Semiannual Report IV

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1. Abstract

The purpose of this project is to develop a system design and fabrication technique for multi-channel, physiologically implantable, telemetering systems for biological measurements. The design is to be flexible, allowing several channels of information to be handled simultaneously, and to be able to telemeter a wide range of physiological signals. This report covers the period from September 1967 to February 1968.

The single channel FM/FM strain-gage transmitter implanted in a dog one year ago is still functioning with the exception, as noted in a previous semiannual report, that the strain-gage pickup apparently failed.

The four-channel transmitter system was reimplanted in January and performed satisfactorily for about two weeks. The unit was then reclaimed to replace a faulty magnetic switch circuit and a defective strain-gage pickup were replaced. The unit was implanted again with fresh batteries and it has been performing satisfactorily for about one week.

Both EKG and EEG signals were telemetered using the eight-channel transmitter test setup. The receiving and demodulating system was expanded to accept eight channels of information. An active, lowpass filter with a break point of 150 Hz was breadboarded and incorporated into the output circuitry of two of the sample and hold circuit boards in the demodulator. These filters

were used in the demodulation of the EKG and EEG signals.

Circuitry has been breadboarded that will allow the demodulator to accept variations in the transmitter ring-oscillator frequency. Consequently, the demodulator system can be used with several transmitter systems without requiring adjustment of the demodulator ring oscillator.

II. Background

See previous semiannual reports for complete explanation of the requirements and guidelines that were used for the design of this system.

During the period of this report, additions were made to the receiver and demodulator circuitry to allow for the reception of eight channels of information, including both EKG and EEG signals.

The four-channel micro-miniature standard component transmitter was implanted and operated for approximately two weeks. At this time, the battery pack failed. The transmitter was recovered and the defective power switching circuit was replaced. A defective strain-gage pickup was also replaced. The transmitter was then reimplanted and has currently functioned satisfactorily for one week.

The printed circuit board for the four-channel integrated circuit transmitter was fabricated, and preparations were made for the construction of this unit.

Signal conditioning circuitry for direct electrical signal input to the transmitter in breadboard form allowed the telemetering of a human EKG signal and the EEG signal from electrodes implanted in the brain of a cat.

III. Results of Single-Channel Transmitter Implant

The single-channel strain-gage transmitter which was implanted in a dog in January 1967 has continued to function as was described in the preceding semiannual report. There are still no signs of infection or reaction to the implanted transmitter.

IV. Four-Channel, Micro-Miniature Standard-Component Transmitter

The four-channel, micro-miniature standard-component transmitter was constructed as described in the preceding semi-annual report.

After repair of the moisture proofing, the transmitter was reimplanted in a dog on January 17. Following a post operation recovery period of one week, a twenty-four hour recording of the gastro-intestinal activity was made of the unrestrained dog. The transmitter functioned satisfactorily for about two weeks. At this time, the unit ceased to function. The transmitter was reclaimed and the problem was found to be a faulty power supply switching circuit. This circuit had allowed the batteries to discharge slowly even though the magnetic reed switch was off. A flat pack containing the new electronic switching circuitry was installed in the transmitter. This new circuitry uses the magnetic reed only as a trigger to turn the power supply on or off.

Before reencapsulating the transmitter, one of the strain-gage pickups was found to have a broken wire. This pickup was replaced with the higher sensitivity 5,000 ohm silicon strain-gages which will be used in the four-channel integrated circuit transmitter.

The transmitter was implanted again on February 26, and it is currently performing satisfactorily. Another twenty-four hour recording has been made since this last implant.

V. Four-Channel, Integrated Circuit Transmitter

See the preceding semiannual report for a description of the flat pack circuits which will be used in the construction of the four-channel integrated circuit transmitter.

The printed circuit board layout for this transmitter was completed and several tests were performed to find the best method of obtaining a double-sided circuit board with gold plated copper conductive paths. The method finally used was as follows:

1. gold plate a double-sided copper clad board
2. apply positive working photo resist, expose and develop
3. use gold stripper to remove gold from exposed areas
4. remove exposed copper with ferric chloride

A board prepared in this manner will be used in the construction of the four-channel integrated circuit transmitter. This construction will be completed in the next reporting period.

VI. Eight-Channel Transmitter System

Telemetered recordings were made of a human EKG using the eight-channel test setup as the transmitter. An EEG signal from electrodes implanted in the brain of a cat were also telemetered using this system. These recordings are shown in Figures 1 and 2. The signal conditioning circuitry used for the EKG and EEG signals is shown in Figure 3.

An active lowpass filter was designed to give a break-point at 150 Hz. This filter also yielded 40 db of rejection at the sampling frequency, 900 Hz. This active filter circuitry was added to the sample and hold circuitry to allow for demodulating and recording the EKG and EEG signals.

Circuitry was designed and breadboarded to allow the demodulator ring oscillator to be adjusted automatically to the frequency of the transmitter ring oscillator. Presently the effective range of control is sufficient to permit the use of the demodulator with different transmitters of similar design without need for manual adjustment of the demodulator circuitry.

Construction of the eight-channel transmitter system will begin as soon as the construction of the four-channel transmitter system has been completed and preliminary tests have been made on the latter's operation. Construction and testing of the four-channel I. C. transmitter should be completed by August 1968.

The test setup for the eight-channel transmitter system has also been used to evaluate the flat packs which will be used in the construction of the four channel integrated circuit transmitter.

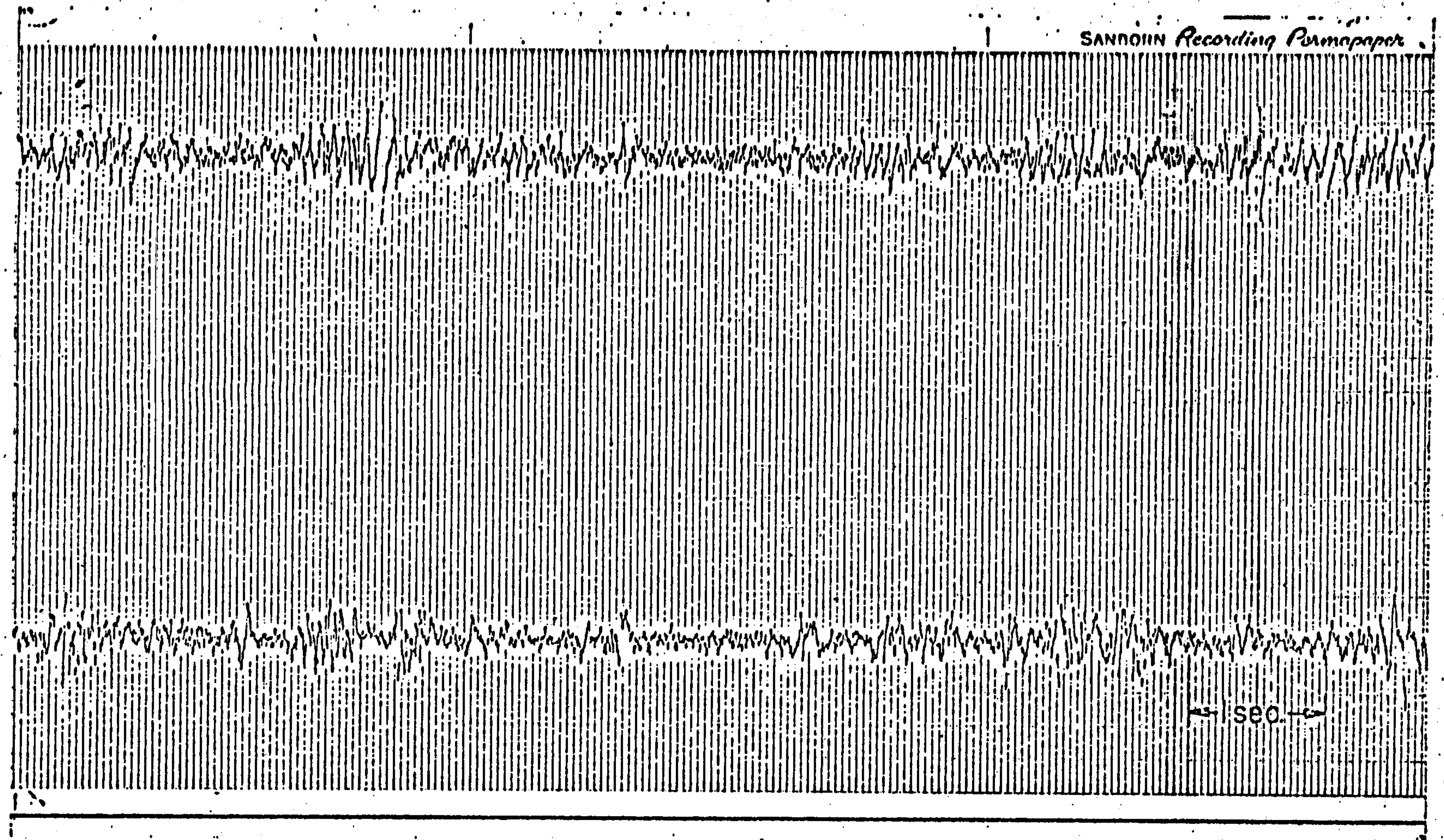

Figure 1. Telemetered EEG. Signals picked up by implanted electrodes in the brain of a cat.

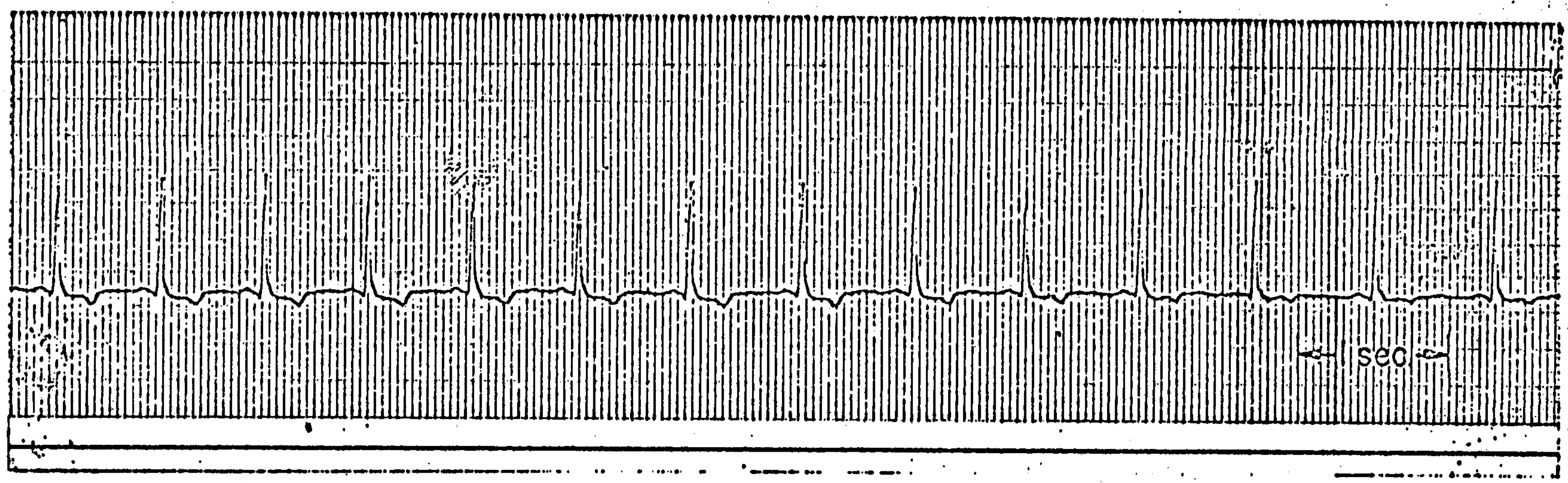

Figure 2. Telemetered EKG. Signal picked up by surface electrodes.

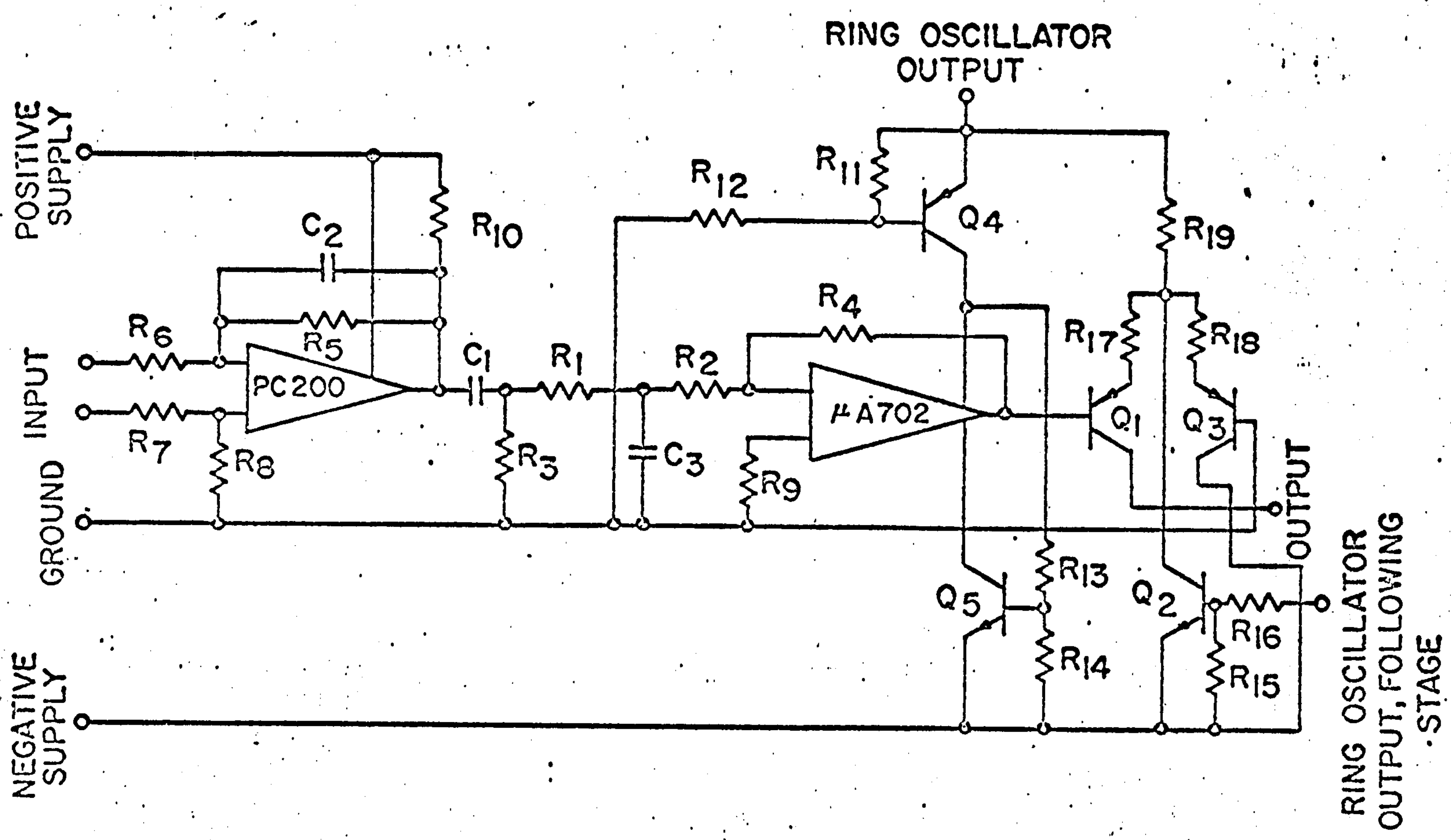

Figure 3. Electrical-signal channel