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THE EFFECT OF BEDREST ON VARIOUS PARAMETERS OF PHYSIOLOGICAL FUNCTION

PART III. BIOINSTRUMENTATION

By F. B. Vogt, R. J. Lamonte, J. R. McConnell, T. O. Hallen,
C. Vallbona, D. Cardus, W. A. Spencer, and T. W. Holt

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ABSTRACT

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A bioinstrumentation system for collecting and recording multiple cardiovascular measurements was developed for use in tilt-table tests and for bedside monitoring during bedrest studies. Each component unit of the system is discussed in this paper.

Author

FOREWORD

This study is a part of a NASA investigation of the effect of bedrest on various parameters of physiological function. It was sponsored by NASA Manned Spacecraft Center under Contract NAS-9-1461, with Dr. Lawrence F. Dietlein, Chief, Space Medicine Branch serving as Technical Monitor.

This study was conducted in the Immobilization Study Unit of the Texas Institute for Rehabilitation and Research, the Texas Medical Center. The authors are affiliated with Baylor University College of Medicine as follows: Dr. Vogt, Department of Rehabilitation; Mr. McConnell, Department of Medicine; Mr. Hallen, Department of Rehabilitation; Dr. Vallbona, Departments of Rehabilitation, Physiology, and Pediatrics; Dr. Cardus, Departments of Rehabilitation and Physiology; and Dr. Spencer, Department of Rehabilitation. Mr. Lamonte and Mr. Holt are affiliated with the Bio-instrumentation Section - Space Medicine Branch of the Manned Spacecraft Center.

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SUMMARY

This paper describes a bioinstrumentation system developed and built in the Bioinstrumentation Section - Space Medicine Branch of the Manned Spacecraft Center for use in bedrest studies conducted at the Texas Institute for Rehabilitation and Research under Contract NAS-9-1461. The system is built primarily from commercially available component units to provide a recording and display capability for multiple physiological measurements. Included is a general discussion of the variety of sensor inputs available to the system, the signal processing and display of data for monitoring as the data are collected, and the means of coding and storing data on magnetic tape.

Author

INTRODUCTION

The bioinstrumentation system described in this paper was built to meet physiological data collection requirements in studies designed primarily to measure cardiovascular deconditioning of bedrest immobilization. It was required that there be processing units for a multitude of sensor inputs, and that measurements be made from either a central study area where tilt tests were performed, or the bedside of an individual subject during the period of recumbency. A moveable signal conditioner unit was built which could be rolled to the test area, either the bedside or tilt-table, and connected by wire to a central monitoring console at which the recording equipment was located.

DESCRIPTION OF APPARATUS

A block diagram of the component units of the bioinstrumentation system is shown in Figure 1. The output of each sensor or detecting unit is connected to a signal conditioner to provide signal amplification or detecting capability. A single channel oscilloscope can be connected to the output of each signal conditioner to allow monitoring of the signal as it is collected at the test area. These

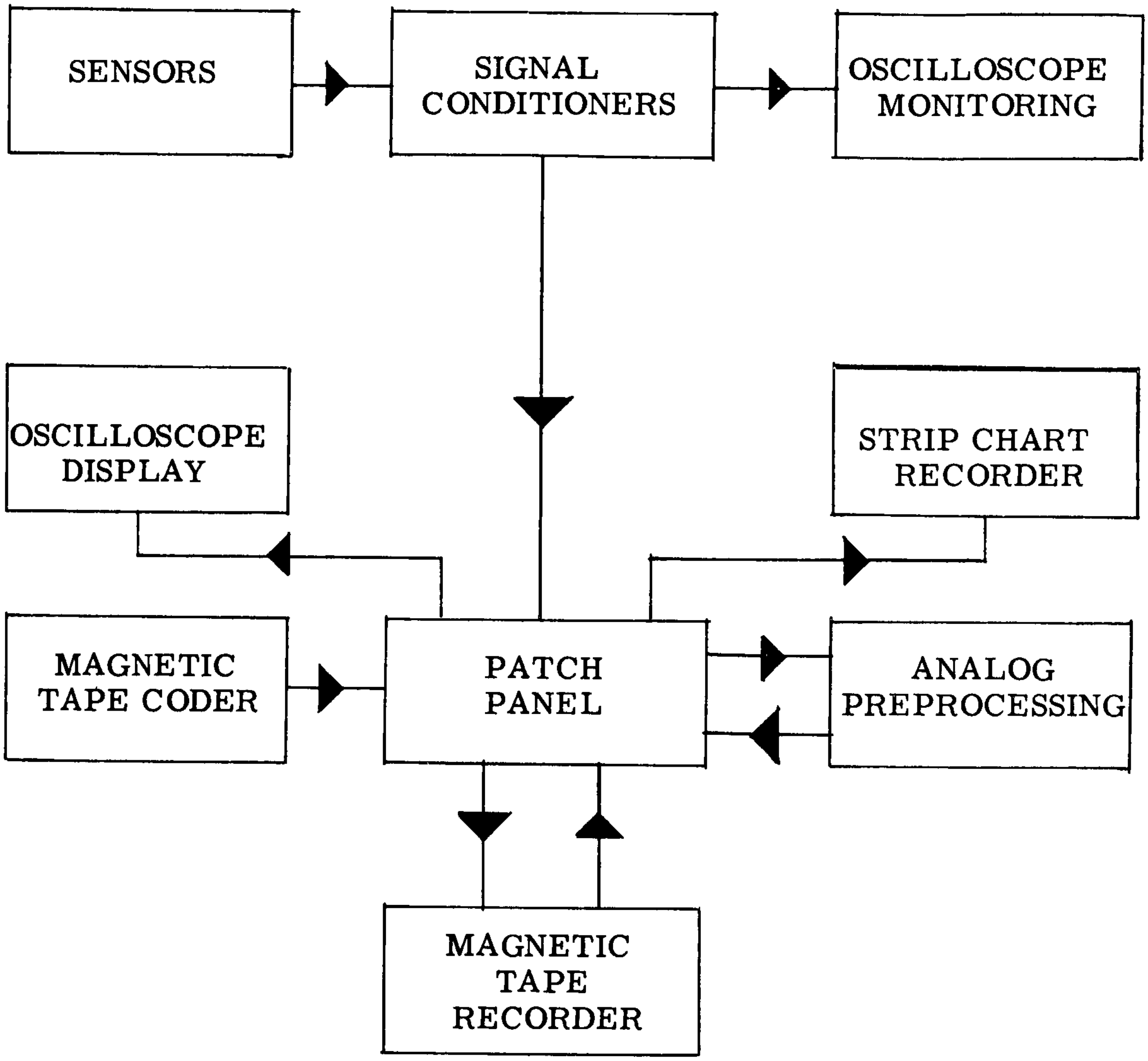

Figure 1. - Block diagram of component units of bioinstrumentation system.

units are assembled in a moveable rack which is connected by wire to a central monitoring console.

A patch panel matrix located in the central monitoring console is used for routing signal flow and for programming all control logic and signal processing to and from the tape recorder. This patch panel is used also to route signals to the oscilloscope, to the strip-chart recorder, and to and from special processing circuits such as bandpass filters or cardiotachometer units. A magnetic tape coder provides a means to identify the data collected on magnetic tape or the strip-chart recorder.

Sensors

A variety of sensors or detecting units were available for use with the system. A brief description of each sensor is presented to indicate its use in this particular experiment. Figure 2 shows a collection of these sensor units.

Intra-arterial blood pressure. The unit A in Figure 2 shows a Statham*, Type P-23-Gb, pressure transducer which is connected to the artery by a fluid-filled, flexible, No. 8 cardiac catheter, B, which is terminated in a No. 20 disposable needle, C. The transducer is used with a Sanborn** Carrier Preamplifier, Model 350-1100.

Skin electrodes. The electrocardiogram and impedance pneumogram are detected by means of skin electrodes attached to the skin with an adhesive of either Eastman*** 9-10 glue or double-backed colostomy tape. The electrodes used for this study are of the NASA type[1] and are shown at E in Figure 2. They are stainless steel wire mesh electrodes of approximately 5/8 inch diameter and are connected to the signal conditioner unit by a coaxial type single-shielded wire with the shield grounded.

Indirect blood pressure. Indirect blood pressure is obtained by a cuff-microphone technique[2], shown at F and I in Figure 2, by using an E & M Company**** cuff and inflator system which provides automatic cycling of the cuff every 30 seconds.

Carotid pulse. The carotid pulse contour is detected by means of a crystal pickup located in a plastic cup, K, as shown in Figure 2. The unit is placed on the skin over the carotid artery and held in place by a spring-loaded attachment, J, which fits around the neck.

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* Statham Instruments, Inc.; Los Angeles, California
** Sanborn Company; Waltham, Massachusetts
*** Eastman Kodak Company; Rochester, New York
**** E & M Instrument Company; Houston, Texas

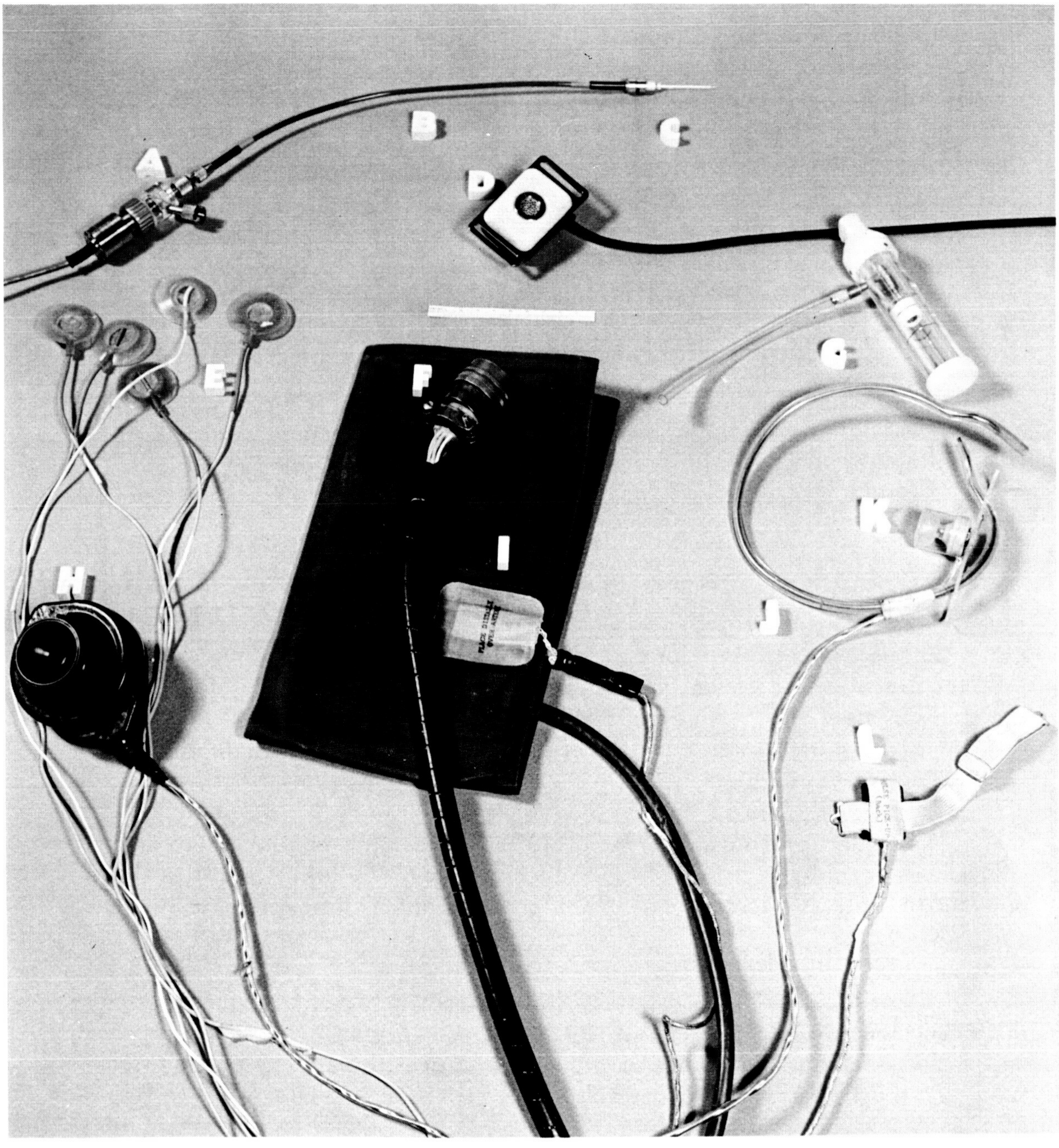

Figure 2. - Sensor inputs to bioinstrumentation system.

Radial pulse. The radial pulse contour is detected by an E & M Company* crystal pickup mounted on a firm board and covered by an elastic cloth as shown at L in Figure 2. The unit is placed on the skin over the radial artery and held in place by an elastic wrist band.

Vibrocardiogram. The precordial vibrations corresponding to the vibrocardiogram are detected by a Ling - Temco - Vought** capacitance microphone operated by a carrier system. The microphone is shown at D in Figure 2.

Phonocardiogram. The precordial vibrations corresponding to the phonocardiogram are detected by a crystal type microphone of the type shown at H of Figure 2.

Mobile Unit

The mobile unit contains the signal conditioners, amplifiers, detecting units, and accessory equipment which can be rolled to the bedside or to the tilt area. Figure 3 shows the unit at the bedside of an experimental subject.

Electrocardiogram preamplifier. A Gulf Aerospace Amplifier***, Model 702, amplifies the ECG signal level to approximately 1.5 volts output for transmission to the central monitoring console. The frequency response of the amplifier is from 0.5 to 100 cycles per second.

Impedance pneumograph. Respiration is detected by using an E & M Company* impedance pneumograph[3] connected to an E & M Company* DC amplifier which is used to drive the magnetic tape recorder.

Central Monitoring Console

The central monitoring console provides for signal routing, signal processing, magnetic tape recording, signal monitoring on an oscilloscope, and signal monitoring on a direct recorder. The console is shown in Figure 4.

Oscilloscope display. An 8 channel Sanborn****, Model 769, oscilloscope is used for simultaneous display of multiple signals. The device can be connected to either the input or output of the tape recorder. The oscilloscope provides a convenient means of monitoring signals while sensors are placed correctly to assure collection of good quality recordings.

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* E & M Instrument Company; Houston, Texas
** Ling-Temco-Vought, Inc.; Los Angeles, California
*** Gulf Aerospace Corporation; Houston, Texas
**** Sanborn Company; Waltham, Massachusetts

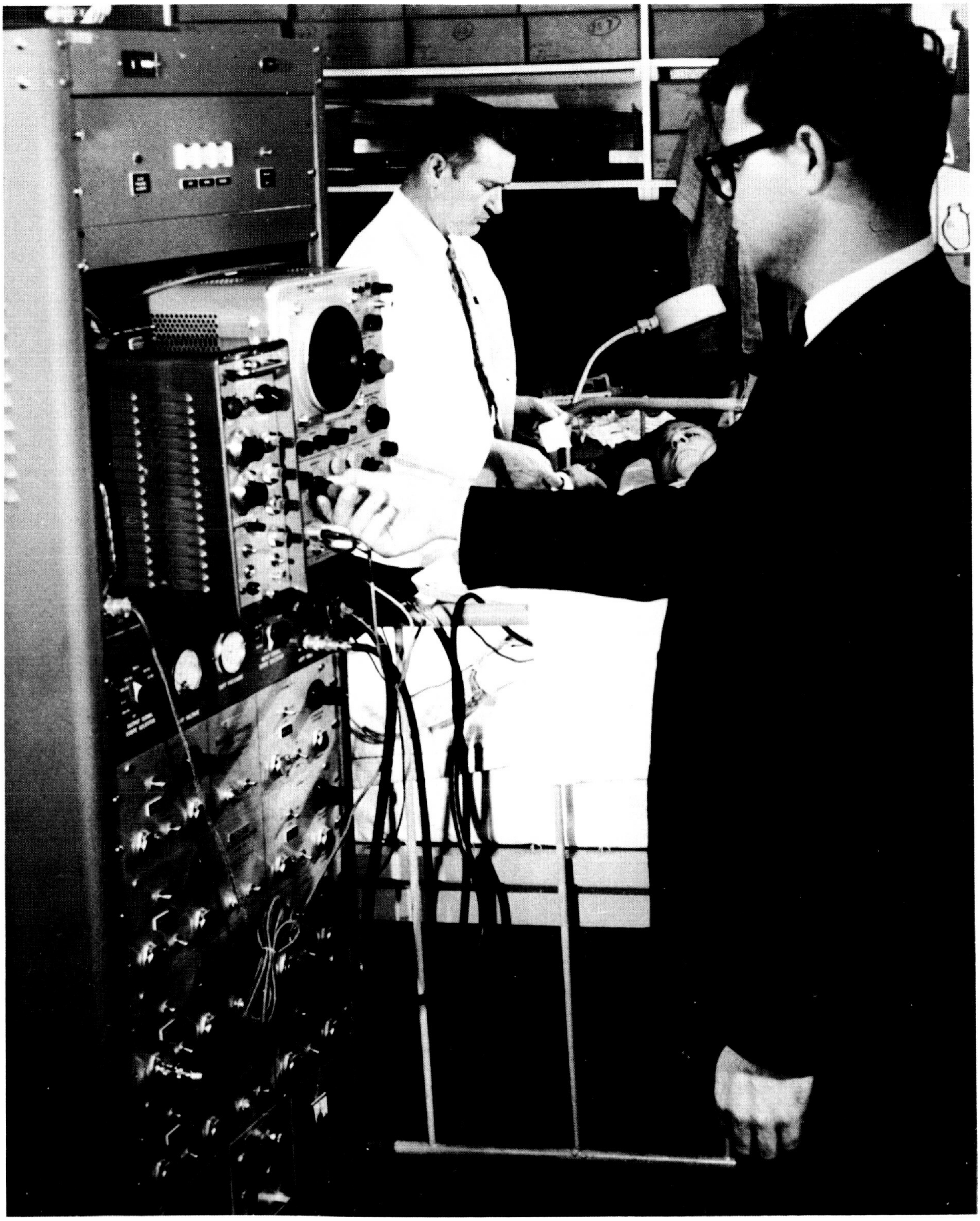

Figure 3. - Portable unit containing signal conditioners.

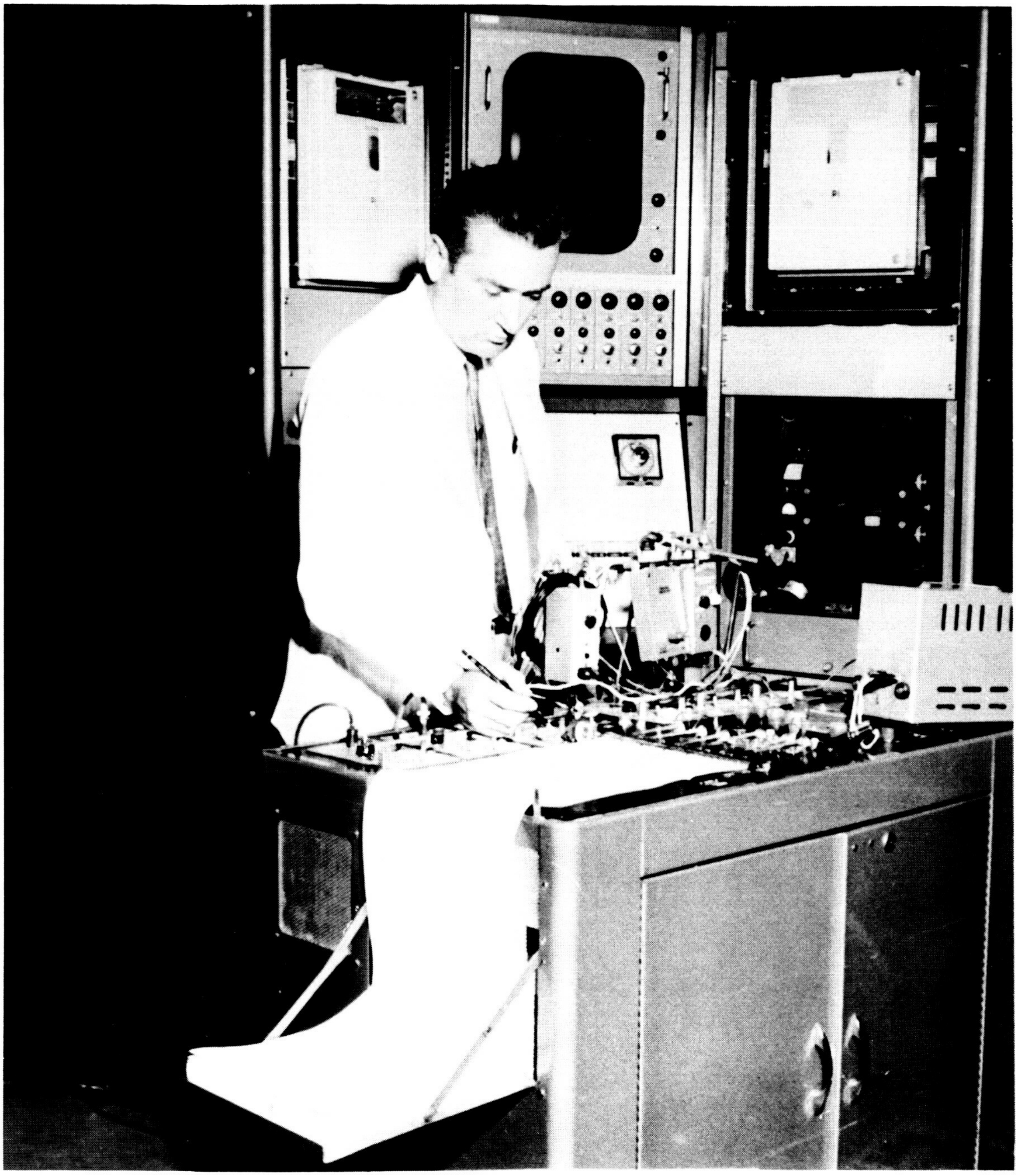

Figure 4. - Central monitoring console for bioinstrumentation system.

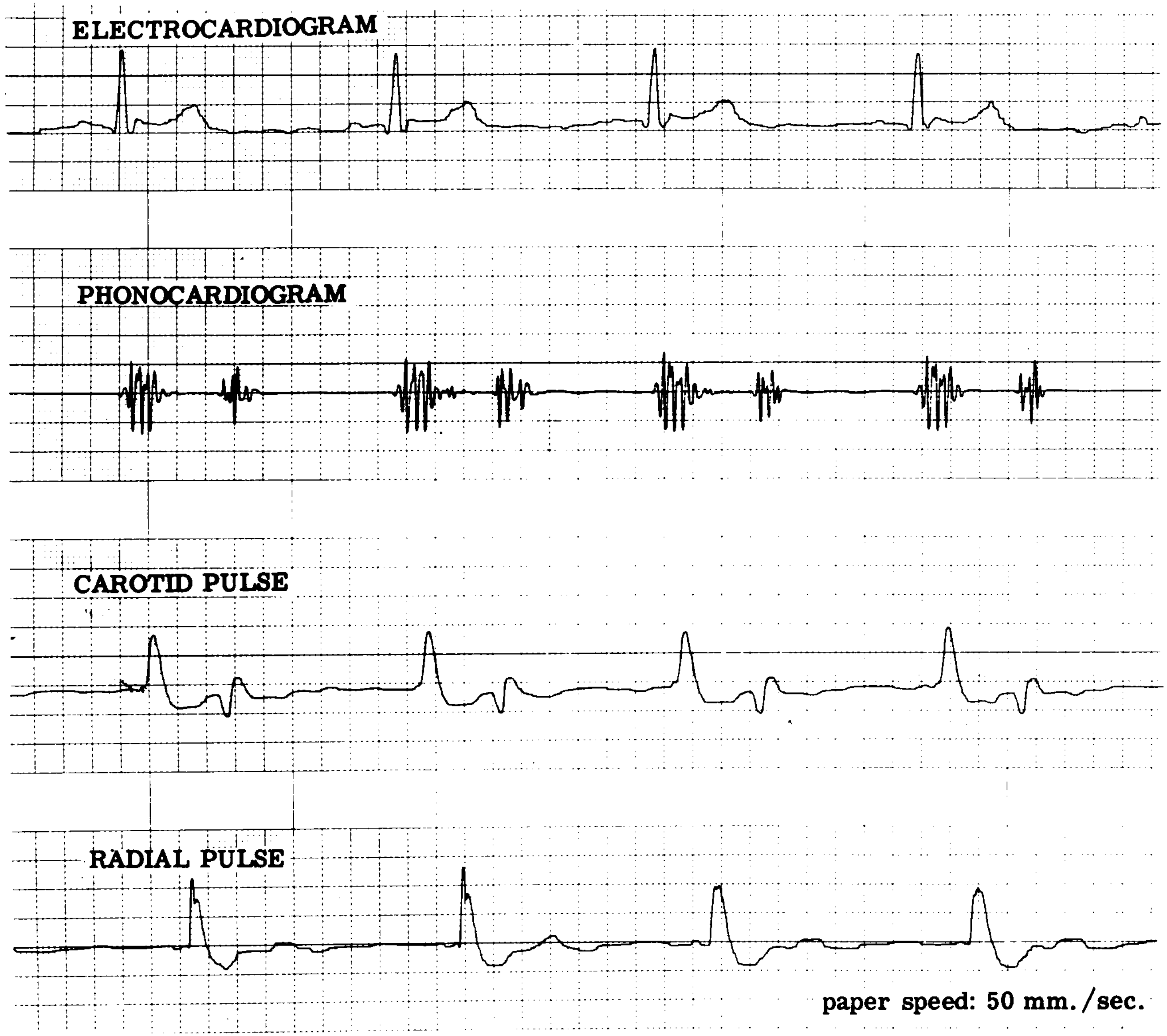

Figure 5. - Simultaneous display of the electrocardiogram, phonocardiogram, carotid pulse tracing, and radial pulse tracing.

Magnetic tape recorder. Two 7 channel Precision Instruments*, Model PS-200, tape recorders were used in the earlier part of studies at the Texas Institute for Rehabilitation and Research. Later, a single 14 channel PI 200 magnetic tape recorder provided for simultaneous recording of the multiple channels of data collected. The units were operated in the FM mode at a speed of 1 7/8 inches per second to provide a frequency response from 0 to 312 cycles per second.

Magnetic tape coder. A Cutler-Hammer, Airborne Instruments Laboratory**, Model 483, coder unit provides a signal code with a 12 bit binary code generated at a slow speed for display on the strip chart recorder and for recording on an FM channel of the tape recorder. A log of experimental events is kept to correlate with the code signals which are provided either automatically at a preset time interval, or manually for special events.

Bandpass filter. A Krohn-Hite***, Model 330-AR, bandpass filter could be inserted into any desired part of the system to provide bandpass filtering in the frequency range of 0.02 to 2000 cycles per second.

Cardiotachometer. An E & M Company**** cardiotachometer provides an RC decay curve whose amplitude represents approximately a linear relation to the R-R interval of the electrocardiogram; the longer the R-R interval, the greater the amplitude of the ramp voltage. A beat-by-beat indicator of the preceding R-R interval is thus provided in an analog form.

Strip-chart recorder. A Consolidated Electrodynamics Corporation***** optical galvanometer type recorder system is attached to the central monitoring console for playback of data. Galvanometers with an upper frequency response of 2000 cycles per second are available in this unit. A physiograph[4] system****and an Offner******, Model Type S, Dynograph, pen recorder system are used also for monitoring and playback of data.

RESULTS

A sample of the type of data collected, amplified, recorded, and played back on a strip chart recorder is shown in Figures 5 and 6. Figure 5 shows a simultaneous display of the electrocardiogram, the phonocardiogram, the carotid pulse tracing and the radial pulse tracing at a paper speed of 50 mm. per second to allow clear identification of the components of each measurement and their temporal relationships. Figure 6 shows a recording of some of the measurements obtained during a tilt test. A slow speed writeout is used to show the trend of changes in the measurements for the 5 minute period of the record.

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* Precision Instruments; San Carlos, California

** Cutler-Hammer, Airborne Instruments Division; Long Island, N.Y.

*** Krohn-Hite Corporation; Cambridge, Massachusetts

**** E & M Instrument Company; Houston, Texas

***** Consolidated Electrodynamics Corporation; Pasadena, California

****** Beckman Instruments, Inc., Offner Division; Shiller Park, Illinois

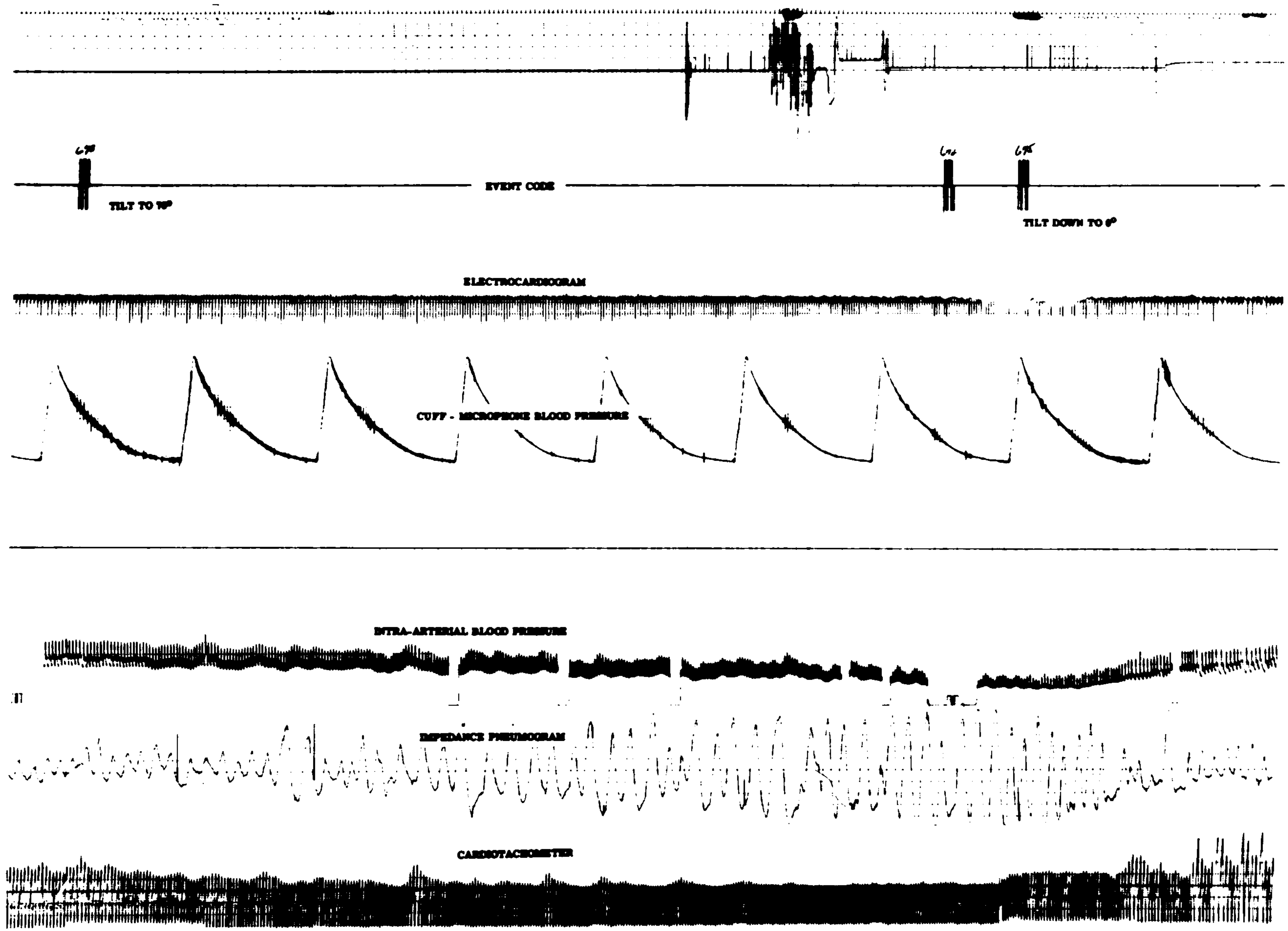

Figure 6. - Sample recording of measurements obtained during a tilt-table test.

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