Mean Pulse Pre-NP	76.542	77.167	80.208	75.229	75.639
	5.21	8.22	5.75	7.55	3.38
Total Sys Steps	105.750	109.542	110.833	109.[illegible]79	109.69[illegible]
	5.43	6.23	3.97	9.25	5.98
Total Pulse Steps	43.833	[illegible]5.000	[illegible].083	[illegible]9.2[illegible]0	50.958
	11.20	6.7[illegible]	9.1[illegible]	10.1[illegible]	7.17
Total Mean Steps	76.528	79.5[illegible]2	81.[illegible]	76.353	75.722
	6.[illegible]9	7.50	6.08	6 73	[illegible].22
Sys Post-NP	106.625	110.375	112.375	111.750	110.208
	7.98	7.66	6.30	10.22	5.99
Dia Post-NP	62.125	65.[illegible]75	65.500	58.750	58.917
	9.78	7.3[illegible]	9.97	5.[illegible]	6.97
Pulse Post-NP	[illegible].500	[illegible].500	[illegible]6.875	53 000	51.292
	11.[illegible]0	9.7[illegible]	12.89	10.56	7.63
Mean Post-NP	76.958	80.708	81.125	76.[illegible]17	76.01[illegible]
	7.[illegible]9	5.87	6.53	5.[illegible]	5.61
Min Systolic	99.500	105.750	107.500	10[illegible].313	105.000
	5.00	6.08	3.[illegible]2	9.62	5.19
Max Diastolic	66.000	6[illegible].000	73.667	63.71[illegible]	63.909
	10.03	11.17	10.26	9.02	6.1[illegible]
Min Pulse	3[illegible].500	38.750	37.250	42.938	[illegible].833
	12.71	8.38	8.26	10.10	9.1[illegible]
Min MBP	73.333	76.083	77.[illegible]17	73.375	72.167
	6.87	6.11	6.13	6.[illegible]8	[illegible].00
Delta Pulse Max	11.750	8.250	6.875	7.250	9.333
	[illegible].9[illegible]	[illegible].9[illegible]	5.79	6.31	6.73

NEGATIVE PRESSURE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Blood Pressure					
Pct Delta Pulse Max	72.736 14.5[illegible]	92.146 10.94	84.7[illegible]3 11.94	85.578 12.01	83.0[illegible]1 12.10
Delta BP Mean Avg	-0.014 1.32	2.375 1.97	1.236 1.40	1.424 3.30	0.083 3.33
Delta BP Mean Max	-3.208 2.48	-1.083 2.27	-2.792 2.79	-1.854 3.36	-3.472 3.38
Pct Return Pulse	95.609 15.17	94.229 11.21	107.451 26.08	106.754 19.12	95.494 14.76
Pct Return BP Mean	100.402 3.14	104.865 3.94	101.143 4.09	101.893 [illegible]	100.486 5.70

NEGATIVE PRESSURE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Blood Pressure					
Avg Sys Pre-NP	118.813 9.22	119.688 [illegible]	118.813 6.59	117.643 5.81	119.250 7.03
Avg Dia Pre-NP	76.875 10.11	72.938 6.00	66.563 5.59	68.571 8.04	64.438 5.97
Avg Pulse Pre-NP	41.938 5.80	45.750 [illegible]	52.250 7.29	49.071 6.89	54.813 9.07
Avg Mean Pulse Pre-NP	90.854 9.28	88.187 4.98	83.979 1.83	84.929 6.62	82.708 4.68
Total Sys Steps	115.854 8.15	116.937 6.25	119.375 7.14	116.500 7.34	119.437 7.19
Total Pulse Steps	39.521 4.58	40.979 6.08	48.116 6.30	45.476 5.73	54.167 9.26
Total Mean Steps	89.507 8.62	89.618 5.07	87.278 5.23	86.183 5.50	83.326 5.12
Sys Post-NP	117.500 9.84	118.625 5.83	123.875 8.05	117.214 6.19	118.688 8.08
Dia Post-NP	75.750 9.87	75.375 5.97	72.125 10.06	70.571 3.39	65.563 7.17
Pulse Post-NP	41.750 5.51	43.250 5.42	51.750 9.09	46.643 5.86	53.125 9.86
Mean Post-NP	89.667 9.51	89.792 5.35	89.375 8.39	86.119 7.22	83.271 5.87
Min Systolic	111.875 7.62	111.250 9.74	115.250 7.23	111.143 5.55	114.875 6.92
Max Diastolic	82.250 10.00	81.571 5.91	76.875 5.36	76.333 6.44	70.125 6.96
Min Pulse	32.500 5.24	32.125 6.56	41.375 5.21	38.571 4.31	47.500 9.50
Min MBP	85.083 8.26	85.750 5.37	83.000 5.17	82.333 7.01	80.667 5.90
Delta Pulse Max	9.438 7.53	13.625 8.36	10.875 6.32	10.500 3.62	7.313 6.69

NEGATIVE PRESSURE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Blood Pressure					
Pct Delta Pulse Max	7?.8?7 [illegible]	79.398 15.79	79.823 1?.1?	79.057 5.58	86.99? 12.16
Delta BP Mean Avg	-1.347 4.19	1.131 [illegible]	3.253 1.00	1.251 3.19	0.618 2.70
Delta BP Mean Max	-5.771 ?.93	-2.?38 3.96	-0.979 1.25	-2.595 ?.28	-2.042 3.1?
Pct Return Pulse	101.274 16.82	95.050 12.37	99.865 17.58	95.086 11.?5	96.973 9.33
Pct Return BP Mean	99.735 4.10	101.917 5.09	106.293 5.98	101.405 3.32	110.675 4.05

NEGATIVE PRESSURE TESTS

Measure Condition	SET 31	SET 32	SET 33
Blood Pressure			
Avg Sys Pre-NP	116.938 4.86	111.500 6.36	115.500 3.71
Avg Dia Pre-NP	67.375 6.23	63.750 1.06	72.125 7.78
Avg Pulse Pre-NP	49.563 8.45	47.750 5.30	43.375 8.27
Avg Mean Pulse Pre-NP	83.896 4.23	79.667 2.83	86.583 5.46
Total Sys Steps	118.958 6.21	111.917 4.60	116.750 4.58
Total Pulse Steps	49.687 8.48	46.667 5.89	42.458 7.45
Total Mean Steps	85.833 4.46	80.806 0.67	88.444 5.27
Sys Post-NP	119.063 6.49	111.500 7.07	118.563 6.95
Dia Post-NP	66.813 6.72	65.000 1.41	74.500 6.39
Pulse Post-NP	52.250 10.72	46.500 8.49	44.063 11.20
Mean Post-NP	84.229 4.32	80.500 1.41	89.187 3.93
Min Systolic	114.750 5.97	107.000 9.90	110.875 5.17
Max Diastolic	75.143 7.49	69.000 4.24	79.875 6.99
Min Pulse	42.875 7.20	43.000 8.49	35.250 7.80
Min MBP	81.958 4.69	77.833 3.54	83.833 6.02
Delta Pulse Max	6.688 5.57	4.750 3.18	8.125 3.46

NEGATIVE PRESSURE TESTS

Measure / Condition	SET 31	SET 32	SET 33
Blood Pressure			
Pct Delta Pulse Max	86.954 9.22	89.618 7.82	81.221 8.33
Delta BP Mean Avg	1.937 [illegible].01	1.139 2.16	1.861 3.12
Delta BP Mean Max	-1.938 3.96	-1.833 0.71	-2.750 3.78
Pct Return Pulse	105.259 12.09	96.994 7.00	101.931 20.01
Pct Return BP Mean	100.5[illegible]5 6.01	101.078 1.81	103.270 6.36

NEGATIVE PRESSURE TESTS

Measure / Condition	SET 1	SET 2	SET 3	SET 4	SET 5
Leg Volume					
DV/DP1 Left Leg	0.055 0.38	0.230 0.27	0.345 0.17	0.332 0.45	0.252 0.2[illegible]
DV/DP1 Right Leg	-0.073 0.08	-0.028 0.04	-0.070 0.03	-0.025 0.05	-0.002 0.11
DV/DP2 Left Leg	0.340 0.20	0.257 0.10	0.367 0.16	0.447 0.22	0.317 0.11
DV/DP2 Right Leg	-0.019 0.16	-0.017 0.03	-0.057 0.07	-0.008 0.01	-0.052 0.04
T15 Left Leg	-0.225 0.44	0.270 0.45	0.457 0.47	0.302 0.72	0.142 0.22
T15 Right Leg	-0.544 0.57	-0.6[illegible]2 0.43	-0.317 0.52	-0.560 0.49	-0.7[illegible]0 0.42

NEGATIVE PRESSURE TESTS

Measure Condition	SET 6	SET 7	SET 8	SET 9	SET 10
Leg Volume					
DV/DP1 Left Leg	0.440 0.25	0.402 0.14	0.102 0.26	0.190 0.00	0.417 0.12
DV/DP1 Right Leg	-0.057 0.03	-0.013 0.06	0.028 0.08	-0.050 0.00	-0.070 0.06
DV/DP2 Left Leg	0.462 0.08	0.333 0.07	0.315 0.09	0.280 0.00	0.387 0.12
DV/DP2 Right Leg	-0.067 0.03	-0.013 0.08	0.035 0.07	0.040 0.00	-0.117 0.11
T15 Left Leg	1.195 0.92	0.517 0.98	0.003 0.50	0.560 0.00	0.747 0.63
T15 Right Leg	-0.462 0.32	-0.497 0.62	-0.450 0.32	-0.380 0.00	-0.810 0.45

NEGATIVE PRESSURE TESTS

Measure Condition	SET 11	SET 12	SET 13	SET 14	SET 15
Leg Volume					
DV/DP1 Left Leg	0.307 0.26	0.175 0.24	0.395 0.29	0.290 0.20	0.400 0.17
DV/DP1 Right Leg	-0.070 0.12	-0.027 0.05	0.012 0.03	-0.015 0.06	-0.012 0.09
DV/DP2 Left Leg	0.316 0.20	0.305 0.15	0.440 0.16	0.330 0.11	0.322 0.07
DV/DP2 Right Leg	-0.026 0.06	-0.002 0.02	-0.035 0.05	-0.042 0.08	-0.027 0.07
T15 Left Leg	0.400 0.92	0.074 0.52	0.925 0.99	0.242 0.60	0.425 0.78
T15 Right Leg	-0.416 0.26	-0.586 0.19	-0.143 0.39	-0.345 0.42	-0.465 0.37

NEGATIVE PRESSURE TESTS

Measure Condition	SET 16	SET 17	SET 18	SET 19	SET 20
Leg Volume					
DV/DP1 Left Leg	0.[illegible]63 0.08	0.352 0.26	0.162 0.53	0.260 0.00	0.227 0.38
DV/DP1 Right Leg	-0.120 0.0[illegible]	-0.027 0.08	-0.207 0.26	-0.100 0.00	-0.003 0.03
DV/DP2 Left Leg	0.320 0.05	0.370 0.15	0.342 0.12	0.330 0.00	0.425 0.10
DV/DP2 Right Leg	-0.060 0.13	-0.105 0.09	-0.017 0.0[illegible]	-0.070 0.00	-0.020 0.06
T15 Left Leg	1.110 0.30	0.390 0.96	0.675 1.21	-0.140 0.00	0.422 0.98
T15 Right Leg	-0.750 0.24	-0.675 0.63	-0.707 0.55	-0.400 0.00	-0.435 0.54

NEGATIVE PRESSURE TESTS

Measure Condition	SET 21	SET 22	SET 23	SET 24	SET 25
Leg Volume					
DV/DP1 Left Leg	0.272 0.16	0.130 0.21	0.030 0.26	0.181 0.34	0.202 0.25
DV/DP1 Right Leg	-0.035 0.06	-0.058 0.06	-0.085 0.09	-0.071 0.10	-0.027 0.05
DV/DP2 Left Leg	0.197 0.0[illegible]	0.155 0.13	0.142 0.15	0.328 0.1[illegible]	0.281 0.13
DV/DP2 Right Leg	-0.112 0.04	-0.045 0.05	-0.005 0.06	-0.023 0.11	-0.019 0.03
T15 Left Leg	0.265 0.14	0.032 0.39	0.000 0.78	0.067 0.75	0.181 0.52
T15 Right Leg	-0.777 0.19	-0.922 0.35	-0.662 0.20	-0.490 0.43	-0.616 0.33

NEGATIVE PRESSURE TESTS

Measure Condition	SET 26	SET 27	SET 28	SET 29	SET 30
Leg Volume					
DV/DP1 Left Leg	0.365 0.22	0.306 0.32	0.326 0.21	0.450 0.18	0.377 0.19
DV/DP1 Right Leg	-0.029 0.05	-0.020 0.05	-0.007 0.09	-0.084 0.05	-0.021 0.07
DV/DP2 Left Leg	0.404 0.15	0.46[illegible] 0.16	0.320 0.09	0.401 0.10	0.351 0.11
DV/DP2 Right Leg	-0.0[illegible]6 0.06	-0.025 0.06	-0.040 0.05	-0.064 0.08	-0.066 0.09
T15 Left Leg	0.691 0.76	0.272 0.61	0.284 0.[illegible]5	1.159 0.68	0.454 0.85
T15 Right Leg	-0.230 0.44	-0.502 0.[illegible]2	-0.602 0.39	-0.586 0.31	-0.599 0.58

NEGATIVE PRESSURE TESTS

Measure Condition	SET 31	SET 32	SET 33
Leg Volume			
DV/DP1 Left Leg	0.132 0.39	0.225 0.05	0.352 0.27
DV/DP1 Right Leg	-0.090 0.22	-0.080 0.03	-0.036 0.06
DV/DP2 Left Leg	0.329 0.10	0.303 0.04	0.406 0.11
DV/DP2 Right Leg	0.009 0.06	-0.015 0.08	-0.069 0.10
T15 Left Leg	0.339 0.93	0.210 0.49	0.585 0.79
T15 Right Leg	-0.579 0.44	-0.390 0.01	-0.622 0.50

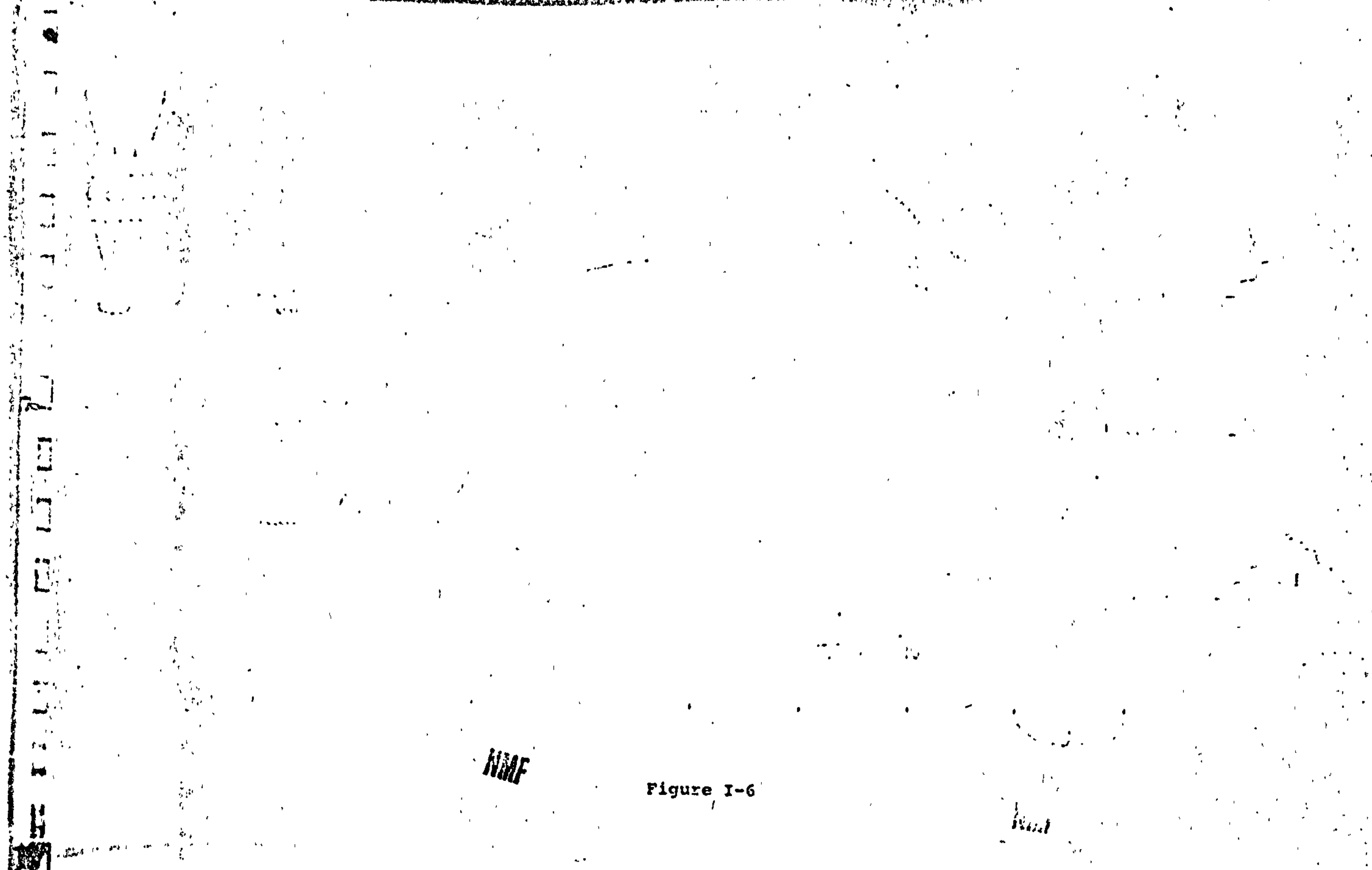


Figure I-6

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

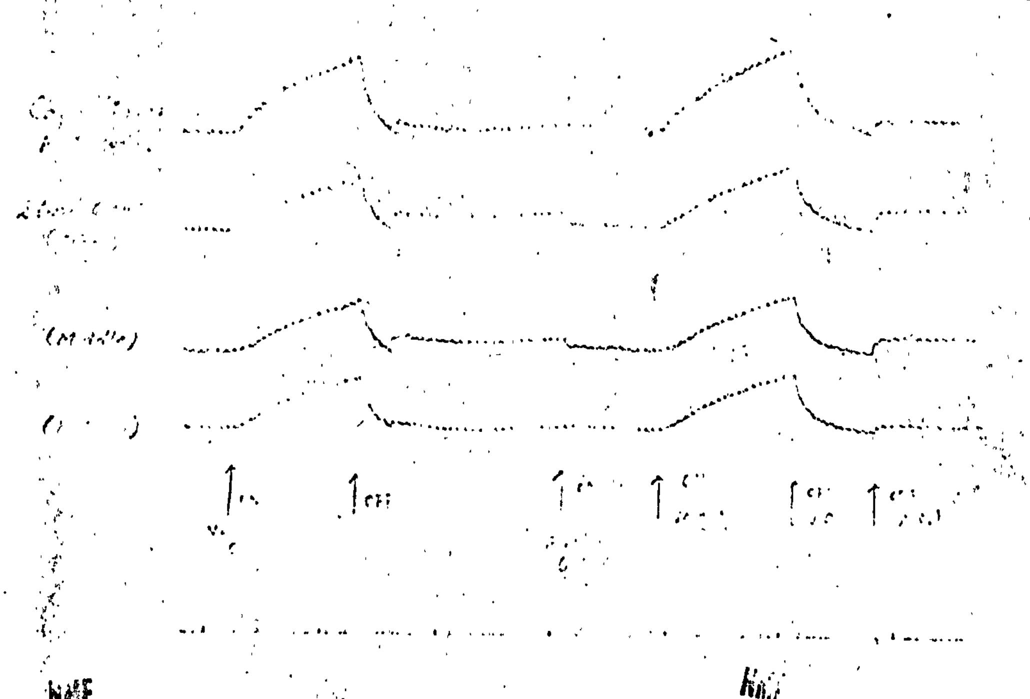


Figure I-7

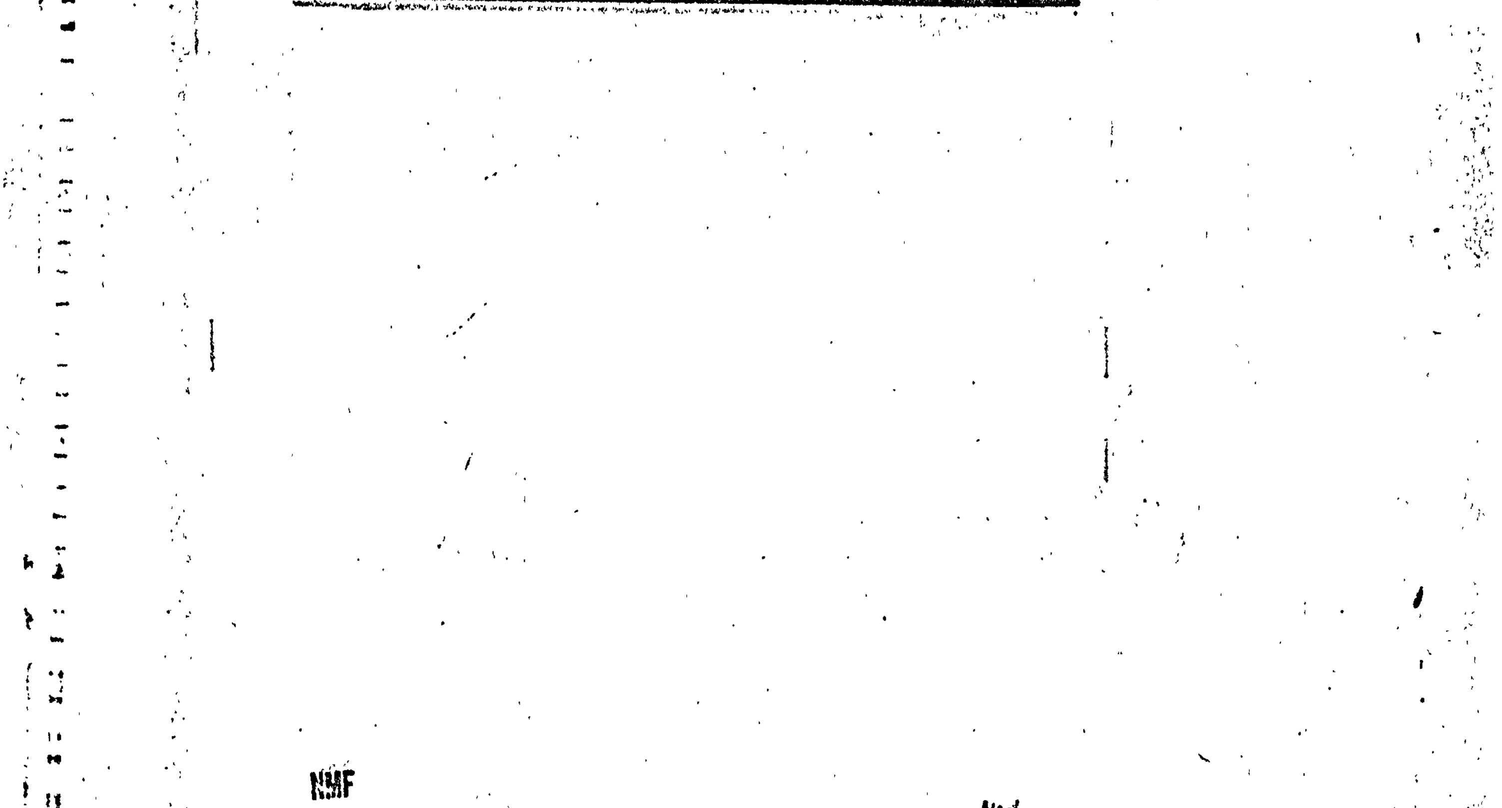


Figure I-8

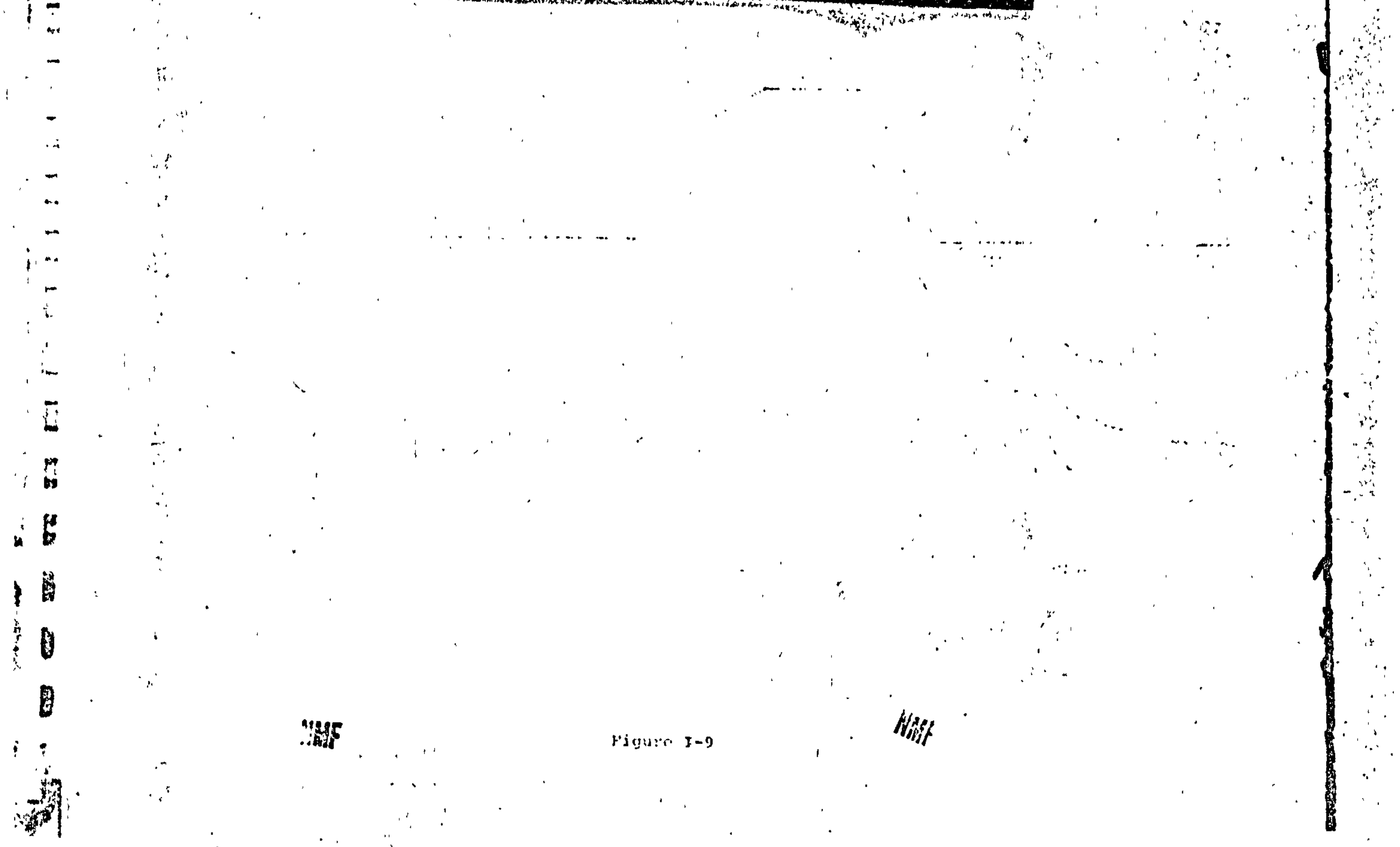


Figure I-9

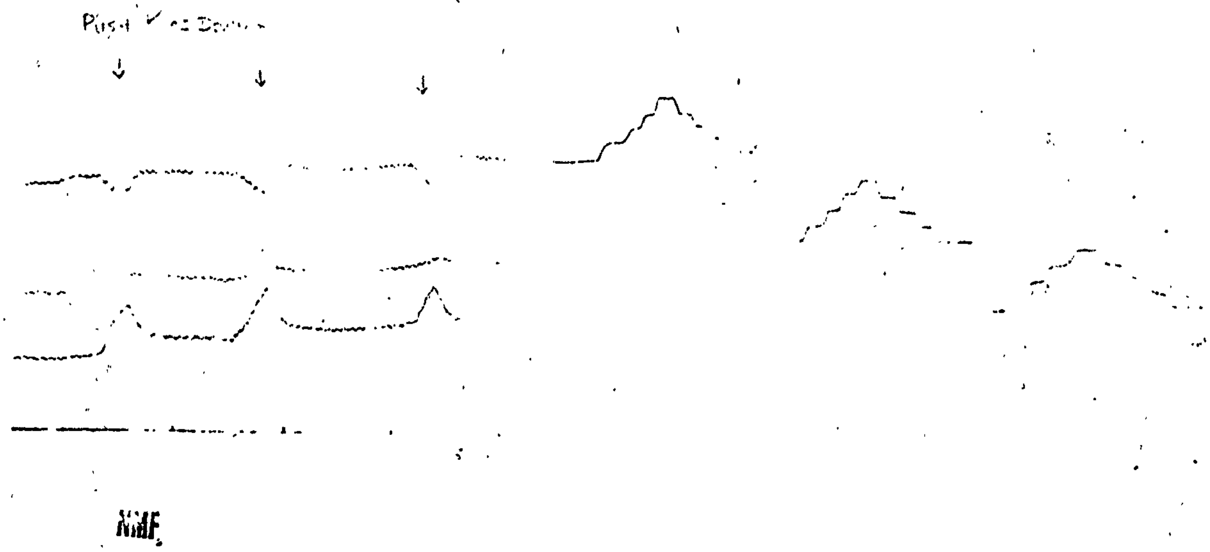


Figure I-10

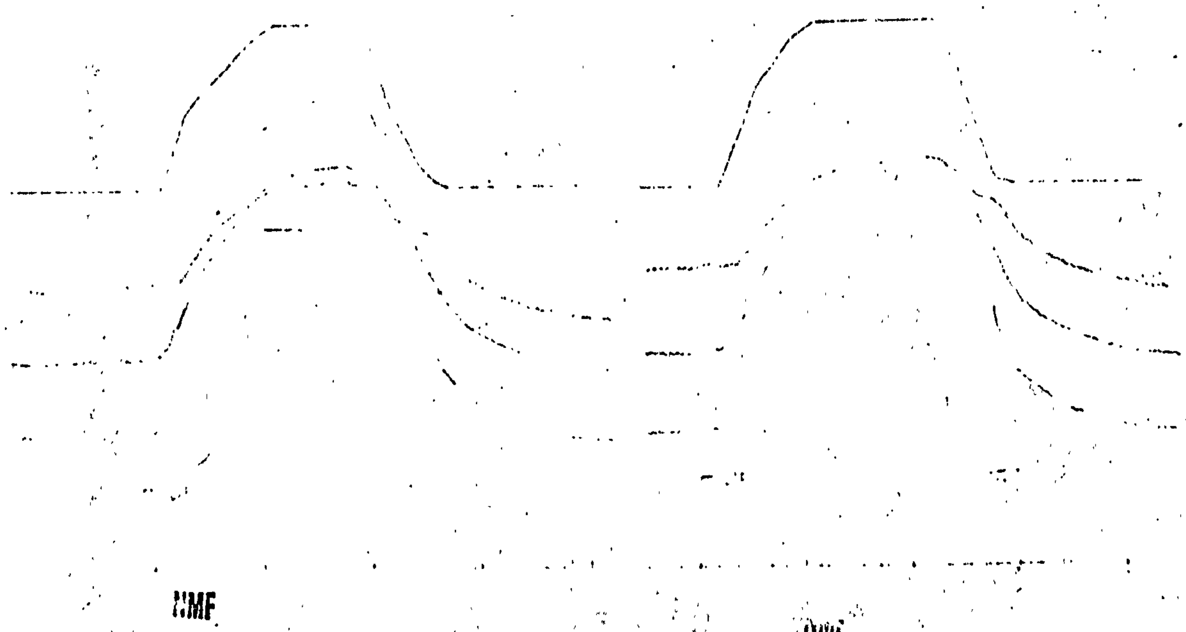


Figure I-11

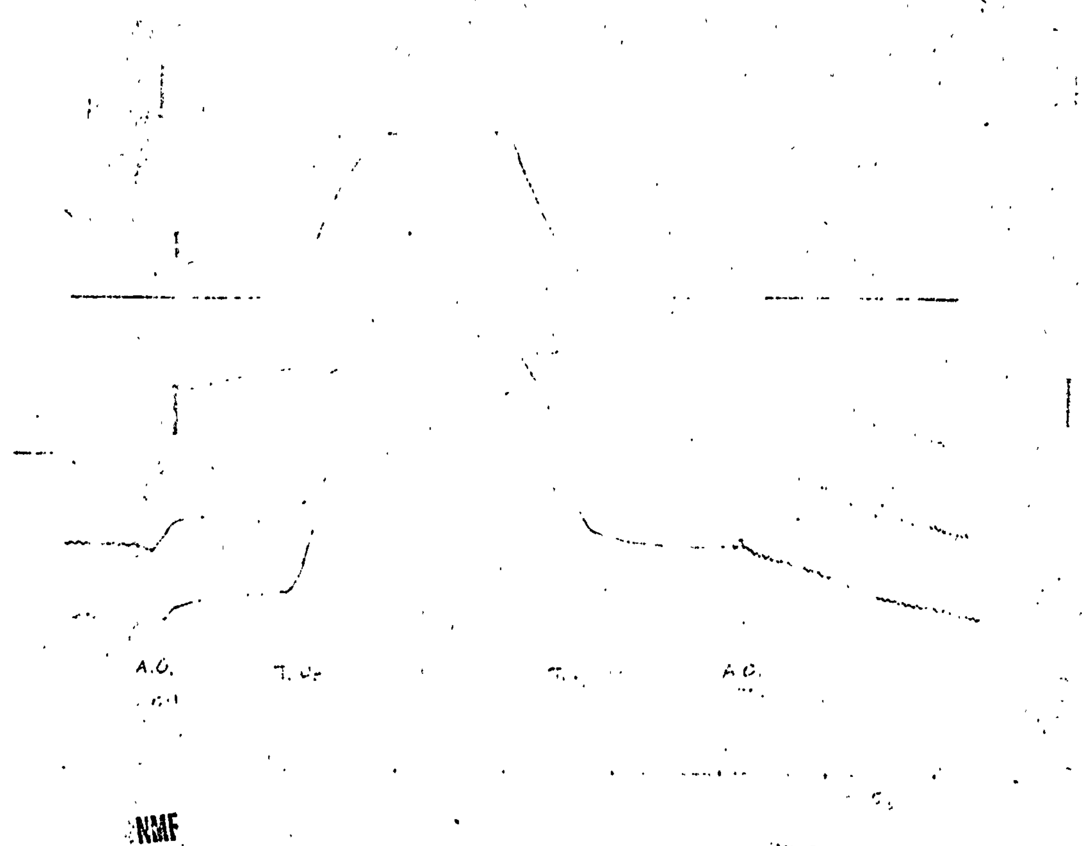


Figure I-12

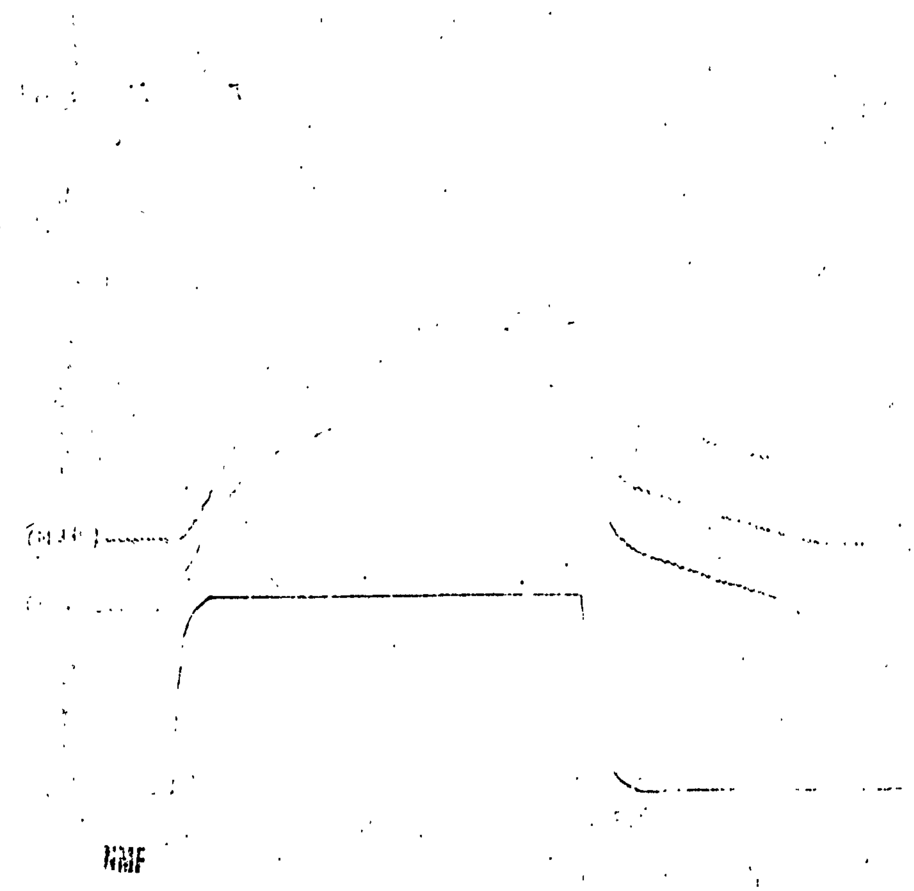


Figure I-13

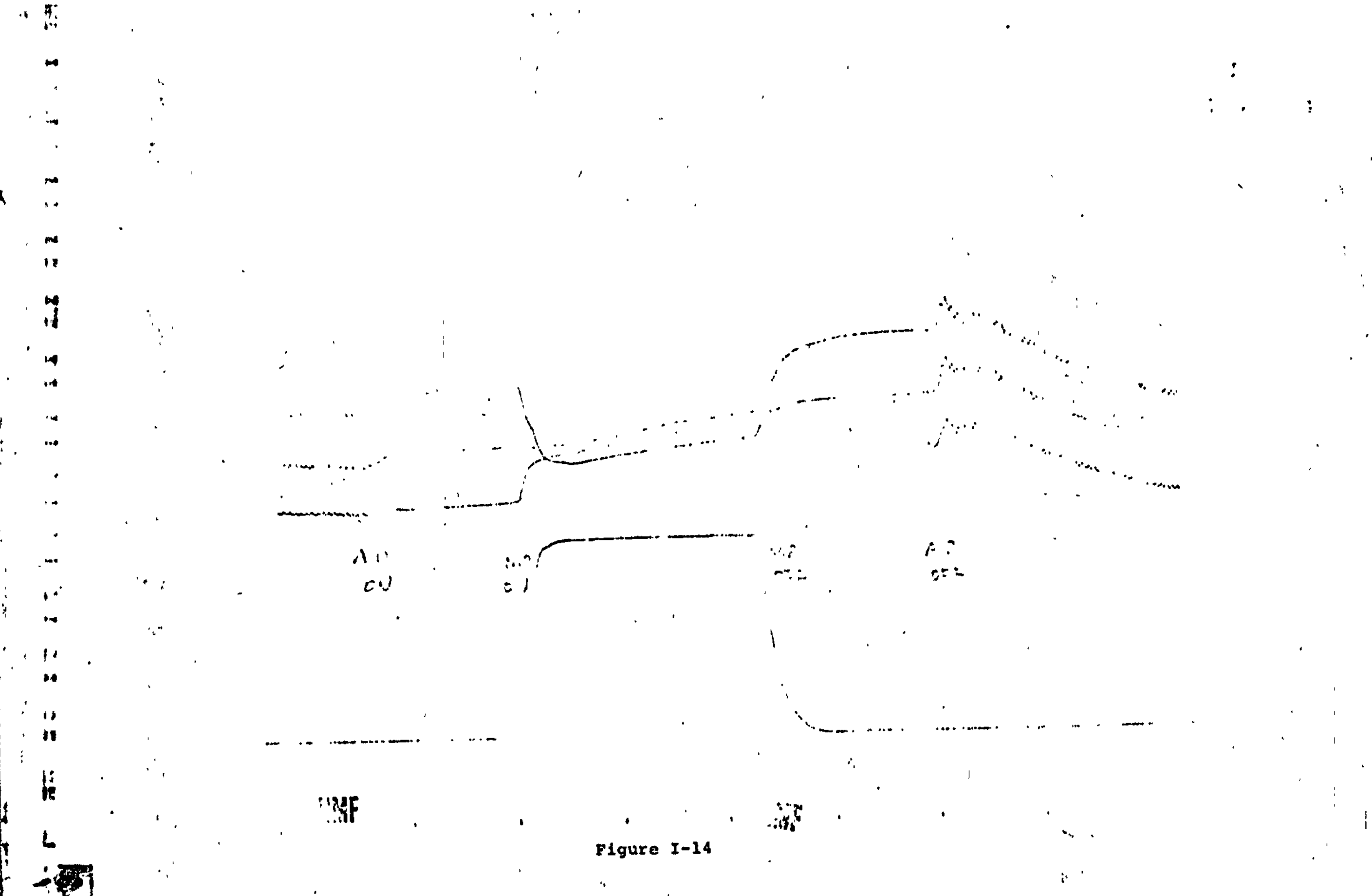


Figure I-14

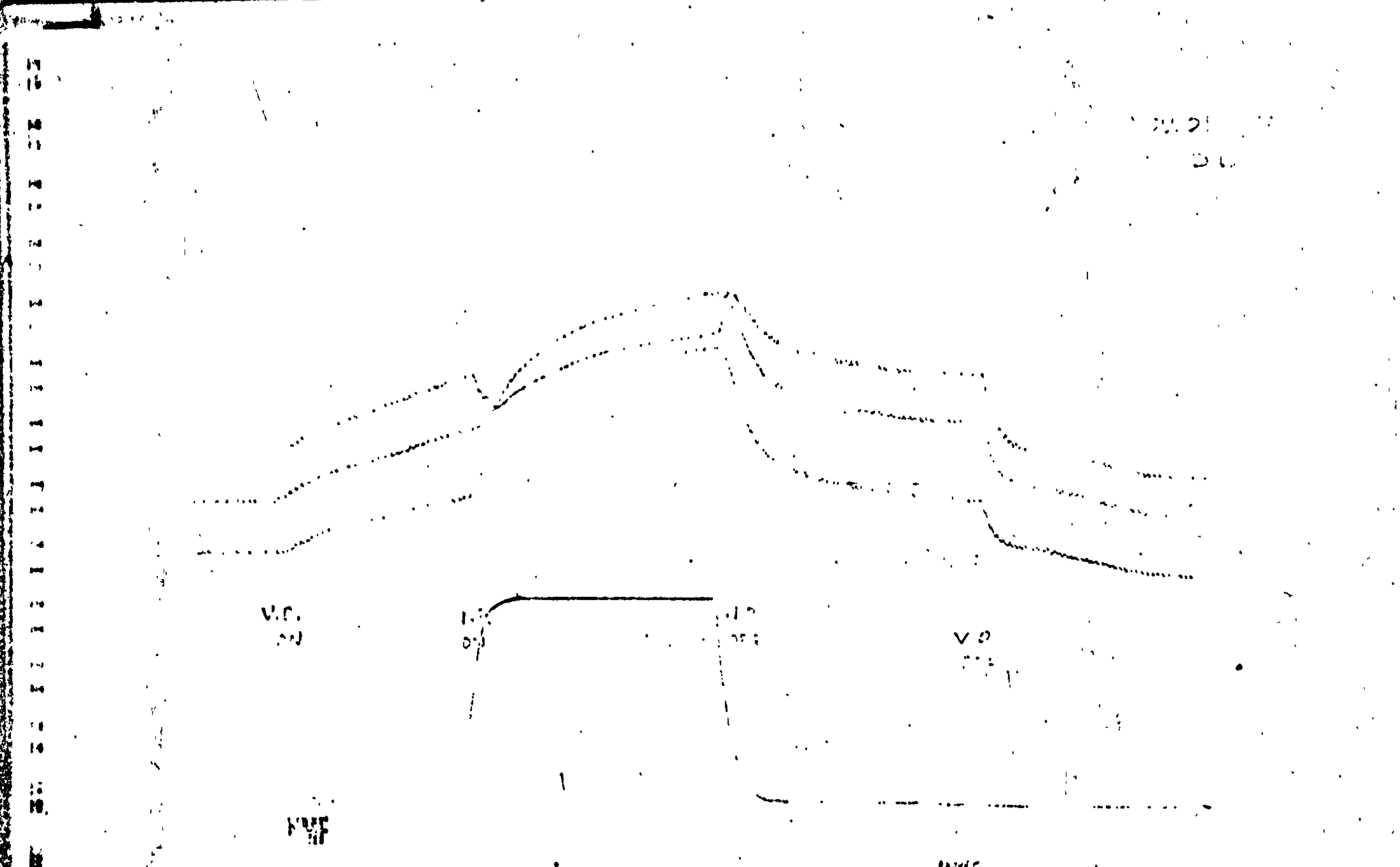


Figure I-15

Table II-6a

Comparative Values

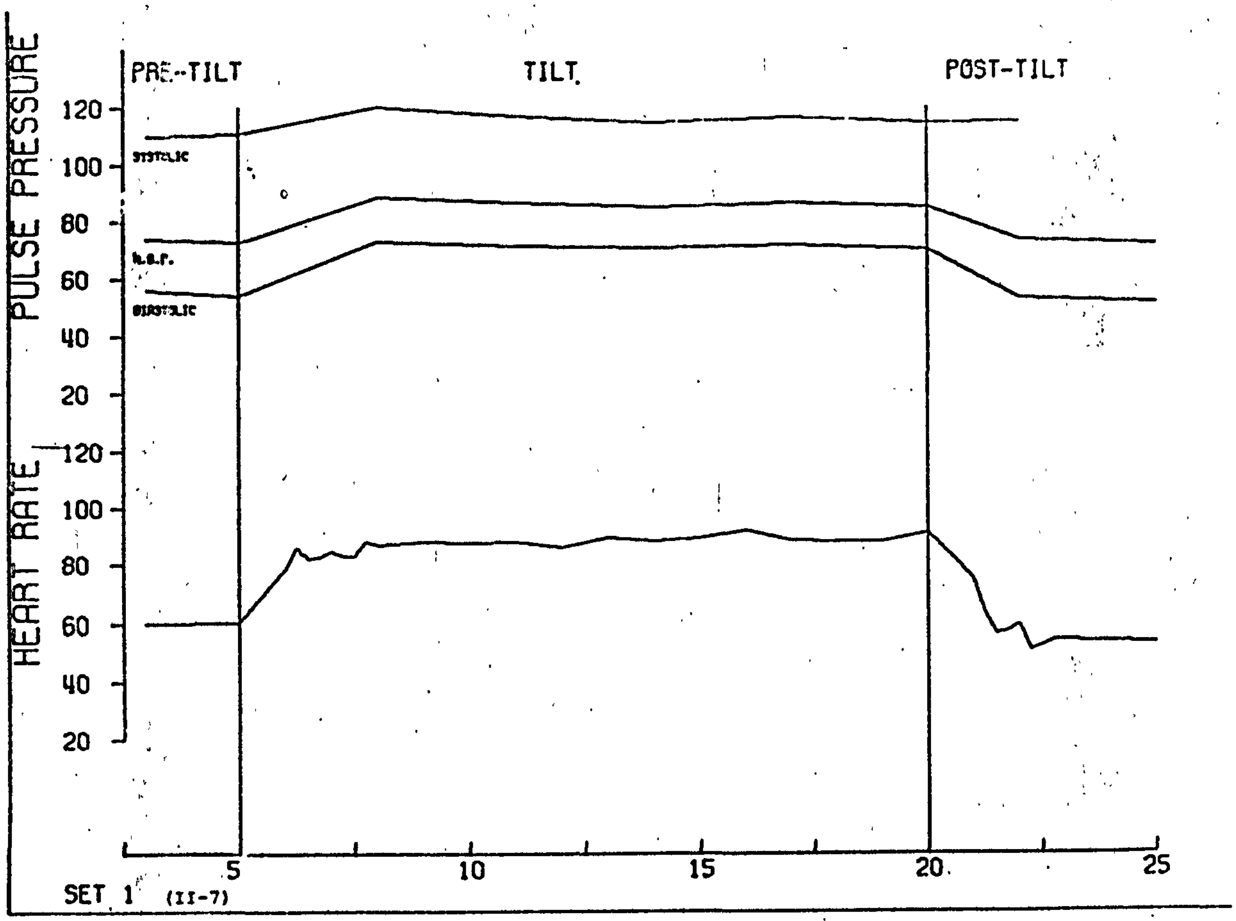
Hour	0	2.5	12.0	24.0	48.0
Mean Resting HR	- 2.875 3.11	- 2.625 3.58	16.125 4.11	2.339 4.15	5.125 4.87
Mean Tilt HR	5.048 5.22	8.067 6.54	17.771 3.[illegible]	7.444 6.17	3.298 6.06
Max Tilt HR	13.000 5.83	12.500 7.34	18.500 4.27	9.857 6.92	3.000 6.48
HR Slope 1st Min of Tilt	5.250 4.26	5.625 3.82	1.875 4.12	1.440 3.10	4.125 3.78
HR Slope 1st Min Post-tilt	- 6.137 7.64	- 5.912 6.37	- 7.037 3.95	- 9.758 4.30	+ 0.188 3.44
Mean Tilt Pulse Pressure	- 3.233 3.59	- 8.156 4.56	+ 0.269 3.76	+ 2.379 4.61	+ 5.425 5.19
Min Tilt Pulse Pressure	- 4.313 4.10	-10.563 5.04	- 1.313 3.40	- 3.545 6.13	+ 3.812 5.96
Max Leg Volume	- 0.099 0.338	- 0.225 0.237	- 0.260 0.237	- 0.112 0.292	+ 0.023 0.269

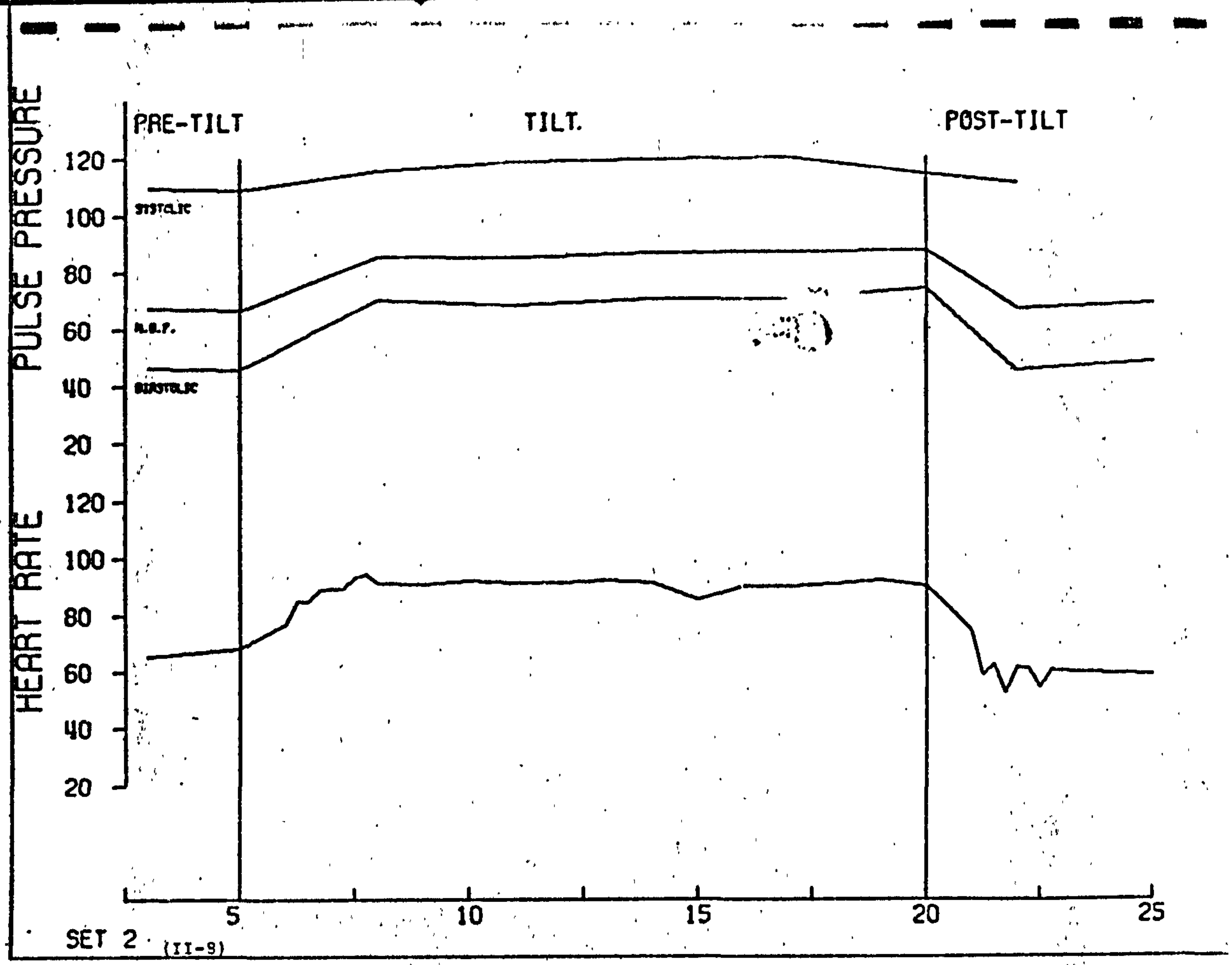
Table II-6b

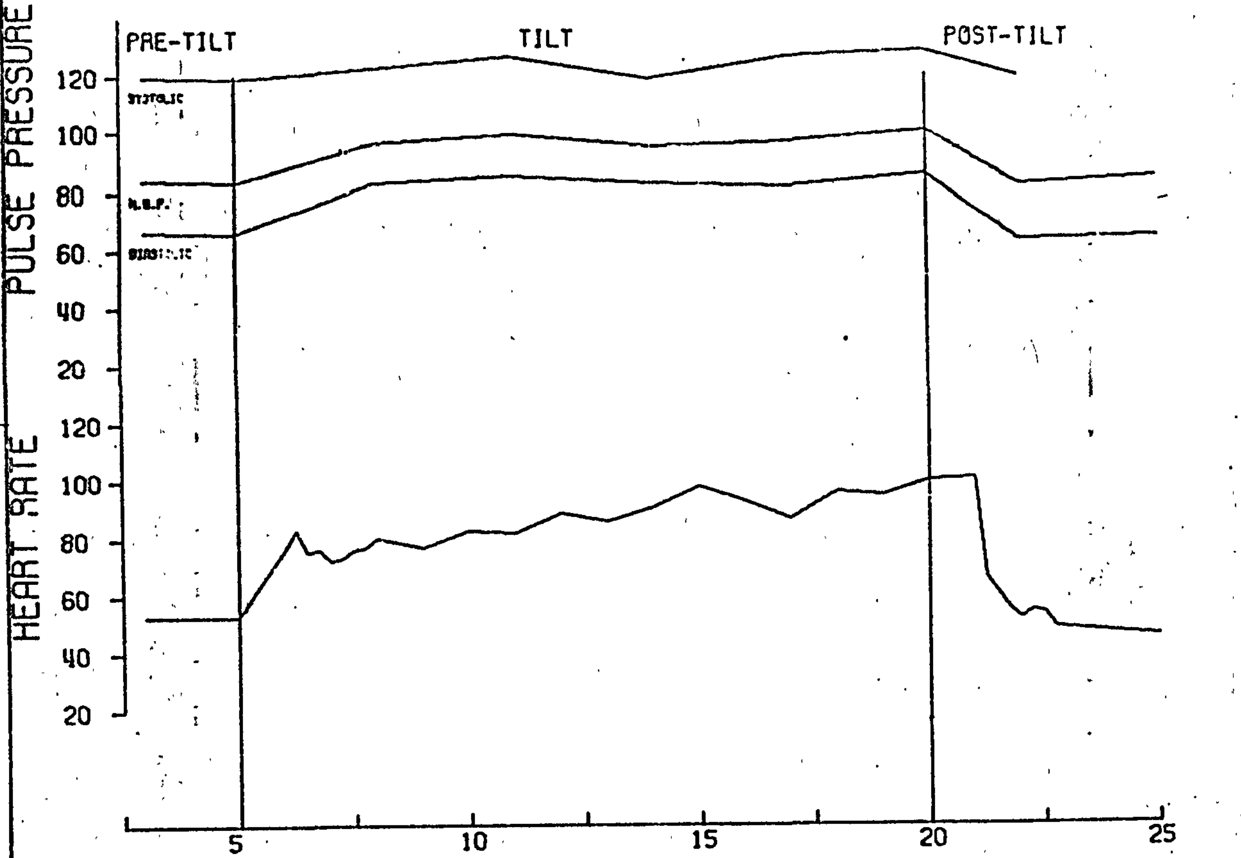
Integrated Score

Hour	0	2.5	12.0	24.0	48.0
Mean Resting HR	- 0.924	- 0.733	3.923	0.564	1.052
Mean Tilt HR	0.954	1.233	4.510	-1.296	0.543
Max Tilt HR	2.239	1.793	4.333	1.445	0.463
HR Slope 1st Min of Tilt	1.232	1.473	0.455	0.767	1.152
HR Slope 1st Min Post-tilt	0.810	- 0.9[illegible]	- 1.9[illegible]	- 2.037	+ 0.055
Mean Tilt Pulse Press [a]	0.901	1.739	- 0.072	- 0.516	- 1.3[illegible]
Min. Tilt Pulse Press [a]	1.052	2.096	0.386	0.578	- 0.6[illegible]
Max Leg Volume	- 0.293	- 0.919	- 1.181	- 0.418	+ 0.016
Integrated Score	4.342	5.670	10.409	1.229	1.666

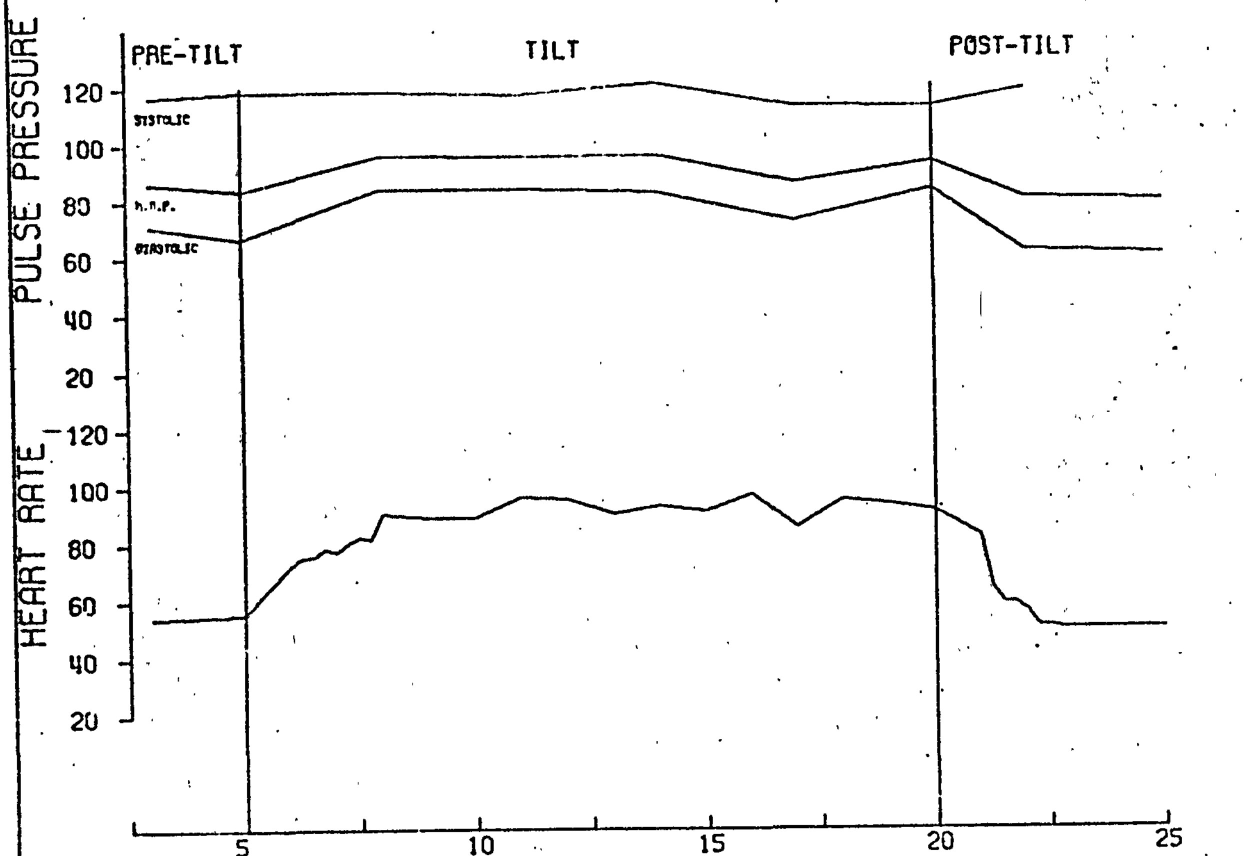
[a] reversed signs included


PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
120
100
80
60
40
20
5
10
15
20
25
SET 1 (II-7)

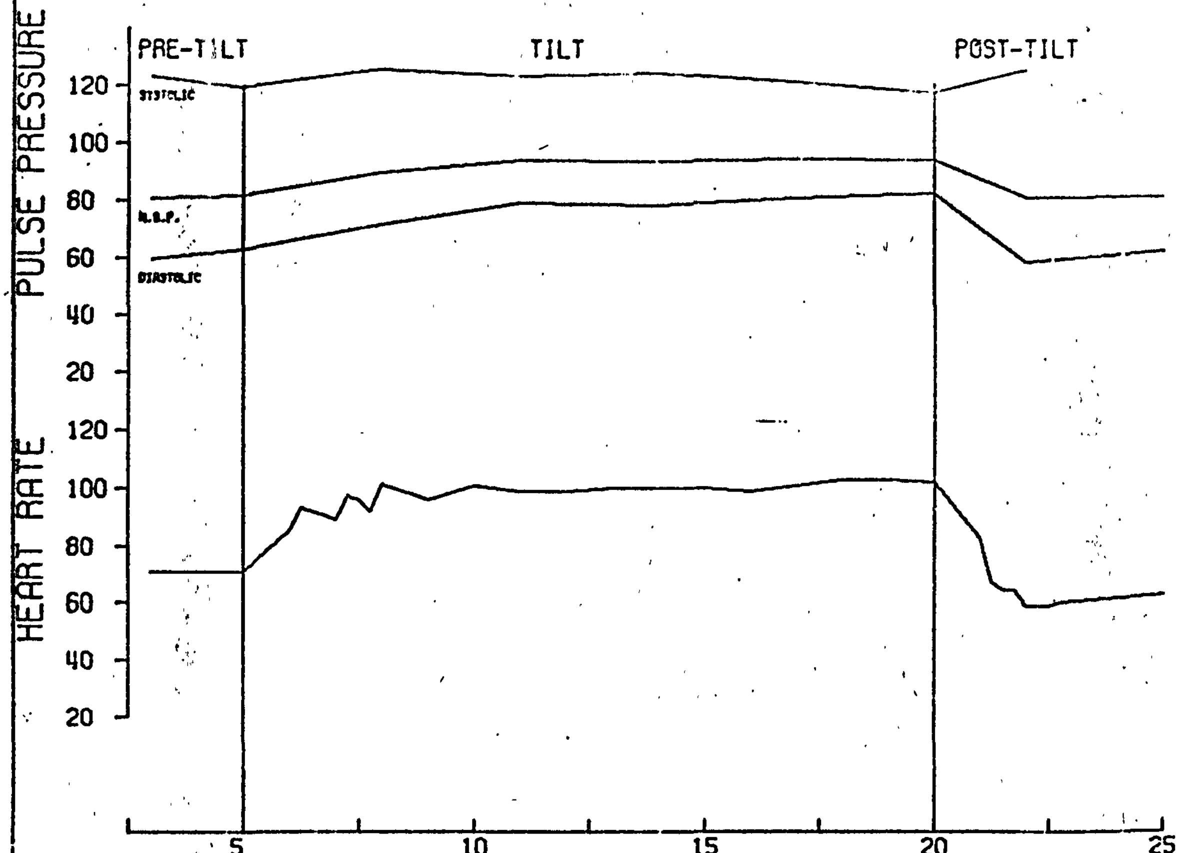

PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
120
100
80
60
40
20
5
10
15
20
25
SET 2 (II-9)



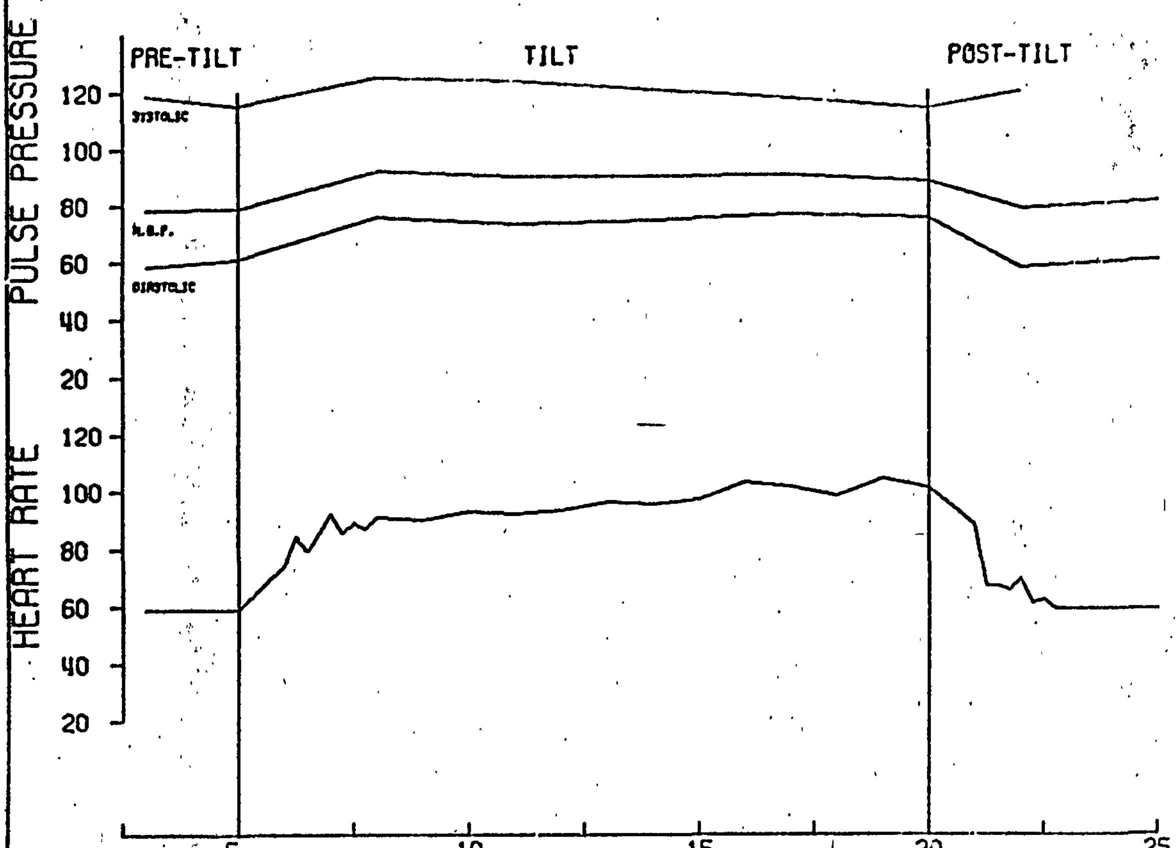
SET 3 (II-9)



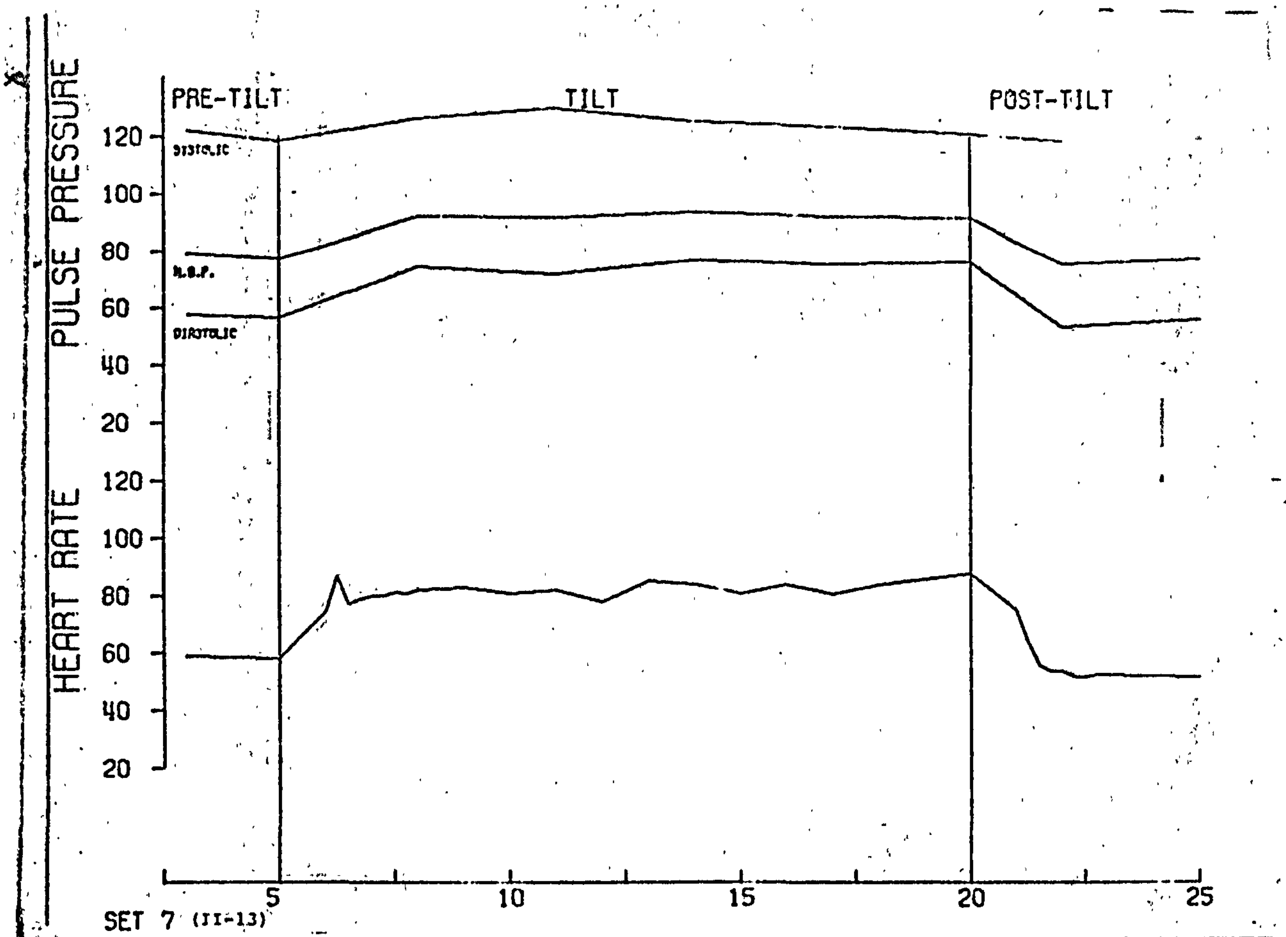
SET 4 (II-10)

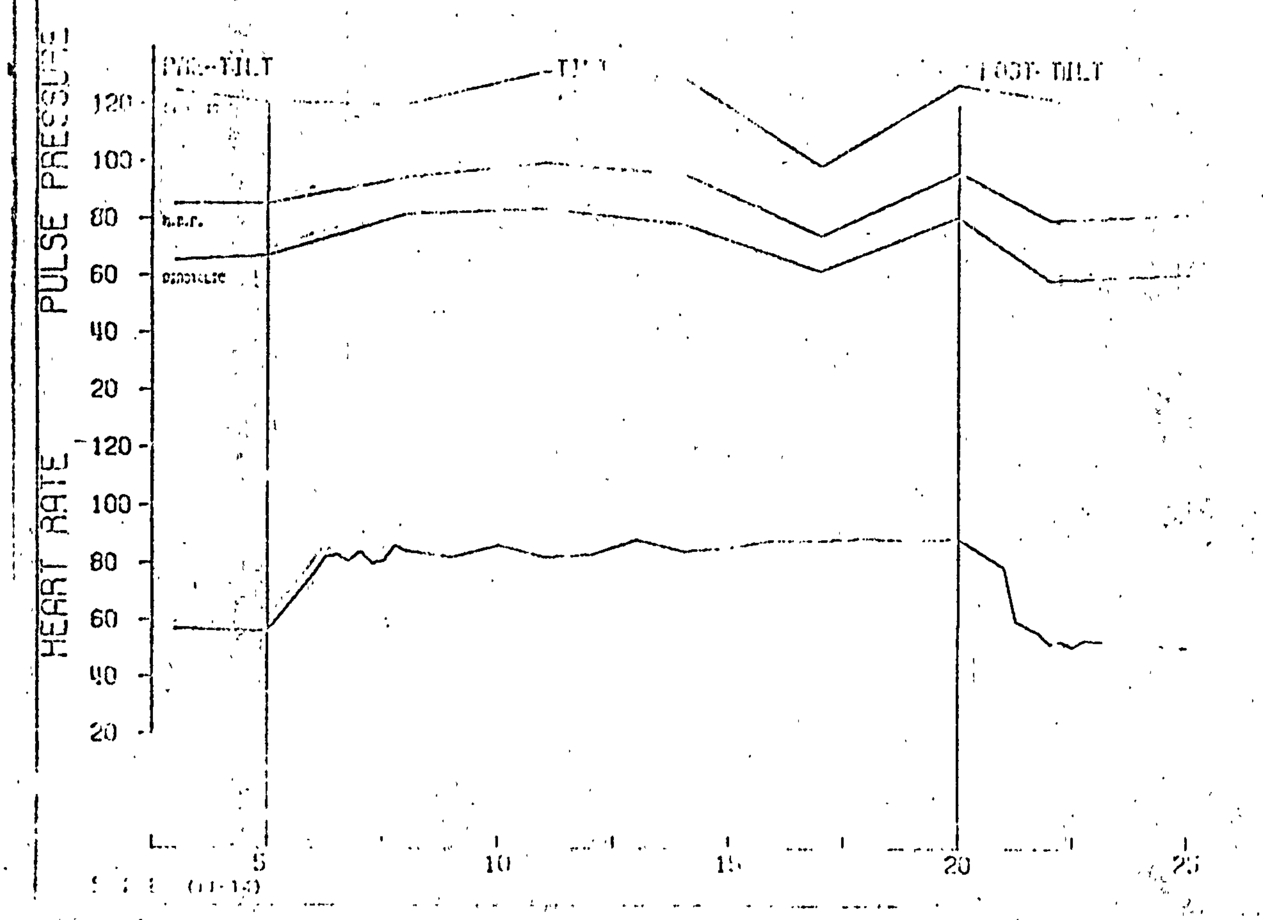


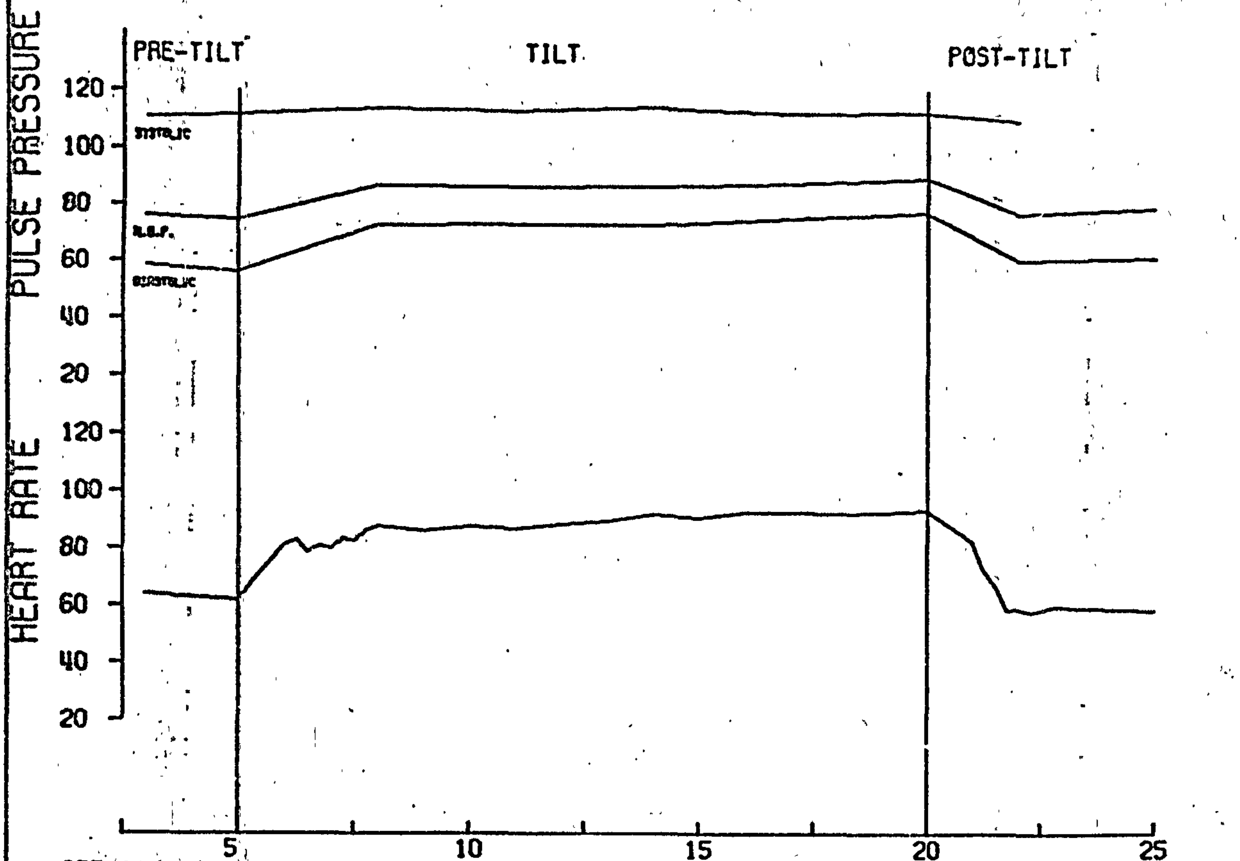
SET 5 (II-11)



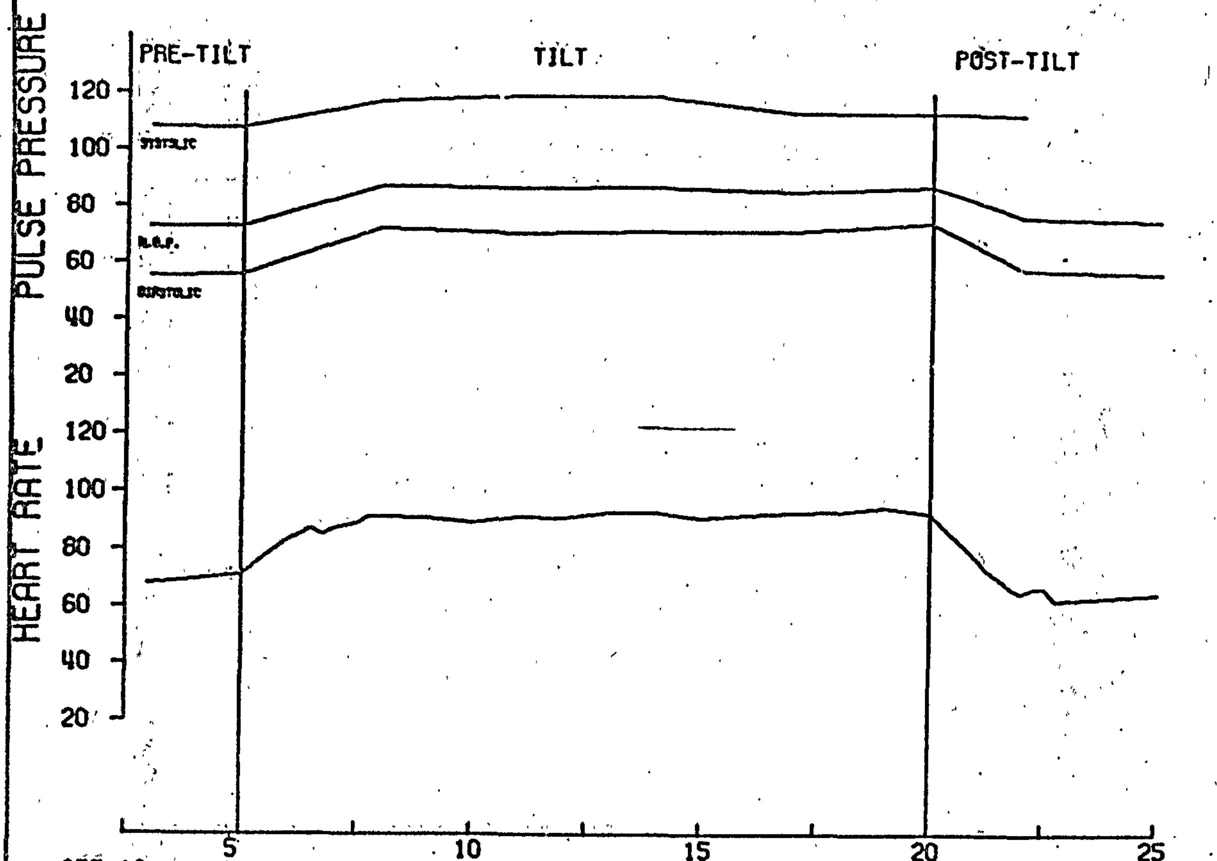
SET 6 (II-12)


PRE-TILT
TILT
POST-TILT
PULSE PRESSURE
HEART RATE
120
100
80
60
40
20
120
100
80
60
40
20
5
10
15
20
25
SET 7 (II-13)

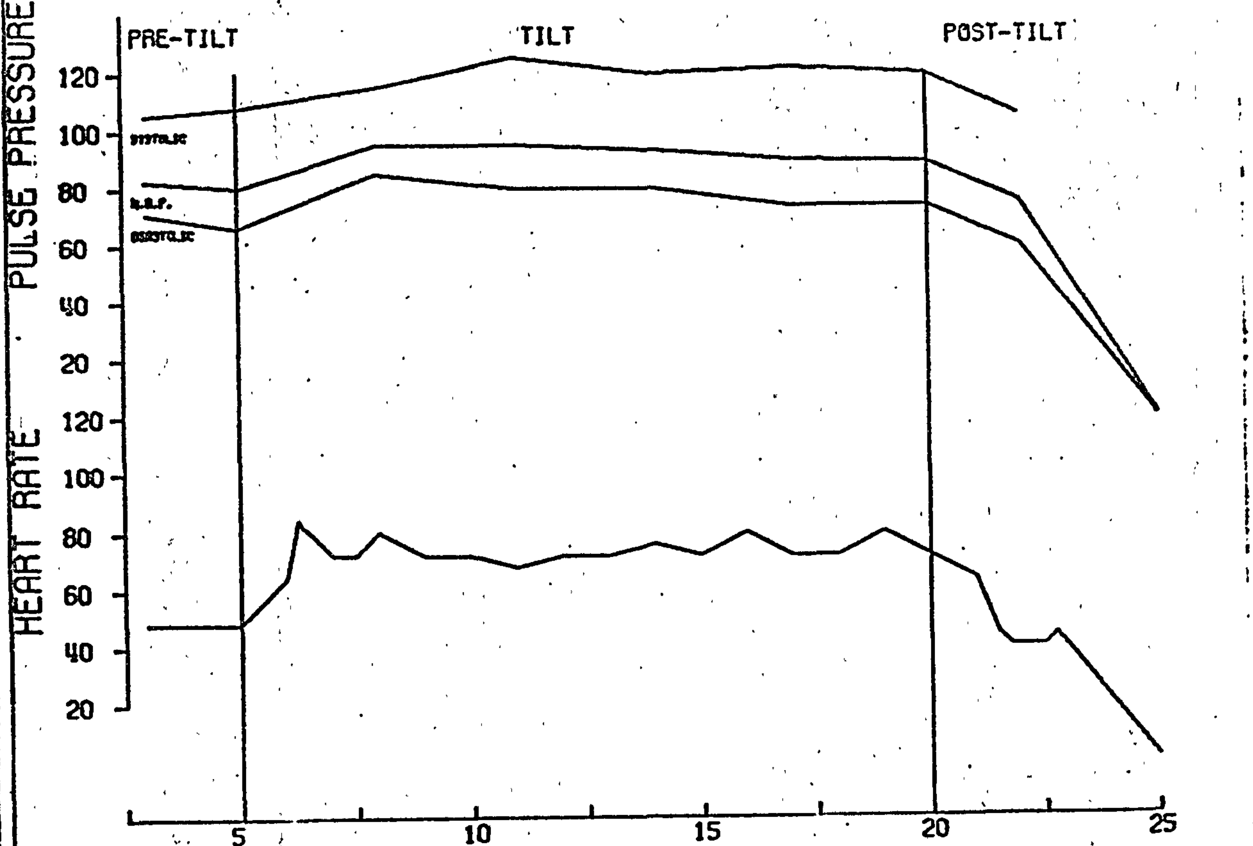

PULSE PRESSURE
HEART RATE
120
100
80
60
40
20
120
100
80
60
40
20
5
10
20



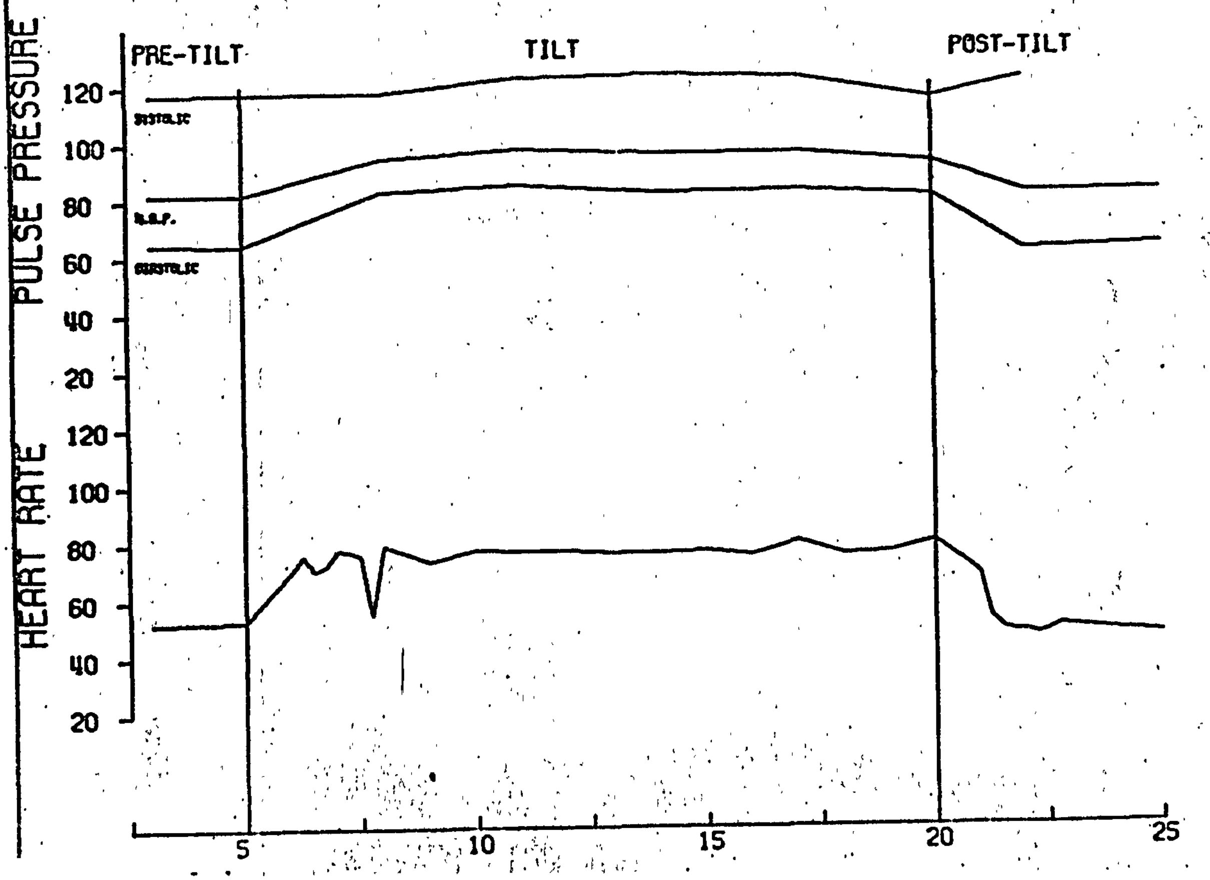
SET 11 (II-17)

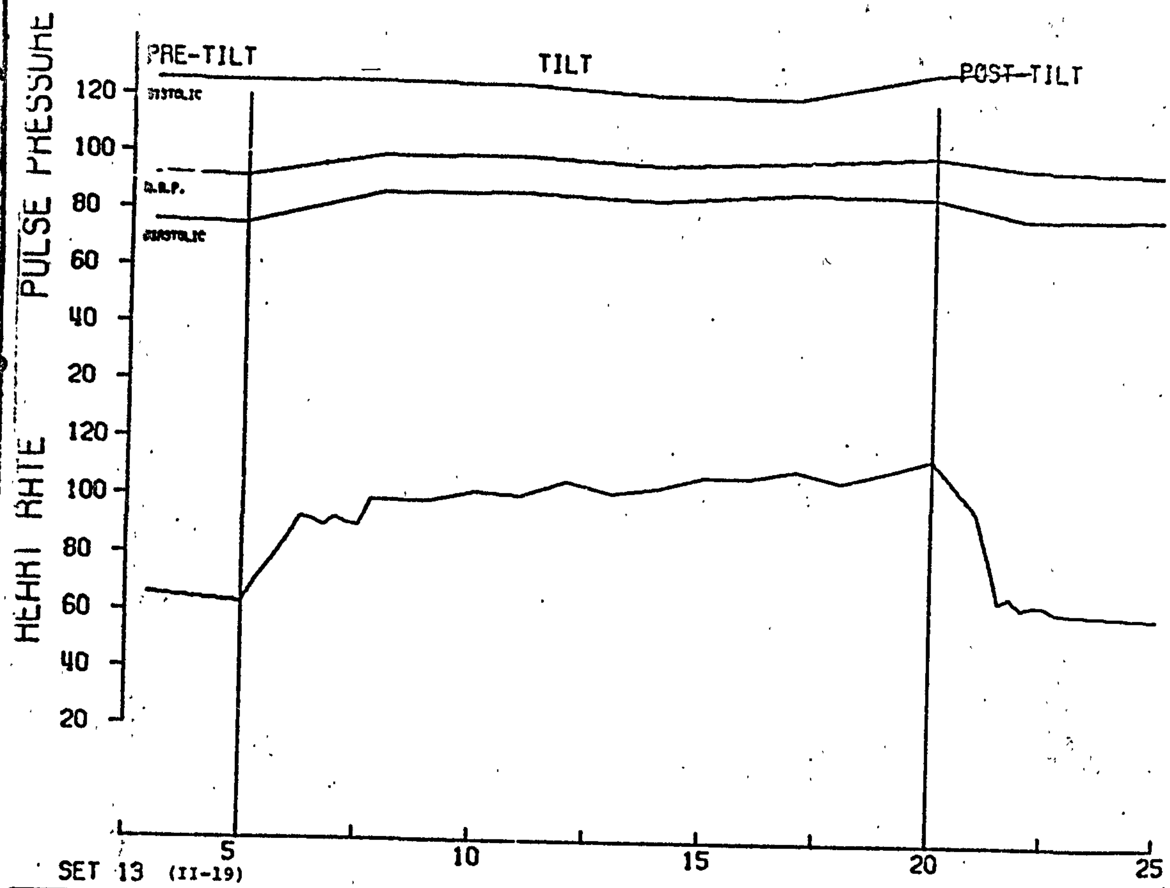


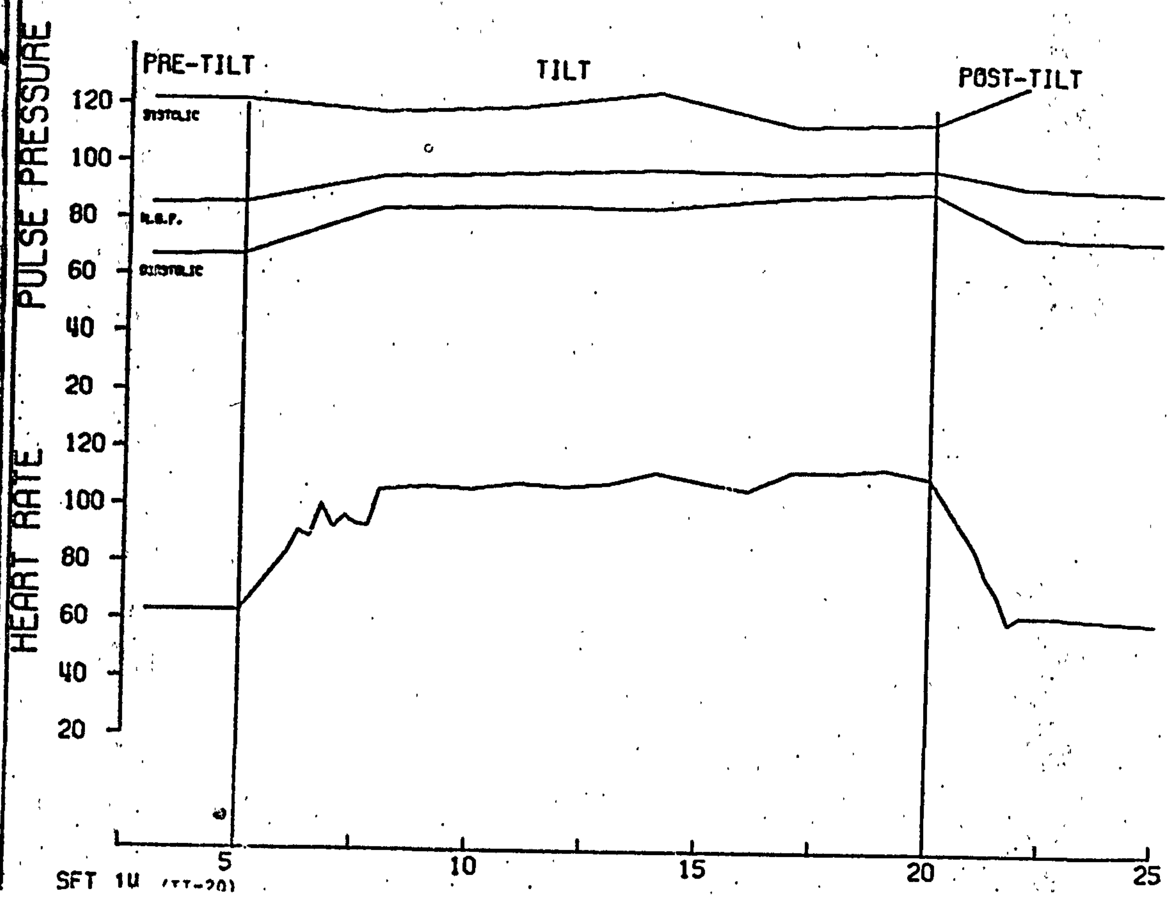
SET 12 (II-18)

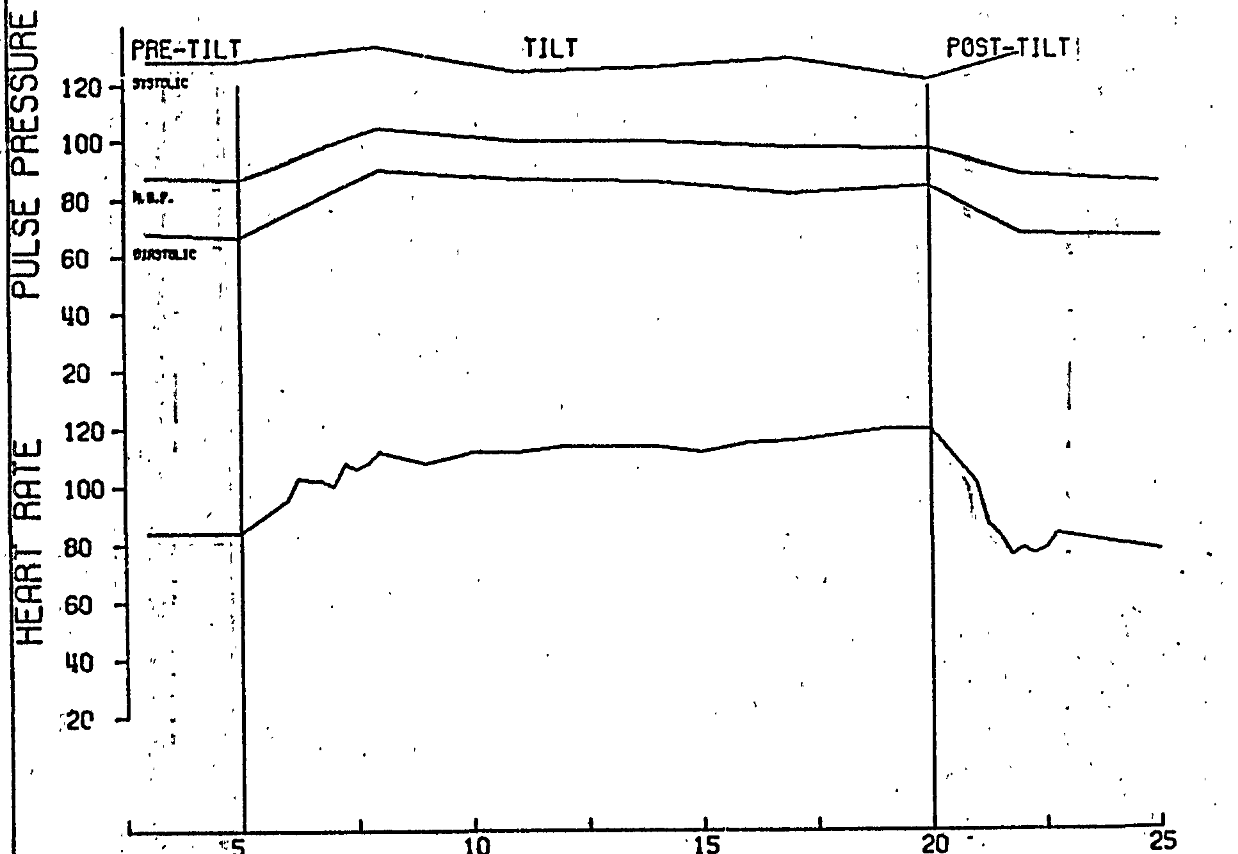

PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
120
100
80
60
40
20
120
100
80
60
40
20
5
10
15
20
25

SET 9 (II-15)

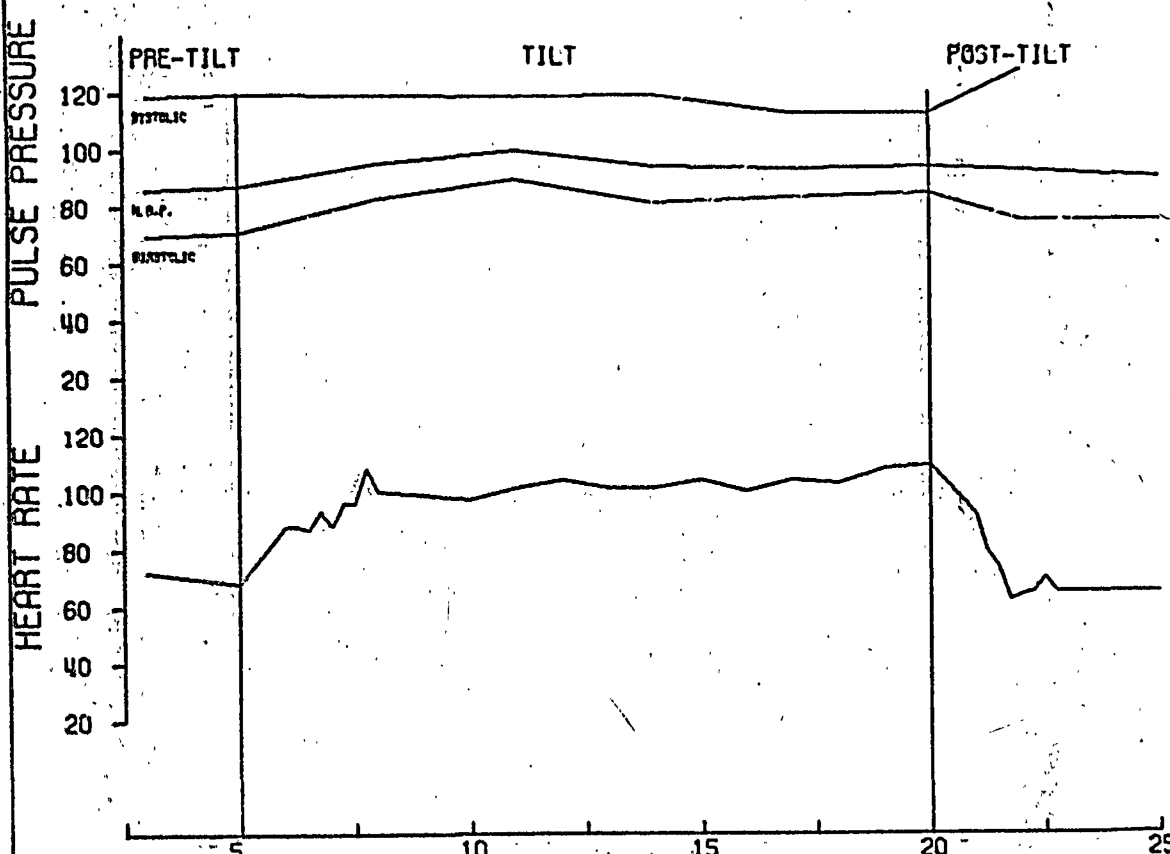

PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
120
100
80
60
40
20
120
100
80
60
40
20
5
10
15
20
25


PRE-TILT
TILT
POST-TILT
PULSE PRESSURE
HEART RATE
120
100
80
60
40
20
5
10
15
20
25
SET 13 (II-19)

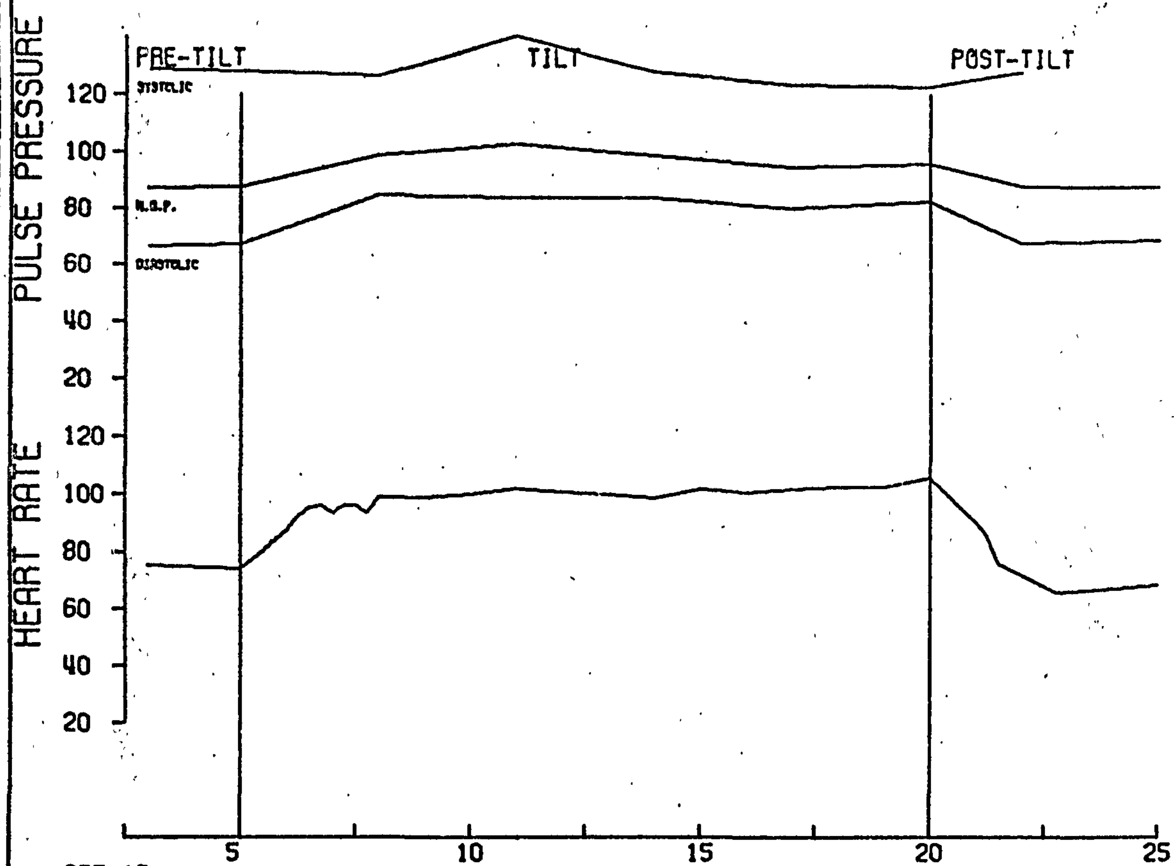

PRE-TILT
TILT
POST-TILT
PULSE PRESSURE
HEART RATE
120
100
80
60
40
20
5
10
15
20
25
SET 14 (II-20)



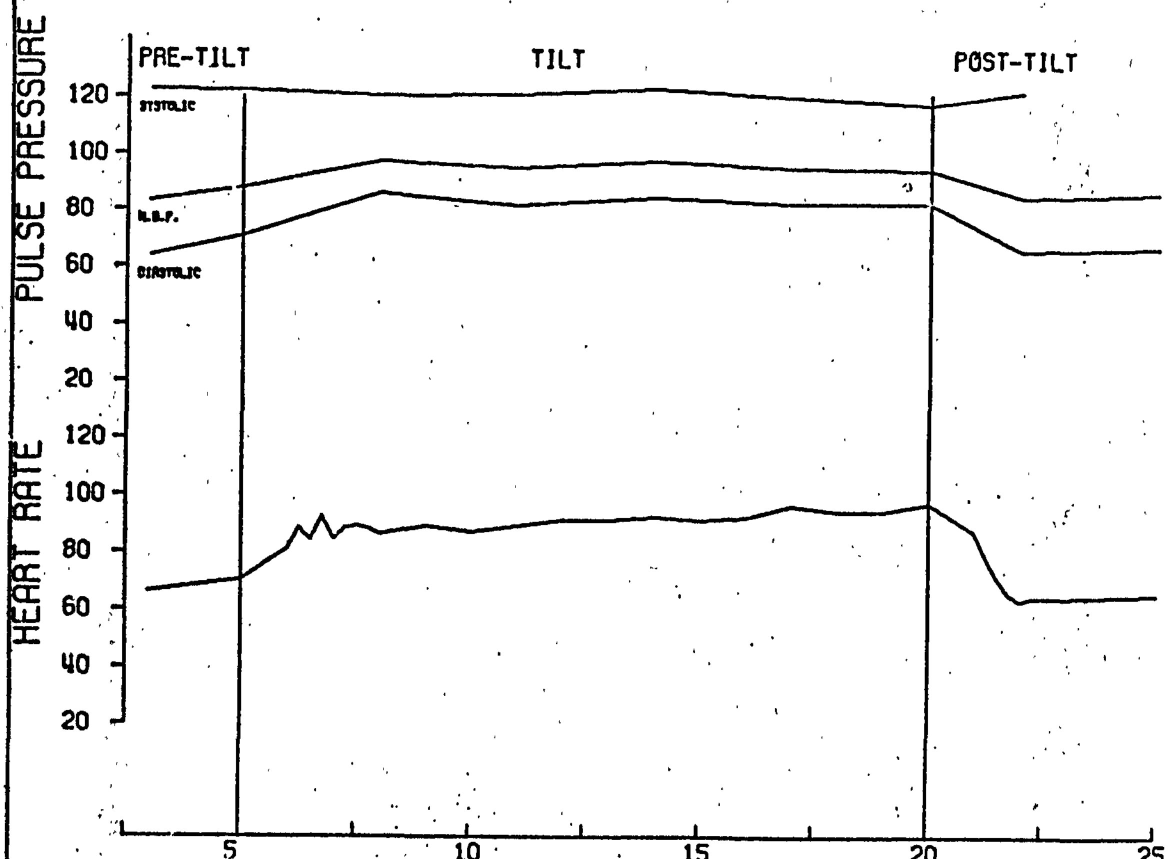
SET 15 (II-21)



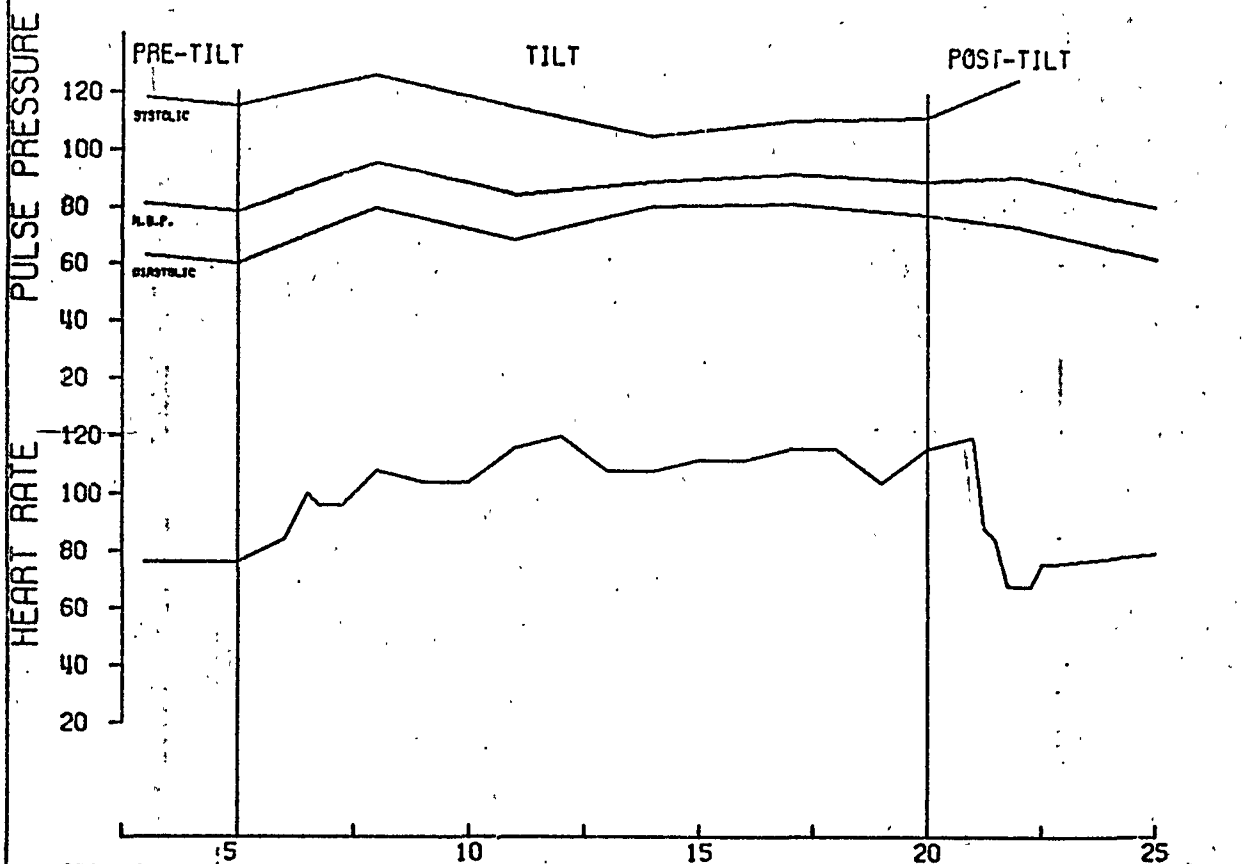
SET 16 (II-22)



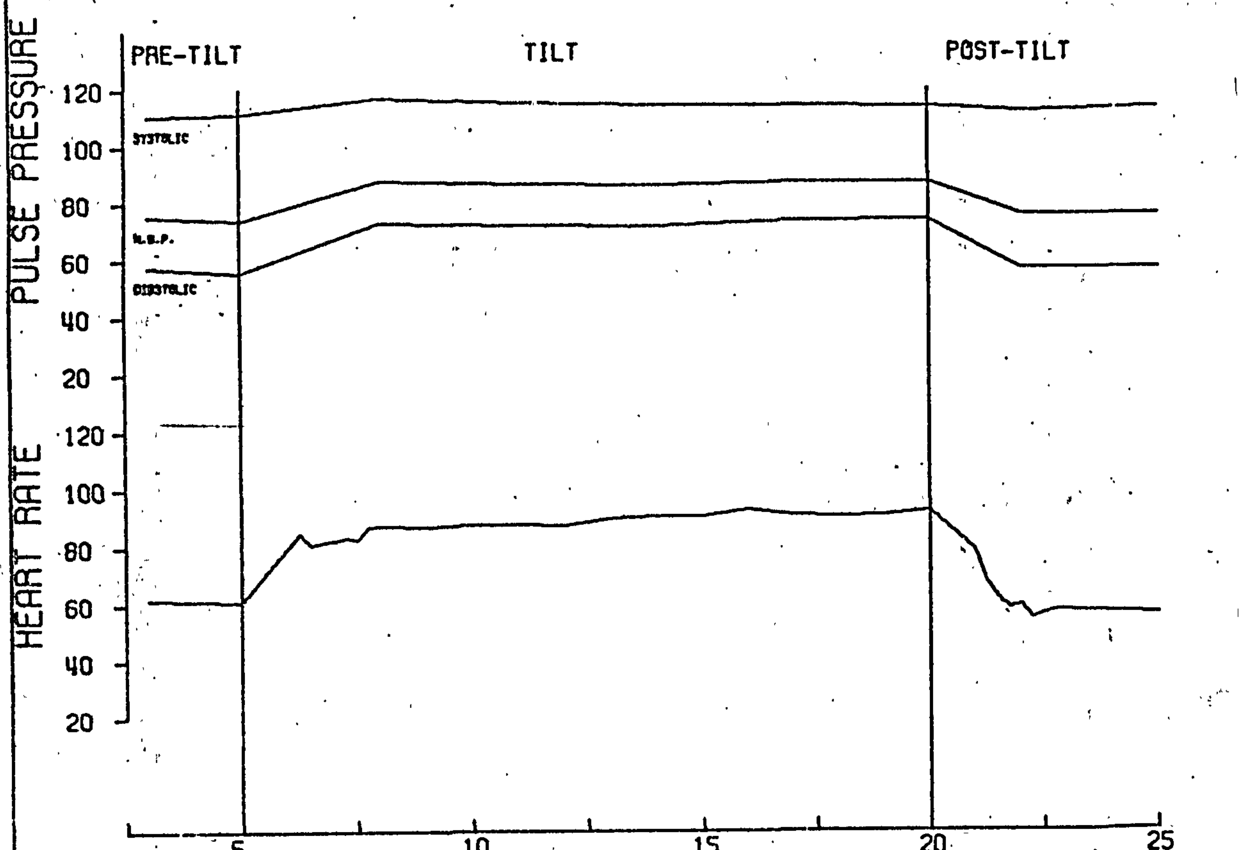
SET 17 (II-23)



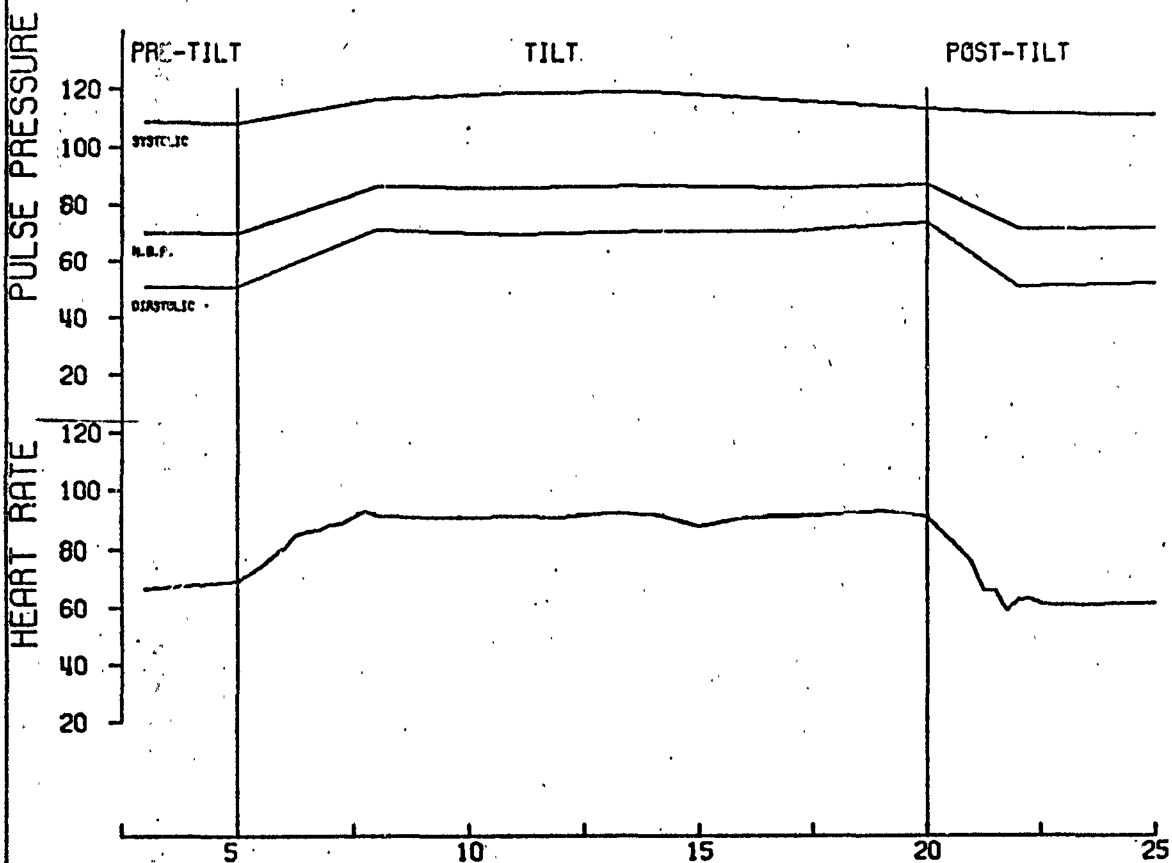
SET 18 (II-24



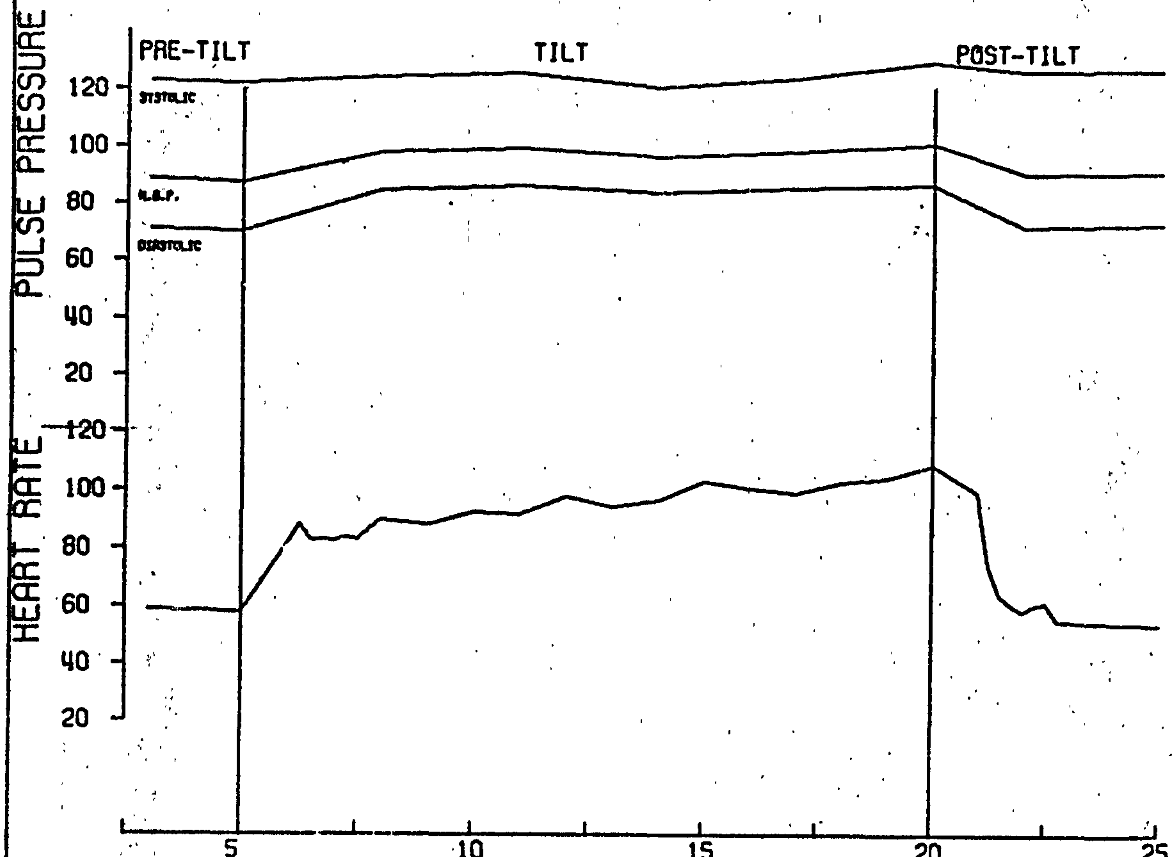
SET 19 (II-25)



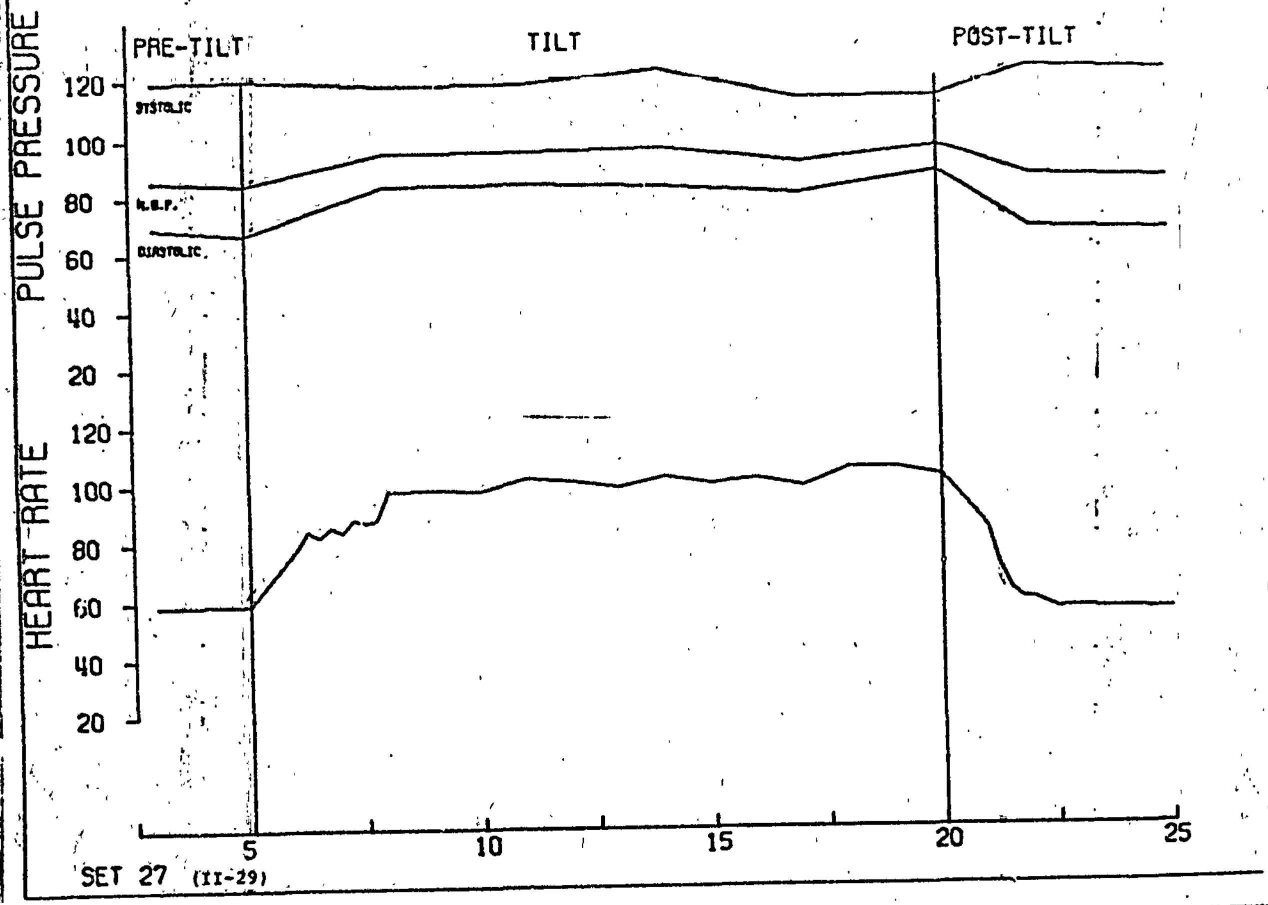
SET 24 (II-26)

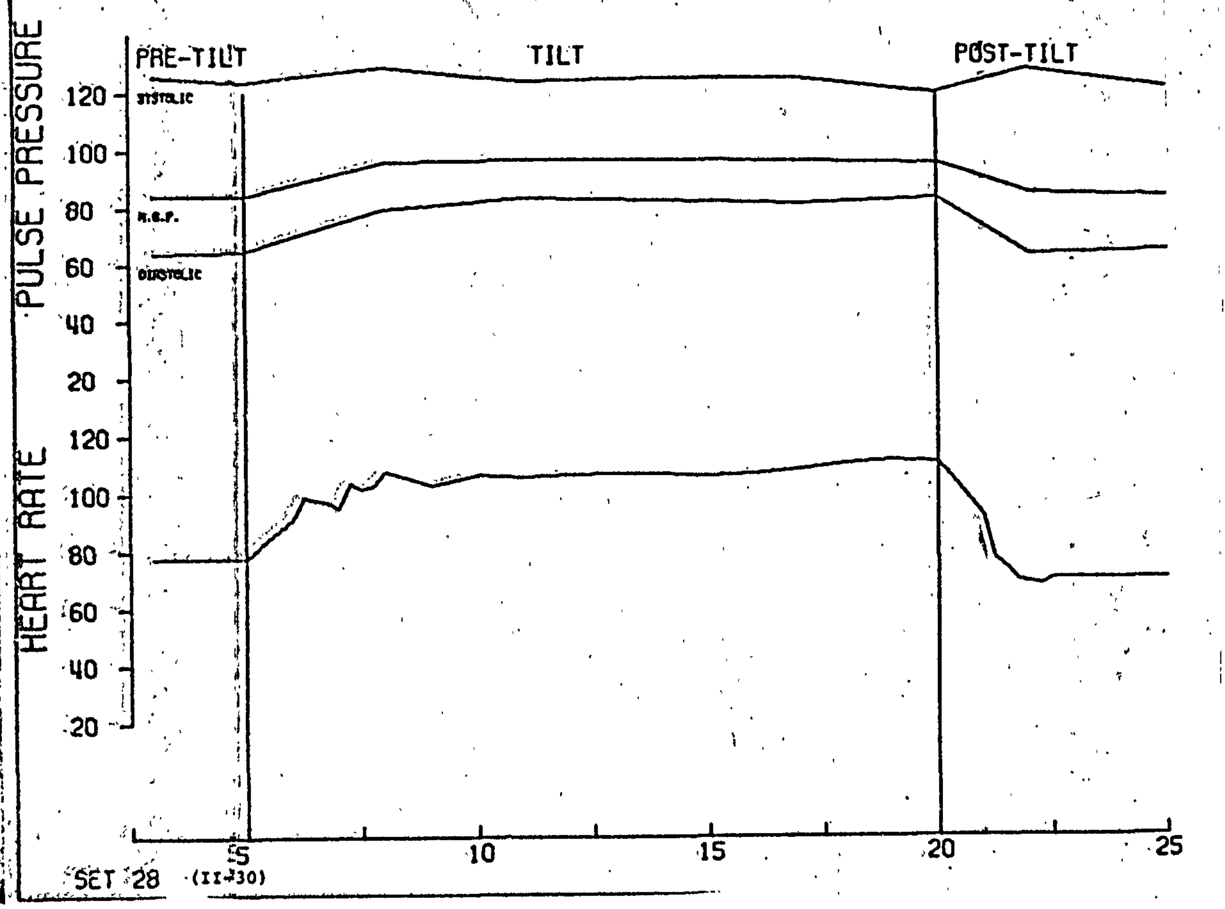


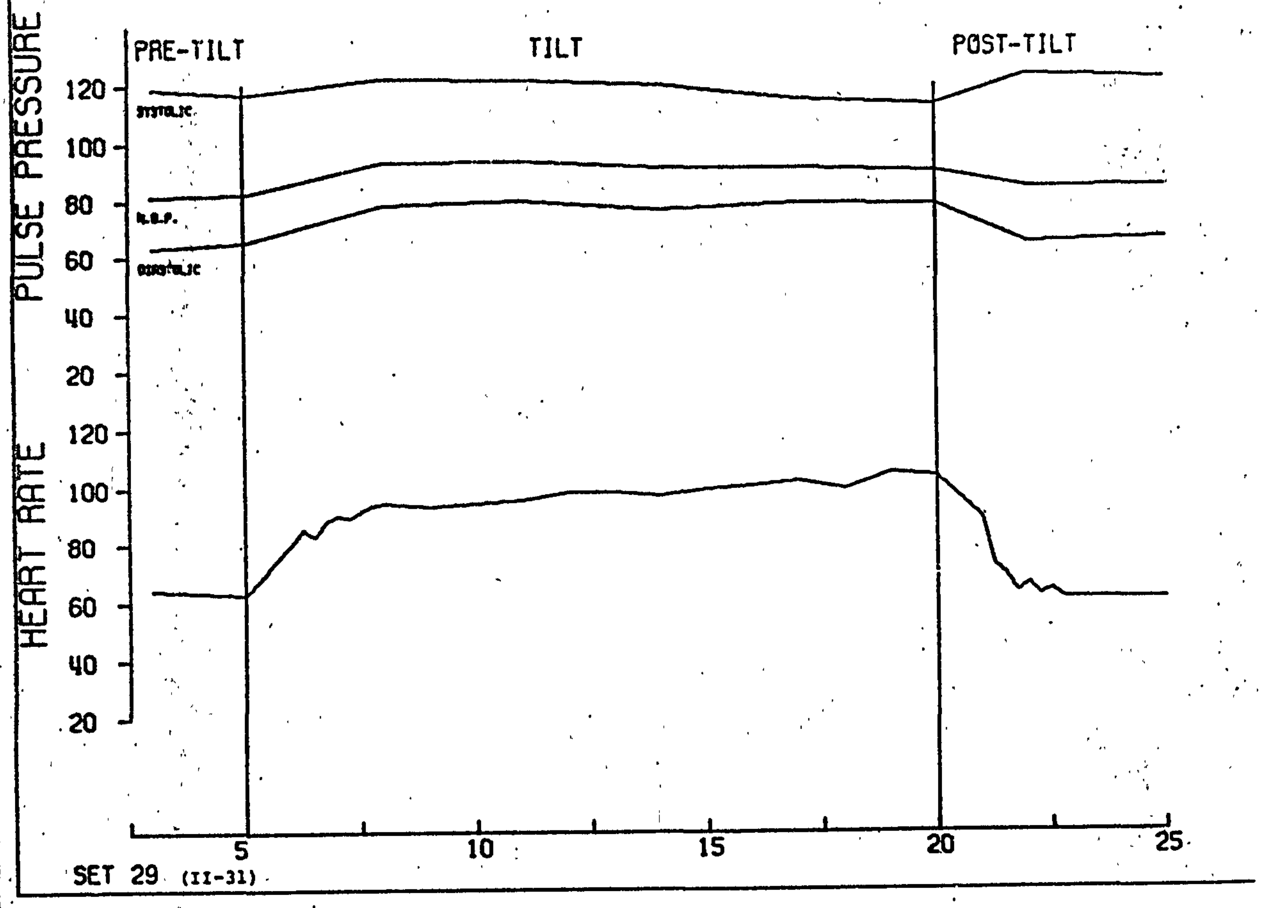
SET 25 (II-27)

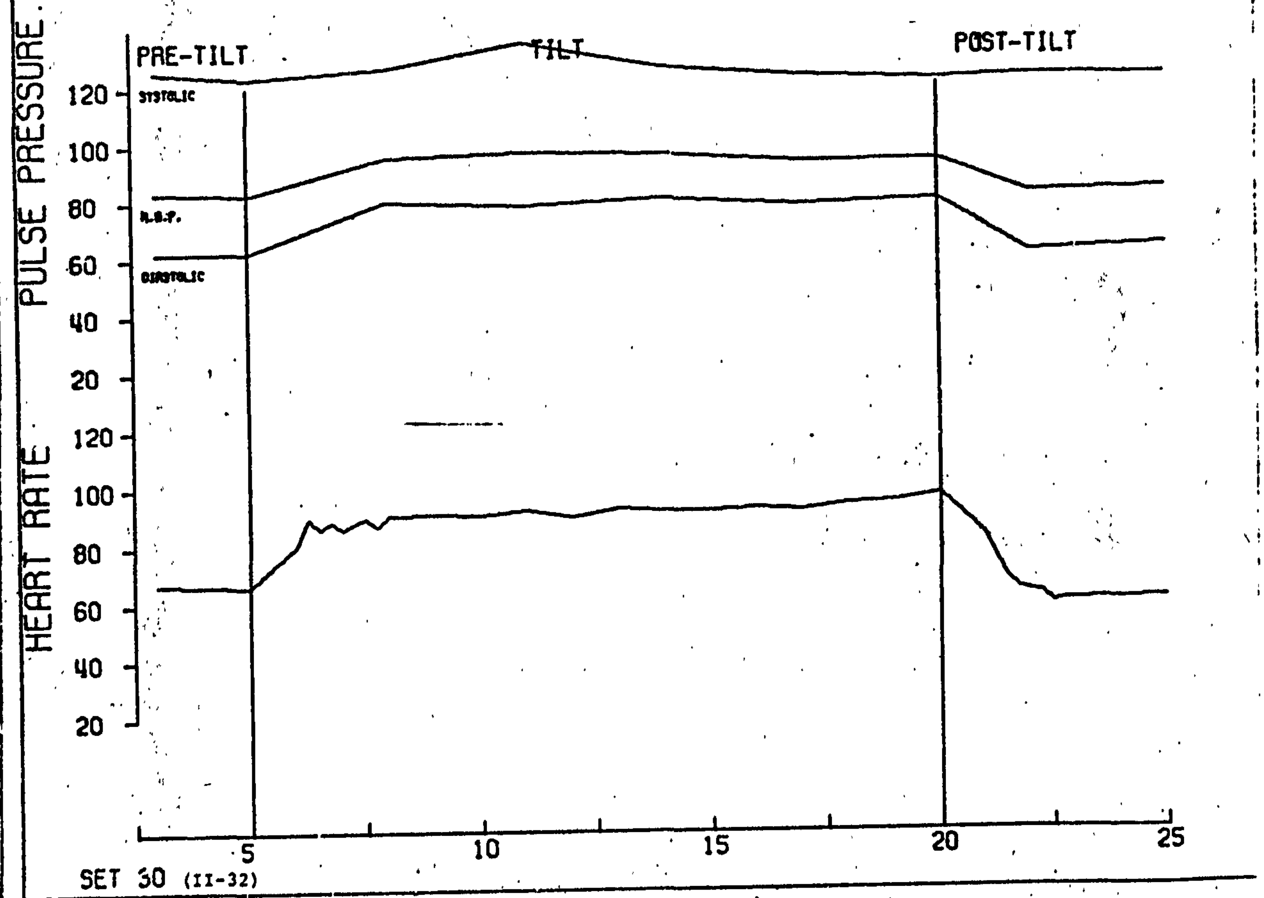


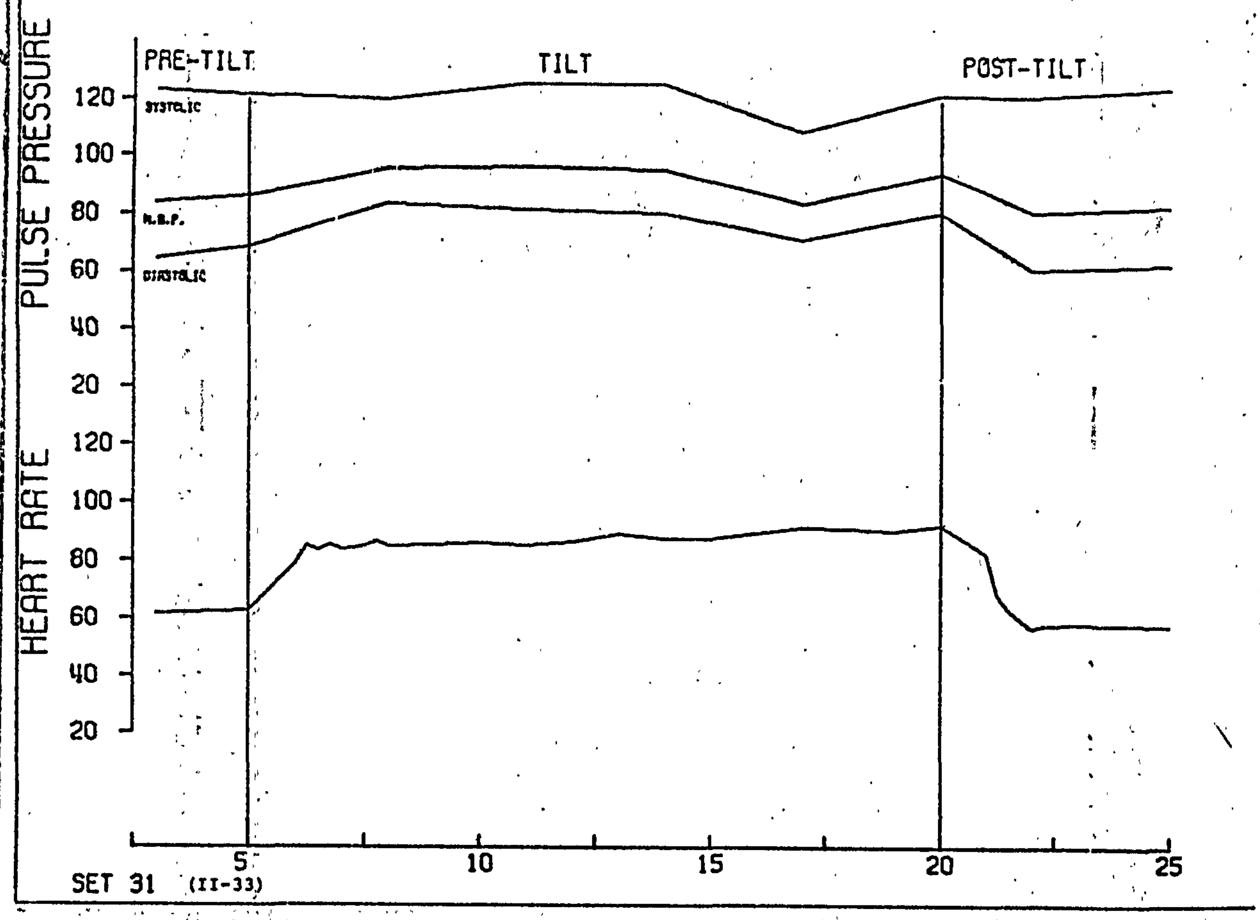
T 26 (II-28)

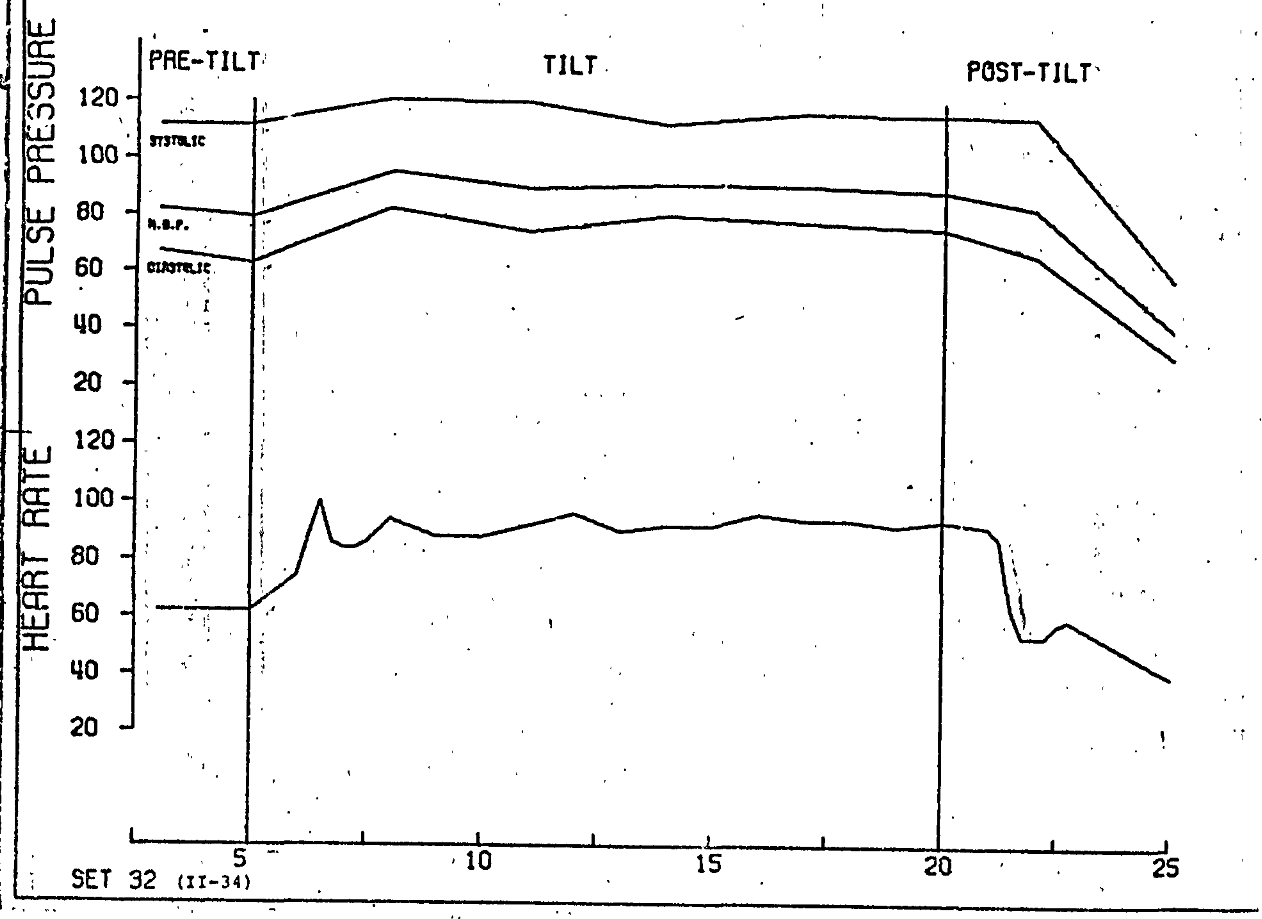

PRE-TILT
TILT
POST-TILT
PULSE PRESSURE
HEART RATE
SYSTOLIC
M.B.P.
DIASTOLIC
120
100
80
60
40
20
5
10
15
20
25
SET 27 (II-29)

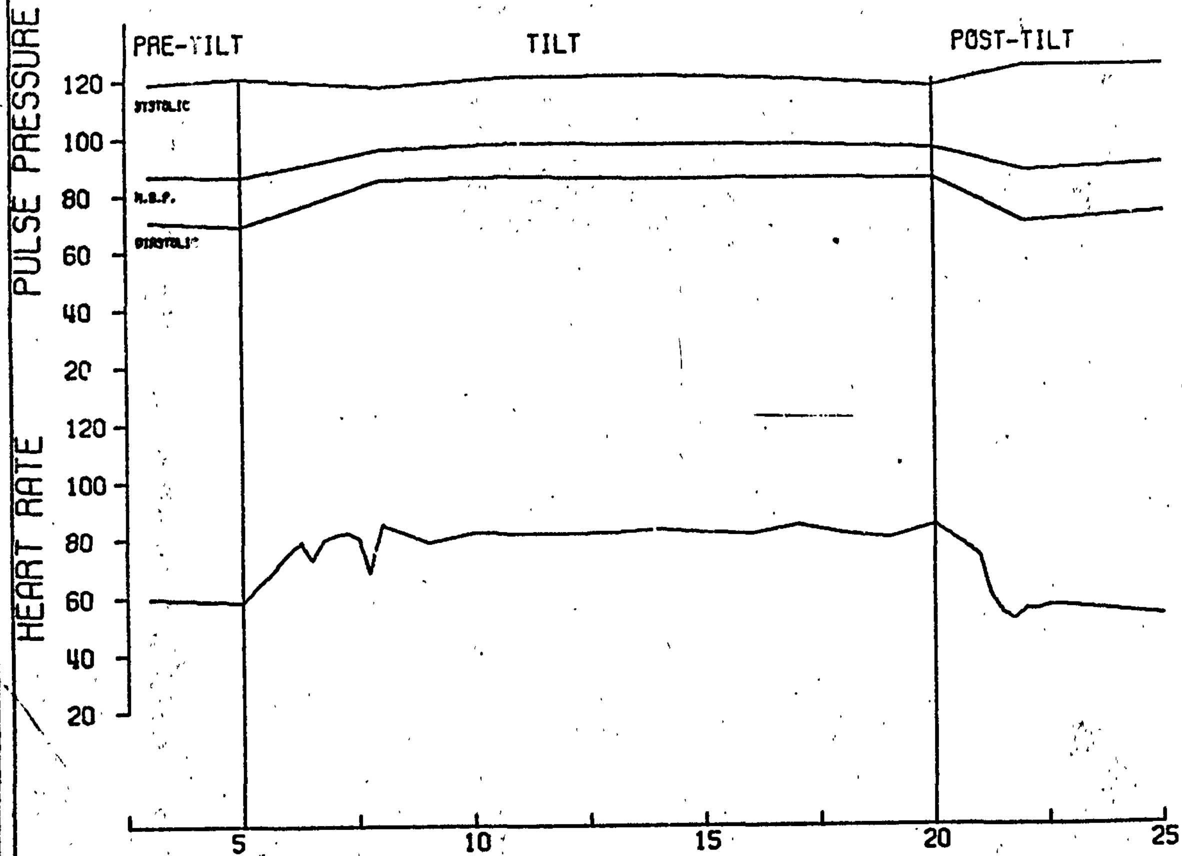

PRE-TILT
TILT
POST-TILT
PULSE PRESSURE
HEART RATE
SYSTOLIC
M.B.P.
DIASTOLIC
120
100
80
60
40
20
5
10
15
20
25
SET 28 (II-30)


PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
SYSTOLIC
M.B.P.
DIASTOLIC
120
100
80
60
40
20
5
10
15
20
25
SET 29 (II-31)

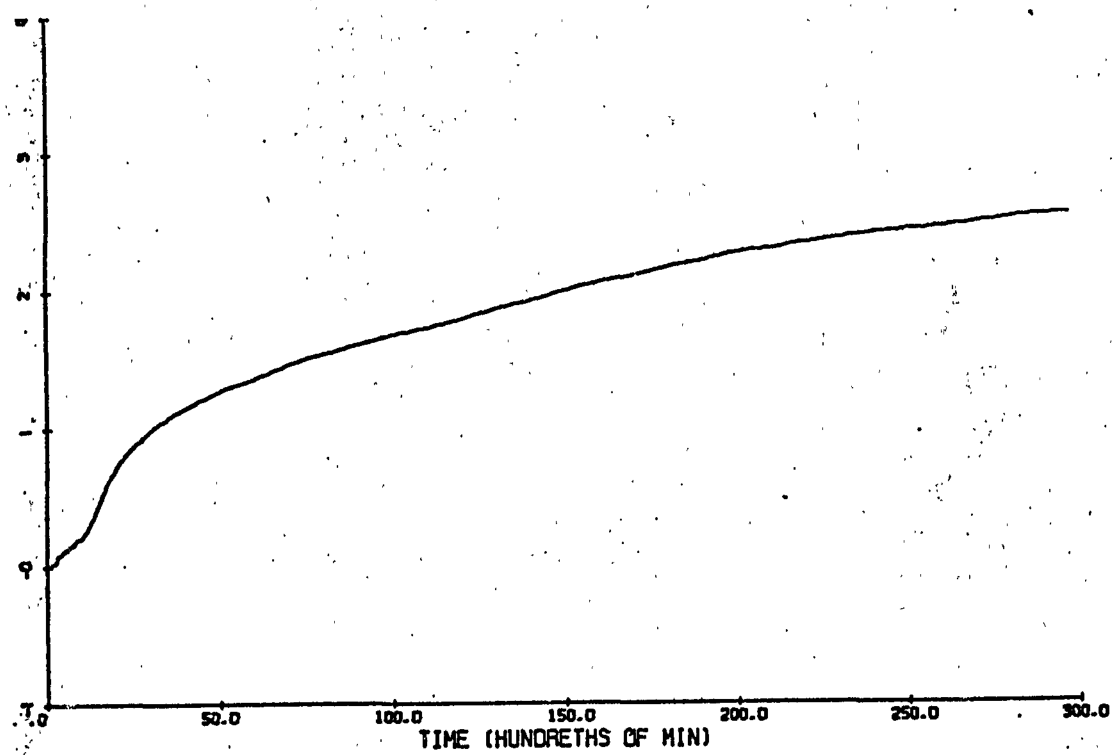

PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
SYSTOLIC
M.B.P.
DIASTOLIC
120
100
80
60
40
20
5
10
15
20
25
SET 30 (II-32)


PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
SYSTOLIC
M.B.P.
DIASTOLIC
120
100
80
60
40
20
5
10
15
20
25
SET 31 (II-33)

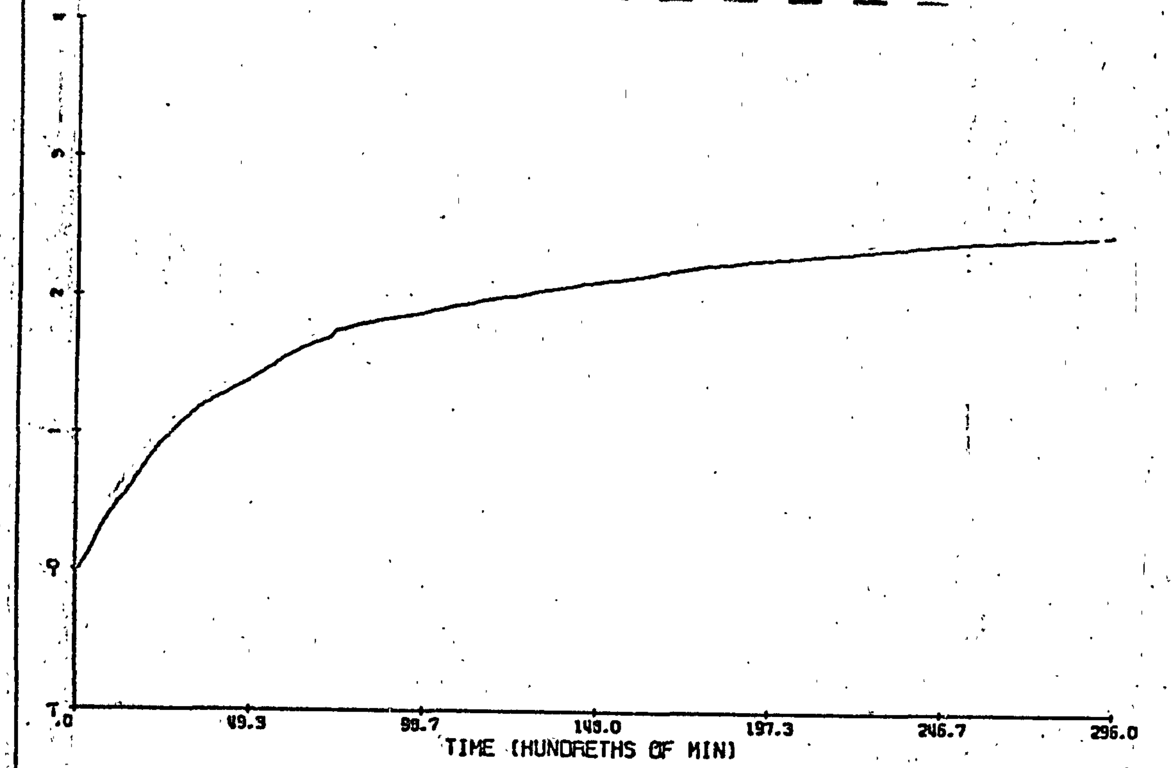

PULSE PRESSURE
HEART RATE
PRE-TILT
TILT
POST-TILT
SYSTOLIC
M.B.P.
DIASTOLIC
120
100
80
60
40
20
5
10
15
20
25
SET 32 (II-34)



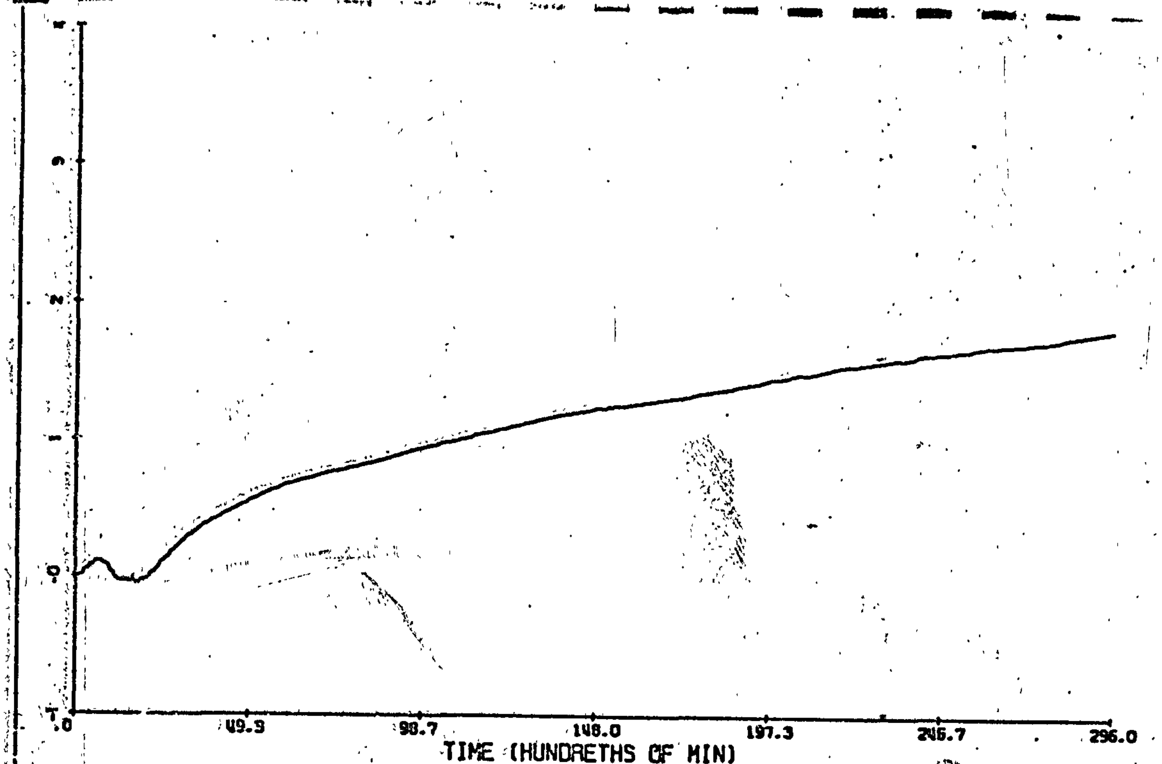
SET 33 (II-35)



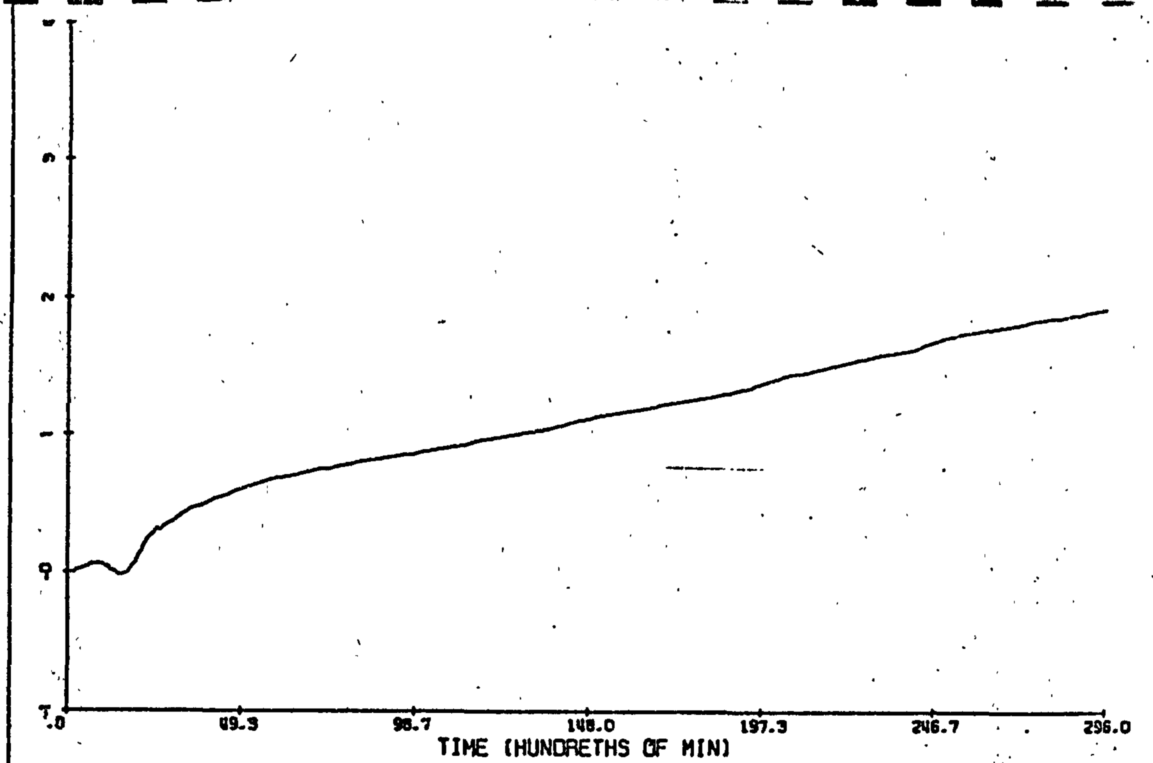
SET 1 (II-36)



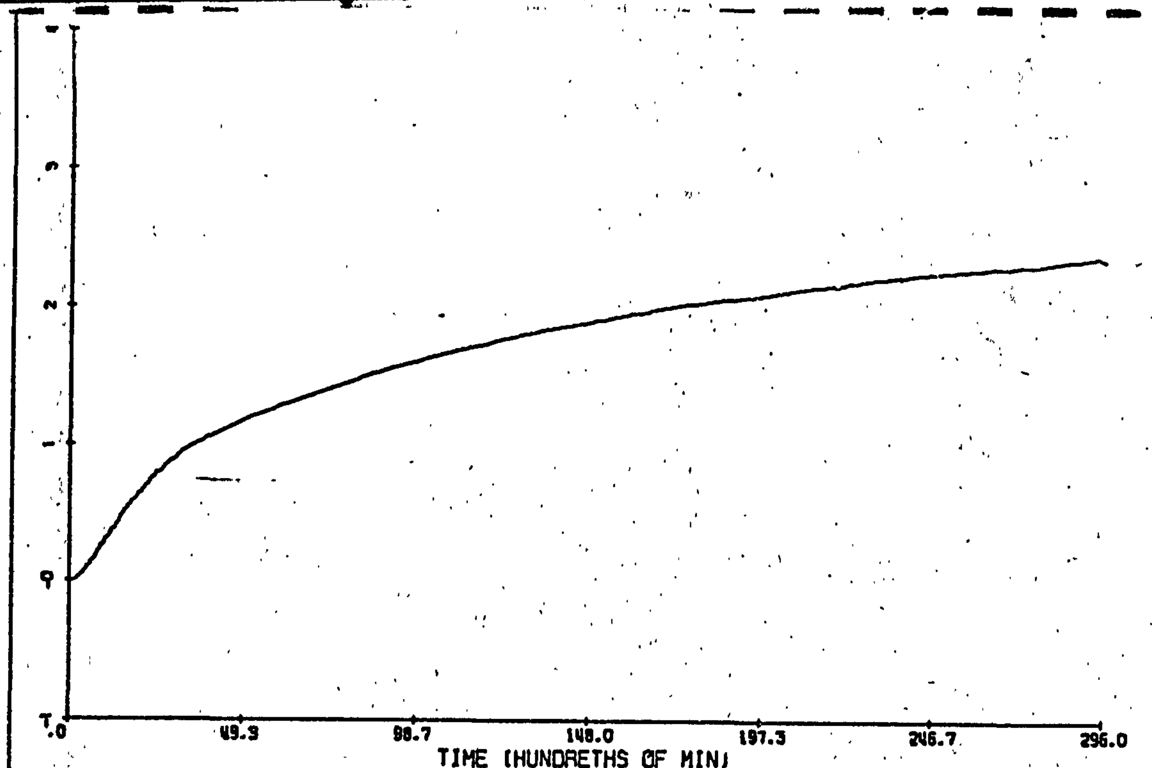
SET 2 (II-37)



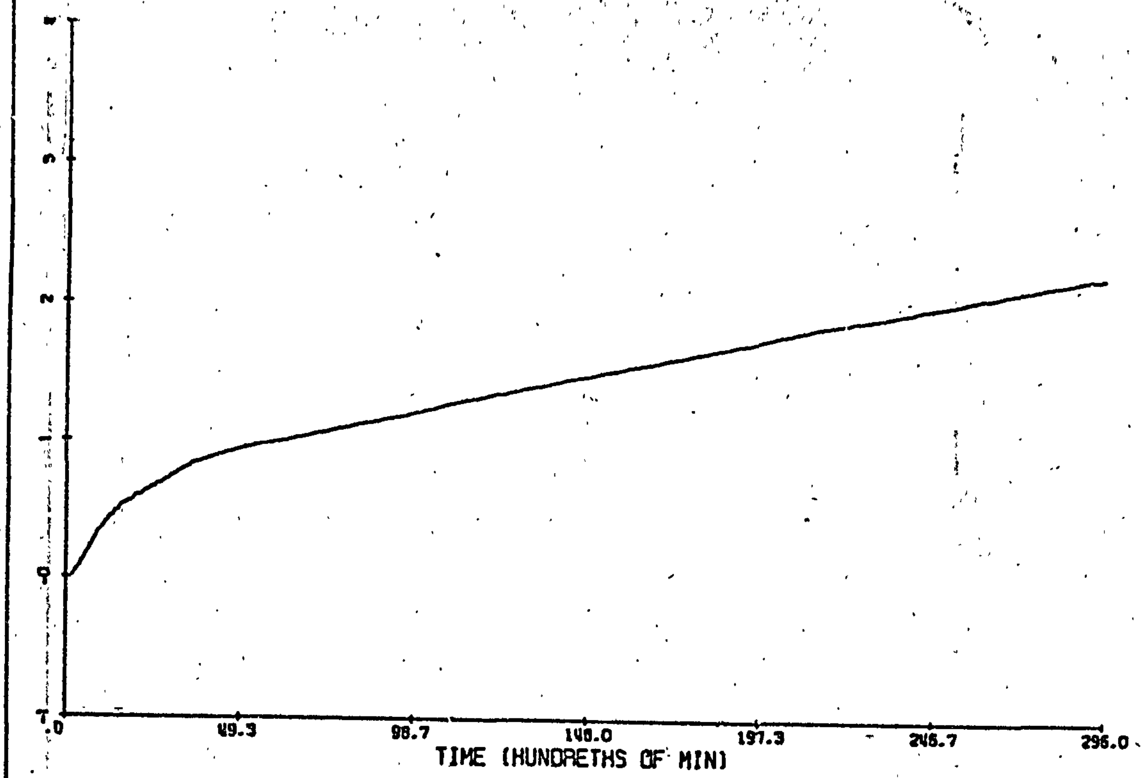
SET 3 (II-38)



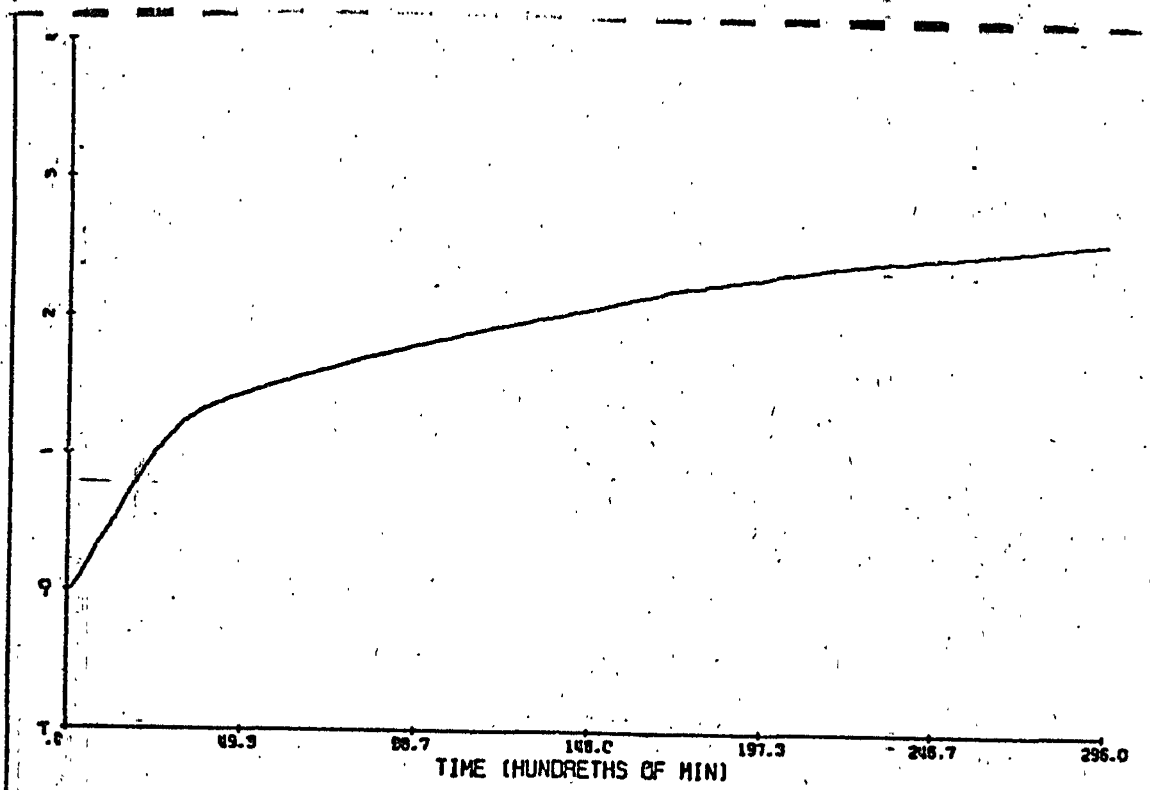
SET 4 (II-39)



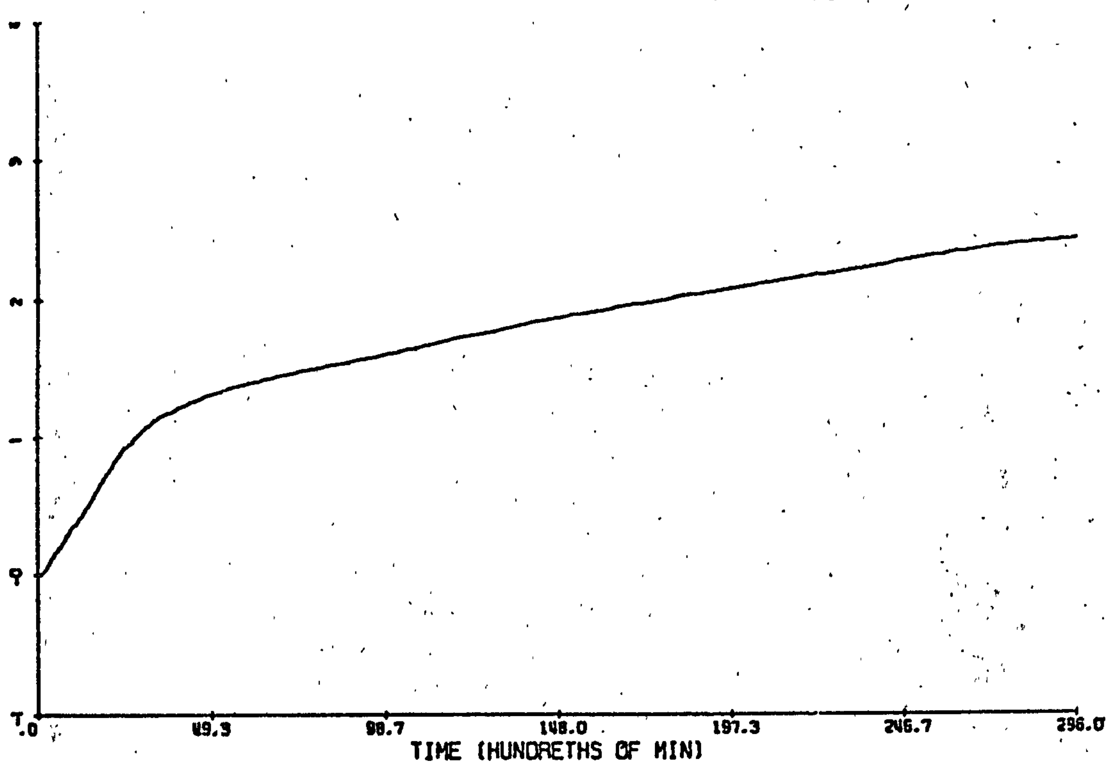
SET 5 (II-40)



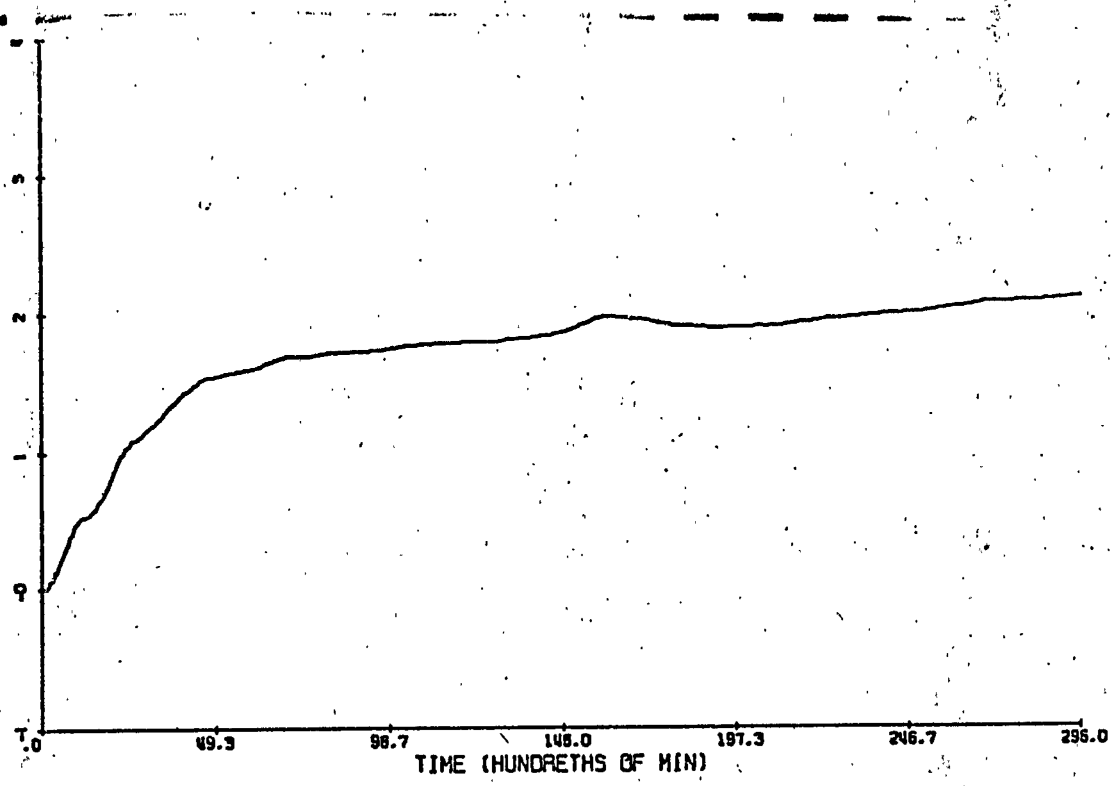
SET 6 (II-41)



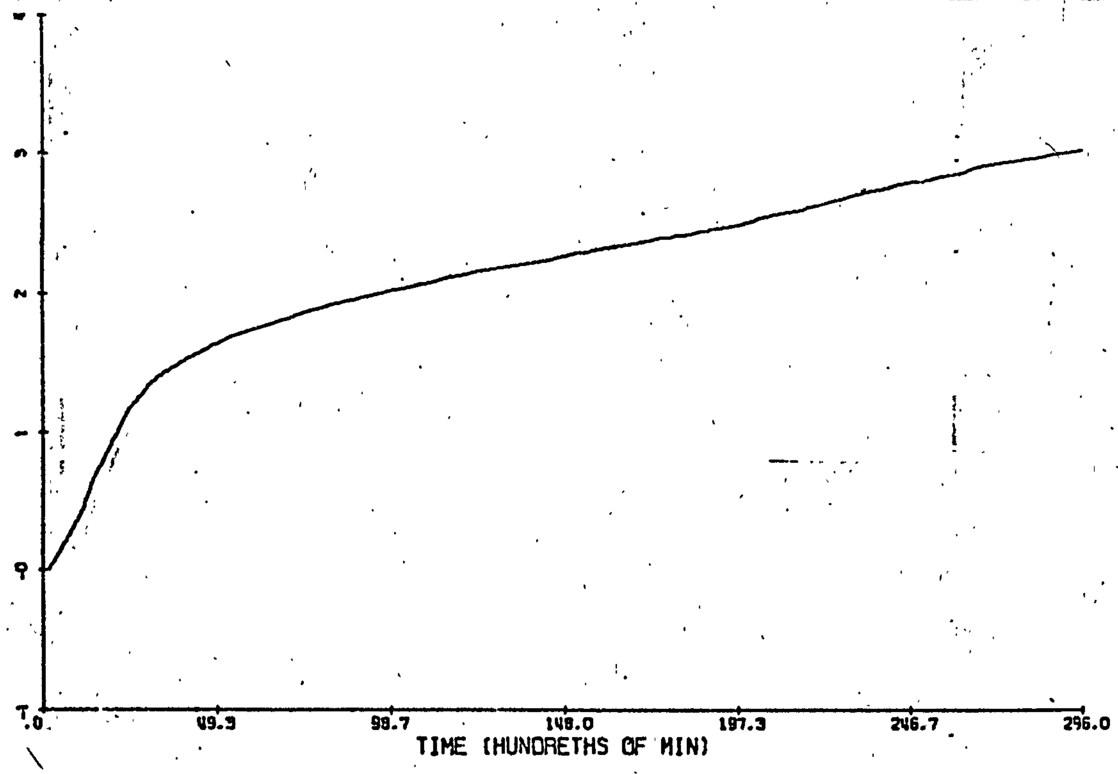
SET 7 (II-42)



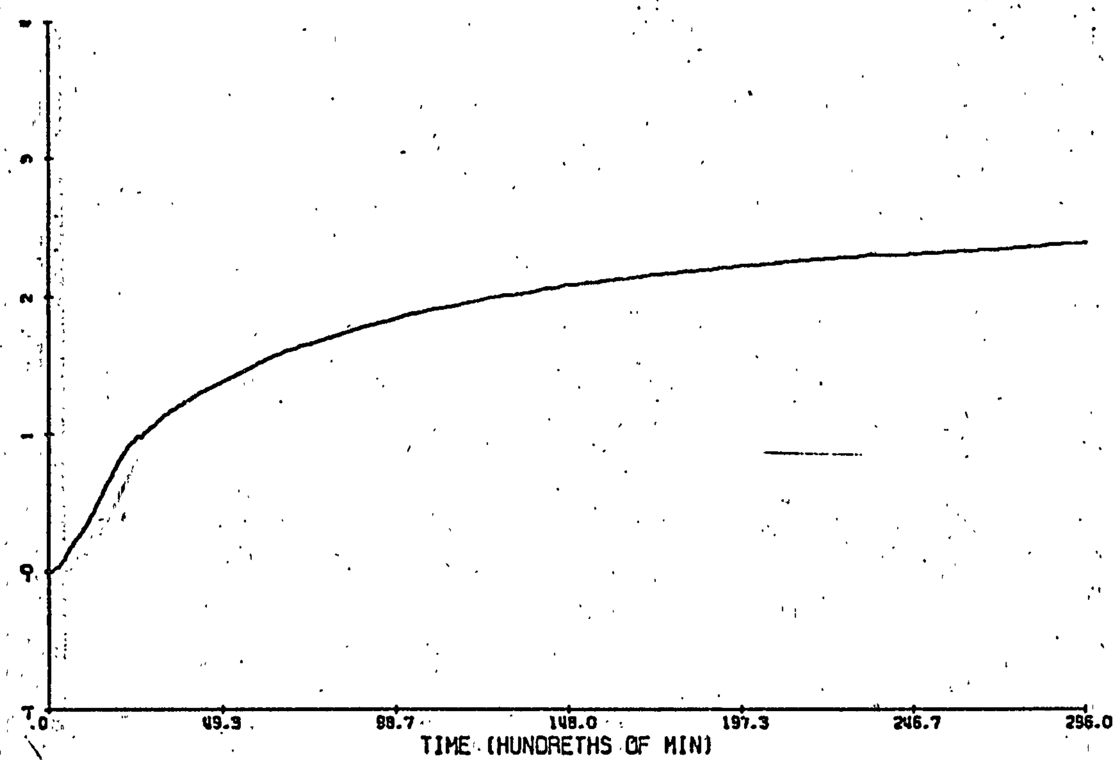
SET 8 (II-43)



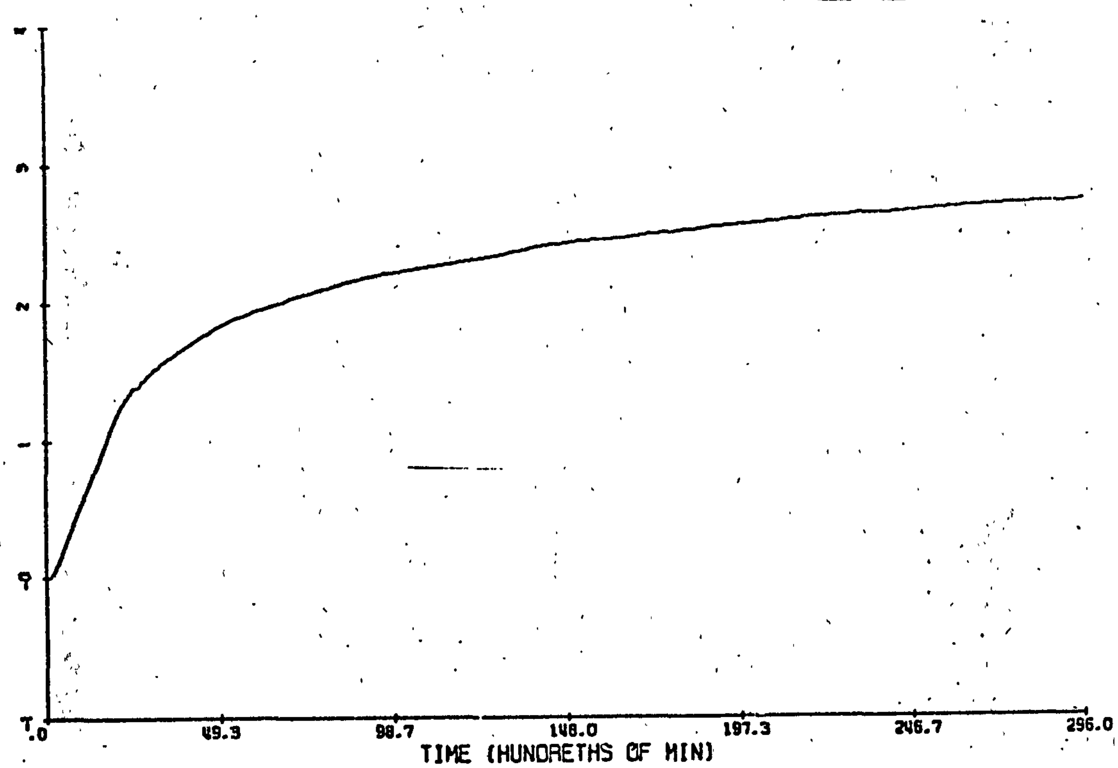
SET 9 (II-44)



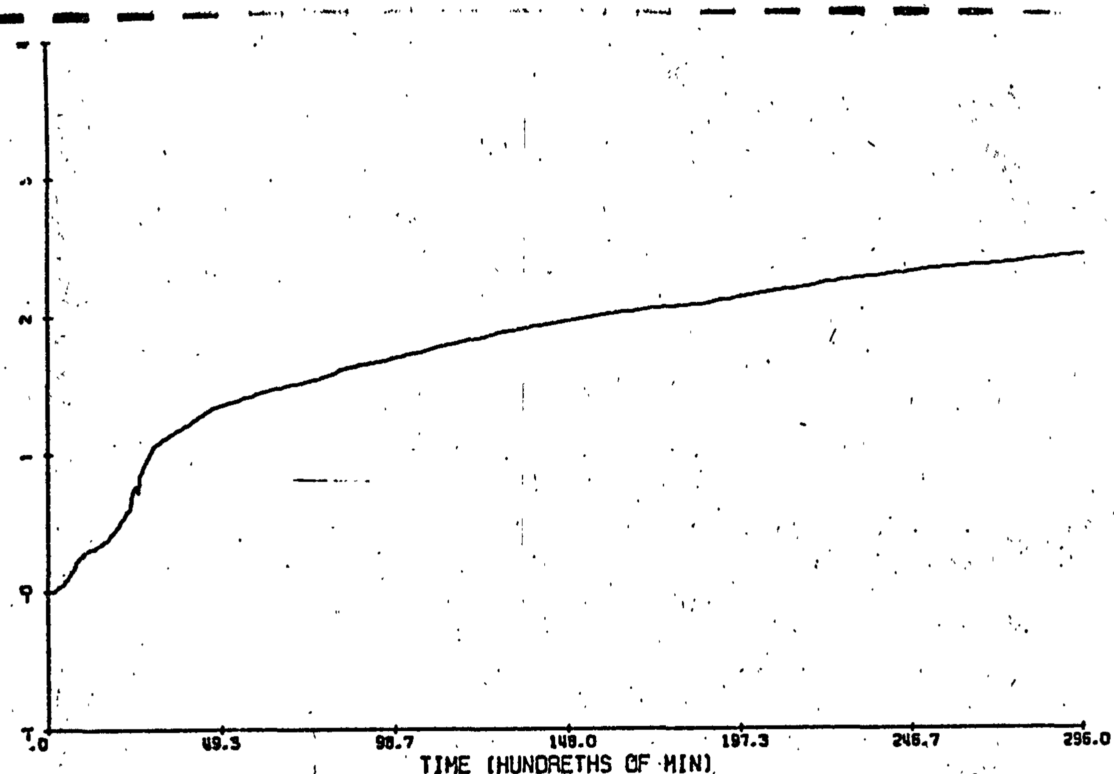
SET 10 (II-45)



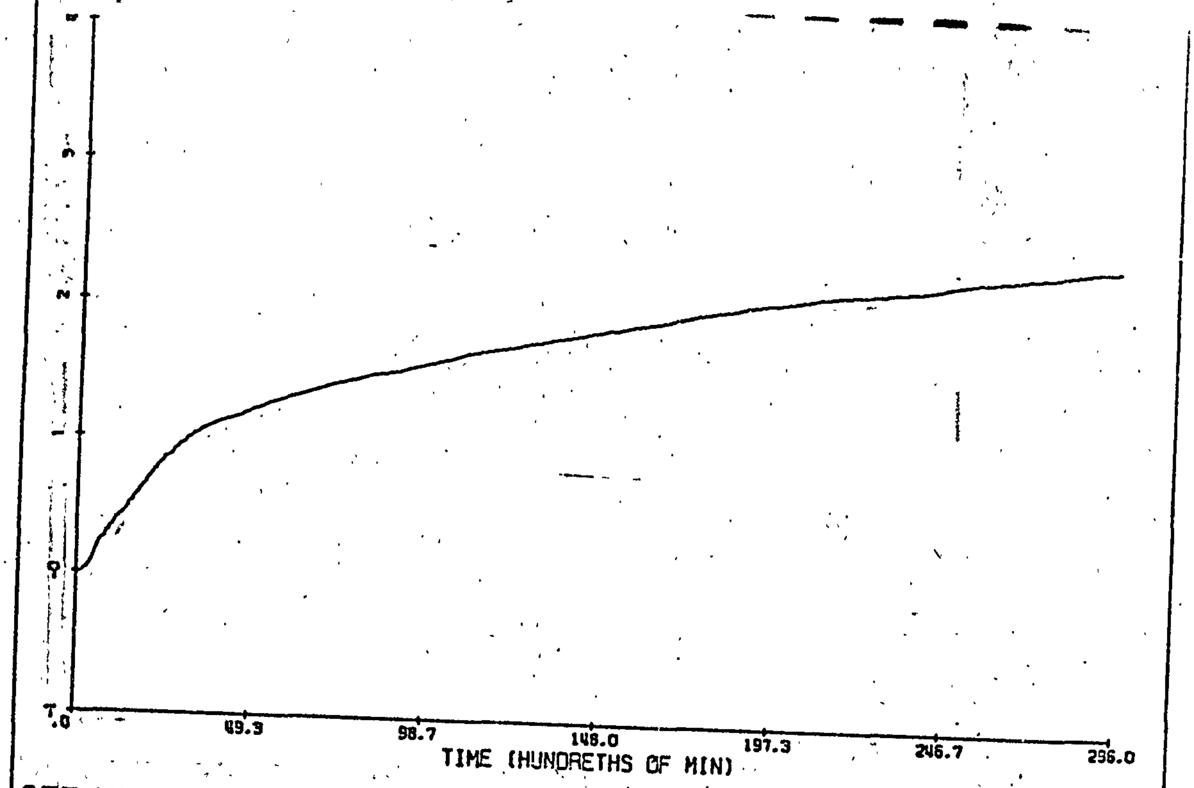
SET 11 (II-46)



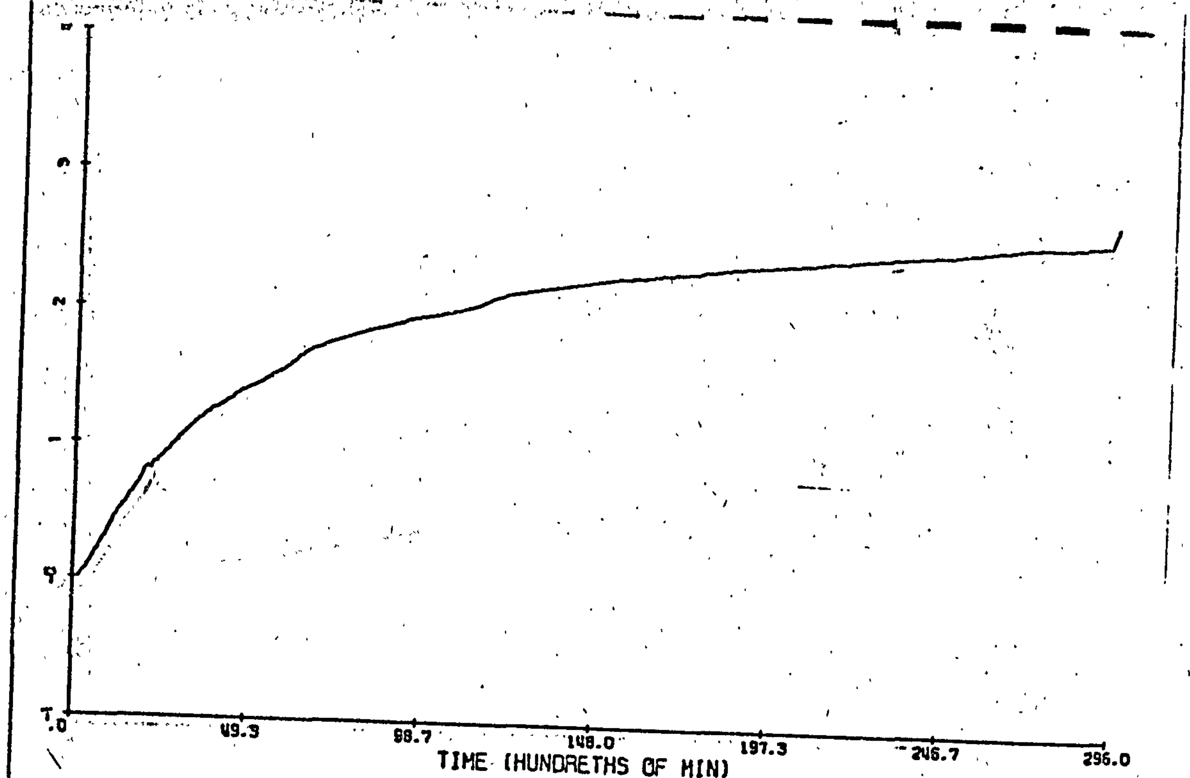
SET 12 (II-47)



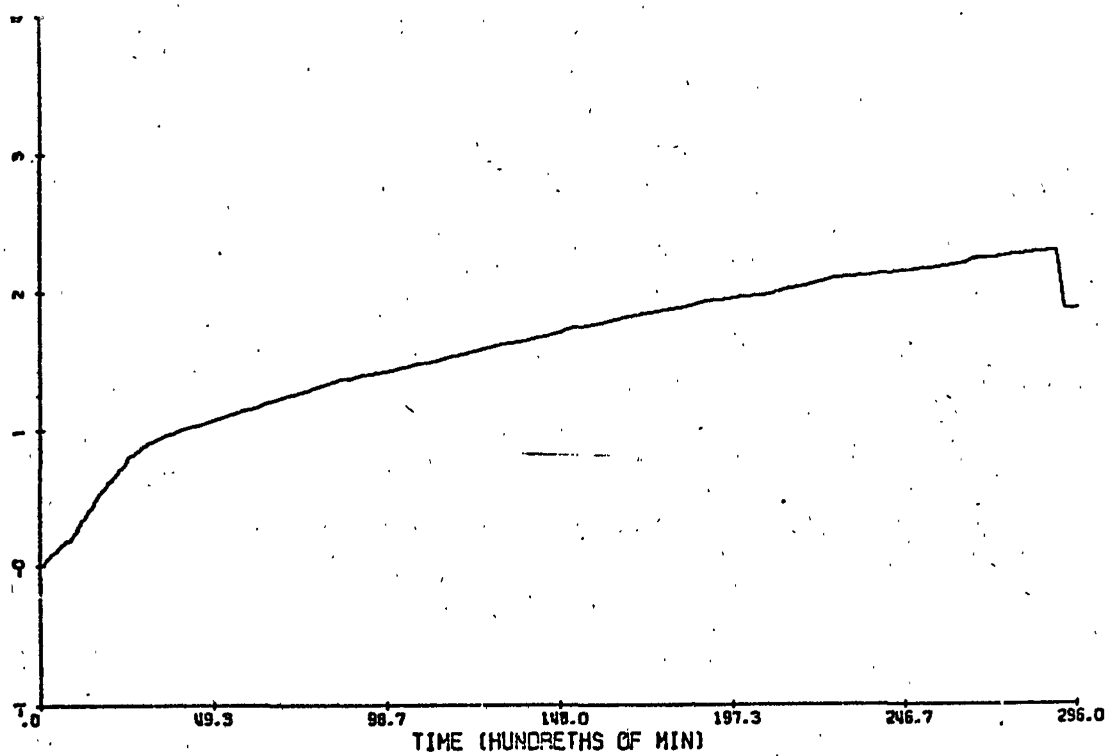
SET 13 (II-48)



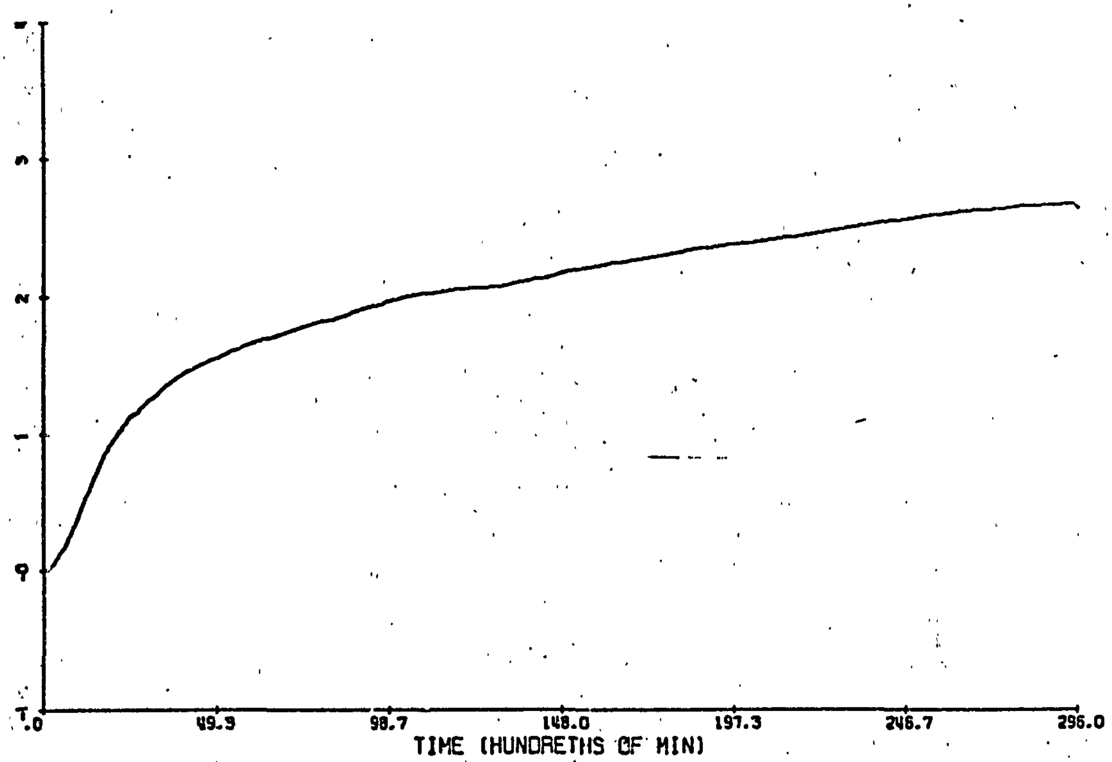
SET 14 (II-49)



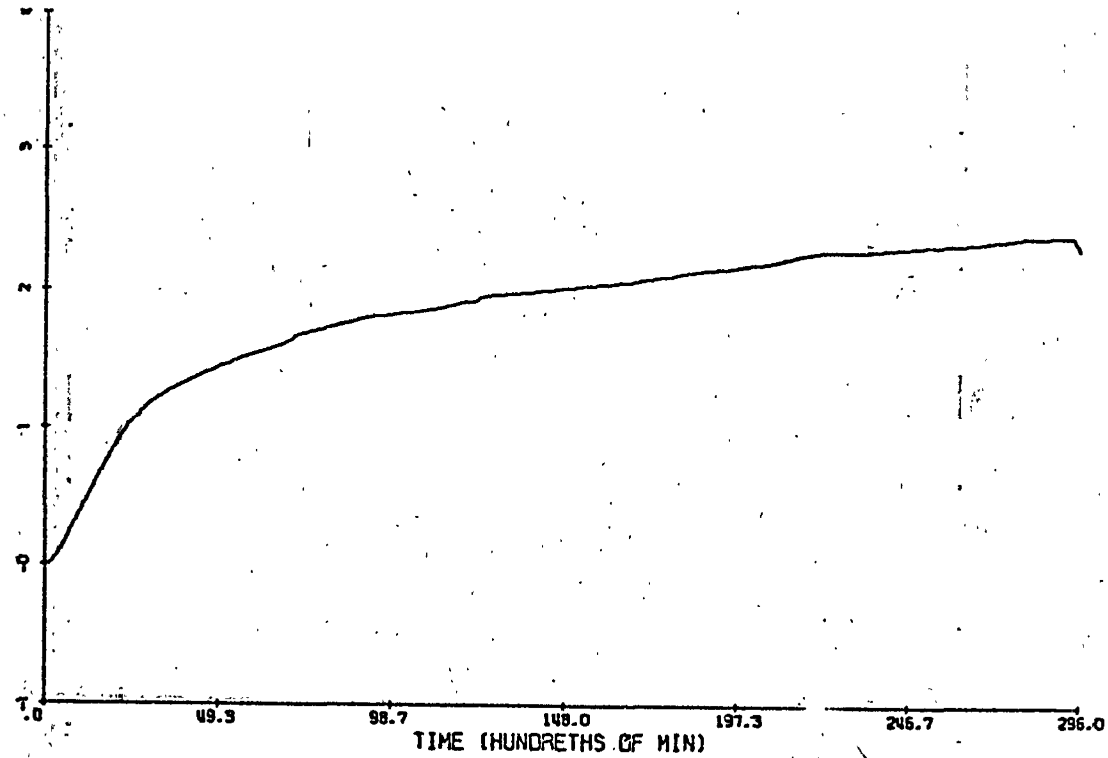
SET 15 (II-50)



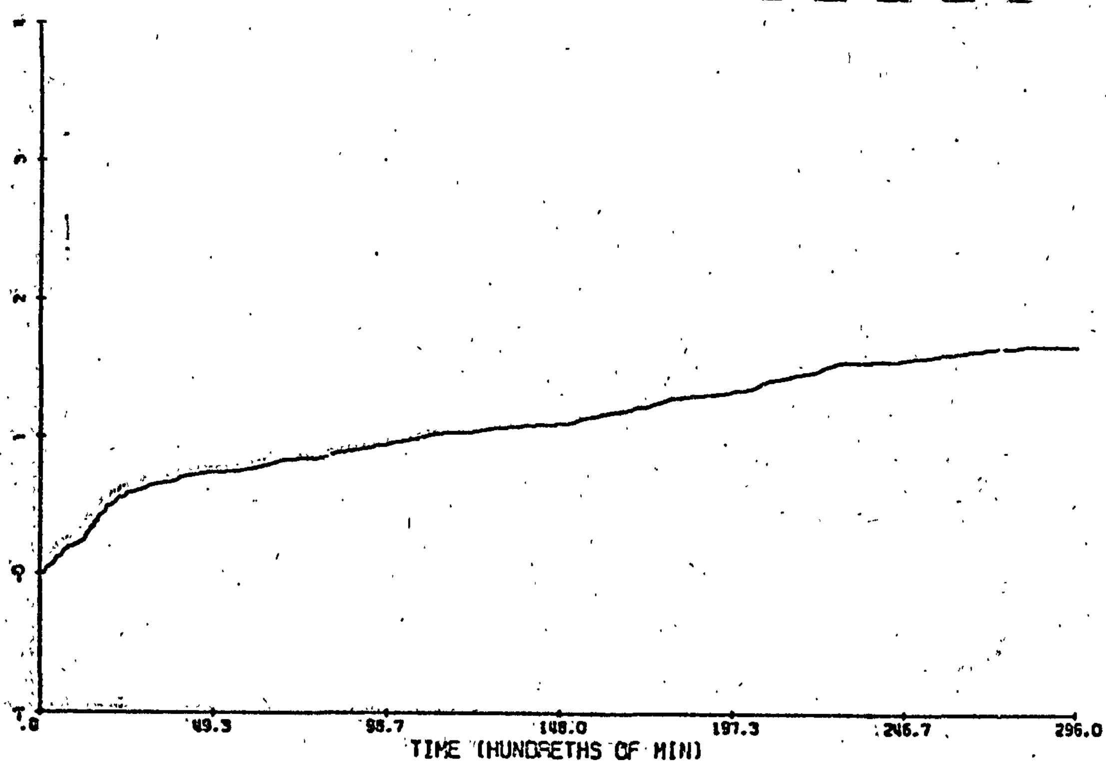
SET 16 (II-51)



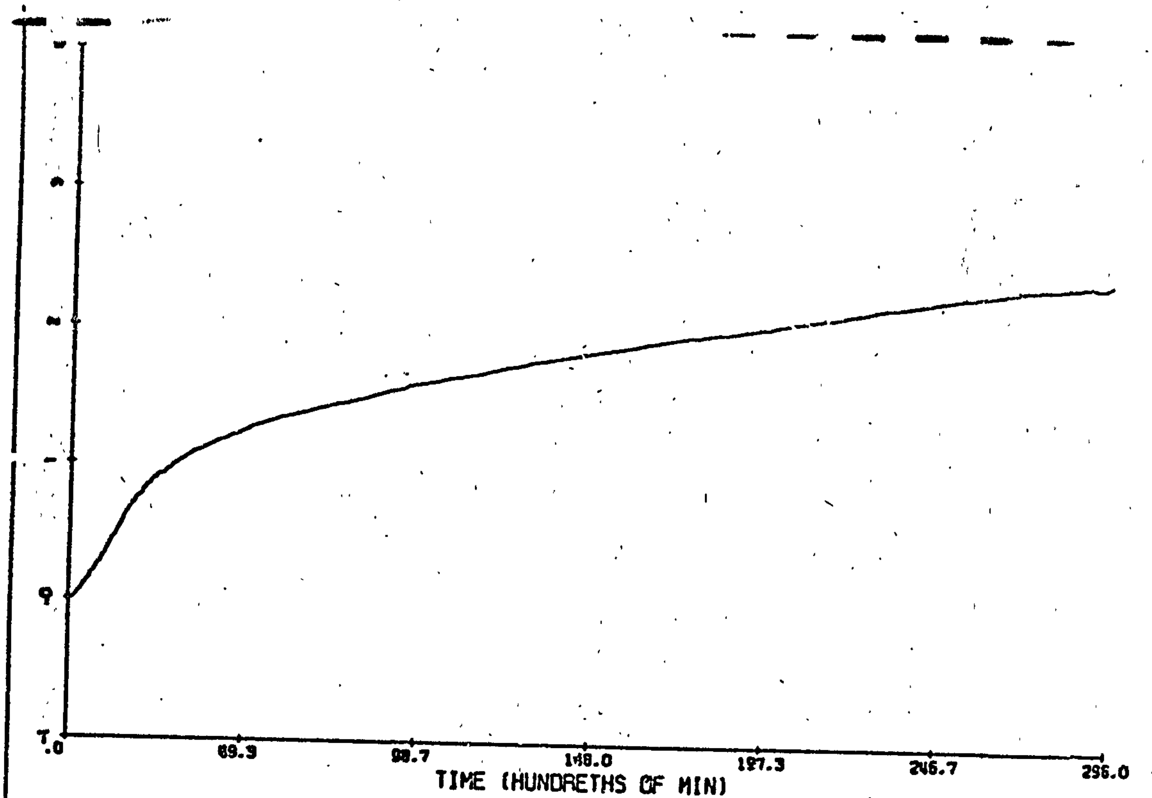
SET 17 (II-52)



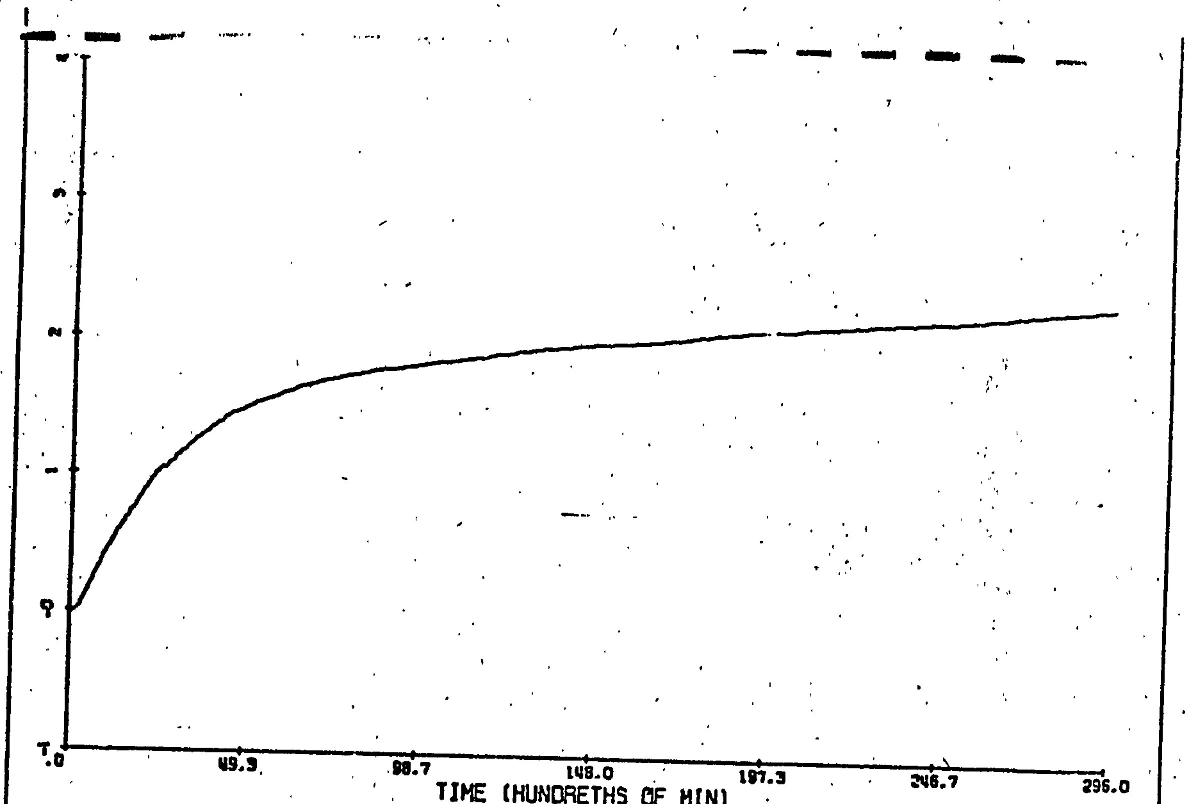
SET 18 (II-53)



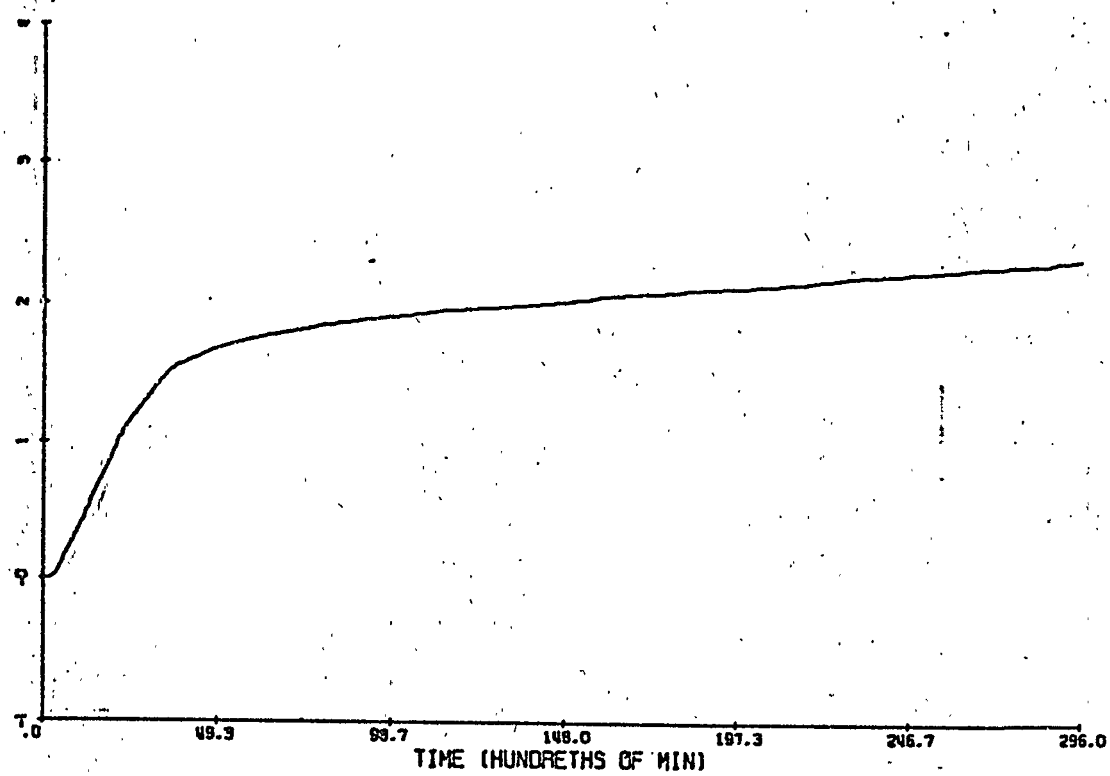
SET 19 (II-54)



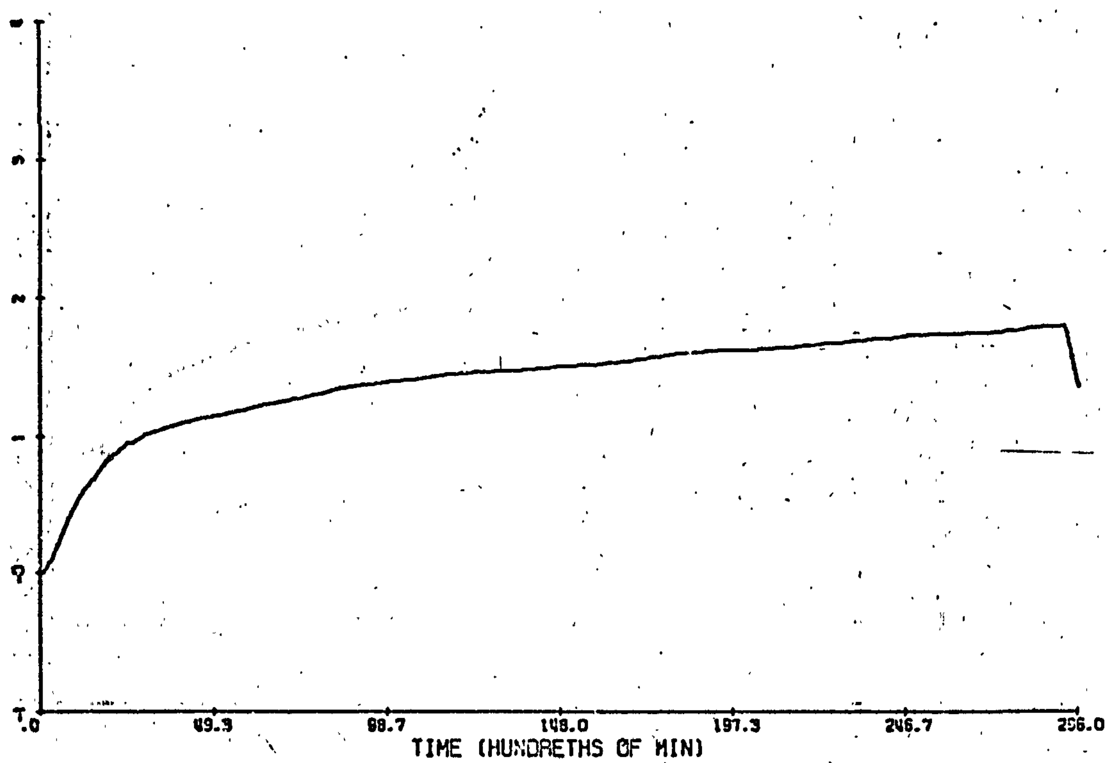
SET 20 (II-55)



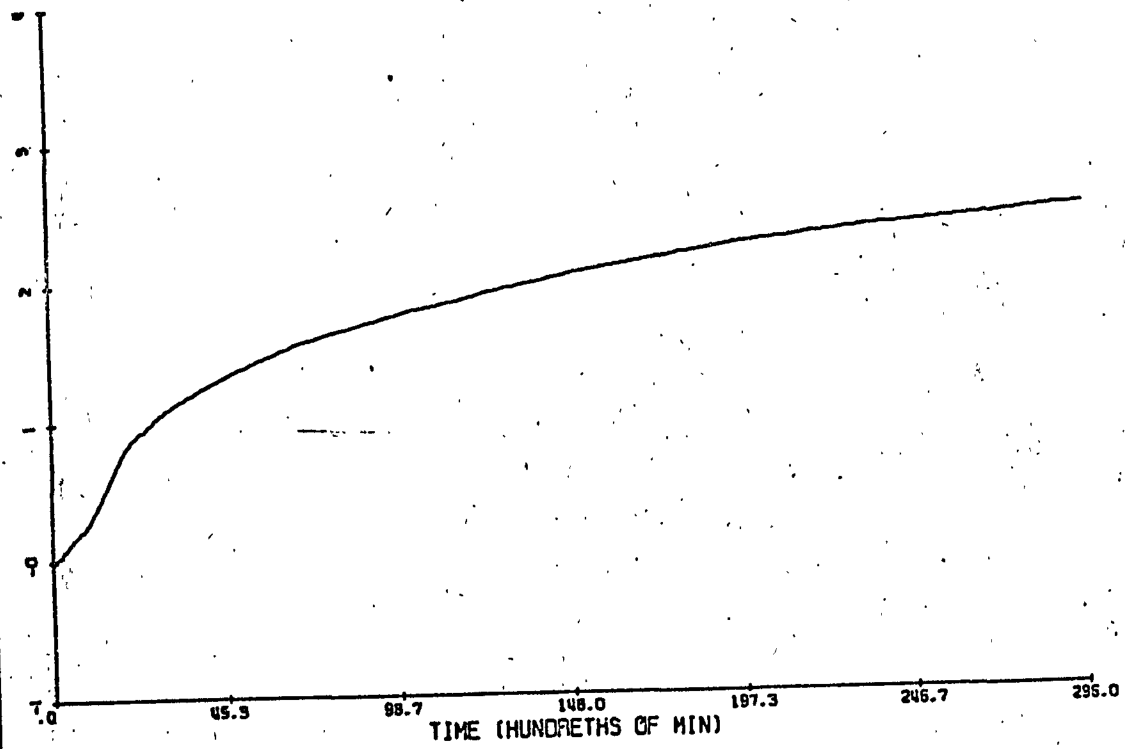
SET 21 (II-56)



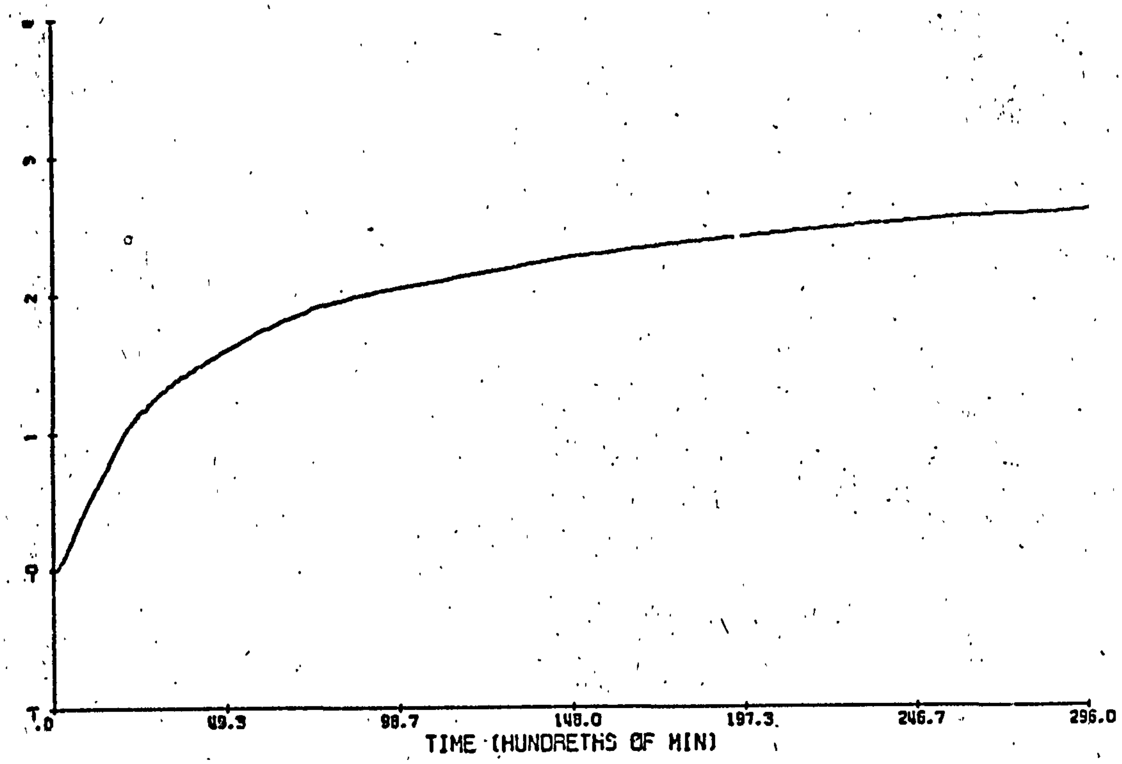
SET 22 (II-57)



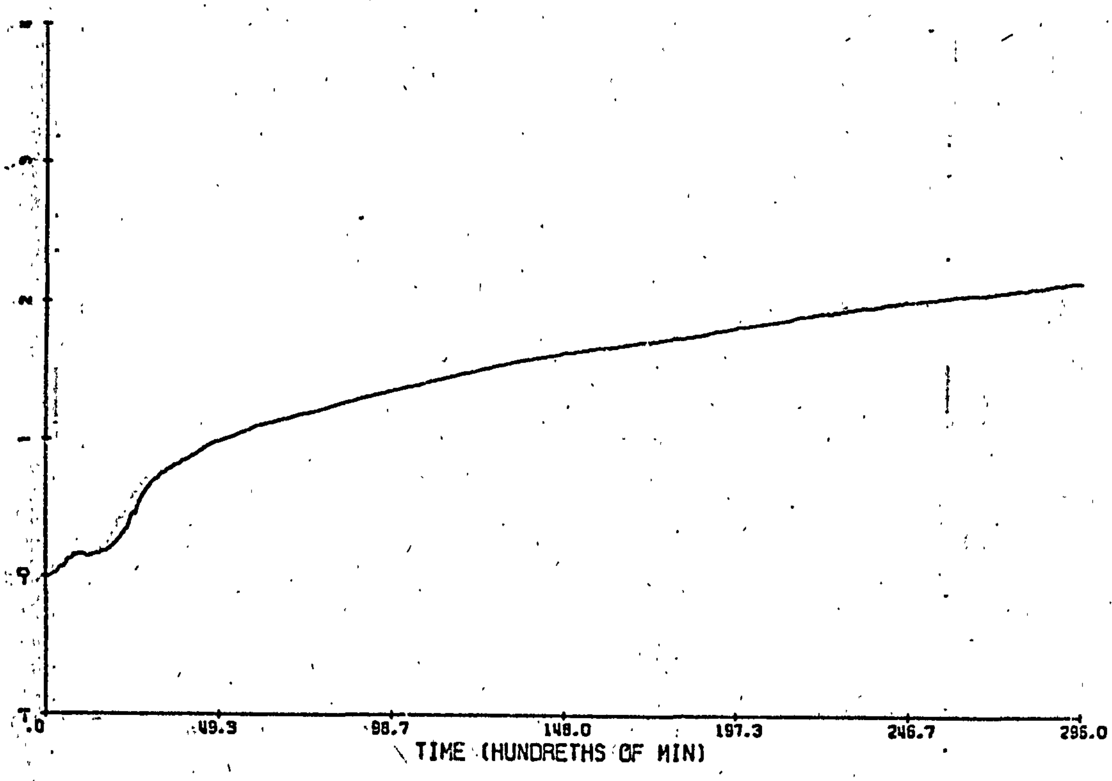
SET 23 (II-58)



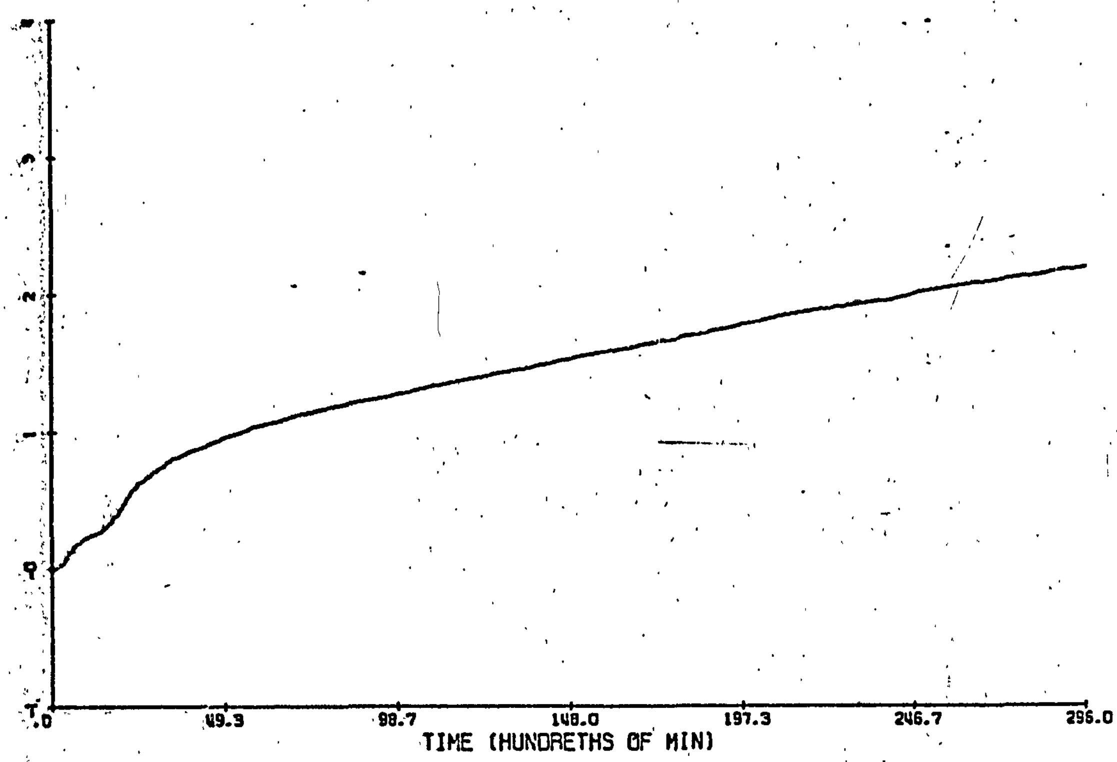
SET 24 (II-59)



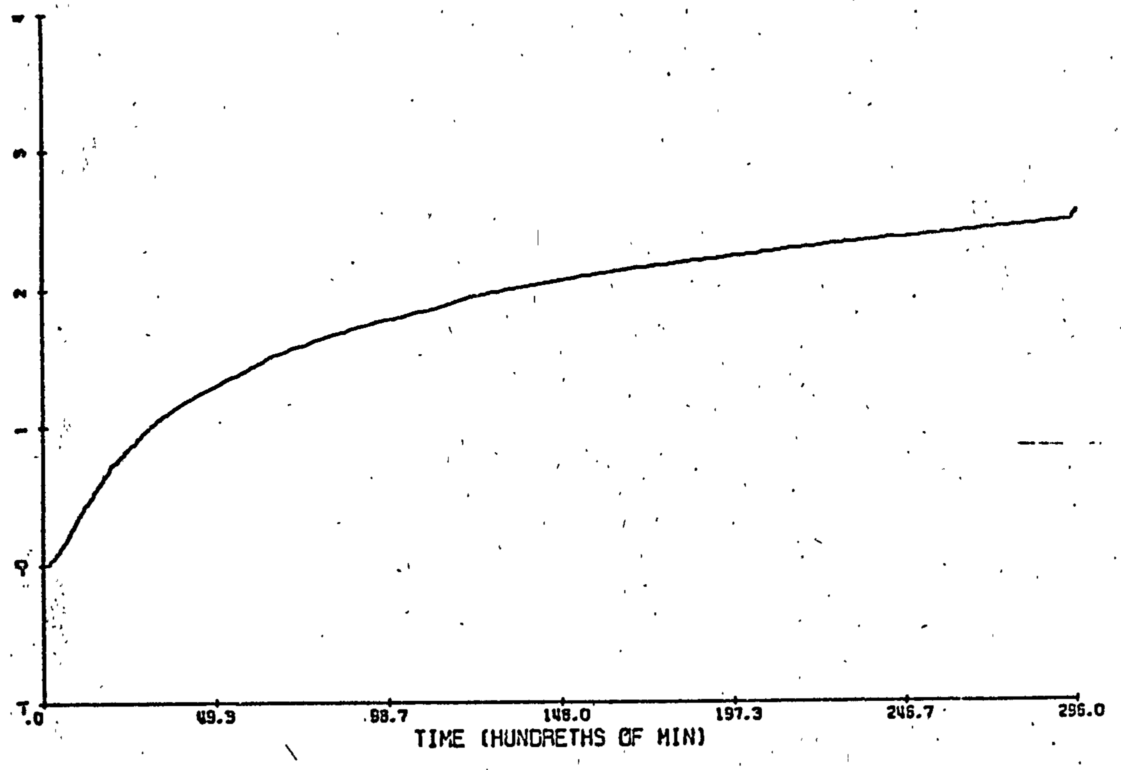
SET 25 (II-60)



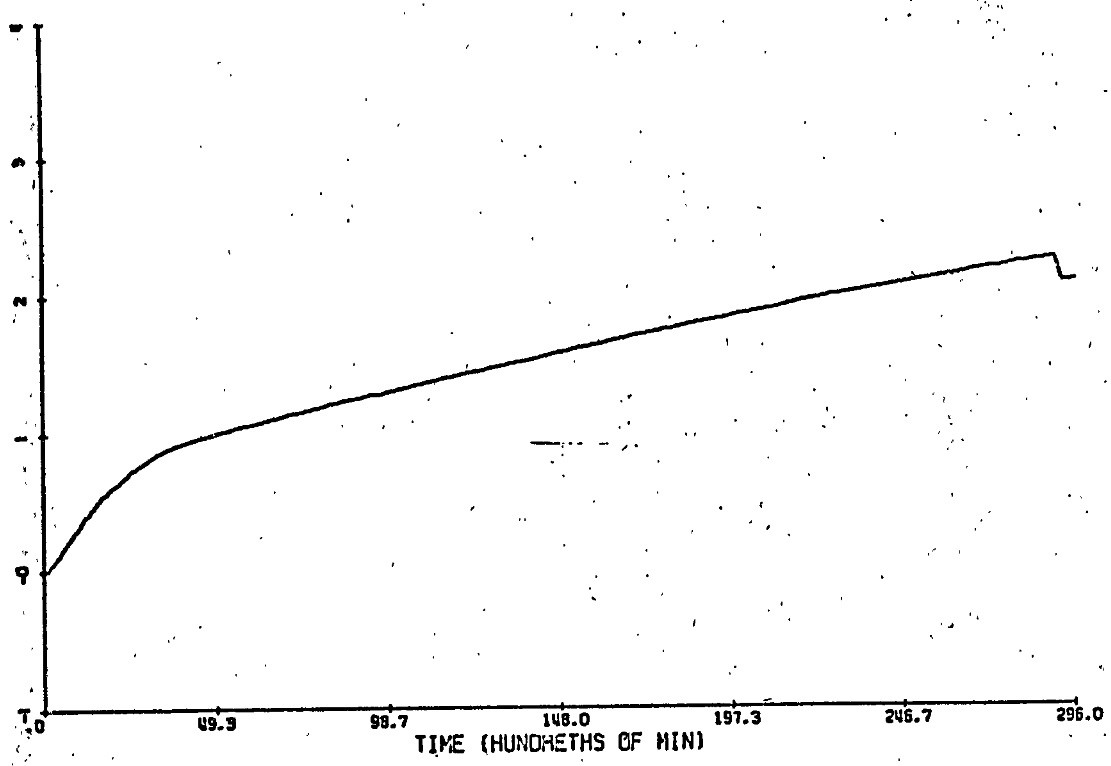
SET 26 (II-61)



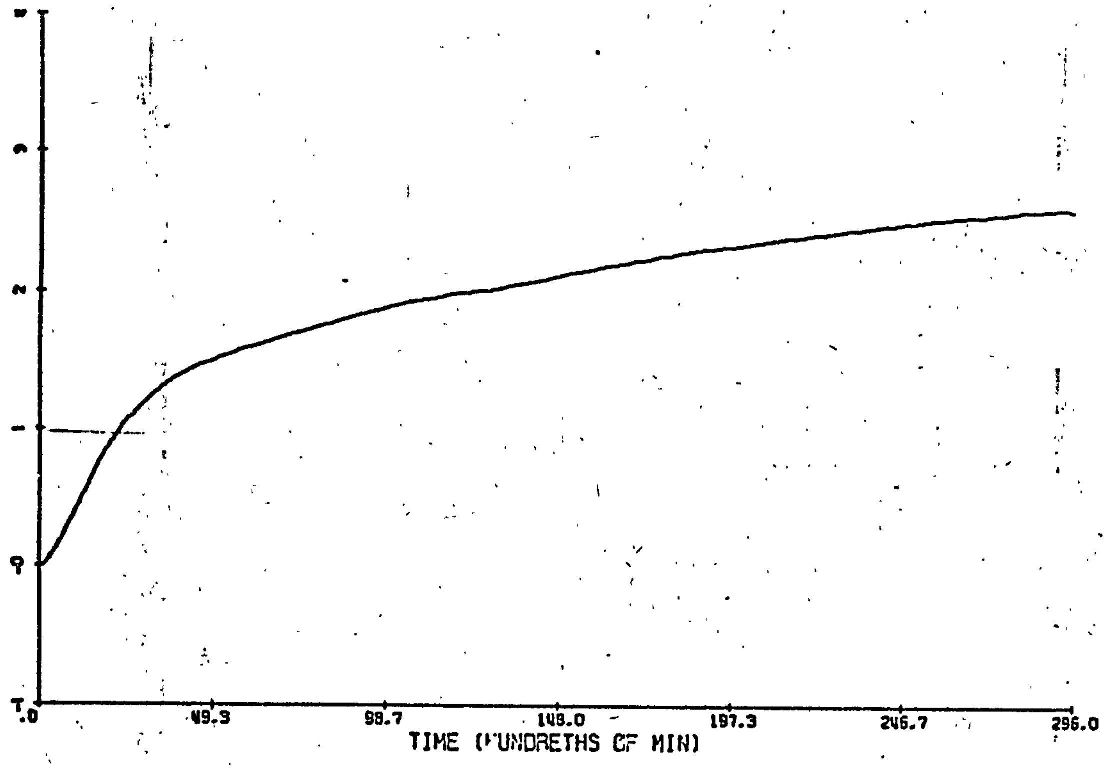
SET 27 (II-62)



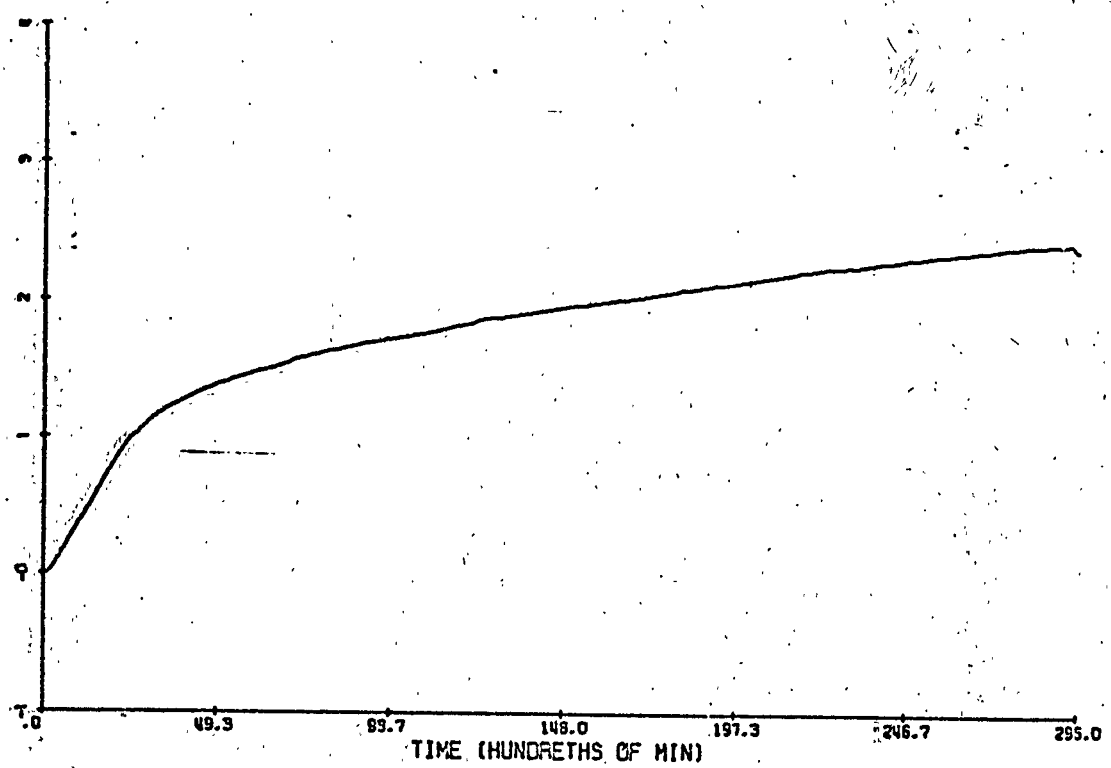
SET 28 (II-63)



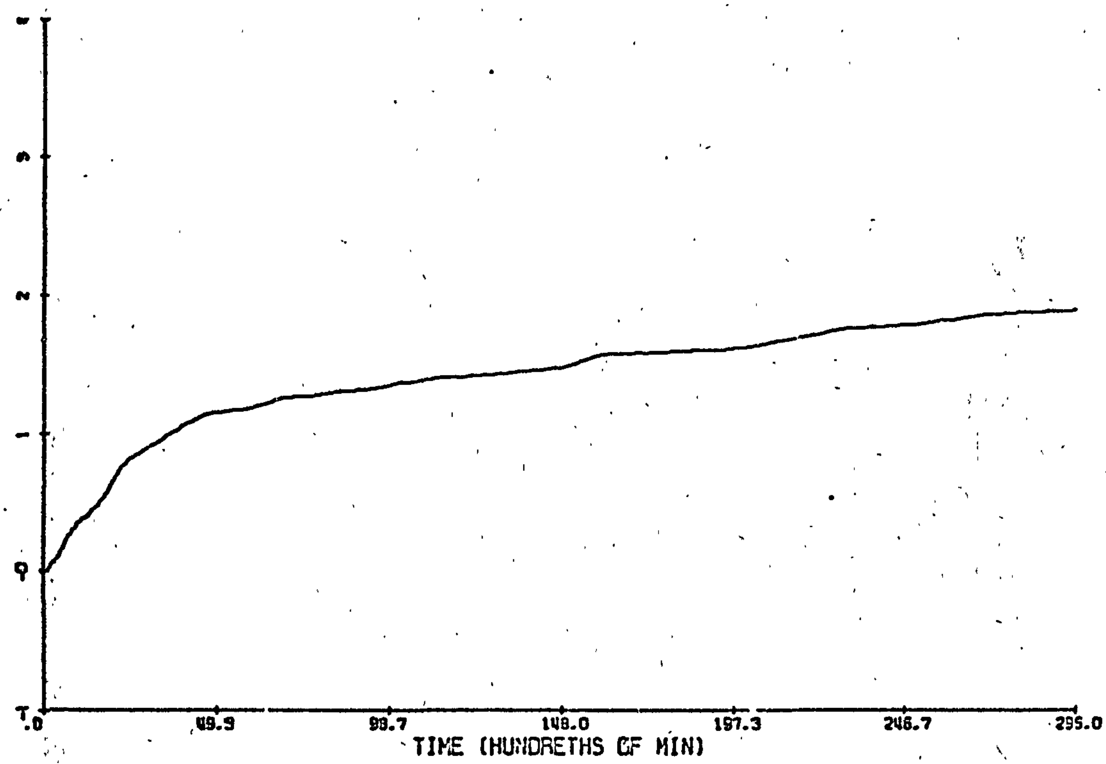
SET 29 (II-64)



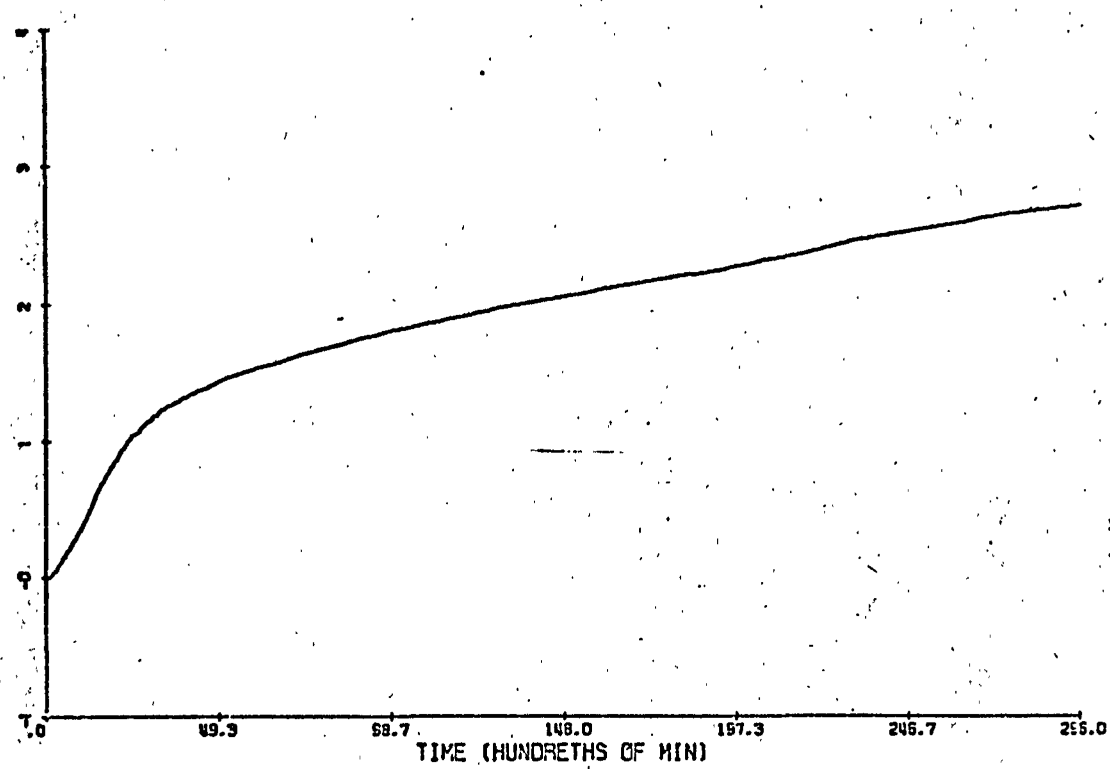
SET 30 (II-65)



SET 31 (II-66)



SET 32 (II-67)



SET 33 (II-68)

Discussion

Evening (1900 - 2100) heart rates are higher than morning (0700-1000) heart rates. Evening blood pressures are also higher. The response to tilt for these two parameters did not show a difference at the two times.

The maximal increase in heart rate during tilt was 30% higher than pre-bedrest at 0 and 2-1/2 hours post-bedrest. The diastolic pressure tended to be higher pre-tilt and increased more during tilt resulting in higher mean pressures and narrower pulse pressures following bedrest. The maximum leg volume after 15 minutes of tilt was unchanged following bedrest, but the slope of the initial change in leg volume with tilt was 50% lower at 0 and 2-1/2 hours post-bedrest than during pre-bedrest or later recovery periods. These filling curves were digitized and the filling pattern at 10 seconds, 30 seconds and 3 minutes was significantly ($p < .05$) lower at 0, 2-1/2 and 12 hours post-bedrest than during pre-bedrest. At 3, 5 and 7 days post-bedrest, the filling curves were still significantly lower at 3 minutes after tilt, but were significantly <u>higher</u> at 5, 10 and 30 seconds after tilt. The four students who were exercised during bedrest showed greater changes in the filling curve than the four who did not exercise.

The negative pressure tests showed changes in heart rate and blood pressure similar to the tilt tests, but to a lesser degree. Leg volume increases were greater following bedrest.

The venous filling curves following blood removal or water immersion are consistently lower than pretreatment values. The values obtained post flight in the Gemini series were consistently higher. These results following bed rest are dissimilar from those of either the simulations or the actual flight. The reason for the difference is not apparent.

BIBLIOGRAPHY

1. Allison, [illegible], 1967, Biomed. Sciences Instrumentation, Vol. 3, p. 309.
2. Burger, H.C., Horeman, [illegible] and Bakker, [illegible], 1959, Physics in Med. Biol. 4 165.
3. Burger, [illegible], Horeman, [illegible] and [illegible], 1959, Physics in Med. Biol. 4 175.
4. Clarke, R.S.J. and Hellon, R.F., 1957, Clin. Sci 16 103.
5. Eagan, C. J. 1961, Arctic Aeromed. Lab. [illegible] 17.
6. [illegible], 1966, J. Appl. Physiol. 21 33[illegible].
7. [illegible], S., 195[illegible], Physiol. Bohemoslov [illegible] 27[illegible].
8. [illegible], 1962, J. Appl. Physiol. 17 572.
9. [illegible], [illegible] and [illegible], 196[illegible], J. Appl. Physiol. 1[illegible] [illegible]7.
10. [illegible], 1959, Electrical Impedance Plethysmography, C. C. Thomas, Springfield, Illinois
11. [illegible], A.F., 19[illegible], Circ. Res. [illegible] 160.
12. [illegible], [illegible], 1965, [illegible] 3 175.
13. Whitney, R J., 1953 J. Physiol. 121 1.

10a. Rushmer, R.F., Baker, D.W., and Stegall, H.F., 1966 J. Appl. Physiol. 21: 554