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Solid State Electronics Laboratory

Engineering Design Center

Case Western Reserve University

by

W. H. Ko
E. Yon
D. Ramseth

I. 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 1968 to February 1969.

An improved transmitter ring oscillator was developed using SCS (silicon controlled switches) as the memory elements. This circuitry allowed two ring oscillator stages to be wired in one flat pack, thereby increasing the packing density for the completed transmitter.

A four-channel strain gauge transmitter was constructed and tested using the new ring oscillator stages and improved strain gauge amplifiers. The total power drain of this transmitter is approximately 15 milliwatts (3 ma. at 4.8 volts).

A micropower heart rate and temperature telemetering system for surface monitoring is being considered using the results from NIGMS supported projects.

II. Background

A complete explanation of the requirements and guidelines that were used for the design of this system can be found in previous semiannual reports.

During the period of this report, improved circuitry was used in the construction and testing of a four-channel strain gauge transmitter. Results from tests made on the new transmitter showed improved stability, power consumption, and packaging density for the new circuitry.

III. Improved, Four Channel, Integrated Circuit Transmitter

Improved circuits were developed for the transmitter ring oscillator stages, the ring oscillator driver and the strain gauge amplifiers. These circuits allowed a reduction in power consumption from 30 mw to 15 mw and a reduction in total transmitter volume from .5 cu. in. to .25 cu. in.

Figure 1 is the schematic diagram for the new ring oscillator driver circuit. The SCS (3N84) is operated as a programmable unijunction transistor, and the timing capacitor is charged from a constant current source formed by Q_1, Q_2, and the associated resistors. Q_3 acts as a capacitance multiplier to increase the amount of time required for the SCS to discharge the capacitor. Q_4 and Q_5 act as an isolation and squaring amplifier for the pulse output from the anode gate of the SCS. External connections are provided in parallel with the emitter resistor of Q_2 to allow adjustment of the charging current into the capacitor, which in turn controls the frame width of each channel.

Figure 2 shows the schematic diagram of a flat pack containing two ring oscillator stages. Q_1 and its associated biasing network are a low value current source. This current source keeps leakage current through the capacitor from holding the SCS on and has a high enough effective resistance to allow almost all of the pulse current through the capacitor to go into the SCS. Q_3 is a clamping diode to prevent the cathode gate of the SCS from being forced too far negative by the leading edge of the preceding stage pulse. Q_2 is the switch which applies power to the appropriate signal input amplifier. The base-emitter voltage drop of Q_2 also provides biasing for Q_1.

The first ring oscillator stage is shown in Figure 3. The automatic restart circuit initially turns the SCS on, and turns it on each time the trigger line goes above the saturation voltage of the SCS. After the pulse is shifted out of the last ring oscillator stage, the trigger line tries to rise to the supply voltage. The automatic restart circuit then switches the first stage on again to start a new cycle. Since this circuit requires only two chips, a tapped resistor, and an NPN transistor, and the input coupling capacitor is no longer necessary, the automatic restart circuit is included in the flat pack with the first two ring oscillator stages.

The modified strain gauge amplifier is shown in Figure 4. This circuit has reduced power drain, and the output was modified to accommodate switching the negative supply instead of the positive supply voltage. Q_5 is a pass transistor which cuts off the output as soon as the next ring oscillator stage is turned on. Q_6 provides a level shift and additional isolation between the differential amplifier and the output to the modulator circuit.

In order to minimize the number of PNP transistors necessary in the transmitter, and yet keep the modulation referenced to the negative supply line, a modulator and sync generator circuit was designed to accept the outputs of the modified strain gauge amplifiers and apply them along with a sync and AGC pulse to the r.f. oscillator unit. The schematic diagram for this circuit is shown in Figure 5.

The same r.f. oscillator circuit was used as was used in previous designs.

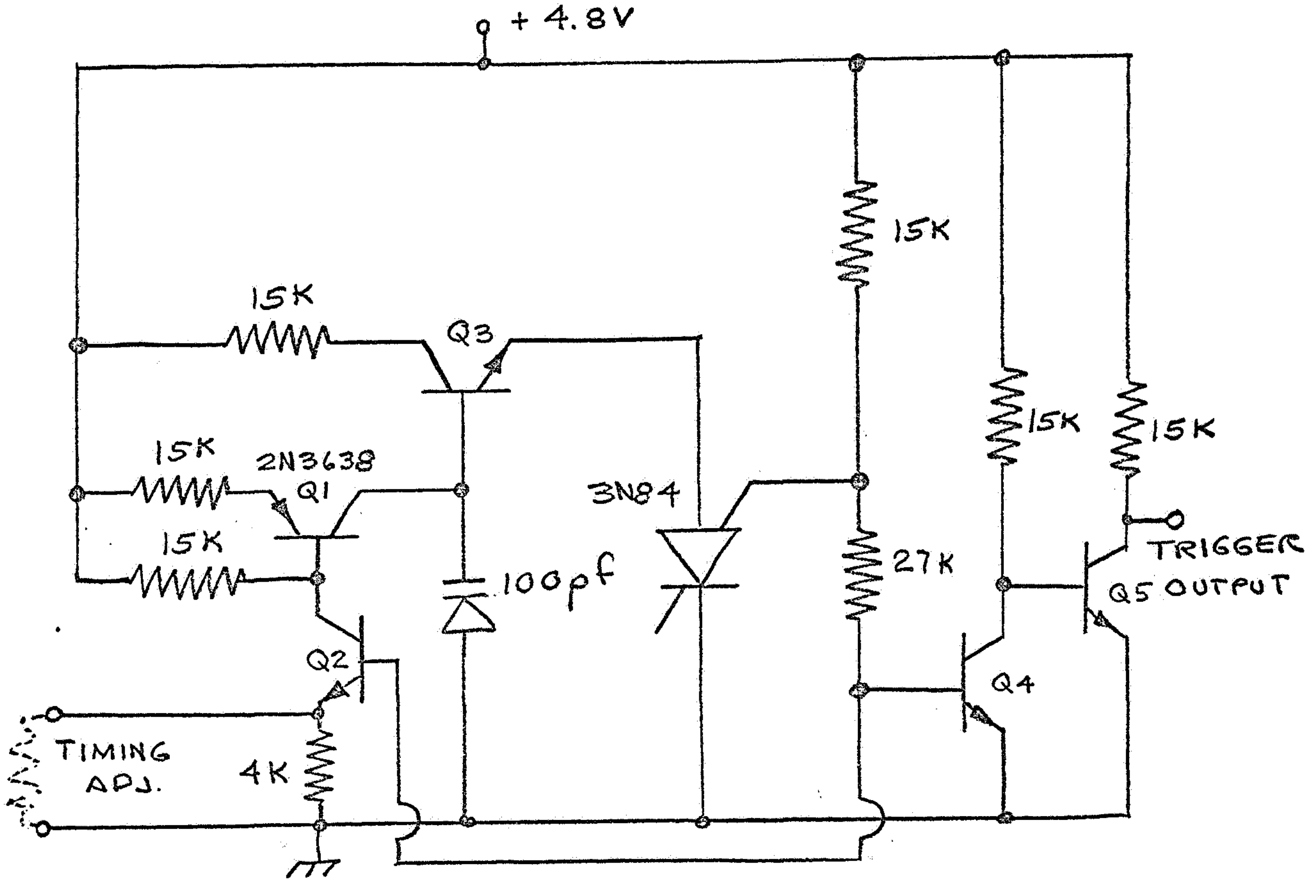
All of the above circuits were wired in 16 lead flat packs with all of the leads necessary for interconnection brought out on one side of the flat pack. The construction of the transmitter progressed rapidly with no major difficulties developing. Figure 6 shows a photograph of the completed transmitter and a printed circuit board identical to the one on which the transmitter was constructed. A scale is included for size comparison. The printed circuit board is approximately 3/4" x 5/8" and the height of the finished transmitter is 3/8".

IV. Other Transmitters

Both the four-channel discrete component transmitter and a single channel FM/FM transmitter have ceased to function. No further information is available about these units at this time since the units are still implanted. Further information will be available when the transmitters are recovered and tested.

V. Micropower Heart Rate Monitoring System using Insulated Electrodes

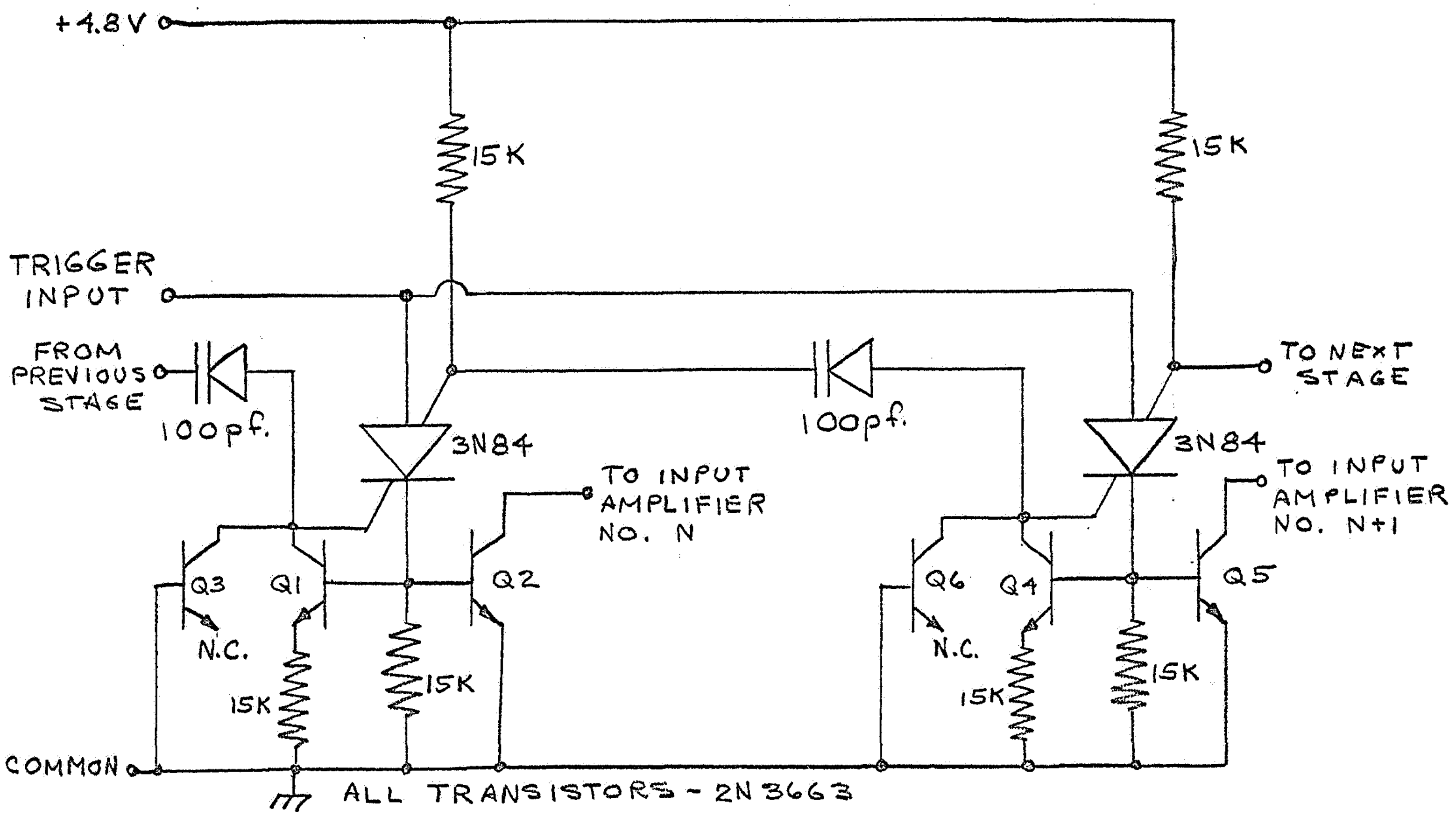
Using the micropower circuit design and hybrid integrated circuit techniques developed under this research grant and other supports from NIGMS, a micropower heart rate monitoring system using insulated electrodes packaged with electronic circuits in a single piece was initiated. The two insulated electrodes will be packaged on the bottom of the package with electronic circuits and batteries potted inside. A conceptual picture is as shown in Figure 7.



ALL NPN's 2N3663

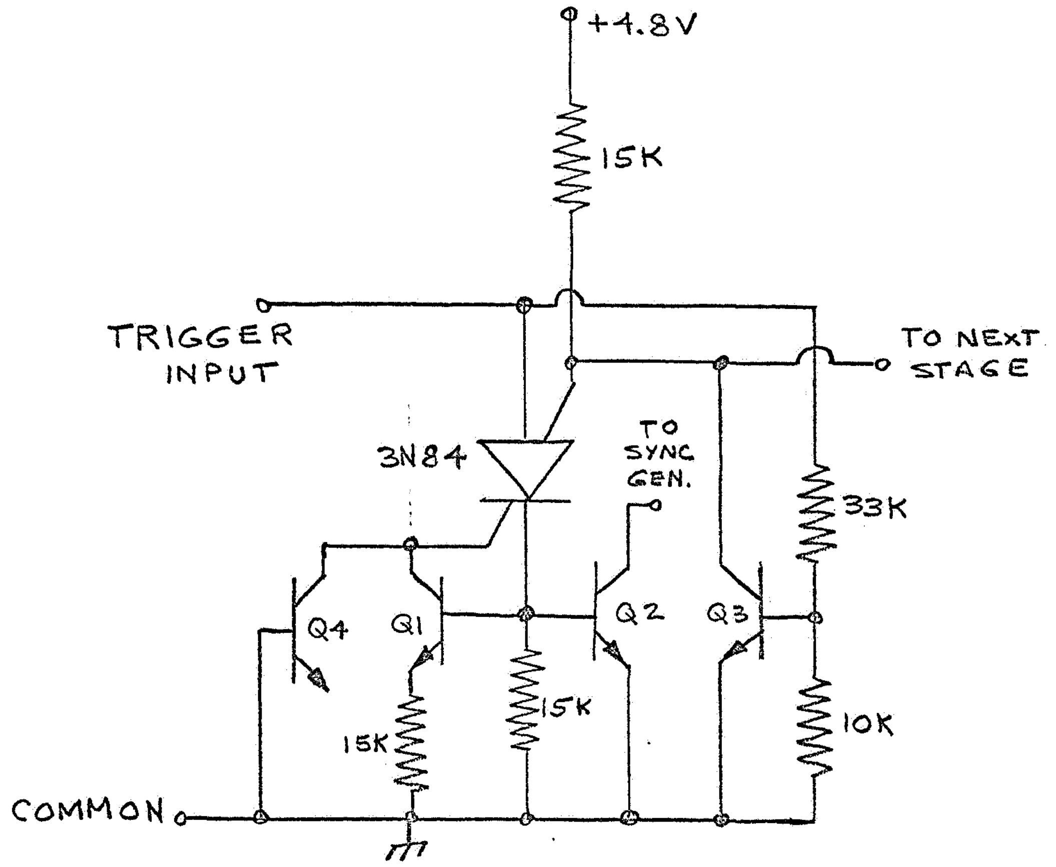
RING OSCILLATOR DRIVER CIRCUIT

FIGURE 1



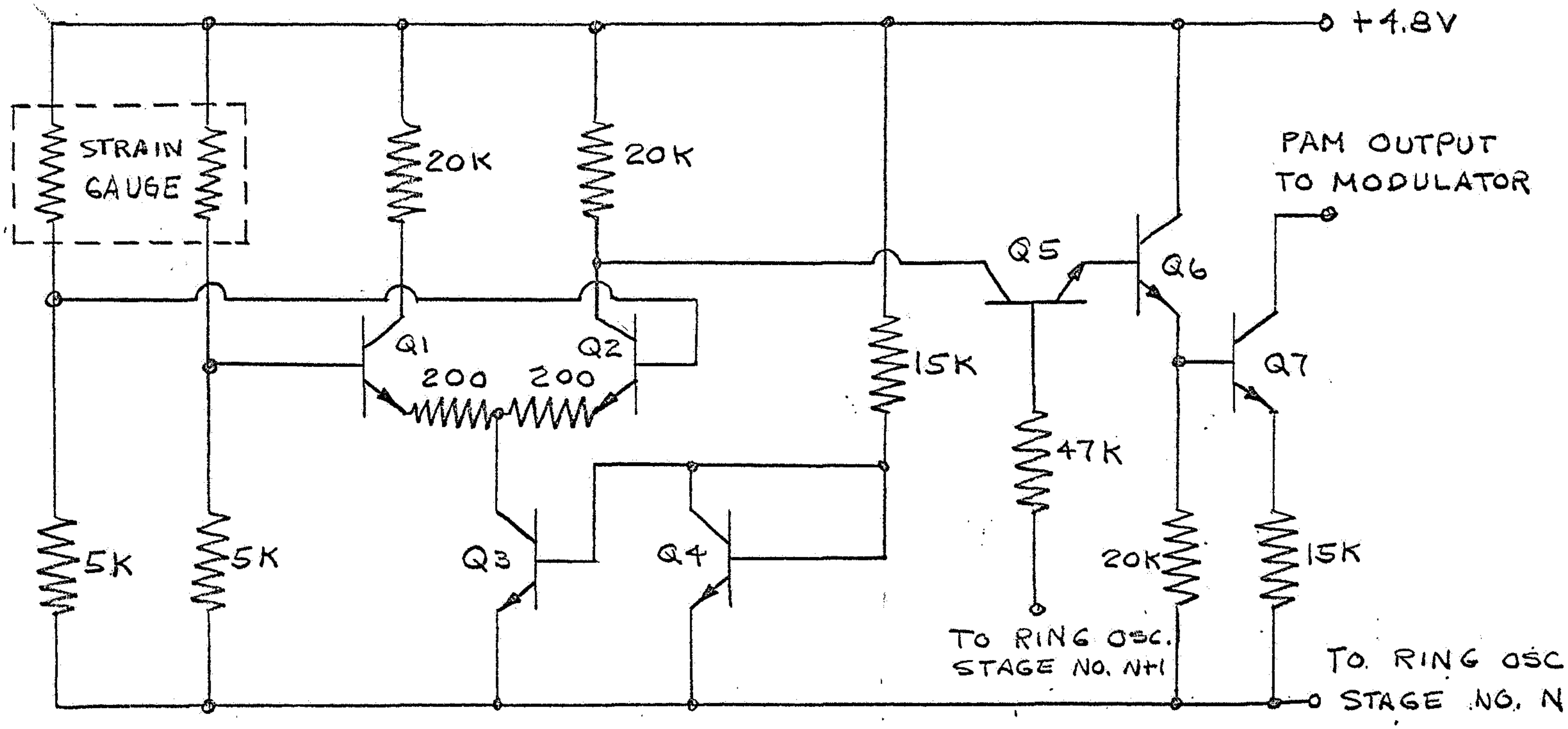
TWO RING OSCILLATOR STAGE CIRCUITS

FIGURE 2



FIRST RING OSCILLATOR STAGE
WITH AUTOMATIC RESTART CIRCUIT

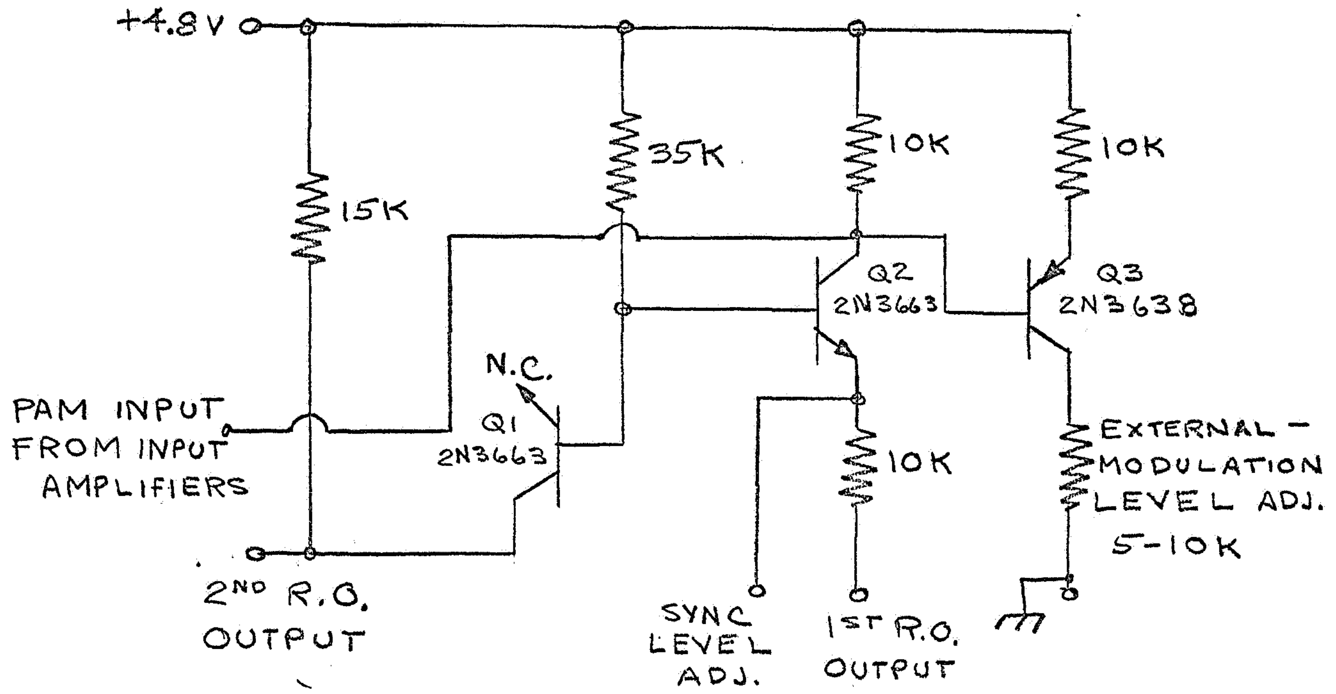
FIGURE 3



ALL TRANSISTORS 2N3663

STRAIN GAUGE INPUT AMPLIFIER CIRCUIT

FIGURE 4



MODULATOR AND SYNC LEVEL GENERATOR CIRCUIT

FIGURE 5

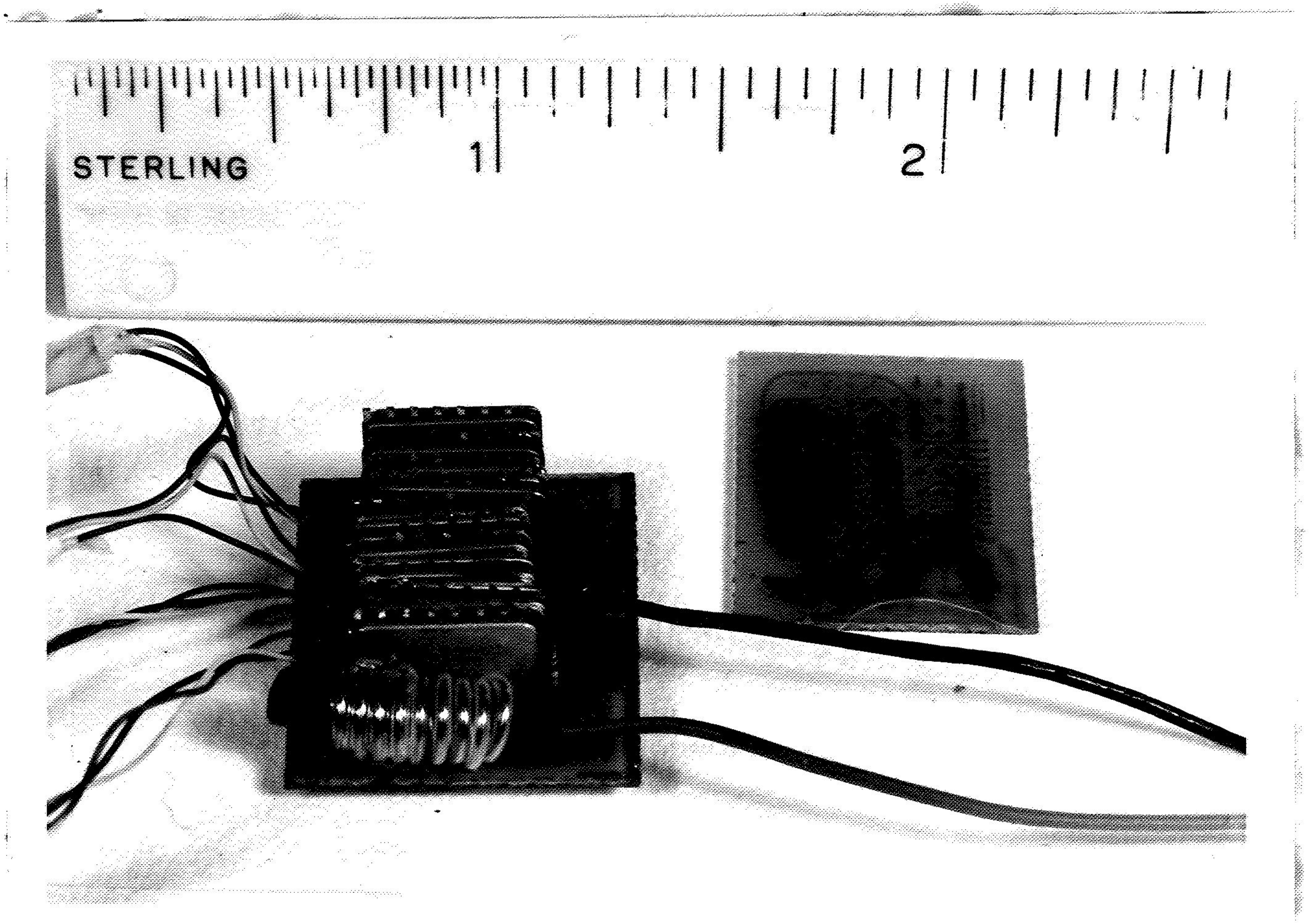


Figure 6 Four Channel Stain Gauge Transmitter and Printed Circuit Board

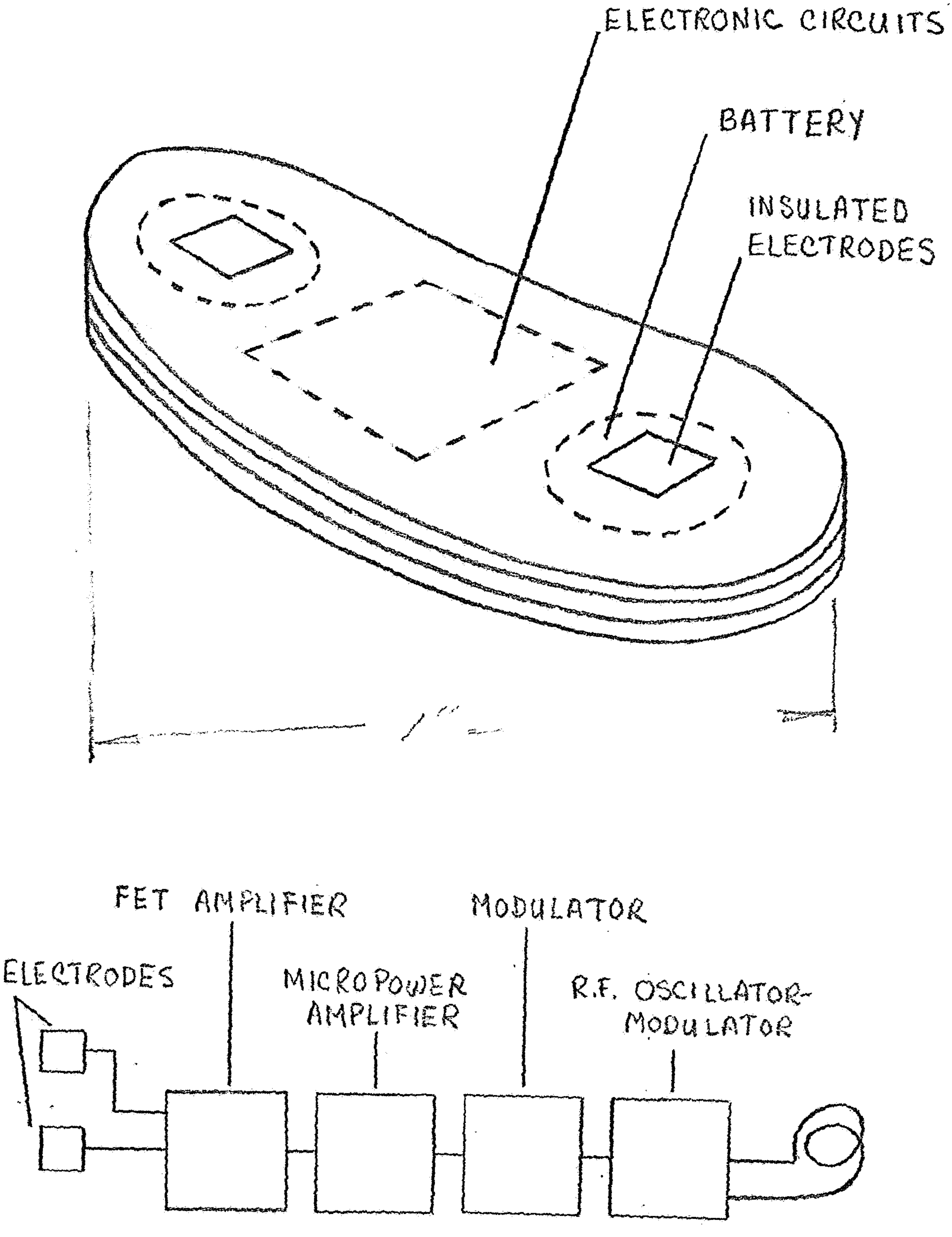


Figure 7 The conceptual picture and block diagram of the heart rate monitoring system.