NASA TECH BRIEF
Lyndon B. Johnson Space Center

NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

Vectorcardiogram

A typical biomedical system for monitoring cardiac parameters consists of several separate units, each having specific functions. Although a system with separate units has some advantage over a completely integrated system, such as easy replacement of units to add technical improvements, an integrated system is much more compact and convenient to operate.

An integrated vectorcardiogram (VCG) system was developed which incorporates the functions of all the separate units and provides easy handling and accurate performance. The VCG measures the electrocardiographic potentials to produce a precise quantitative measurement of the changes that occur in the individual's cardiac function. This measurement is accomplished by summing seven separable electrocardiographic potentials through orthogonal vectors of heart activity. These orthogonal vectors are individually conditioned by a multistage pass-band amplifier which provides three significant data outputs (vectorial).

In addition to the VCG data, the vectorcardiogram system provides two continuous readouts of heartrate: One, a three-numeral light-emitting diode (LED), digital display useful for on-the-spot monitoring of the subject's heartrate; and two, an analog output useful for keeping long-term records of the subject's heartrate activity.

The system has built in safety. Each electrode that attaches to the subject's body is protected with an electroshock protection circuit (ESP). These ESP circuits are specially designed, miniature, hybridized circuits that limit the current that can pass through the subject's body to less than 200 μA. The ESP circuits will perform to this requirement if the subject contacts a potential of up to 200 volts peak at any frequency from dc to 1000 Hz. The ESP circuit requires no power supply and therefore is always active.

The VCG was designed to make operation more convenient and practical than the previous systems. Subjects located some distance away from the system can be monitored remotely. A switch is provided for instant calibration which can be performed each time the VCG is used. Another switch is used to measure the electrode-to-skin impedance of each electrode. The three channels of VCG data are suitable for recording on a storage oscilloscope, strip chart recorder, vector scope, or magnetic tape. The subject's heartrate is automatically computed (averaged over 5 heartbeat periods) and continuously displayed on a three-numeral LED digital display. The electrodes used with the VCG are reusable and require minimal skin preparation for application. Recovery time from transients due to fluctuations in operating voltage or signal strength is less than 5 seconds.

The VCG outperforms previous systems in several parameters. Its high input impedance (greater than 40 megohms) assures accurate sensing of the electrocardiographic potentials at each electrode. Its low output impedance (less than 5 ohms) allows the VCG outputs to be displayed on a variety of equipment. All signals picked up from the body are amplified with differential amplifiers to minimize data degradation due to noise artifacts. System noise is less than 10 μV, and harmonic distortion is less than 1%. The gain of each of the three channels is individually selectable, and the phase of all channels is matched to within 3° at all the gain settings. The system also has circuitry built in to provide good high-frequency noise rejection. In addition, an automatic transient recovery circuit is included that turns on when high voltage transients occur on the input (higher than the ability of circuit to reject).

The VCG is very rugged, built to sustain extremes of temperature, pressure, humidity, shock, and vibration. It can also be used in a pure oxygen environment without danger of combustion.

(continued overleaf)

Notes:

1. Although the system was produced for the space program to monitor the astronauts, it can be modified for use in hospitals and clinics. The basic change requirement is to replace the very expensive high-reliability components with economically acceptable commercial types.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Johnson Space Center
   Code JM7
   Houston, Texas 77058
   Reference: TSP73-10401

Patent status:

NASA has decided not to apply for a patent.

Source: M. Costello of
Martin Marietta Corp.
under contract to
Johnson Space Center
(MSC-14427)