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DEVELOPMENT OF A LOW LEVEL SOUNDING SYSTEM

by

Raymond G. Ramirez
Robert J. Betz, James R. Cosby

The Bendix Corporation
Environmental Science Division
1400 Taylor Avenue
Baltimore, Maryland 21204

Contract No. AF19(628)-5117

Project No. 6682
Task No. 668201
Work Unit No. N/A

FINAL REPORT

Period Covered: February, 1966 through July, 1968

May, 1969

Contract Monitor: Gordon J. Canning, Jr., Capt., USAF
Aerospace Instrumentation Laboratory

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ABSTRACT

The results of a program to develop, design and fabricate a low-level telemetry subsystem to operate in the lower 1,000 meters of the atmosphere and compatibly interface with a modified Rawin Set AN/GMD-4 is presented herein. The subsystem has been designed to provide a detailed analysis of the temperature, humidity and wind structure of the lower atmosphere, employing standard radiosonde sensors and transponder techniques, and consideration has been given for the use of modular construction to facilitate updating as new techniques and equipments are developed. The telemetry device is adaptable for use as a balloonsonde designed for data acquisition on ascent, or as a rocketsonde providing data acquisition on descent, upon deployment of a parachute and a sensor mounting package.

Utilized in the design of this telemetry device are: a solid state and integrated circuit commutator, with a sampling rate of one cycle per second, and a solid state microwave transmitter. The relatively high sampling rate of one every second provides a more complete synopsis of the atmospheric construction than have previous balloon borne or rocket sounding telemetry devices.

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INTRODUCTION

This report includes the development of a low level radiosonde instrument package containing solid state devices consistent with the state-of-the-art technology. Also included is the detailed design approach used in the development of a modification package for the AN/GMD-4 Meteorological Data Processor to make the GMD subsystem operation compatible with the low level radiosonde data sampling and transmission rate.

This report covers the step by step procedure and the analysis of each circuit implemented in the design, includes a detailed description of the various qualifying tests at the circuit and completed unit levels and discusses the results of USAF/Bendix flight tests conducted at Cape Kennedy in June and October of 1967, at L. G. Hanscom Field in April of 1968, and at Vandenberg AFB in June of 1968.

SCIENTIFIC CONTRIBUTORS

Those scientists and engineers who have contributed and their areas of contribution to the research reported on in this document are discussed below:

1. R. G. Ramirez - Engineer

Mr. Ramirez was responsible for reviewing the original design, researching the problem areas and initiating corrective action, building of the prototype units, flight testing these units at Cape Kennedy, employing any necessary redesign resulting from flight testing and the writing and assembling of the necessary data incorporated in this report.

2. R. J. Betz - Engineer

Mr. Betz performed the circuit design and assembled the AN/GMD-4 modification package, had the responsibility for implementing the modification to the GMD-4 at Cape Kennedy and at L. G. Hanscom Field. Mr. Betz also assisted in the design and analysis of the solid state commutator switching device, and contributed to the write up of this report.

3. J. R. Cosby - Engineer

Mr. Cosby was the Program Manager on this development program, with the responsibility for defining and implementing the original design concept. He provided considerable technical assistance in the basic design of the hybrid unit throughout the program.

4. K. Kidd - Engineer

Mr. Kidd as the Project Engineer performed much of the basic research required on this program. He provided technical direction to his subordinate engineers and technicians throughout the development and testing phases on the breadboard units up to the in-house Bendix prototype manufacturing and testing phase.

5. F. H. Stein - Engineer

Mr. Stein contributed to the design of the receiver, the receiving antenna, the low frequency clock, the solid state commutator and the blocking oscillator. He participated in the breadboard build up and testing phases implementing his design.

6. R. Erler - Engineer

Mr. Erler performed much of the basic design of the receiver, the 82 KC amplifier design and assisted in the design of the low frequency clock and the solid state commutator. He also participated in the breadboarding and testing of these circuits.

TECHNICAL

A. GENERAL

The transponder portion of the radiosonde consists of the 403 MHz receiver, 2 stages of 81.94 KC amplification, an emitter follower isolation stage, and a 1.68 GHz solid state transmitter. The receiver demodulates the 81.94 KC ranging signal, provides the driving voltage to the 81.94 KC amplifiers, the amplifiers drive into a Hi-input impedance emitter follower whose output frequency modulates the 1.68 GHz solid state transmitter, thus retransmitting the ranging signal back to the GMD ground station.

The meteorological data is sampled at the rate of once per second, and is transmitted by pulse modulating (FM) the 1.68 GHz transmitter with pulse rates ranging from 200 to 4,000 cycles per second.

Meteorological data commutation is provided by a four (4) channel solid state commutator. The solid state commutator consists of a four (4) Hertz clock (astable multivibrator), a sequencer (provides gating) and appropriate switching transistors. Each data channel pulse modulates the transmitter for a time period of 230 milliseconds with a 20 millisecond blanking time period (off time) provided between data channels. Sequence identification for the commutator is reference, temperature, humidity, and spare channel.

B. BATTERY POWER

Power requirements of the transmitter, receiver, transistor circuits, micrologic circuits and the meteorological pulse generator, commutator and blocking oscillator circuits dictated the size and voltage of the batteries that were required. The RCA solid state transmitter (S-190) requires a -18 V @ approximately 100 ma supply, the 403 MHz receiver and associated 81.94 KC transistor circuitry was designed to operate at -12 V while the met pulse generator, and the micrologic and associated audio transistor circuitry was designed to operate at -4.5 Volts. Total current drains at each voltage are, -18V @ 100 ma max., -12 V @ 15 ma max., and -4.5 V @ 100 ma max.

Consideration was given to several types of batteries and the field was narrowed down to the size AA alkaline cells and the cuprous-chloride water-activated battery. Both batteries were capable of supplying at least 250 ma over a thirty minute period.

The alkaline batteries, after additional testing were found to provide no margin of safety. The time required to baseline and launch a balloon-sonde is approximately 20 minutes, and for the rocketsonde about 30 minutes; therefore, the use of the alkaline battery was abandoned.

The cuprous-chloride water-activated battery manufactured by the Ray-O-Vac Corporation was selected. This unit will supply full power approximately ten minutes after being soaked in fresh water for two to three minutes. The manufacturer specified this unit's capability as 250 ma for approximately sixty minutes. Under test, at the Bendix facility, and during flight tests at Cape Kennedy, the unit was found to exceed this power capability. During flight testing at the Cape, one radiosonde (balloon) was released and met data and ranging information were received for about three hours before fading. Under bench test conditions a battery was activated and allowed to lay for seven hours; the batteries were then put in a sonde under full load, voltage measurements were made and found to still be at their nominal values. From these tests the cuprous-chloride batteries were found to provide at least a 300 to 400 percent safety margin. The weight of the battery is approximately 61 grams activated. The only hardware necessary for connecting this battery is the standard widely used two-terminal snap-on type. This was an additional weight saving factor. In addition to the foregoing, the cuprous-chloride cost per cell was about 20% less than that for the alkaline cell.

See Figures 1 and 2 for a comparison of battery voltage measurement made under full load during laboratory tests.

C. MECHANICAL DESIGN

1. Rocketsonde

The packaging of the instrument was made to specifically fit into the Texaco "Cricket Rocket" which has a modified ejection type nose section. All electronic subassemblies of the instrument except the transmitter are on printed circuit boards. The weight of the electronic package including the activated battery is 645 grams (approximately 1.42 pounds). The electronic package consists of the 1.68 GHz transmitter, the 403 MHz receiver, the 81.94 KHz amplifiers, the power source, the solid state commutator, the met data pulse generator and the associated frame and mounting hardware. Refer to Figure 3 for picture of instrument at various stages during the assembly process.

The electronics package fits into the Texaco "Cricket Rocket," and makes up the nose or payload package. The parachute compartment attaches to the rear of the payload and houses both the parachute, the 15 second timer and the rocketsonde sensor package. The 15 second timer deploys the parachute approximately 15 seconds after firing of the rocket motor. This is the calculated time for the rocket after firing to reach apogee at which time zero G forces are encountered. The parachute is attached just aft of center of the whole assembly and provides a descent of the package with a

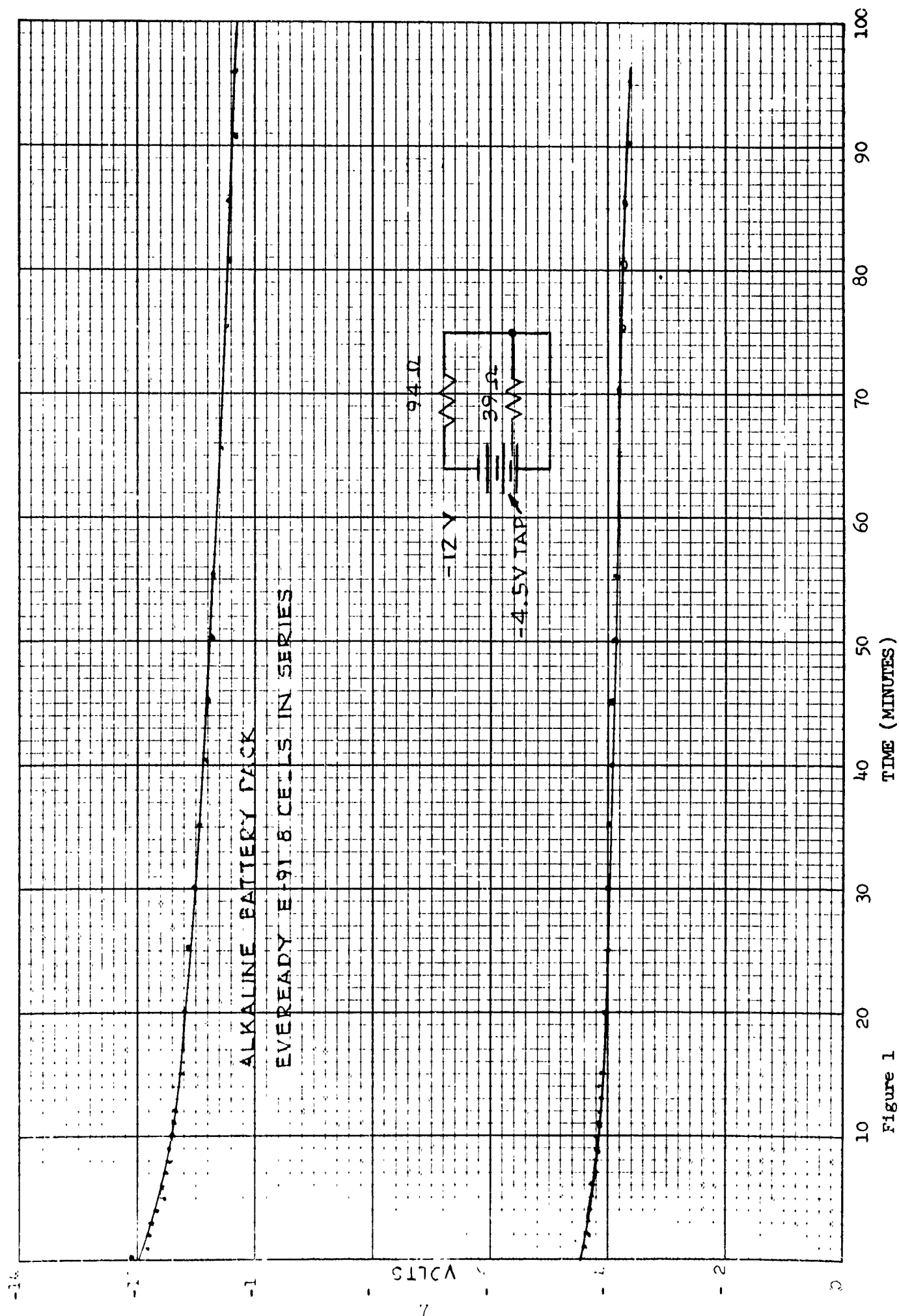


Figure 1

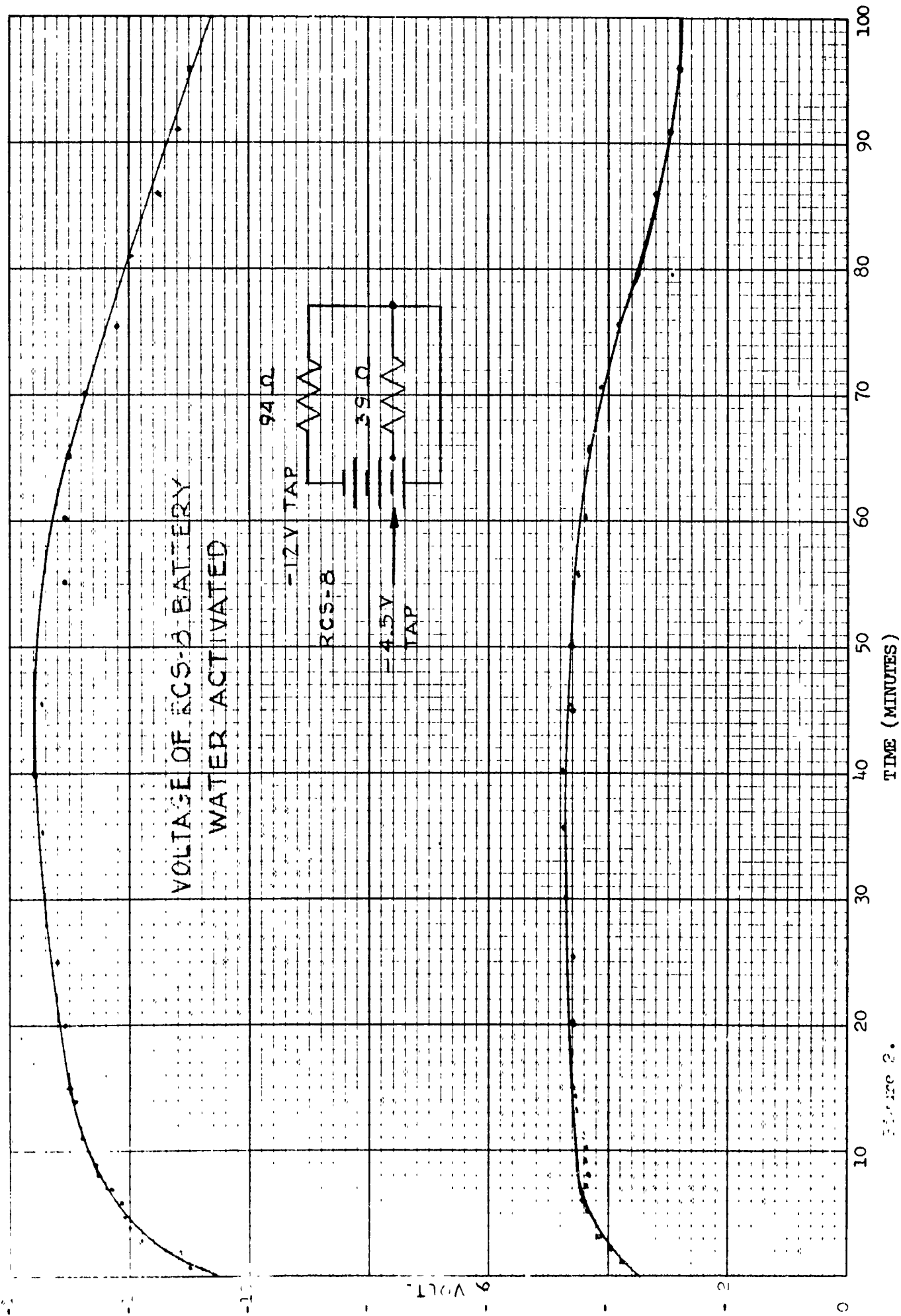


Figure 2.

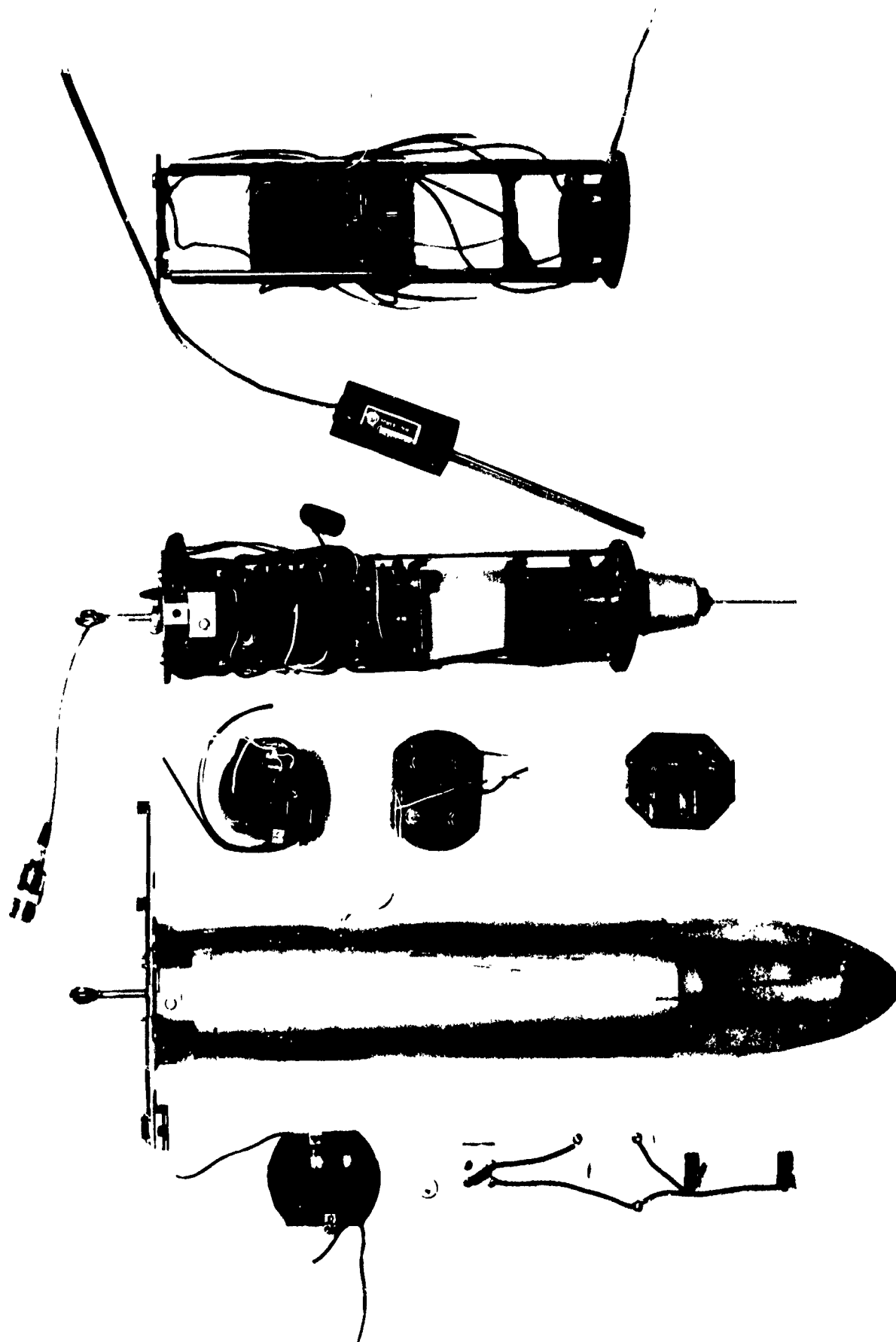


Figure 3

nose down attitude. This eliminates any transmission dead space that would occur if the assembly descended in a nose up attitude whereby the metallic case of the rocket motor would block transmission of the instrument as it revolved between the instrument and the ground receiving station during descent. The nose down attitude angle is approximately 35° below the horizontal.

The outer housing of the instrument package is aluminum and attaches to the instrument package with two (2) machine screws. The payload assembly attaches to the parachute assembly by use of three (3) machine screws fastened to the payload assembly which fit into three (3) slots in the parachute assembly frame, are turned and then tightened. This provides a rigid attachment of the payload to the "Cricket Rocket."

The electronic package is comprised of five (5) printed circuit boards which includes the encased receiver board, which are all equally spaced and each, excluding the receiver subassembly, is fastened to the lightweight aluminum frame by use of two (2) aluminum angle brackets. The receiver board is mounted in a metal shield which is fastened to the aluminum frame with two metal screws. This construction lends itself to a self supporting rigid package sufficient to withstand 84 g's of shock, that is encountered during launch.

The ejection type nose cone originally proposed was found to be inadequate for the purpose intended. Great difficulty was encountered in attaining the necessary rigid fit of the nose cone to the payload assembly needed during descent and then at apogee to have the nose cone jerk loose from the instrument as a result of parachute deployment and gravitational forces. Flight tests conducted by AFCRL at Cape Kennedy showed that another approach was necessary. In addition to the above concept, the sensor board provided had foldable arms. The sensor board plugged into the instrument by use of banana plugs and then folded up to allow installation of the nose cone. At apogee the nose cone was to drop off and the sensor arms were then to deploy. This configuration was changed, and the nose cone was redesigned to lock onto the instrument. With this change in the configuration, it was then required to move the sensor package from the nose cone to the parachute assembly. A new sensor package was designed and during ascent the sensor package was installed into the parachute assembly and fastened to the parachute lanyard. The sensor package was still deployed at apogee. This allowed the sensor package to remain clear of the instrument such as internally generated heat and reflections caused by the rocket assembly. This new concept of securely fastening the nose cone to the instrument during the whole

flight protects the RF transmitter antenna upon impact with the surface, and the use of the low loss plastic material for the nose cone enables the RF transmission to be made through this material.

The center of gravity of the electronic instrument package will be slightly forward of center. This will allow the Cricket Rocket performance to be comparable to other versions of the Cricket Rocket with meteorological payloads.

2. Balloonsonde

The electronic package for the balloonsonde is the same as for the cricketsonde with the exception of the location of the sensor unit.

In the original design, a metal tube was used as the cover for the balloonsonde, as well as for the rocket version. In order to make a cost reduction to the unit, the metal case was abandoned. An aluminum foil wrapped cardboard tube provided a sufficiently tight fit, so that no other means of fastening was necessary. The cardboard tube was much easier to use than the metal container. It enabled the batteries to be inserted, the clock timer to be set with ease, by slipping off the tube, whereas the metal case was secured by two (2) metal screws.

Good sensor position is achieved on the balloonsonde by plugging the sensor board at the end of the instrument package opposite the 1.68 GHz transmitter. The banana plug in feature is also provided here. In this position the sensors will sample clean air during ascent. For shipping purposes, the sensor arms are folded in a disposable cardboard end cap which is attached with two (2) tie wraps.

D. ELECTRONIC INSTRUMENT PACKAGE DESIGN

1. 403 MHz Receiver and 81.94 KHz Amplifiers

The receiver developed for the Low Level Radiosonde was determined from the results of the following calculations and tests.

- a. A mathematical analysis to determine the required receiver sensitivity:

The radiosonde instrument package is designed to sense atmospheric parameters up to an altitude of 1,000 meters with an ascent or descent rate of 150 meters per minute. Therefore, the time of ascent or descent will be approximately six minutes. A maximum wind speed of 50 miles per hour is selected

for design purposes. Then the maximum slant range is approximately five miles.

The path loss for a 5 mile transmission at 400 MHz =

$$37 + 20 \log (400) + 20 \log (5) = 103 \text{ db}$$

$$\text{Fade Margin} = 3 \text{ db}$$

$$\text{Sonde Receiver Antenna Gain} = 0 \text{ db}$$

$$\text{Sonde Receiver Noise Figure} = \text{Assume } 5 \text{ db}$$

$$\text{GMD Transmitter Power} = 18 \text{ watts} = 42.6 \text{ dbm}$$

$$\text{GMD Transmitter 400 MHz Antenna Gain} = 15 \text{ db}$$

The required receiver sensitivity =

$$\begin{aligned} &\text{Transmitter Power} + \text{Antenna Gain} - \text{Path Loss} - \text{Fade Margin} \\ &- \text{Noise Figure} = 42.6 + 15 - 103 - 3 - 5 = -53.4 \text{ dbm.} \end{aligned}$$

For design purposes the antenna was assumed to be 50% efficient. Therefore, the design sensitivity is -55.4 dbm.

b. A mathematical analysis of various receiver configurations:

Three different types of receivers were considered: A self-quenched superregenerative detector, an RF amplifier followed by a diode detector, and an RF amplifier followed by a transistor detector.

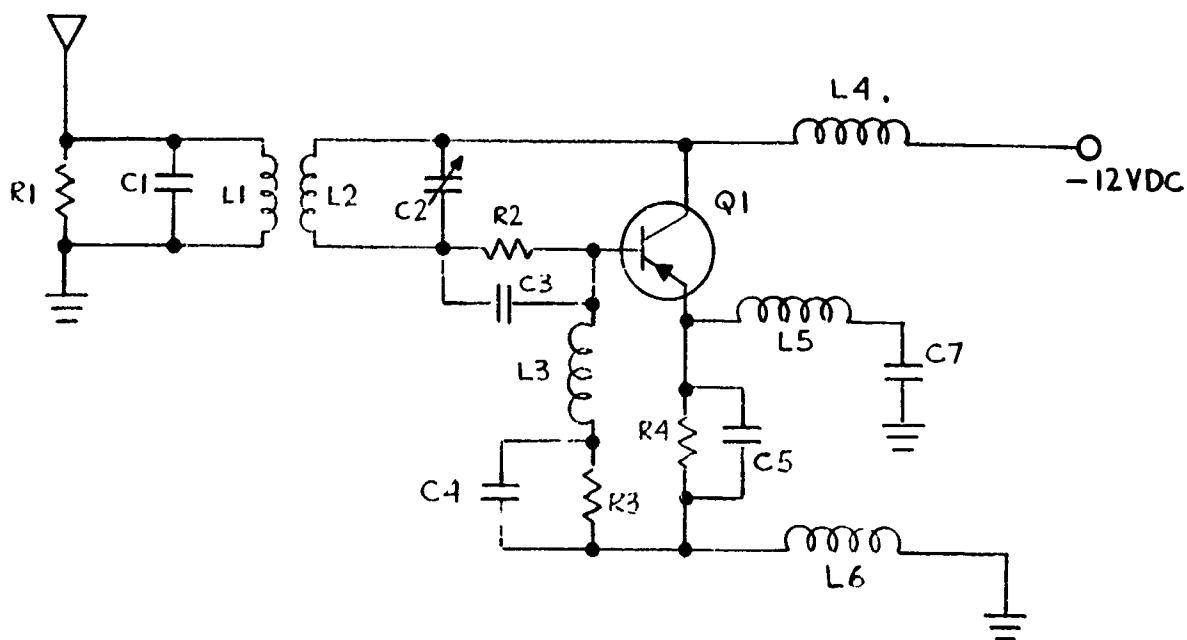


Figure 4. Superregenerative Detector

The superregenerative detector, illustrated in Figure 4 above was analyzed. From past experience with this circuit, it is known that a sensitivity of -72 dbm for a 10:1 detected signal-to-noise ratio can be realized. The detected signal has an amplitude of 15 mv peak-to-peak. This value is relatively constant over a wide range of RF signal strength due to the inherent automatic gain control of a logarithmic mode superregenerative detector.

The RCA S190 solid state power source requires approximately 300 mv peak-to-peak for ± 100 kHz frequency deviation. The superregenerative detector should be followed by one or two amplifier stages and an emitter follower to produce the required modulation voltage and isolation.

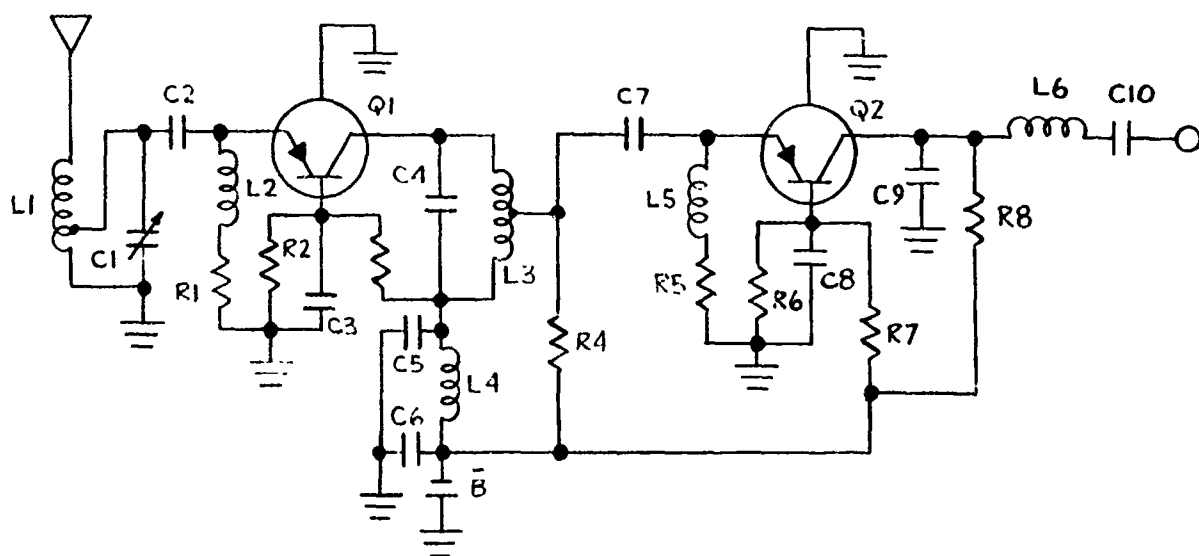


Figure 5. RF Amplifier and Transistor Detector

The transistor RF amplifier and transistor detector, illustrated in Figure 5 were analyzed next. The maximum gain of an RF amplifier using inexpensive RF transistors was calculated to be 13 db with a noise figure of 6 to 7 db. The input to the detector would then be $-56.4 \text{ dbm} + 13 \text{ db} = -43.4 \text{ dbm}$.

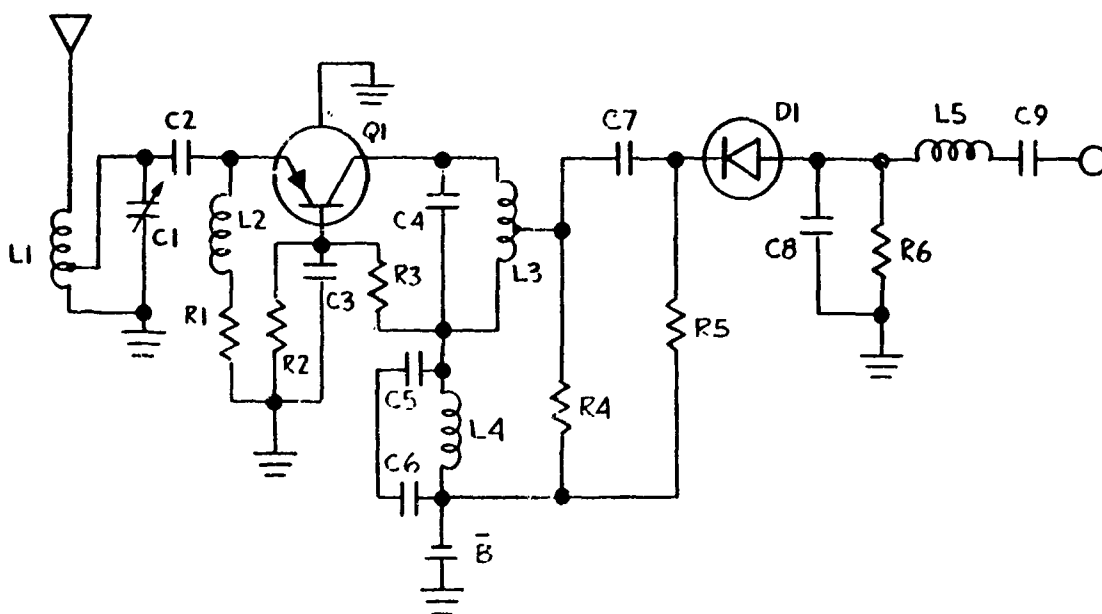


Figure 6. RF Amplifier and Diode Detector

The RF amplifier and diode detector, illustrated in Figure 6 were analyzed next. From the previous calculation, the input to the detector would be -43.4 dbm. If the diode is assumed lossless, then the output is -43.4 dbm = 4.571×10^{-5} mw.

c. Breadboard Testing

Because there was much information on the performance of the superregenerative detector and because the transistor detector had more gain than the diode, the first breadboard built was a transistor detector employing a 2N2996 transistor.

After optimizing the first circuit, a sensitivity of about -48 dbm was obtained. Other 2N2996 transistors were tried in the circuit and sensitivities of -1 to -6 dbm were obtained. An optimum circuit for the majority of the 2N2996 transistors (sample lot of 10) was developed and sensitivity ranged from -42 dbm to -15 dbm with the majority around -28 db. Since the output from the RF amplifier stage would be -43.4 dbm, the transistor detector was rejected. The amplitude of the detected signal was approximately 2 mv peak-to-peak.

The superregenerative detector shown in Figure 4 was built next. (See Superregenerative Receivers, Modern Radio Technique Series, by J. R. Whitehead, The Cambridge University Press, American Branch, New York, for explanation of the operation of a superregenerative detector.)

Breadboard operation of a high frequency receiver is difficult because component lead lengths are critical. Any leads that are connected to the inductance loops become part of the input circuit and cause frequency shifts. Stray capacitance is detrimental to high frequency performance, so printed circuit boards were fabricated to reduce this stray capacitance to a minimum. The use of printed circuit boards also provides control over component placement which can also offset high frequency operation. In addition, the receiver was shielded to minimize interference from the 1.68 GHz transmitter.

Test results of the superregenerative detector using a Texas Instrument 2N2996 transistor showed a sensitivity of -79 dbm when tuned to 403 MHz. With the receiver tuned to 403 MHz, the input frequency from a signal generator was shifted to 395 MHz and the sensitivity measured again. This time the sensitivity was approximately -9 dbm or 70 db less.

Because of the results obtained with the transistor detector, no diode detector was built since any RF amplifier-detector combination would cost more than the superregenerative detector.

The 81.94 kHz amplifier is used in the radiosonde to provide signal amplification and impedance matching with the transmitter. Refer to Figure 7 for a description of the circuit.

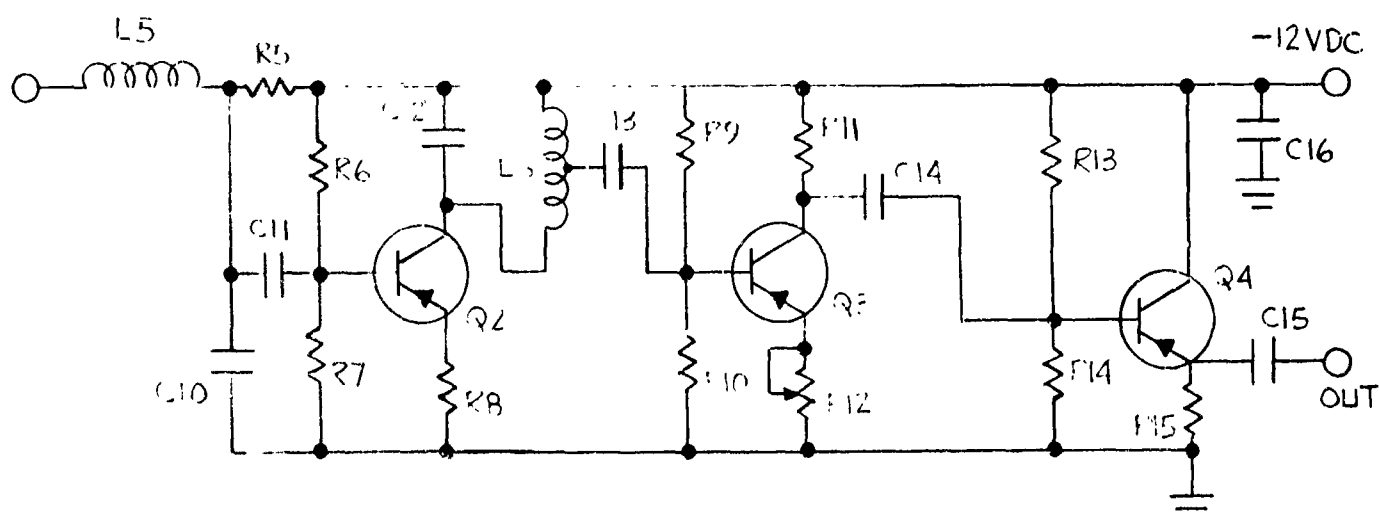


Figure 7. 81.94 KHz Amplifier

The tank composed of C12 and L6 is tuned to resonate at 81.94 KHz. This allows a voltage gain of approximately 15 for signal frequencies and little or no gain for other frequencies. A second stage provides additional voltage gain with gain control R12 used to provide the proper level. An emitter follower is used to provide an impedance match to the 600 ohm input of the transmitter.

2. Meteorological Data Pulse Generator

The Meteorological Data Pulse Generator FM modulates the 1.630 GHz transmitter from 200 to 4,000 pps. The frequency of the meteorological pulses are controlled by the resistance of temperature and humidity sensors switched into the circuit by means of the solid state commutator, which is described in the next section. The four cycle per second solid state clock

provides the timing pulses for gating the temperature, humidity, high reference and spare channel resistances into the net data oscillator circuit. The pulse width supplied is not less than 20 microseconds in width as dictated by the response of the GMD receiver to narrow pulses in the range of repetition rates to be used in the sonde.

A resistance-controlled relaxation oscillation is needed to utilize the resistance variation property of the sensors. Frequency output of the oscillator is 4,000 pps with only the reference resistance in the circuit. Minimum frequency is near 200 pps with the sensors at maximum resistance.

A unijunction transistor is one device suitable for a relaxation oscillator because of its negative resistance characteristic. The low power supply voltage (12 volts) available dictated that a low voltage unijunction transistor such as the G.E. 5E35 be used. Refer to Figure 8 for operation of the unijunction circuit.

Emitter voltage of the unijunction (Q2) rises exponentially to its firing point. At this time the capacitor discharges through Q2 and its voltage drops to 0.2 volts. This voltage is coupled to the base of Q1 to provide a pulse output. Q1 also helps isolate the unijunction transistor from the load.

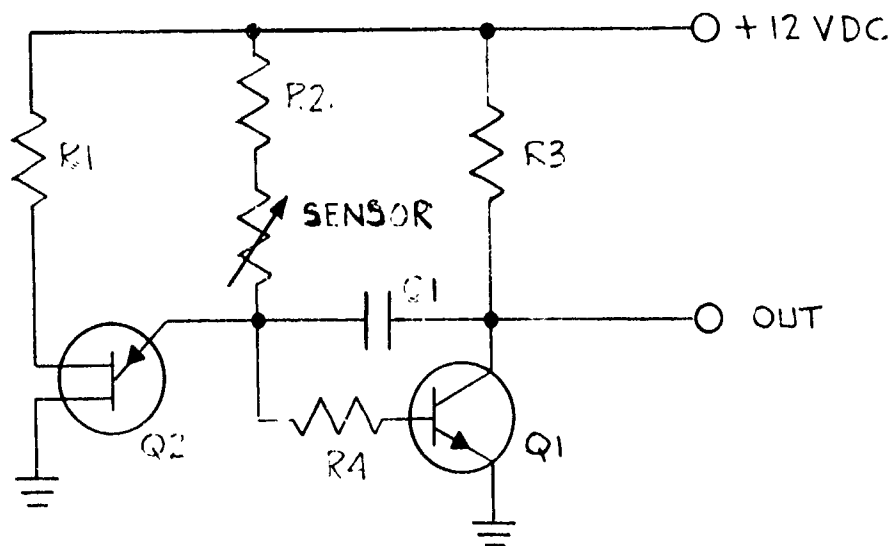


Figure 8. Unijunction Pulse Generator

Temperature stability of the circuit was quite poor; the output frequency varied from 3680 Hz at 15°C to 6585 Hz at -40°C.

Next, a Motorola four-layer diode (M41 3052) was used in a resistor-capacitor relaxation oscillator circuit. The four-layer diode acts similar to a neon bulb. It exhibits high resistance until breakdown then a low resistance while conducting. After the current through the diode decreases below the sustaining current, the device exhibits a high resistance again. Refer to Figure 9 for the circuit diagram.

No temperature check was made since the circuit was unstable at ambient temperature. Successive identical readings on a frequency counter could not be obtained due to pulse-to-pulse jitter. The output is a sawtooth which limits its usefulness unless a pulse shaper is used.

Refer to Figure 10 for a two-transistor saturated switching circuit using Motorola complementary transistors. When power is first applied to the circuit, Q1 saturates driving Q2 into saturation. The -4.5 volts appearing across R3 is coupled to the base of Q1 driving it further into saturation. The capacitor discharges until both transistors come out of saturation. At this time the voltage at the junction of R3 and the collector rises to zero volts. This voltage is coupled to the base of Q1. The capacitor then charges until Q1 again saturates and the process repeats itself.

Output frequency is controlled by the magnitude of the sensor resistor (R). When R equals 0 ohms frequency is 4,000 pps (reference frequency). Increasing R decreases the frequency to approximately 246 pps with R equal to 1.4 megohms.

Pulse width is controlled by C1 and R2. With the components shown, output pulse width is 25 microseconds. Decreasing R2 decreases the pulse width. The emitter follower isolates the met pulse generator from the 1.68 GHz transmitter.

Frequency varied from a low of 3990 pps at -10°C to 4026 pps at +70°C. This is better than $\pm 1\%$ temperature stability over this temperature range.

The two-transistor saturated switching circuit was selected since it had the best temperature stability. This circuit is also more efficient than the other two since the pulse amplitude is almost equal to the power supply voltage in magnitude. Figure 13 shows the audio curve of this circuit.

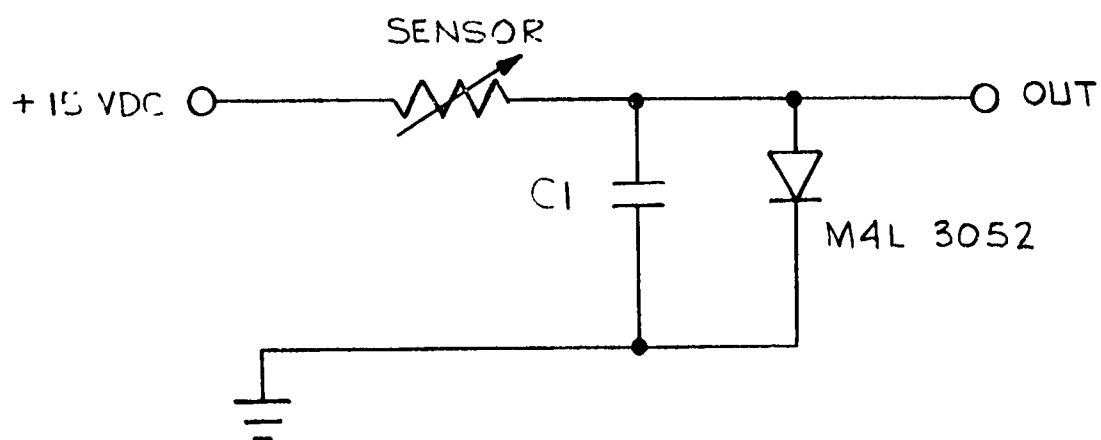


Figure 9. Four Layer Diode Pulse Generator

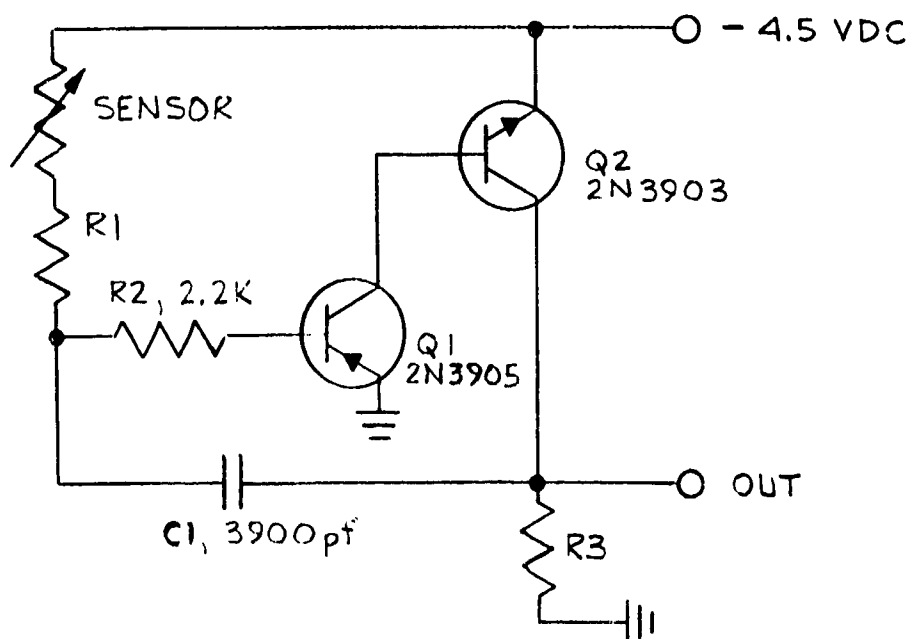


Figure 10. Complementary Transistor Pulse Generator

3. Solid State Commutator

A solid state commutator composed of a clock, sequencer, and switching transistors is used to gate the meteorological sensors in a resistance-controlled oscillator. To obtain the necessary sequence and duration for the sensors, a 4 Hz flip-flop is used to generate clock pulses. Each successive clock pulse switches the sensors and reference in the resistance-controlled oscillator circuit for the required time and in proper sequence.

a. Clock

Five different flip-flop circuits were tested in an effort to find a temperature and voltage stable clock circuit with low current drain.

The first circuit was composed of a Fairchild-type 914 micrologic dual 2-input gate with external feedback resistors and capacitors as shown in Figure 11. The 914 micrologic element is a digital device whose output is high (approximately zero volts) when the input is low (approximately -4.5 volts) and vice-versa. The inputs charge exponentially toward zero volts since they are connected to ground through resistor (R1 or R2). Since the output of element # 1 is connected to the input of element # 2 and output # 2 to input # 1 the unit will oscillate.

With all components in a temperature chamber, frequency varied from a low of 3.81 Hz at 50°C to 22.2 Hz at -10°C. The electrolytic capacitors were assumed to be unstable at low temperatures, so they were removed from the temperature chamber and attached to the micrologic circuit with long leads. Results of a retest showed a frequency variation of 5.11 Hz. While the capacitors affect the frequency to a large extent, the frequency shift due to the micrologic characteristics is still quite large.

A Fairchild-type 929 quad inverter was substituted for the dual 2-input gate as shown in Figure 12. The 929 inverter flip-flop circuit operates in the same manner as a 914 unit, but the 929 output has increased drive capability for charging the capacitors.

When the capacitors and resistors selected to produce 2 Hz at ambient temperature, frequency varied from 1.55 Hz to 70°C. to 2.76 Hz at -40°C. This was an improvement over the 914 element, but the percent change (35%) in frequency is still quite large.

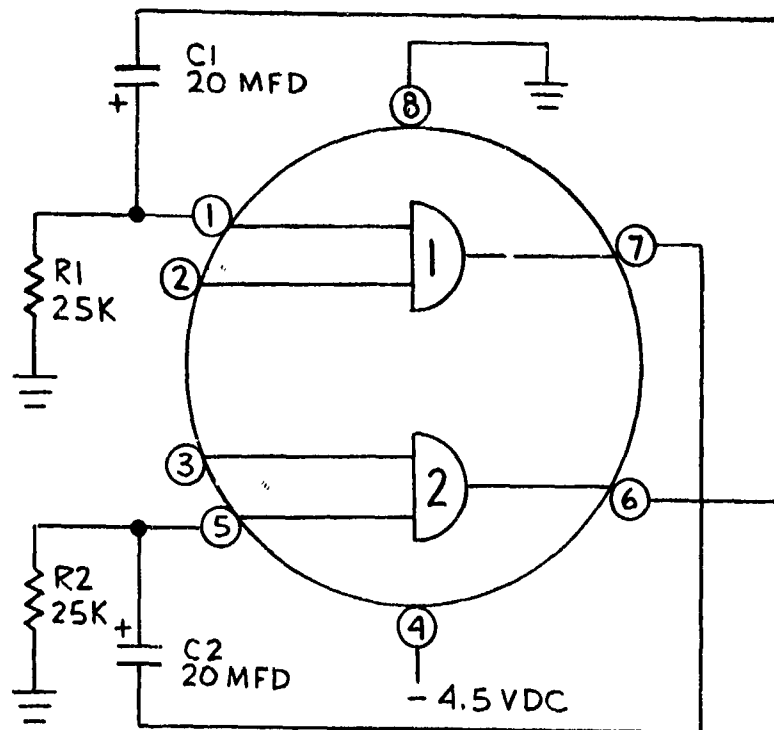


Figure 11. 4 Hz Micrologic Clock (Fairchild 914 Gate)

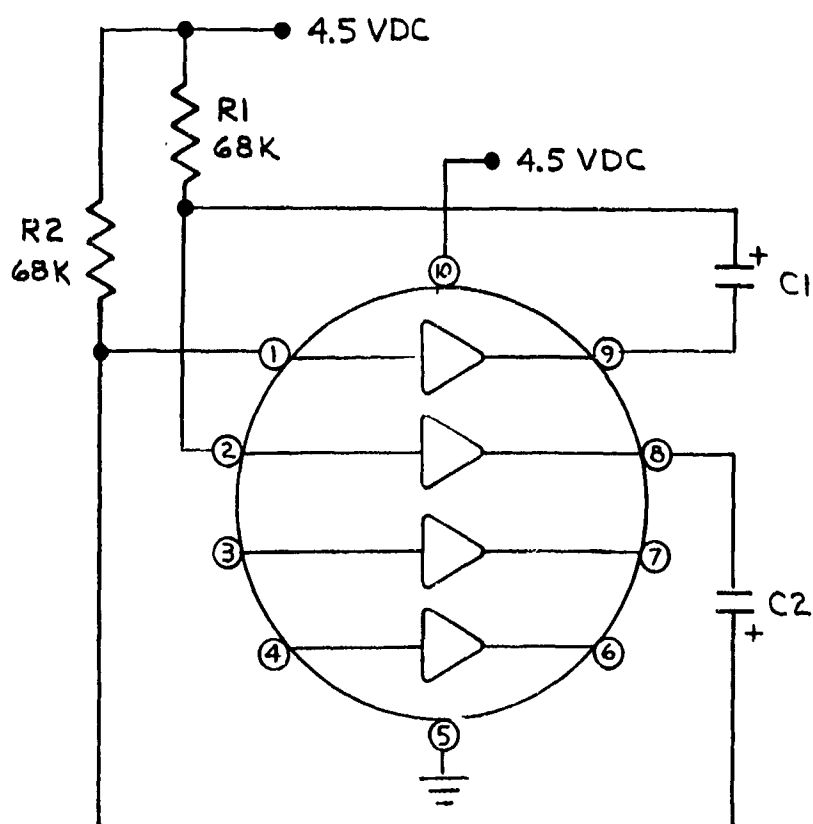


Figure 12. 4 Hz Micrologic Clock (Fairchild 929 Inverter)

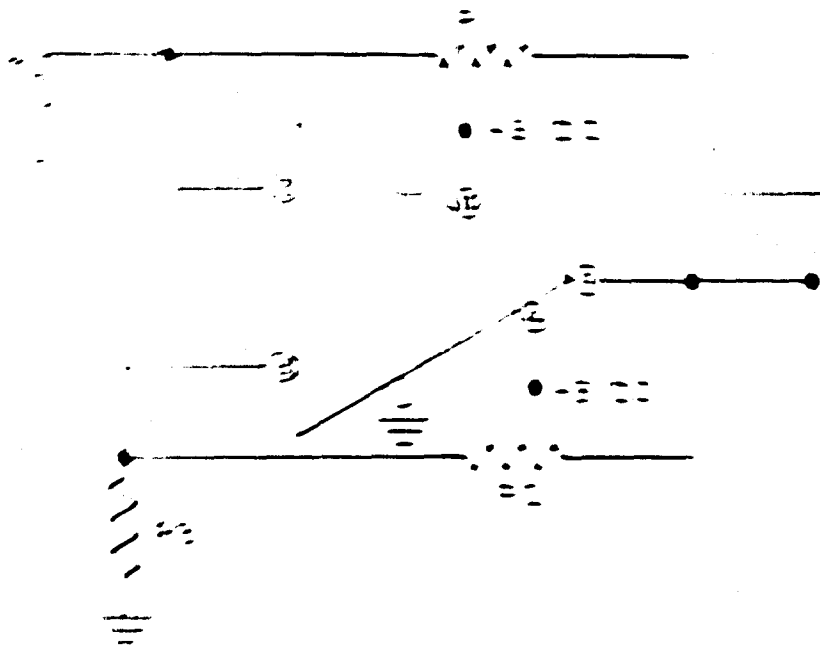


Figure 13. Operational Amplifier Flips

Next, an RCA 741C micrologic operational amplifier with a capacitor connected to the inverting input, as shown in Figure 13, was tested. Output voltage of the operational amplifier is of the opposite polarity as the input voltage. The capacitor prevents the input from changing as rapidly as the output, thereby allowing the circuit to operate as a flip-flop. With a nominal frequency of 25 Hz, the output varied only 0.6 Hz (2.4%) over the temperature range of -40°C to 170°C . As can be seen in Figure 13, this circuit requires a positive as well as negative power supply for operation. Stability is obtained, but at the expense of an additional power supply.

To avoid the difficulties with temperature instability of micrologic elements, a discrete component flip-flop was tested next. Figure 14 is a circuit for a flip-flop with an asymmetrical output. As the base voltage of Q1 increases, Q1 switches from a non-conducting state to saturation. The collector of Q1 is coupled to be base of Q2 which falls below

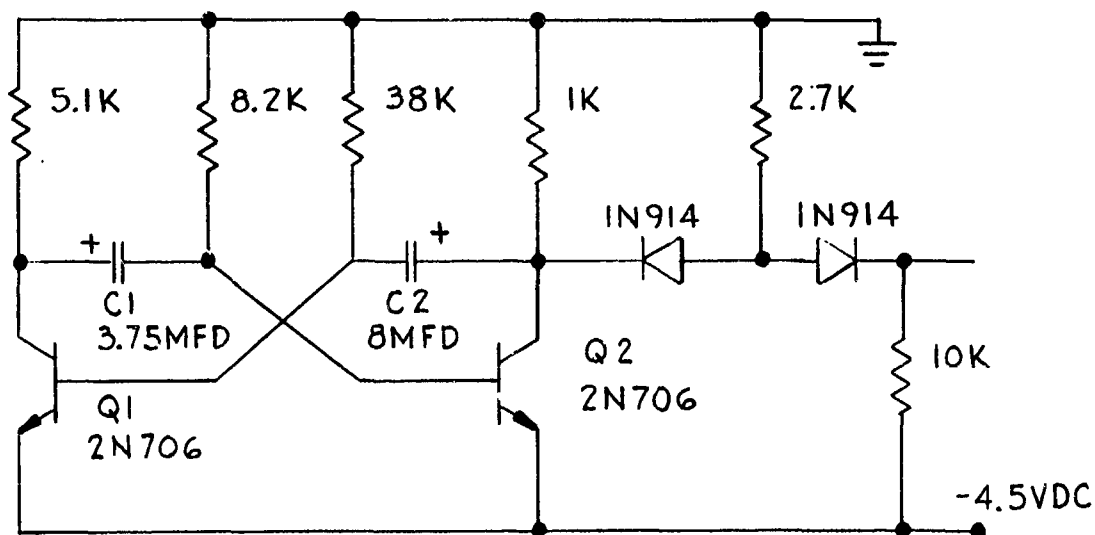


Figure 14. Asymmetrical Flip-Flop Clock

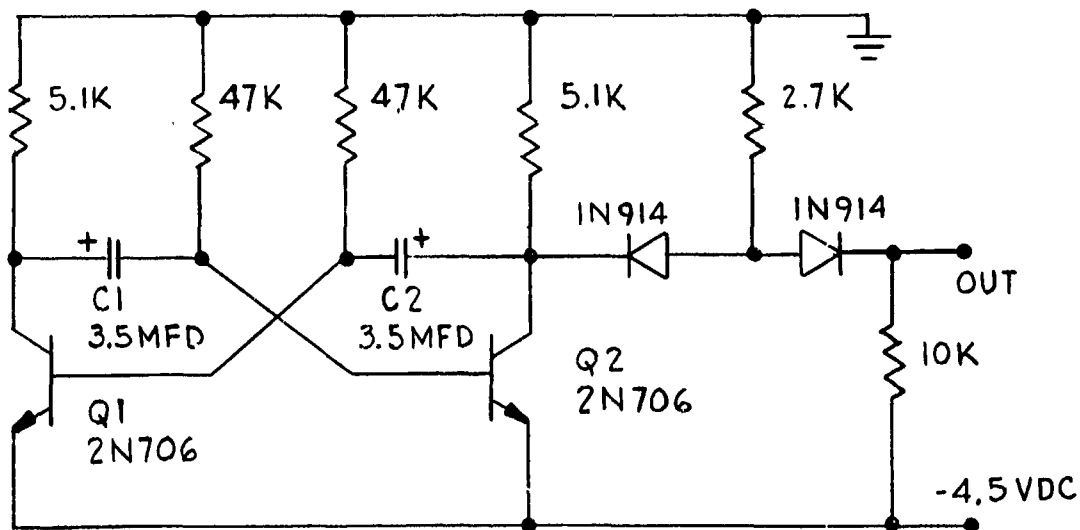


Figure 15. Symmetrical Flip-Flop Clock

cutoff when Q1 saturates. Collector of Q2 rises which drives Q1 further into saturation. This state continues until Q2 goes into saturation by the charging of C1.

This circuit exhibited only a 0.02 Hz variation over the temperature range of -40°C to $+70^{\circ}\text{C}$. However, the exponential rise of the 20 millisecond pulse is unsuitable for triggering micrologic elements and current drain is high (8.0 ma).

The output was changed to a square wave by slight modification to the circuit (refer to Figure 15). The frequency varied from a low of 4.00 Hz at 70°C to 5.00 Hz at -40°C . Although the temperature stability was not as good as the circuit shown in Figure 14, voltage stability was better.

A summary appears in Table I for comparison of the various circuits.

The symmetric flip-flop was selected since it has low current drain and good voltage stability.

Table I.

Circuit	Temperature Variation -40°C to $+70^{\circ}\text{C}$	% Voltage Variation 3.0 V to 5.0V	Current Drain at -4.5 V	Comments
Fairchild Micrologic dual 2-input	500	5.3	20 ma	Unstable. High current drain.
Fairchild Micrologic Quad Inverter	35	5.3	30 ma	Unstable. High current drain.
RCA Micrologic Operational Amp.	2.4	11.3	Did not measure.	Need two voltage sources.
Flip-Flop Asymmetric	0.5	4.5	8 ma	High current drain. 20 ms pulse not suitable for blanking.
Flip-Flop Symmetric	12.5	1.25	1 ma	Fairly stable. Low current drain.

b. Sequencer

The sequencer consists of two Fairchild micrologic flip-flops and two 914 micrologic gates. Each 923 micrologic element divides the output of the clock by two. Thus, outputs are available at 4 Hz, 2 Hz, and 1 Hz. By combining the 2 Hz and 1 Hz outputs with the 914 micrologic "AND" gates, four pulses are available with 250 millisecond duration. These pulses are used to "turn on" the switching transistors. The "ON" transistor determines which sensor resistor is being used to control the frequency of the met pulse generator. The pulses also give the proper sequence for the meteorological pulse generator; reference, temperature, humidity, and spare channel.

A 20 millisecond monostable multivibrator is slaved to the 4 Hz clock to provide blanking pulses. When the commutator switches from one sensor to the next, the output of the meteorological pulse generator is prevented from modulating the 1.68 GHz transmitter. See Figure 16 for the timing diagram of the solid state commutator.

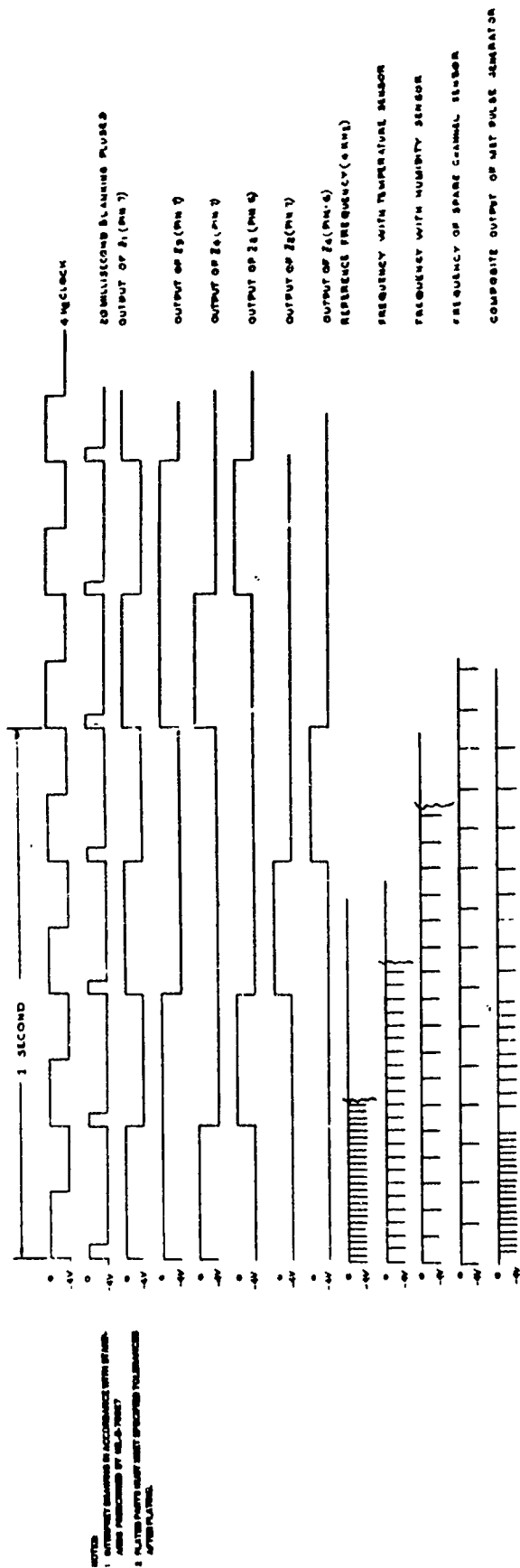
c. Switching Transistors

The meteorological sensing elements must be switched in the time constant circuit of the meteorological pulse generator. This can be accomplished with reed relays or switching transistors. Reed relays have almost zero contact resistance when "ON" and almost infinite back resistance when open. They would be ideal for use in the radiosonde applications except for two major disadvantages:

1. Contact bounce
2. High coil power needed for operation.

The contacts in a reed relay are springs which distort in the presence of a magnetic field. The force experienced by the contacts when closing is sufficient to cause the contacts to make and break several times before remaining closed. During this period of contact bounce (2 or 3 milliseconds), the sensor resistor would be switched in and out of the meteorological pulse generator circuit causing erratic operation.

A coil is needed to furnish the magnetic field for the reed relays. During the time a relay is energized, the coil must dissipate power (approximately 0.5 watt). This power drain would necessitate a large battery for the sonde. A latching



TIMING DIAGRAM, SOLID STATE COMMUTATOR

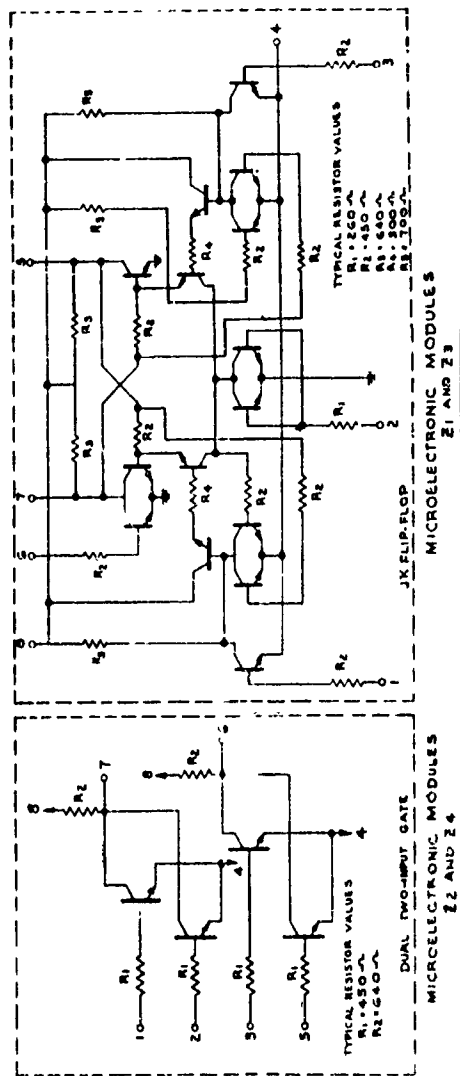


Figure 16. Timing Diagram

reed relay could be used, but at added expense. Several types of switching transistors were tested in conjunction with the meteorological pulse generator to find a suitable switching transistor. Rather than attempting to measure the "ON" resistance of a transistor which could vary considerably, a comparison was made of meteorological pulse generator frequency with a toggle switch and various transistor switches. The frequencies were selected by means of a variable resistance in the time constant circuit of the meteorological pulse generator. The same value of resistance for a given frequency with the toggle switch was used to obtain the frequency reading with the various transistors tested.

Shunting the meteorological pulse generator with an "open" transistor did not produce any frequency shift for any of the above transistors.

Table II.

Frequency (Hz):	4,000	3,000	2,000	1,000	500
Switch Type:					
Toggle Switch	4,000	3,000	2,000	1,000	500
2N2905A	4,000	3,000	2,000	1,000	500
2N3638	4,000	3,000	2,000	1,000	500
2N3903	3,996	2,997	1,998	999	499

Table II indicates either a 2N2905A or 2N3638 transistor could be used without introducing error. However, these are p-n-p units and two transistors would be required per sensor due to the fact that the sensors must be switched to -4.5 volts. The 2N3903 unit is n-p-n, so only one of these per sensor is necessary for switching.

See Figure 17 for the switching transistors circuit.

The two Hz errors introduced by the 2N3903 results in a maximum temperature error of 0.1°C at 40°C . This is much less than the error introduced by truncating the temperature-reference ratio at three decimal places in the data processor. The truncating error for three decimal places is 0.17°C , which corresponds to a 4 Hz frequency change.

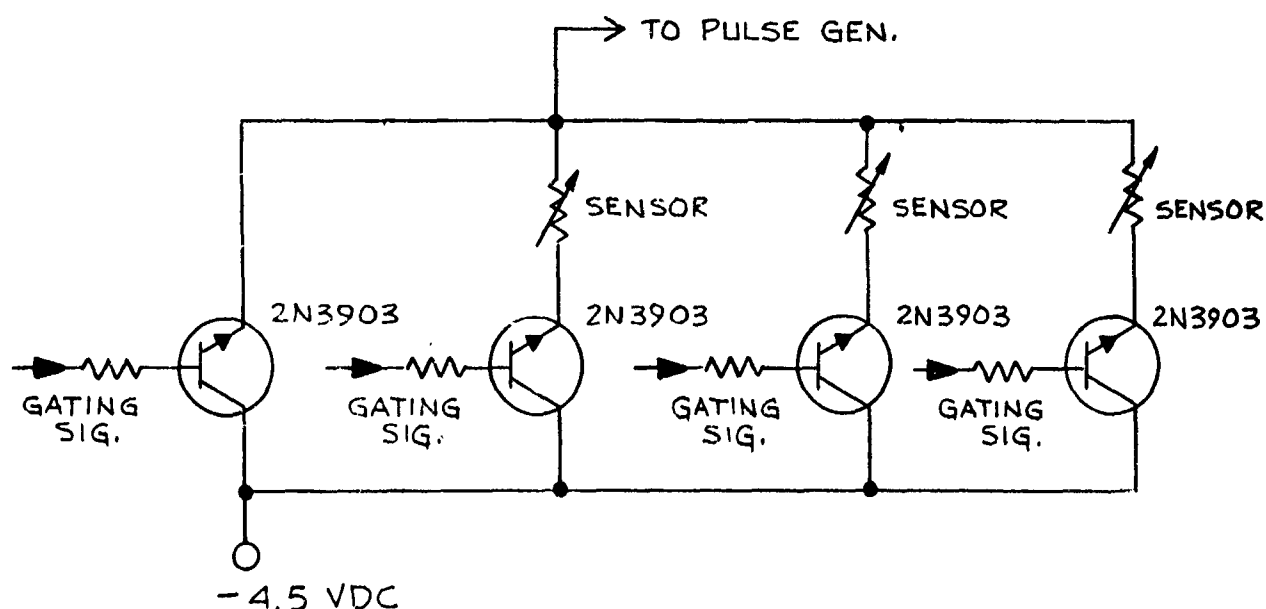


Figure 17. Switching Transistor Circuit

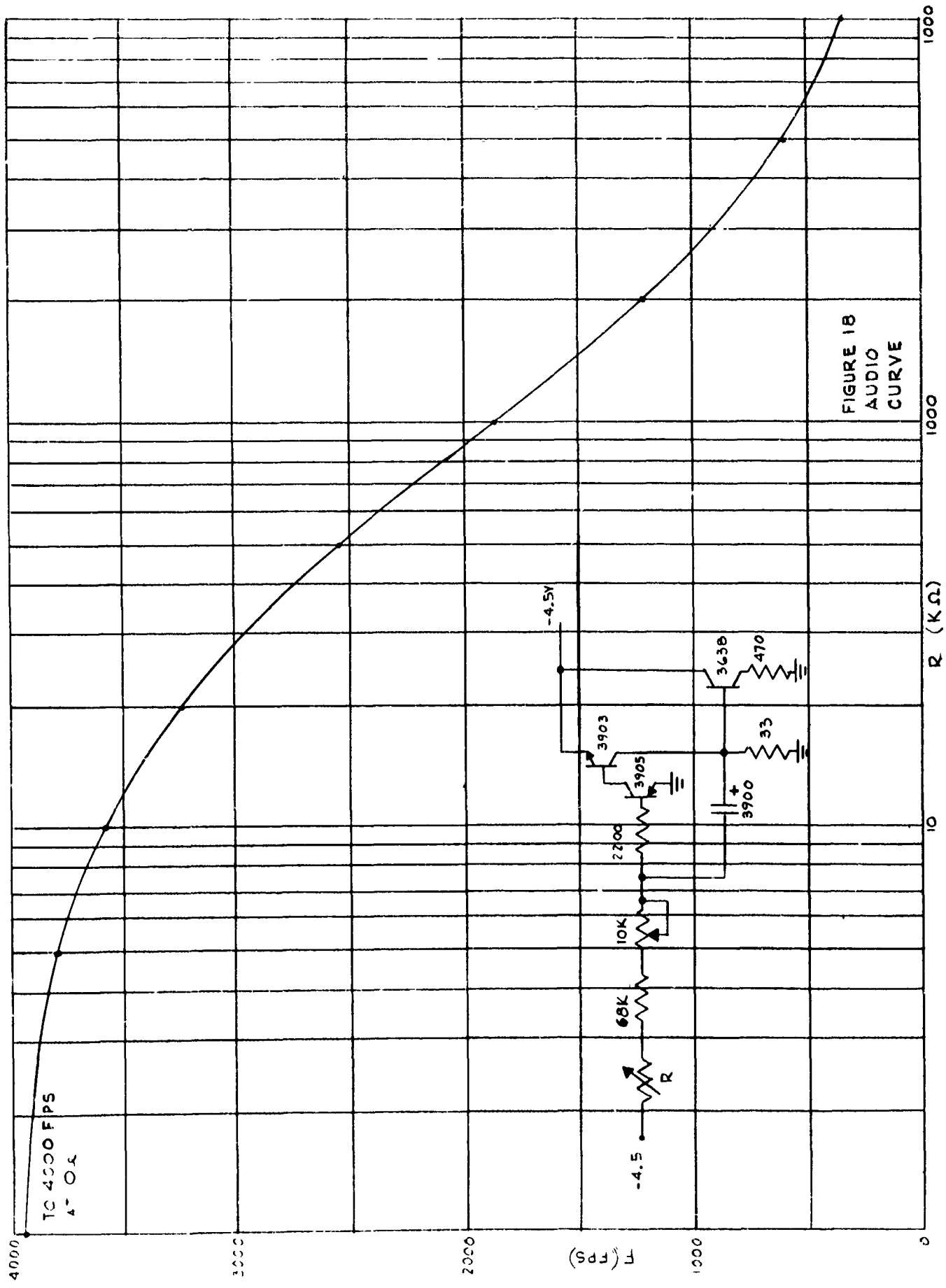
Example: $\frac{2,000}{4,000} = 0.500$

$\frac{2,004}{4,000} = 0.501$

Therefore, any frequency change less than 4 Hz results in no change in the ratio punched out by the Meteorological Data Processor.

In addition, the ML 419 thermistor to be used has an accuracy of $\pm 0.5^\circ\text{C}$. Thus, the error introduced by the switching transistor is negligible.

Resistance of the ML 476 humidity element depends upon air temperature as well as relative humidity. Maximum error introduced by the switching transistor is 0.2% relative humidity at 25°C . The error introduced by truncating the humidity-reference ratio at three decimal places results in an error of 0.4% relative humidity. Accuracy of the humidity sensor is $\pm 5\%$ relative humidity for humidities less than 20%. Again, the error introduced by the switching transistor is negligible. Refer to Figure 18 for the audio curve.



4. 1.68 GHz Transmitter

Originally four types of transmitters were considered:

- a. Tunnel Diode Fundamental
- b. Transistor Fundamental
- c. Transistor with Multiplier
- d. Vacuum Tube

The maximum power that could be realized from a tunnel diode with reasonable current drain (200 ma) would be 12.5 mw. While this transmitted power would be sufficient under ideal propagation conditions, it would be marginal and provide unreliable communications under normal atmospheric conditions.

Microwave printed circuits can be used as the resonant circuit in microwave oscillators. The oscillator circuit is basically a tuned collector-tuned base circuit with the transistor operating in a common collector configuration. Figure 19 shows the equivalent circuit.

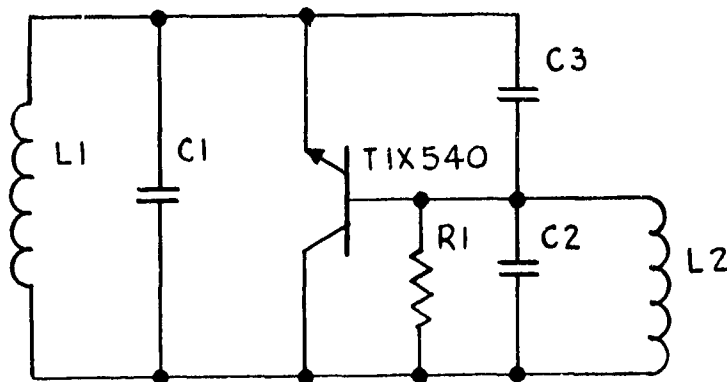


Figure 19. Equivalent Circuit

The resonant circuit composed of L_1 and C_1 can be represented by a transmission line which is $1/4$ wavelength at the resonant frequency. (The emitter-collector capacitance is small enough to be neglected.) C_2 is the collector-base capacitance, therefore, the base circuit can be made resonant at the desired frequency by adding an inductive transmission line. The condition for parallel resonance dictates that (X_C) must equal (X_L) at resonance. A shorted ideal transmission line has an input impedance which is purely inductive and expressed by the equation:

$$Z_{IN} = j Z_0 \tan \beta l$$

where: Z_0 = characteristic impedance

$$\beta = \text{phase constant} = \frac{2\pi}{\lambda} \text{ for an ideal line}$$

l = line length.

The collector base capacitance can be determined from the transistor specification sheet and the (X_C) can be calculated from:

$$(X_C) = \frac{1}{\omega C}$$

then $(X_C) = (X_L) = (Z_{IN}) = Z_0 \tan \beta l$ and l can be determined.

C_3 is the emitter-base capacitance and provides the feedback path. R is the load presented to the transistor and is determined by the value and the position of the external load from the shorted end of the collector-base transmission line. If the external load is known the position of the power tap from the shorted end of the line can be determined from the equation:

$$\text{External load} = R \sin^2 B l_T$$

where l_T is the length of line from the shorted end of the base collector line and R is the load presented to the transistor.

The physical layout of the board follows a design built by Texas Instruments. The configuration is a micro strip on $1/8$ " "Rexolite 2200." The design calculations were based on the 2.62 dielectric constant of "Rexolite 2200." However, due to the unavailability of "Rexolite 2200," "Custom Poly CR" was used. "Custom Poly CR" has

has dielectric constant of 2.7, therefore, the actual frequency was lower than the design frequency. Figure 20 shows the board. (A half wavelength has been added to the collector-base line to give a workable dimension.)

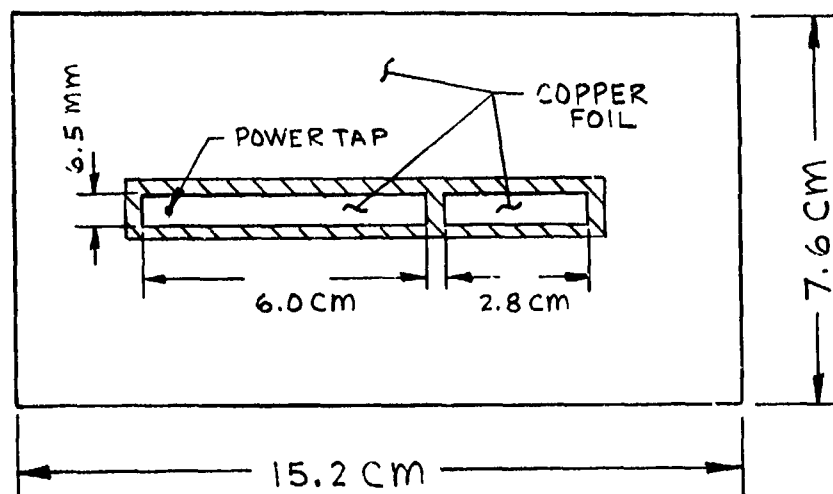


Figure 20

Calculations indicated that the power tap should be $1/8$ " from the end of the line to produce maximum power output from the transistor. However, on the test model the tap was closer to $3/16$ " from the end of the line. This made it necessary to use a 3-stub impedance match to make the transistor produce appreciable power.

The test model oscillated at 1.62 GHz and produced 150 mw output when $V_{ce} = 25$ volts and $V_{cb} = 15$ volts. When the voltage was raised to $V_{ce} = 32.5$ volts and $V_{cb} = 20$ volts, the power output was 225 mw and the frequency was 1.63 GHz.

The physical configuration of this unit does not lend itself to the payload restrictions imposed by the Cricket Rocket, however, although there are techniques available for reducing the size of stripline devices, the cost of dielectric materials to achieve this is quite high and the amount of development required to

optimize the circuit was felt to be out of line with the intent of the project.

Transistor oscillators with multiplier are already on the market (RCA, Western Microwave Laboratories, and Frequency Sources, Inc.) and are now being employed in several types of meteorological devices. Although these are currently quite expensive, the price is expected to drop to around \$15.00 within the next two years.

These solid state transmitters are characterized by their small size, rugged construction and minimal power supply requirements. For these reasons, this type of transmitter is ideally suited to the recoverable rocketsonde design.

Any comparison of transmitter devices for the radiosonde design must, of course, include an analysis of the vacuum tube cavity oscillator. While it is true that the vacuum tube transmitter costs considerably less than solid state devices at the present time, several additional features of the tube must be considered. In the first place, the tube requires more power than the transistor device. In fact, the filament power alone is not much less than the total power required for the solid state transmitter. The tube also requires a plate voltage supply so that the power supply for a tube type transmitter must be larger and more expensive. Some reduction in size can be achieved by using a dc-dc converter to obtain the plate voltage rather than a B battery section, because the dc-dc converter components and added capacity in the low voltage battery require less volume than a practical B battery. This is the design approach that would have to be taken for the rocketsonde where space is at a premium. However, a dc-dc converter circuit including transformer, switching transistors and associated circuit components would add approximately \$17.00 to the cost of a tube-type transmitter. The tube has thus lost its only advantage, cost, when considering the development of new radiosondes where volume must be minimized.

Since the currently available transistor oscillator-multiplier device is the choice for the rocketsonde, it will also be used in the balloonsonde so that the two sondes will be as nearly alike as possible. If the tube-type transmitter were to be used for the balloonsonde, a different battery would be required as discussed above. In addition, however, changes would be required to other parts of the circuit. For example, with the solid state transmitter, the remainder of the circuit is designed to operate from a negative supply, while the tube transmitter, the remainder of the circuit should properly be designed to operate from a positive supply. While this is not difficult, it does represent a difference in design. Also, the pulse signal level required to modulate the two types of transmitters is different which would necessitate other circuit changes.

The RCA S190 solid state power source has been chosen since it is the least expensive of the devices presently available. The standard S190 supplies at least 200 mw of power at 1.68 GHz at 25°C. The device is temperature-compensated to be frequency stable within 4 MHz over the operating temperature range of 0° to 70°C. Operation is possible below -30°C at the expense of additional frequency shift. It is pointed out, however, that the temperature range to which a sonde will be exposed during a particular flight is small so that the change in frequency during a flight will not be appreciable.

The S190 features a compact (1" diameter X 1.4" length), rugged package which is capable of withstanding a shock of 1600 g's for 2 milliseconds, an acceleration of 200 g's for 10 seconds, and a vibration of 20 g's from 20 to 2,000 Hz during operation, with negligible frequency or power changes. The operating frequency can be shifted ± 10 MHz by means of a single tuning screw accessible from the side. Provisions are included for frequency and ON-OFF pulse modulation. The S190 is designed for 18-volt operation to achieve optimum utilization of battery weight and space allocation.

The frequency stability of the standard S190 is less than 2 MHz shift with voltage changes from -12.5 to -11.5 volts.

See Figures 1 and 2 for a comparison of the batteries operated under simulated load conditions.

6. Sensors

The ML-419 Temperature Sensor and the ML-476 Humidity Sensor are used in both the Cricketsonde and the Balloonsonde as specified in the project work statement.

7. Antennas

The Transmitting Antenna will be a one-quarter wave dipole with a one-quarter wave counterpoise. The antenna system has a characteristic impedance that is very close to 50 ohms, thus providing a good match to the 50 ohm output impedance of the 1.68 GHz solid state power source. The VSWR will not exceed 1.5, thereby minimizing losses in the antenna system.

The receiving antenna is a $1/4$ wave length insulated conductor for the balloon package. The antenna is extended and attached to the lanyard prior to launch. For the rocketsonde package, before launch, the receiving antenna is tied to the parachute lanyard, folded and packed along with the parachute, in the parachute compartment. At apogee, the antenna is fully extended as the parachute is deployed.

8. Power Terminator

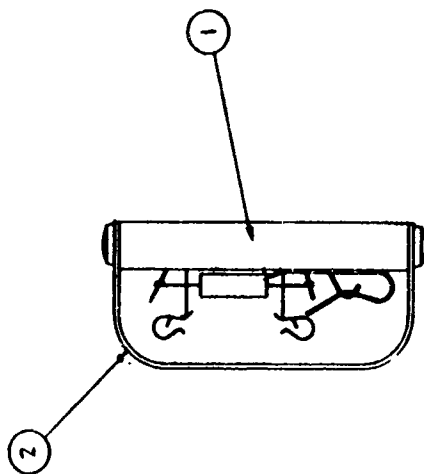
In order to prevent interference from a previously released sonde when several sondes are launched in quick succession, a power termination device is provided. Two mechanical timers were investigated for this purpose. One is the same timer used in the Cricket Rocket to deploy the parachute at apogee, but modified so that it could be set for any time delay up to ten minutes; the other is a Swiss-made pocket timer that provides up to a two-hour delay and is distributed in the United States by an electronics supply house. Contact with the vendors indicated that the Cricket-type timer would be less expensive than the pocket timer. It has, therefore, been selected for use in the sonde design.

In addition to the cost advantage, the Cricket-type timer already incorporates a "g" switch that would be required for the rocket application and has proved that it can withstand the rocket-environment. For balloonsonde use, the "g" switch can be tripped manually just prior to launch.

Refer to Figures 21, 22 and 23 for the mechanical assembly drawings of the radiosonde and the sensor package and the complete schematic of the unit.



Figure 21. Low Level Radiosonde Mechanical Assembly



CITY REG	ITEM NO	DWG SIZE	PART OR IDENTIFYING NO.		DESCRIPTION
	3	4	M53573-12		SUBM NACH 4-10-53
	1	3	RCOTGF 245		RESISTOR 24K 1/2 W
	1	2	C 24105		COVER, SENSOR HOUSING
	1	2	C 24105-1		HOUSING ASSEMBLY

FORM NO. 107
1-58-100-00-00000-1007

Figure 22. Mechanical Assembly Sensor Package

3. Power Supply
 4. Power Supply
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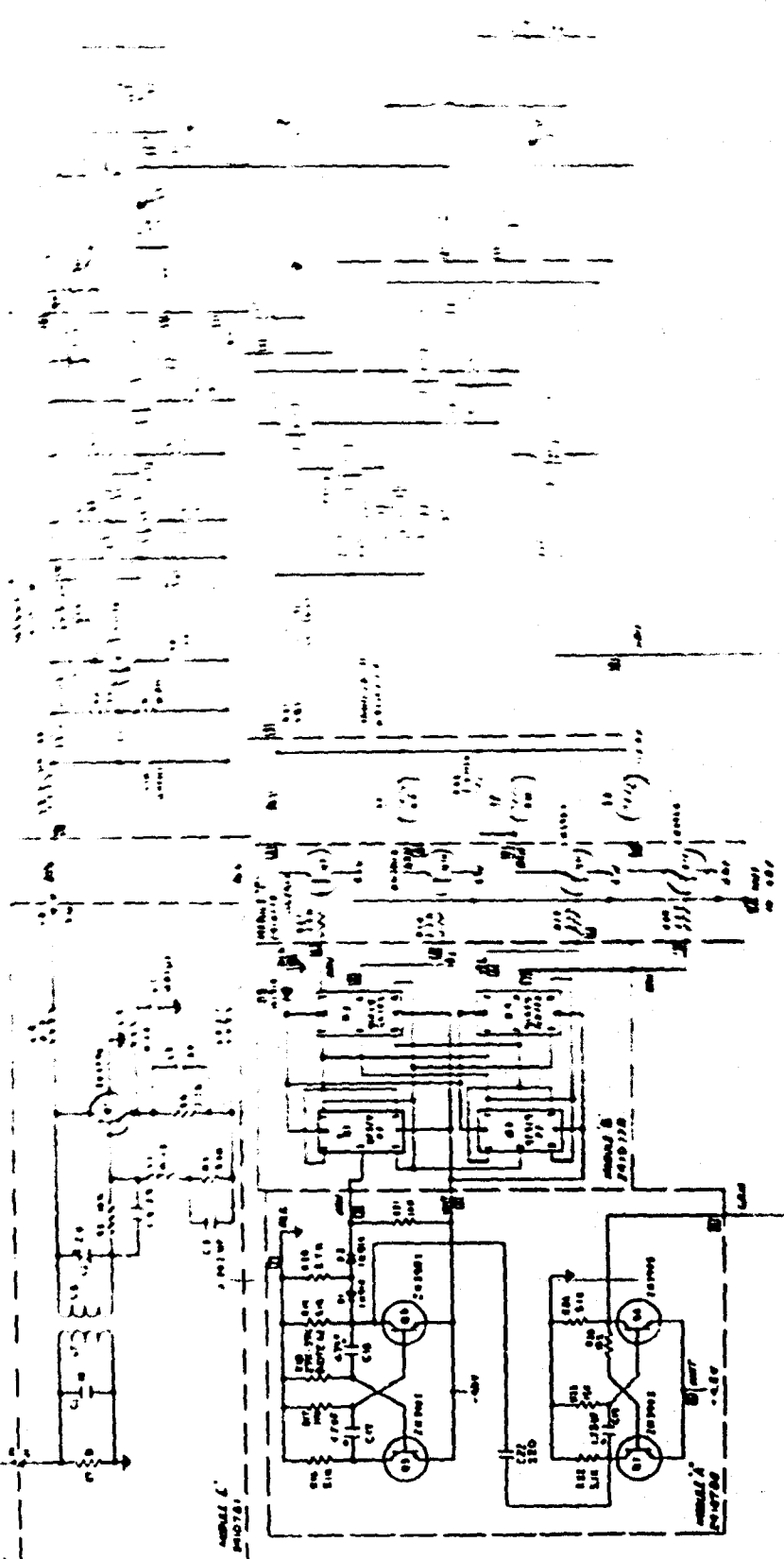


Figure 23. Schematic diagram of the radio receiver.

E. AN/GMD-4 DATA PROCESSOR MODIFICATION

TELEDYNAMICS MET. DATA PROCESSOR

1.0 Purpose

The purpose of this specification is to describe those changes required in the Teledynamics Meteorological Data Processor to make it compatible with the Low-Level Radiosonde.

2.0 Modifications

2.1 Cabinet Modifications

2.1.1 Voltage-Controlled Oscillator

Purpose - To provide power to the additional circuitry located on the modified VCO card.

Modification - Connect a wire from Pin E on the VCO connector to the most convenient + 15 volt terminal.

2.1.2 Integrating Amplifiers

Purpose - To change time constants and gain of integrating amplifiers.

Modification - Install a rotary switch on the Processing Drawer close to operational amplifiers 1 and 2. Wire as shown in Figure 24.

2.1.3 Purpose - To reduce met. data pulse from receiver to 100 usec.

Remove

C 1022 from V1008 pin 1

Add

C1022 to contact A of DPDT switch; common terminal of switch to V1008 pin 1; add capacitor C1022A (62 pf); one side to V1008, pin 7, other side to contact B of switch. See Figure 25.

Add a wire between J-205, pin 7 and J-206, pin 15.

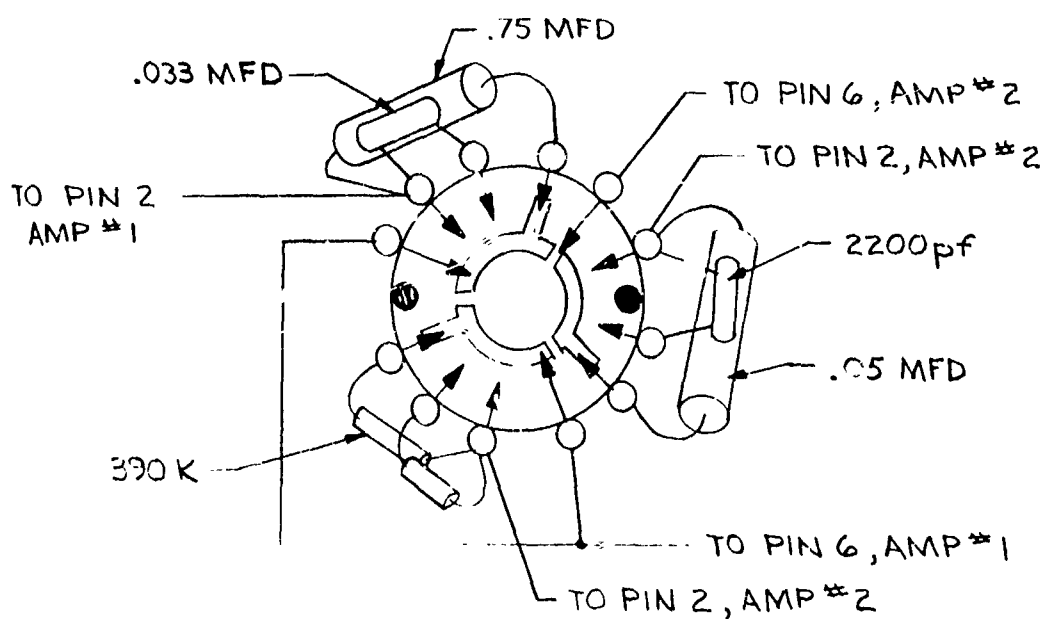
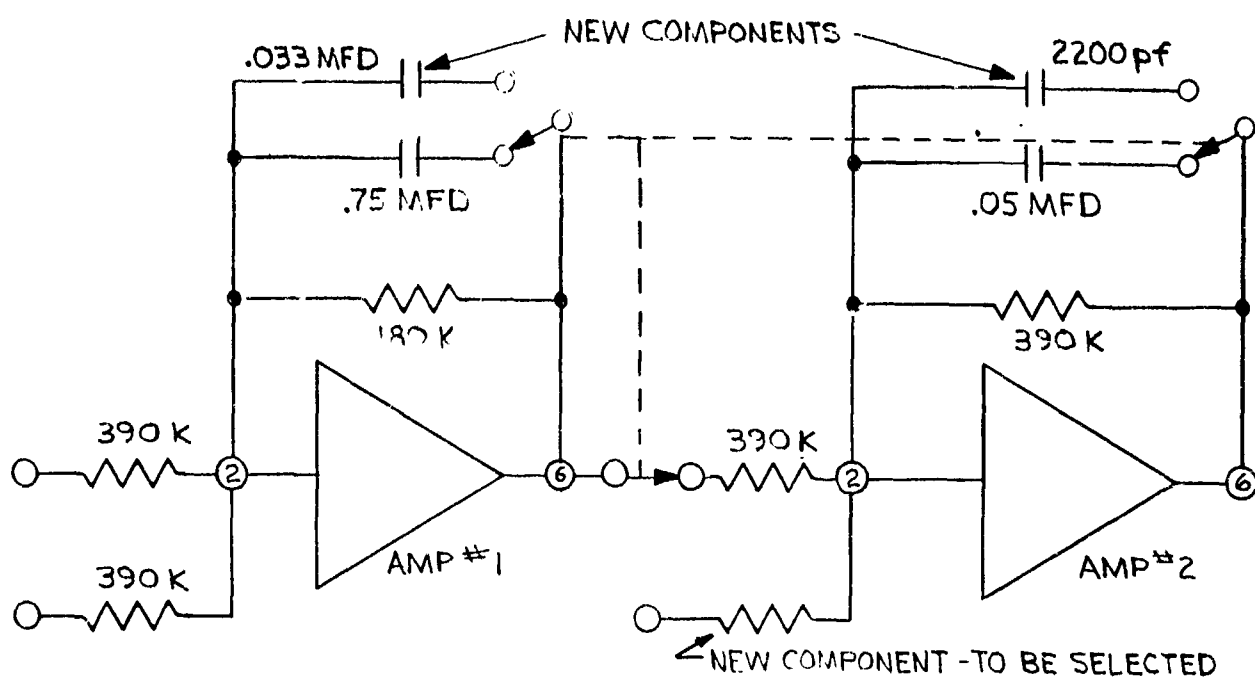


FIGURE 24

INTEGRATING AMPLIFIER MODIFICATION

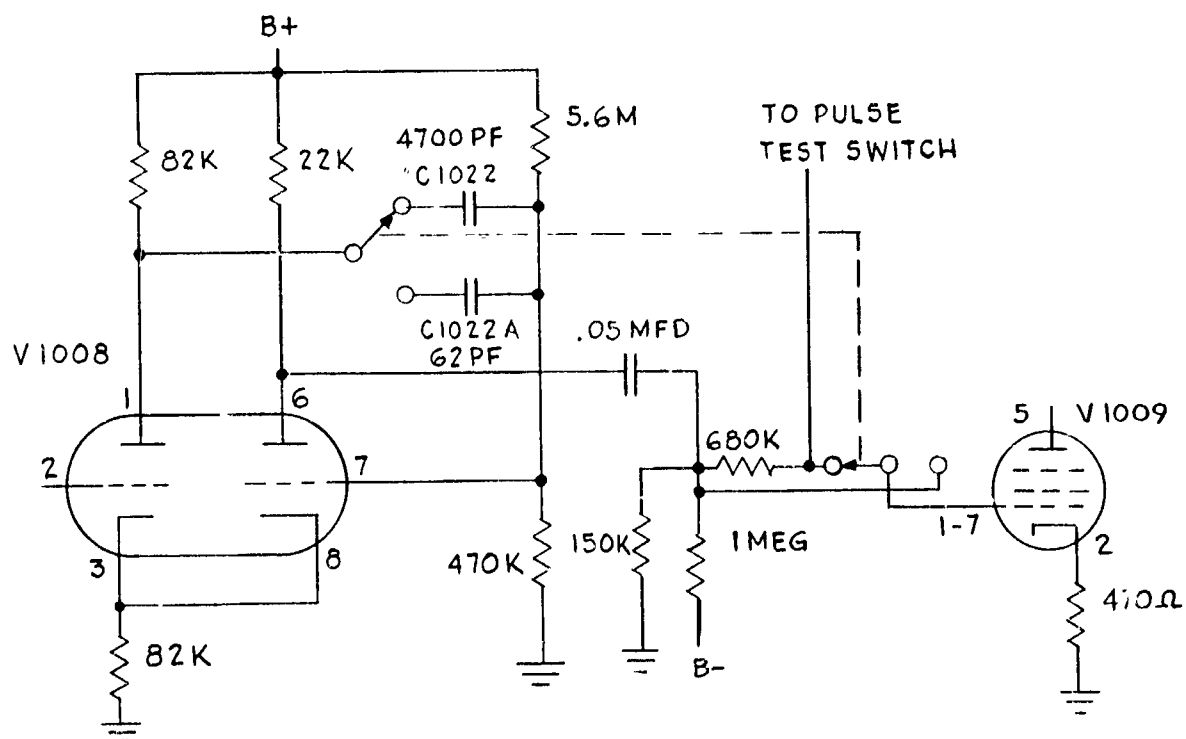


FIGURE 25
RECEIVER MODIFICATION

- 2.1.4 Purpose - Addition of a counter to provide a
1 KHZ counting signal to the Reference
Detector counter.

Modification - Add the following wires: (See Figure 26)

J203N to J215-B
J215-2 to J218-B
J218-F to J208-4
J208-2 to J215-P
J215-P to J215-C
J215-C to J215-13
J215-13 to J215-J
J215-J to J218-J
J218-J to J222-N
J218-18 to J215-12
J215-12 to J215-1

- 2.1.5 Purpose - To modify the counter in the pulse
standardization circuit.

Modification - Add a wire from J205-4 to J206-15.

2.2 Card Modifications

2.2.1 Pulse Standardization

Purpose - To modify counter in Pulse Standardizer
circuitry so that a reset is initiated after
counting Forty-three 200 KHZ pulses instead
of eight hundred sixty 200 KHZ pulses as
presently required.

Modification

Card J204; Remove wire from pin P to CR5,
add wire from CR5 to pin J.
Card J205; Remove wires from pin P to CR5,

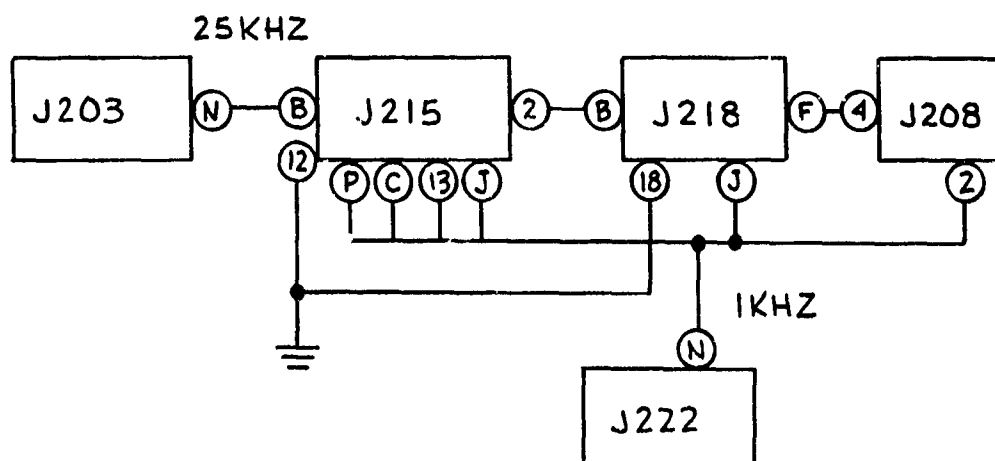


FIGURE 26

ADDITIONAL COUNTER TO PROVIDE A 1KHZ
SIGNAL TO REFERENCE DETECTOR

CR12 to pin C, and CR26 to pin 12. Add wires between CR5 (cathode) and pin J, cathodes of CR12 and CR26 to pin 13.

Isolate pin 2 from circuitry.

Isolate pin H from circuitry.

Add a wire between TP2 and pin 2.

Card J206; This will be a blank jumper card.

Add wires between pin B and pin H, and between pin 15 and pin 7.

Card J208; Remove C5 (.01 ufd). Replace C5 with .0022 ufd.

2.2.2 Meteorological Data Envelope Detector - J209

Purpose - Reduce the integrator time constant from 350 usec to 17.5 usec. Reduce the pulse width of the one-shot delay generator from 3.0 seconds to 0.15 second.

Modification - Replace C10 (2.7 ufd) with 0.135 ufd.
Replace C4 (50 ufd) with 2.5 ufd.

2.2.3 Missing Channel Detector - J210

Purpose - Reduce integrator time constant by a factor of 20. Reduce period of delay generator to .3 seconds.

Modification - Replace C5 (3.3 ufd) with 0.165 ufd.
Replace C5 (20 ufd) with 2.7 ufd.

2.2.4 Digital Reference Detector

Purpose - To increase the counting rate from 50 HZ to 1000 HZ. This will be accomplished by utilizing the 25 KHZ output on J203, adding a five-stage counter, and utilizing a spare one shot on J208. The new counter will be preset to a count of seven and after twenty-five additional counts will trigger the one-shot which will serve as the input to the Digital Reference Detector and as the reset signal to the new counter.

Modification - Add Binary Counter cards, Sonex type 2106-D (Dwg. No. 2217) in slots J215 and J218. No modifications are required on these cards.

Card J208 - Remove C11 (.01 ufd). Replace C11 with .0025 ufd.

Card J222 - Remove CR10 from pin 7. Add wire from CR10 to pin N.

2.2.5 Fall-out Detector During Reference Gate, J211

Purpose - To reduce the time constants in the integrator circuit by a factor of twenty. Reduce the period of the time delay generator from 1.5 seconds to 75 milliseconds.

Modification - Replace C2 (0.03 ufd) with .033 ufd. Replace C4 (20 ufd) with 1 ufd.

2.2.6 Reference Detector, Storage and Regeneration

Purpose - Modify BCD Reference Counter to generate a reset after accepting 1000 pulses. Change the counting frequency from 12.5 KHZ to 50 KHZ. Reduce time delay of one-shot J222-F from 1.5 seconds to 60 milliseconds.

Modification - Card J226: Replace with jumper card with pin B and pin 2 connected.

Card J203 - Isolate pin 2. Connect pin 2 to TP2.

Card J222 - Replace C7 (20 ufd) with 1.0 ufd capacitor.

2.2.7 Temperature, Humidity, and X-Channel Counters

Purpose - The tens, hundreds, and thousands positions of the counters are now being sampled by the output circuits and the data is punched on paper tape. The modification will provide sampling of the units, tens, and hundreds positions of the counters.

Modification - Cards J1, J5 and J30: Replace with jumper cards with pin B and pin 2 connected.

2.2.8 Modification to Timing for Punch Rate

Purpose - Maximum punch rate is now once every 6 seconds. The new punch rate must be once per second. Card J102 must be modified to divide by 2 and Cards J103 and J105 must be modified to divide by 25.

Modification - J102 - Isolate pin H. Add a wire between pin H and pin F.

J103 - Remove CR12 from pin C. Add jumper from CR12 to pin P.

J105 - Remove CR5 from pin P. Add jumper from pin 12 to cathode of CR5.

Isolate pins N and 14 from circuitry. Add jumpers between pins N and F and pins 14 and 6.

2.2.9 Programming Connector

Purpose - To provide substitute Program Connectors P93 and P193 so that the programming of the MDP will be compatible with the Low Level Radiosonde.

Modification - See Tables I and II for wiring information of P93 and P193.

TABLE I. WIRING FOR P93 IN GROUPS

I.	7-13	1-17	V.	11-49	35-54
	13-14	2-18		49-50	55-45
	14-15	3-78		50-51	46-56
	15-21	5-25		51-52	47-57
	21-22	76-26		52-53	48-58
II.	8-23	17-27	VI.	12-28	54-62
	23-66	72-78		28-59	55-63
	66-67	4-71		59-60	56-64
	67-73	25-70		60-74	57-65
III.	29-30	35-27			
	30-31	36-18			
	31-32	37-72			
	32-33	38-71			
	33-34	39-70			
	34-77	40-26			
IV.	10-41	36-45			
	41-42	37-46			
	42-43	38-47			
	43-44	39-48			

Table 2. Wiring for P193

Wire 70 to 74	Spare Channel in Block No. 3
77 to 73	Humidity Channel in Block No. 1
76 to 71	Temperature Channel in Block No. 2
Wire 14 to 4	Space after Humidity
13 to 7	Space after Humidity
Wire 15 to 8	Space after Temperature
16 to 2	Space after Temperature
Wire 39 to 15	Space after Spare Channel
38 to 34	Space after Spare Channel
Wire 17 to 10	Space after Range
18 to 1	Space after Range
Wire 20 to 17	Space after Elevation
36 to 38	Space after Elevation
Wire 22 to 11	Space after Hz
21 to 36	Space after Hz
Wire 25 to 12	Carriage Return
26 to 5	Carriage Return
Wire 23 to 25	C/R
24 to 21	C/R
Wire 27 to 37	L/F
28 to 18	L/F
Wire 32 to 27	Seq. Stop Gate
33 to 28	Seq. Stop Gate

VOLTAGE CONTROLLED OSCILLATOR

The requirements for the Voltage Controlled Oscillator in the Low Level Sounding System are to oscillate over a frequency range of zero to 20 KHZ with an input voltage range of zero to +10 volts, and to provide a positive-going output signal. Since the VCO presently used has a maximum operating frequency of 10 KHZ, it is necessary to replace it with an oscillator which conforms to the new specification.

The Vidar VCO, Model 211-07, which has a frequency range of zero to 50 KHZ was selected as the replacement unit. The negative output of the Model 211-07 is converted to a positive pulse by a single-transistor level changing circuit. The frequency range is changed to zero to 25 KHZ by the addition of a flip-flop which is driven by the level changer. The frequency range is adjusted to zero to 20 KHZ by increasing the value of one of the operational amplifier summing resistors.

Complete information on the modification of the VCO card is given in The Bendix Corporation's Environmental Science Division drawing number 2410494.

SONEX MET. DATA PROCESSOR

1.0 Purpose

The purpose of this specification is to describe those changes required in the Sonex Meteorological Data Processor to make it compatible with the Low Level Radiosonde.

2.0 Modifications

2.1 Cabinet Modifications

2.1.1 Voltage-Controlled Oscillator

Purpose - To provide power to the additional circuitry located on the modified VCO card.

Modification - Connect a wire from pin E on the VCO connector to the most convenient + 15 volt terminal.

2.1.2 Purpose - To reduce met. data pulse from receiver to 100 usec.

Modification

Remove

C1022 from V1008 pin 1

Add

C1022 to contact A of DPDT switch; common terminal of switch to V1008 pin 1; add capacitor C1022A (62 pf); one side to V1008, pin 7, other side to contact B of switch. See Figure 27.

2.1.3 Purpose - Addition of a counter to provide a 1KHZ counting signal to the Reference Detector counter.

Modification - Add the following wires: (See Figure 28).

J203-N to J216-B

J216-2 to J217-B

J217-F to J208-4

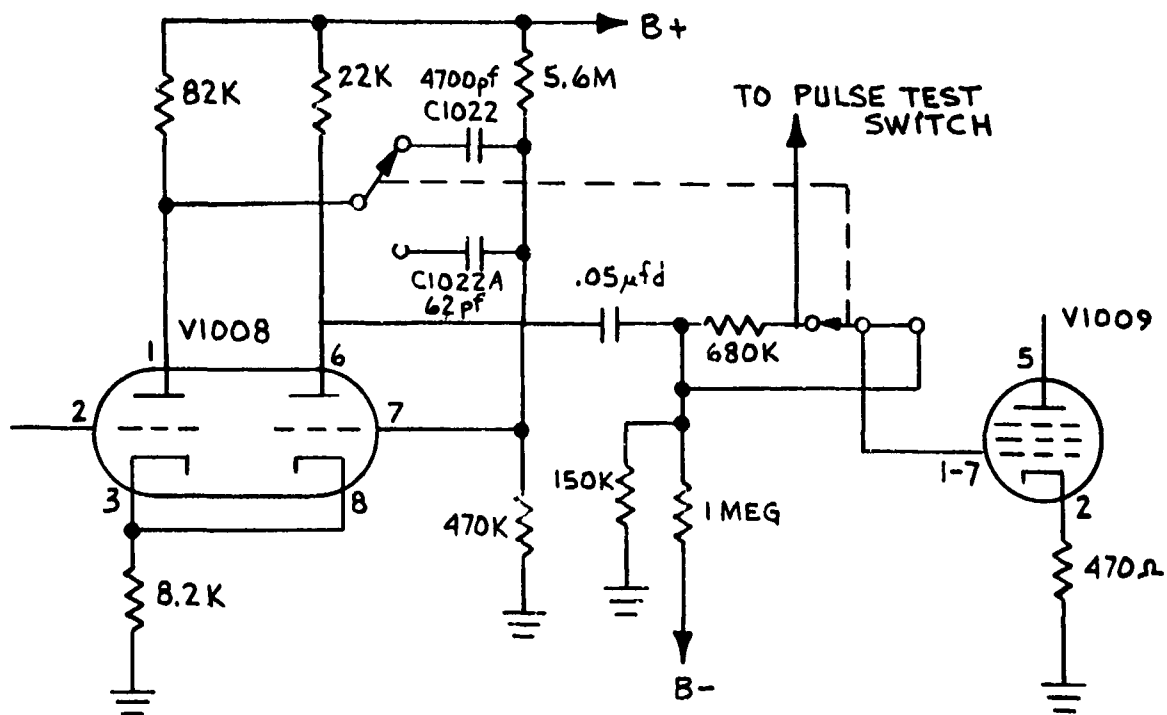


Figure 27.

Receiver Modification

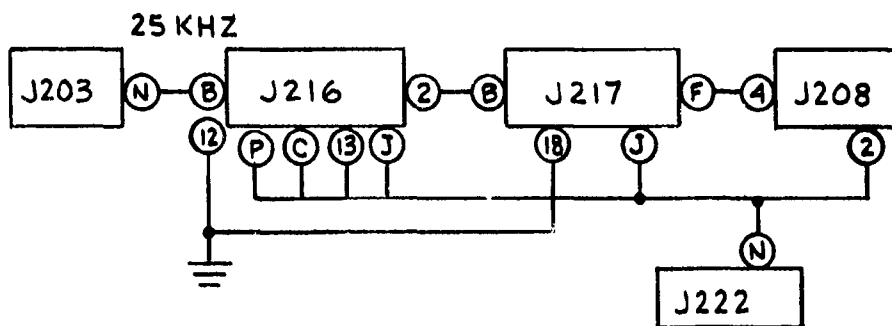


Figure 28.

Additional Counter to Provide a 1KHZ
Signal to Reference Detector

J208-2 to J216-P
J216-P to J216-C
J216-C to J216-13
J216-13 to J216-J
J216-J to J212-7
J217-J to J222-N
J217-18 to J216-12
J216-12 to J216-1

2.1.4 Add a wire between J205, pin 7 and J206, pin 15.

2.1.5 Purpose - To modify the counter in the pulse standardization circuit.

Modification - Add a wire from J205-4 to J206-15.

2.2 Card Modifications

2.2.1 Pulse Standardization

Purpose - To modify counter in Pulse Standardizer circuitry so that a reset is initiated after counting forty-three 200 KHZ pulses instead of eight hundred sixty 200 KHZ pulses as presently required.

Modification - Card J204 - Remove wire from pin P to CR5; add wire from CR5 to pin J.

Card J205 - Remove wires from pin P to CR5, CR12 to pin C, and CR26 to pin 12. Add wires between CR5 (cathode) and pin J, cathodes of CR12 and CR26 to pin 13.

Isolate pin 2 from circuitry.

Isolate pin H from circuitry.

Add a wire between TP2 and pin 2.

J208-2 to J216-P
J216-P to J216-C
J216-C to J216-13
J216-13 to J216-J
J216-J to J212-7
J217-J to J222-N
J217-18 to J216-12
J216-12 to J216-1

2.1.4 Add a wire between J205, pin 7 and J206, pin 15.

2.1.5 Purpose - To modify the counter in the pulse standardization circuit.

Modification - Add a wire from J205-4 to J206-15.

2.2 Card Modifications

2.2.1 Pulse Standardization

Purpose - To modify counter in Pulse Standardizer circuitry so that a reset is initiated after counting forty-three 200 KHZ pulses instead of eight hundred sixty 200 KHZ pulses as presently required.

Modification - Card J204 - Remove wire from pin P to CR5; add wire from CR5 to pin J.

Card J205 - Remove wires from pin P to CR5, CR12 to pin C, and CR26 to pin 12. Add wires between CR5 (cathode) and pin J, cathodes of CR12 and CR26 to pin 13.

Isolate pin 2 from circuitry.

Isolate pin H from circuitry.

Add a wire between TP2 and pin 2.

Card J206 - This will be a blank jumper card.

Add wires between pin B and pin H, and between pin 15 and pin 7.

Card J208 - Remove C5 (.01 ufd). Replace C5 with .0022 ufd.

2.2.2 Meteorological Data Envelope Detector - J209

Purpose - Reduce the integrator time constant from 350 usec to 17.5 usec. Reduce the pulse width of the one-shot delay generator from 2.0 seconds to 0.10 seconds.

Modification - Replace C10 (2.7 ufd) with 0.135 ufd.
Replace C4 (50 ufd) with 2.5 ufd.

2.2.3 Missing Channel Detector - J210

Purpose - Reduce integrator time constant by a factor of 20. Reduce period of delay generator to .3 seconds.

Modification - Replace C5 (3.3 ufd) with 0.165 ufd.
Replace C5 (20 ufd) with 2.2 ufd.

2.2.4 Digital Reference Detector

Purpose - To increase the counting rate from 50 HZ to 1000 HZ. This will be accomplished by utilizing the 25 KHZ output on J203, adding a five-stage counter, and utilizing a spare one-shot on J208. The new counter will be preset to a count of seven and after twenty-five additional counts will trigger the one-shot which will serve as the input to the Digital Reference Detector and as the reset signal to the new counter.

Modification - Add Binary Counter cards, Sonex type J2106-D (Drawing No. 2217) in slots J216 and J217. No modifications are required on these cards.

Card J208 - Remove C11 (.01 ufd). Replace C11 with .0025 ufd.

Card J222 - Remove CR10 from pin 7. Add wire from CR10 to pin N.

2.2.5 Fall-out Detector During Reference Gage, J211

Purpose - To reduce the time constants in the integrator circuit by a factor of twenty. Reduce the period of the time delay generator from 1.0 second to 50 milliseconds.

Modification - Replace C2 (0.68 ufd) with .033 ufd.
Replace C4 (20 ufd) with 1 ufd.

2.2.6 Reference Detector, Storage and Regeneration

Purpose - Modify ECD Reference Counter to generate a reset after accepting 1000 pulses. Change the counting frequency from 12.5 KHZ to 50 KHZ. Reduce time delay of one-shot J222-F from 1.5 seconds to 60 milliseconds.

Modification - Card J226 - Replace with jumper card with pin B and pin 2 connected.

Card J203 - Isolate pin 2. Connect pin 2 to TP2.

Card J222 - Replace C7 (20 ufd) with 1.0 ufd capacitor.

2.2.7 Temperature, Humidity, and X-Channel Counters

Purpose - The tens, hundreds, and thousands positions of the counters are now being sampled by the output circuits and the data is punched on paper tape. The modification will provide sampling of the units, tens, and hundreds positions of the counters.

Modification - Card J215 - Replace with jumper card with pin B and pin 2 connected.

2.2.8 Modification to Timing for Punch Rate

Purpose - Maximum punch rate is now once every 6 seconds. The new punch rate must be once per second.

Card J102 must be modified to divide by 2 and Cards J103 and J105 must be modified to divide by 25.

Modification - J102 - Isolate pin H. Add a wire between pin H and pin F.

J103 - Remove CR12 from pin C. Add jumper from CR12 to pin P.

J105 - Remove CR5 from pin P. Add jumper from pin 12 to cathode of CR5. Isolate pins N and 14 from circuitry. Add jumpers between pins N and F and pins 14 and 6.

2.2.9 Integrating Amplifiers - J219

Purpose - To change the time constants of the integrating amplifiers.

Modification - Remove C4 (.33 ufd); replace with .015 ufd.

Remove C5 (.01 ufd); replace with .510 pf.

2.2.10 Programming Connector

Purpose - To provide substitute Program Connectors P93 and P193 so that the programming of the MIP will be compatible with the low level radiconde.

Modification - See Tables I and II for wiring information of P93 and P193.

TABLE I. WIRING FOR P93 IN GROUPS

I.	7-13	1-17	V.	11-49	35-54
	13-14	2-18		49-50	55-45
	14-15	3-78		50-51	46-56
	15-21	5-25		51-52	47-57
	21-22	76-26		52-53	48-58
II.	8-23	17-27	VI.	12-28	54-62
	23-66	72-78		28-59	55-63
	66-67	4-71		59-60	56-64
	67-73	25-70		60-74	57-65
III.	29-30	35-27			
	30-31	36-18			
	31-32	37-72			
	32-33	38-71			
	33-34	39-70			
	34-77	40-26			
IV.	10-41	36-45			
	41-42	37-46			
	42-43	38-47			
	43-44	39-48			

Table 2. Wiring for P193

Wire 70 to 74	Spare Channel in Block No. 3
77 to 73	Humidity Channel in Block No. 1
76 to 71	Temperature Channel in Block No. 2
Wire 14 to 4	Space after Humidity
13 to 7	Space after Humidity
Wire 15 to 8	Space after Temperature
16 to 2	Space after Temperature
Wire 39 to 15	Space after Spare Channel
38 to 34	Space after Spare Channel
Wire 17 to 10	Space after Range
18 to 1	Space after Range
Wire 20 to 17	Space after Elevation
36 to 38	Space after Elevation
Wire 22 to 11	Space after Hz
21 to 36	Space after Hz
Wire 25 to 12	Carriage Return
26 to 5	Carriage Return
Wire 23 to 25	C/R
24 to 21	C/R
Wire 27 to 37	L/F
28 to 18	L/F
Wire 32 to 27	Seq. Stop Gate
33 to 28	Seq. Stop Gate

VOLTAGE CONTROLLED OSCILLATOR

The requirements for the Voltage Controlled Oscillator in the Low Level Sounding System are to oscillate over a frequency range of zero to 20 KHZ with an input voltage range of zero to +10 volts, and to provide a positive-going output signal. Since the VCO presently used has a maximum operating frequency of 10 KHZ, it is necessary to replace it with an oscillator which conforms to the new specification.

The Vidar VCO, Model 211-07, which has a frequency range of zero to 50 KHZ was selected as the replacement unit. The negative output of the Model 211-07 is converted to a positive pulse by a single-transistor level changing circuit. The frequency range is changed to zero to 25 KHZ by the addition of a flip-flop which is driven by the level changer. The frequency range is adjusted to zero to 20 KHZ by increasing the value of one of the operational amplifier summing resistors.

Complete information on the modification of the VCO card is given in The Bendix Corporation's Environmental Science Division drawing number 2410494.

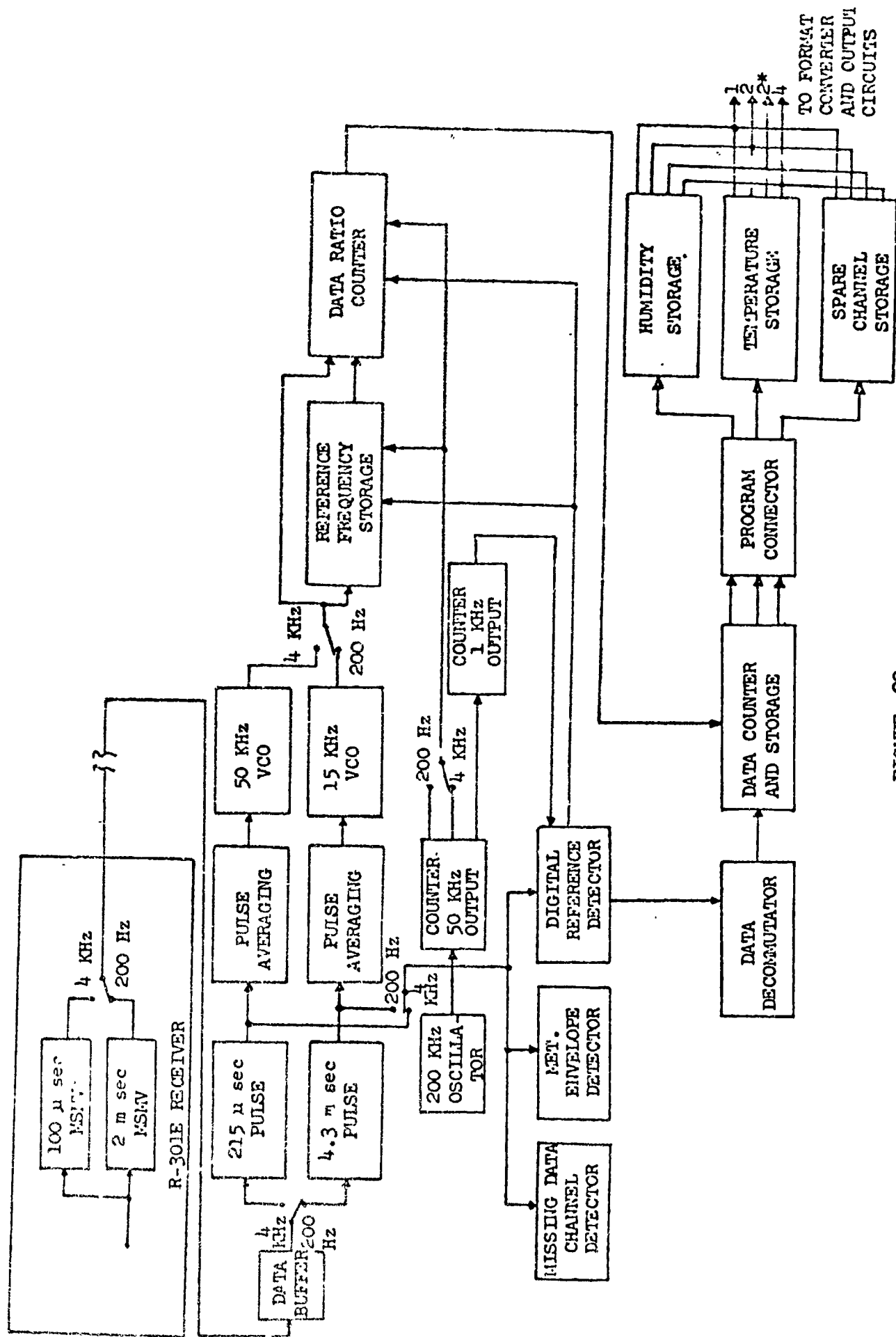


FIGURE 29

AN/GSD-4 MODIFICATION BLOCK DIAGRAM

F. CRICKET ROCKET

1. General

The Cricket Rocket (Cold Rocket Instrument Carrying Kit) is an economical aerial reconnaissance unit designed to aid in the study of the lower atmosphere. The system was designed and manufactured by Texaco Experimental Incorporated of Richmond, Virginia.

The system was designed to carry a payload to a predetermined altitude and then to safely return the vehicle, by means of a parachute, to earth. The two major parts of the system are the rocket and the launcher.

One of the most important features of this system is that the propellant produces no flame and therefore no heat. In addition, the propellant requires no special handling techniques, and has an indefinite storage life and is commercially available at low cost.

The rocket consists of a payload section (low level radiosonde), a recovery section and motor section.

G. FLIGHT TEST RESULTS

1. The participants during the flight tests of the Low Level Sounding System at the Air Force Eastern Test Range, Cape Kennedy, Florida, the week of June 5, 1967, were as follows:

Captain T. Smith	CREU-AFCRL
Mr. R. Betz	Bendix ESD
Mr. J. Wills	Bendix ESD
Mr. R. Ramirez	Bendix ESD
Mr. D. Nolte	Texaco Experimental Inc.
Mr. J. Davis	Pan Am
Mr. R. Stickland	Pan Am
Mr. O. Daniels	Pan Am

Analysis of these flight test results indicated two major problem areas. One of these was attributed to an incompatibility between the RCA S-190 transmitter and the GMD-2 receiver. The automatic frequency control mode of operation of the GMD-2 receiver was not capable of being used because of its bandwidth and slow response time characteristic. It seemed apparent that the S-190 transmitter frequency drift was greater than 450 KC either side of the carrier

frequency, causing the AFC of the GMD-2 receiver to lose frequency lock and drift to its upper frequency limit. As a result of this condition, it was necessary to manually tune the GMD receiver to maintain frequency lock throughout the radiosonde flights.

A mechanical problem was encountered with the rocketsonde version. The original design of the radiosonde (rocket version) required the nose cone to physically drop from the radiosonde unit at approximately T + 15 seconds (apogee) with only gravitational forces providing the separation. This approach was not feasible because of the lack of uniformity of nose cone and radiosonde case dimensions. In conjunction with the above approach, a field replaceable S-190 transmitter quick disconnect and connect antenna was provided. This was necessary due to the drop-off nose cone design for the recoverable and reusable radiosonde design philosophy, whereby the transmitter antenna received damage on impact with the surface.

Captain T. Smith and Bendix personnel agreed to those areas requiring additional investigation before further flight testing.

The flight test data accumulated was reduced and documented by Captain G. Canning, CRER-AFCRL and is presented in tabulated form in the following:

Low Level Sovie System Flight Tests

June 7-9, 1967

Balloonsondes - 4 Flights (Summary)

Average time before acquiring good meteorological data	.75 seconds
--	-------------

Average time before acquiring good range and angle information	39.75 seconds
--	---------------

Number of sets of unusable met data vs. number of sets of data considered starting when usable met data acquired:

At approximately T + 5 minutes (#11, 10, 5 and 7)	34/1108 = 3.069%
At approximately T + 10 minutes (#11, 10 and 7)	21/1799 = 1.167%
At termination at approximately T + 11 minutes (#11, 10 and 7)	22/1986 = 1.108%

Number of sets of unusable met data vs. number of sets of data considered starting when first usable range data acquired:

At approximately T + 5 minutes
(#11, 10, 5 and 7) $8/952 = 0.840\%$

At approximately T + 10 minutes
(#11, 10 and 7) $0/1669 = 0.0\%$

At termination at approximately
T + 11 minutes (#11, 10 and 7) $0/1856 = 0.0\%$

Average of maximum variation of spare channel ratio:

Not including questionable data acquired = .00375

Including questionable data acquired = .00525

Number of data jumps in fine ranging
 ≥ 20 yards/second vs. number of sets
of data considered $49/1846 = 2.654\%$

Average of maximum data jumps in fine
ranging 35.5 yards/second

Maximum questionable changes in
temperature data ratio .005

Maximum questionable changes in
humidity data ratio .060, .031 and .026

The above summarized data was obtained from the following test
data of individual radiosondes:

Balloonsonde Serial #11

Met Data

Time before acquiring usable met data T + 0 seconds

Sonde transmission termination time T + 10.1 minutes

Number of sets with unusable met data vs. number of sets of
met data considered at:

T + 5 minutes - $1/300 = .333\%$

T + 10 minutes - $1/600 = .167\%$

Termination - $2/609 = .328\%$

Number of sets with unusable met data vs. number of sets
considered starting when usable range data acquired:

T + 5 minutes - $0/265 = .0\%$

T + 10 minutes - $0/565 = .0\%$

Termination - $1/574 = 0.17\%$

Largest questionable data jump in temperature
ratio -

702 to 697 = 5

Largest questionable data jump in humidity
ratio -

206 to 266 = (60)

High spare channel ratio
Low spare channel ratio

504
497

Ranging Data

Time elapsed before usable fine ranging signal = T + 35 seconds.

Data jumps in fine ranging \geq 20 yards after T + 35 seconds =
5 in 572 printouts.

Maximum data jump in fine ranging after T + 35 seconds =
31 yards (680 - 711).

Course range data jumps 000 to 104 after 1 - 2 seconds.

Course range data accumulated correctly but off by 104 K yards
from T + 2 seconds on. Maximum course range change occurred at
T + 33 to T + 34 seconds. 207 to 266

Angle data jumps

None

Balloonsonde Serial #10

Met Data

Time before acquiring good met data

T + 1 second

Sonde transmission termination time

T + 11 minutes

Number of sets with unusable met data vs. number of sets of
met data considered at:

T + 5 minutes - 1/299 = .33%

T + 10 minutes - 1/599 = .17%

T + 10.99 minutes - 1/659 = .15%

Number of sets with unusable met data vs. number of sets
considered starting when usable range data acquired.

T + 5 minutes - 0/271 = .0%

T + 10 minutes - 0/571 = .0%

Termination - 0/631 = .0%

There were no questionable data jumps in temperature or humidity.

Spare channel printout range

501 to 504

Ranging Data

Time elapsed before usable ranging data = T + 29 seconds.

Maximum fine range jumps after T + 29 seconds = 30 yards/second.

Number of data jumps \geq 20 yards after T + 29 seconds =
7/630 = 1.11%.

Course ranging data jumps:

000 102 at T + 29 - 30 seconds

103 106 at T + 402 - 403 seconds

Coarse ranging usable data after T + 403 seconds.

After T + 659 seconds, no temperature or spare channel data received.

Humidity data still constant.

Ranging data jumps in 35 to 40 yard increments.

Azimuth angle jumps 180° to 193° at T + 10 - 11 seconds.

Balloonsonde Serial #5

Met Data

Time elapsed before acquiring good data T + 2 seconds

Sonde data transmission termination T + 672 seconds

No met data received after T + 210 seconds.

Number of sets with unusable met data vs. number of sets of met data considered at:

T + 2 to T + 210 seconds 13/209 = 6.22%

T + 28 to T + 210 seconds 8/183 = 4.37%

Erratic data jumps in temperature data were obviously bad.

Maximum data jumps in humidity printout 536 to 505 = 31

Ranging Data

Maximum data jumps in ranging data after T + 28 seconds:

2858 to 2914 yards = 56 yards

Maximum data jumps \geq 20 yards occurring
between T + 26 to T + 671 seconds 37/643 = 5.75%

Low-High spare channel printouts 499 - 503

Maximum Azimuth Angle data jumps	188.4° to 197.85°
Maximum Elevation Angle data jumps	12.67° to 19.33°

Even though met data appeared to be good at T + 2 seconds, the data jumps in angle information indicated that the GMD unit was not on target. This might explain some of the unusable data accumulated at T + 17, 18, 24, 25 and 26 seconds. Using this assumption, the GMD receiver was then manually tuned for the remainder of the flights and the AFC problem with the system was diagnosed.

Course ranging data jump from 003 to 006 occurred at T + 577 and T + 578 seconds.

At T + 327 seconds, no range, angle, or time printouts occurred.

At T + 335 seconds, printout started with range, angle and time of T + 327.

Next good range, angle, and time printout occurred at T + 336 seconds.

Balloonsonde Serial #7

Met Data

Time elapsed before acquiring good data T + 0 seconds

Sonde data transmission termination T + 718 seconds

Number of sets with unusable met data vs. number of sets of met data considered at:

T + 5 minutes	19/300 = 6.33%
T + 10 minutes	19/600 = 3.17%
T + 11.95 minutes	19/718 = 2.65%

Number of sets with unusable met data vs. number of sets considered starting when usable range data acquired:

T + 5 minutes	0/233 = 0%
T + 10 minutes	0/533 = 0%
T + 11.95 minutes	0/151 = 0%

Maximum data jump in temperature ratio printouts--data jumps occurring were obviously bad.

Maximum data jump in humidity ratio printout 402 - 428

Low-High spare channel ratio printouts 500 - 504

Ranging Data

Elapsed time before usable ranging data acquired = T + 67 seconds.

Data jumps in fine ranging ~~20~~ 20 yards after

T + 67 seconds 3/650 = .46%

Maximum data jumps in fine ranging occurred between T + 167
and T + 168 seconds:

$$1201 - 1226 = 25 \text{ yards}$$

At beginning of flight, in coarse range printout were 4 sets
of number's reading 999(9--) from T + 5 to T + 8 seconds.

Operation of the system indicates switching between coarse
range and fine range can cause an internal error in the GMD
readout as evidenced from the flight test data recorded.
When going from 999997 to 000078 the latter reading was
indeterminate.

After T + 67 seconds, coarse ranging data was usable.

Maximum angle data jumps in elevation 9.44° to $18.71^{\circ} = 9.27^{\circ}$

Maximum angle data jumps in azimuth 163.47° to $173.4^{\circ} = 9.93^{\circ}$

Printout data for this balloonsonde indicated that release
occurred at T + 46 seconds although ranging data began
accumulating at T + 0 seconds.

Rocketsondes (Summary of 2 Flights Considered)

Sondes, serial numbers 1 and 12, were considered out of 3 flights
conducted. The third sonde provided no usable data. It was during
the third test flight, that the original design drop-off nose cone
became detached from the unit on ascent. Hopes of recovering the
unit to determine cause were shattered when the unit landed in the
ocean about 200 yards offshore. After discussion between
Captain Smith and Bendix personnel, it was assumed that cause of
failure be attributed to bending over of the RCA S-190 transmitting
antenna and destruction of the sensors when the nose cone was
ripped from the unit on ascent. None of the three rocketsondes
flight-tested provided usable ranging information. The same
parties investigated this problem at the site as a low signal level,
coupled with the AFC problem previously mentioned. Both of these
were to be investigated further by Bendix.

Average elapsed time before acquiring
usable met data T + 54 seconds

Average sonde transmitting termination
time T + 273.5 seconds

Number of sets of unusable met data vs. number of sets of met
data considered starting with first usable data acquired:

$$15/438 = 3.424\%$$

Average maximum variation of spare
channel ratio 0.00250

Ranging Data

No usable ranging data accumulated.

Average maximum elevation angle of 15.44° at an average time of T + 14.5 seconds.

The above summarized data was obtained from the following test data of individual rocketsondes:

Rocketsonde Serial #1

Met Data

Time before acquiring usable met data T + 33 seconds

Sonde transmitting termination time T + 275 seconds

Number of sets of unusable met data vs. number of sets of met data considered starting with first usable data acquired:

$$14/242 = 5.79\%$$

Low-High spare channel ratio printout 504 - 506

Temperature and humidity data jumps observed were obviously in error.

Ranging Data

No usable ranging data acquired.

Fine range data changed only a maximum of 18 yards in 54 seconds.

Coarse range data was very erratic.

Maximum elevation angle recorded was 15.23° at T + 15 seconds.

Rocketsonde Serial #12

Met Data

Time before acquiring usable met data T + 75 seconds

Sonde transmission termination time T + 272 seconds

There were no questionable data jumps in the temperature or humidity data acquired.

Low-High spare channel ratio printout 504 - 507

Number of sets with unusable met data vs. number of sets of data considered from first usable data acquired:

$$1/196 = .51\%$$

Ranging Data

The system did not function properly in either coarse or fine ranging modes. The weak ranging signal being transmitted from the sonde was the apparent problem here.

Maximum elevation angle recorded was 15.64° at T + 14 seconds.

2. The participants of the second flight tests conducted at Cape Kennedy, Florida during the week of October 8, 1967 were:

Captain T. Smith	CREU-AFCRL
Mr. R. Betz	Bendix ESD
Mr. J. Wills	Bendix ESD
Mr. D. Nolte	Texaco Experimental Inc.
Mr. R. Ramirez	Bendix ESD
Mr. J. Davis	Pan Am
Mr. R. Stickland	Pan Am
Mr. O. Daniels	Pan Am

After investigating those problem areas evidenced during the first flight tests conducted, Bendix made redesign changes to the nose cone, the RCA S-190 transmitter antenna and input circuitry, and the balloon case design. Bendix and the U. S. Air Force personnel then returned to the Air Force Eastern Test Range to conduct further tests. The results of these tests are as follows:

Low Level Sonde System Flight Tests

October 9-11, 1967

Balloonsondes - 7 Flights (Summary)

Average time before acquiring usable met data	T + 27.14 seconds
Average time before acquiring usable ranging data	T + 21.00 seconds

Number of sets of unusable met data vs. number of sets of met data considered after first usable met data acquired:

T + 5 minutes	139/1827 = 7.61%
T + 10 minutes	294/3855 = 7.67%
Termination (4 Flights)	296/2516 = 11.76%

Number of sets of unusable met data vs. number of sets of data considered after first usable ranging data acquired at:

T + 5 minutes (4 Flights)	73/811 = 9.00%
T + 10 minutes (3 Flights)	178/1711 = 10.40%
Termination (2 Flights)	171/1229 = 13.91%

Average of maximum variation in spare channel ratio:

With only usable data	.00400
Including questionable data	.00671

Number of data jumps in fine ranging ≥ 20 yards/second vs. number of sets of data considered: (6 Flights)

307/3597 = 8.56%

Average of maximum data jumps in fine ranging:

39.9 yards/second

Rocketsondes - 5 Flights (Summary)

Average time before acquiring usable met data T + 12 seconds (4 Flights)

Average time before acquiring usable ranging data T + 2 seconds

Number of unusable data sets vs. number of data sets considered from beginning of usable data:

152/1069 = 14.22% (4 Flights)

Sonde transmission termination time T + 276.2 seconds

Average maximum variation of spare channel with:

Usable data only	.0040 (3 flights)
Questionable data included	.00725 (4 flights)

Number of data jumps in fine ranging \geq 20 yards/second vs.
number of data sets considered:

18/1296 = 1.39% (5 flights)

Average of maximum data jumps in fine ranging	37.0 yards (4 flights)
--	------------------------

Average of maximum elevation angles	17.88° at average time of 15 seconds
-------------------------------------	---

Average of payload apogee times @ maximum elevation angle occurrence	T + 14.9 seconds
---	------------------

The above balloonsonde flight test summaries were derived from the
following individual sonde flights:

Balloonsonde Serial #18

Met Data

Good met data at	T + 26 seconds
Good range and angle data at	T + 53 seconds
Sonde termination time	T + 674 seconds

Unusable met data vs. number of data sets considered starting
when good met data acquired:

T + 5 minutes	- 14/274	=	5.11%
T + 10 minutes	- 15/574	=	2.61%
T + 11.2 minutes	- 16/648	=	2.47%

Unusable met data vs. number of data sets considered starting
when good ranging data acquired:

T + 5 minutes	- 9/247	=	3.64%
T + 10 minutes	- 10/547	=	1.83%
T + 11.2 minutes	- 11/621	=	1.77%

Low-High spare channel printout	498 - 503
---------------------------------	-----------

Maximum temperature data jumps at T + 469 - T + 470 = .010.

Maximum humidity data jumps at T + 53 - T + 54 = .020.

Ranging Data

Ranging data jumps \geq 20 yards/second after T + 52 seconds:

91/620 = 14.68%

Maximum ranging data jump 52 yards
 Coarse ranging good between T + 53 and T + 316 seconds.
 Coarse ranging not usable after T + 316 seconds.
 Maximum angle data jumps: Elevation 8.53°
 Azimuth 10.22°

Balloonsonde Serial #13

Met Data

Good met data at T + 29 seconds (temperature and humidity at T + 15).

Good range and angle data T + 17 seconds
 Termination time: Met data T + 528 seconds
 Range data T + 572 seconds

Unusable met data vs. number of data sets considered at:

T + 5 minutes 40/271 = 14.76%

Termination 42/499 = 8.42%

Low-High spare channel 496 - 503

Temperature data jumps None

Humidity data jump from T + 115 to T + 117 = .026.

Ranging Data

Data jumps in fine range \geq 20 yards/second after T + 17 seconds:

59/554 = 10.65%

Maximum data jump in fine range 37 yards

Maximum data jump in coarse range None

No significant angle data jumps.

Many channel shifts occurred in data printout. Majority of these were spare channel to temperature and temperature to humidity.

Balloonsonde Serial #6

Met Data

Good met data at T + 21 seconds
Good ranging and angle at T + 23 seconds
Termination time T + 631 seconds
Unusable met data vs. number of data sets considered at:

T + 5 minutes 64/279 = 22.94%

T + 10 minutes 160/579 = 27.63%

Termination 160/610 = 26.23%

Low-High spare channel 491 - 508

Maximum temperature data jump at T + 713 - 714 = 014.

Maximum humidity data jump at T + 351 - 352 = 014.

Ranging Data

Data jumps in range \geq 20 yards/second after T + 23 seconds:

102/607 = 16.8%

Maximum range data jump at T + 402 - 403 = 54 yards.

No usable coarse range data acquired.

Erroneous number value of 599 printed out in spare channel four successive printouts while remaining channels exhibited good usable data.

Balloonsonde Serial #9

Met Data

Good met data at T + 7 seconds
Good range data at T + 13 seconds
Termination time T + 2444 seconds
(40.7 minutes)

This sonde was released without setting the 10 minute timer so as to obtain data in excess of the design requirement. The GMD data processor was also set to provide interval printouts. Unusual

breaks in data translation occurred during this flight which can be traced to either loss of high reference, or the met data processor subsystem.

Unusable met data vs. number of data sets considered at:

T + 5 minutes	0/293 = 0%
T + 10 minutes	8/593 = 1.35%
Low-High spare channel printout	500 - 503
Temperature data jumps	None
Humidity data jumps	None

Ranging Data

Data jumps in ranging \geq 20 yards/second not meaningful with the large number of breaks in data.

Maximum data jump in ranging at T + 546 to T + 547 seconds = 40 yards.

Number of angle data jumps	None
----------------------------	------

Balloonsonde Serial #14

Met Data

Good met data at	T + 47 seconds
Good range data at	T + 18 seconds
Termination time at	T + 580 seconds

Unusable met data vs. number of data sets considered at:

T + 5 minutes	2/253 = .79%
Termination	2/533 = .38%
Low-High spare channel printout	502 - 504

Ranging Data

Data jumps in range \geq 20 yards/second after T + 18 seconds:

30/561 = 5.35%

Maximum data jump in range at T + 192 - 193 seconds = 32 yards.

Coarse range data satisfactory except for printouts between T + 6 to T + 15 seconds at 0000(--).

Number of angle data jumps	None
----------------------------	------

Balloonsonde Serial #8

Met Data

Good met data at T + 26 seconds
Good range data at T + 11 seconds
Termination time T + 618 seconds

Unusable met data vs. number of data sets considered at:

T + 5 minutes	5/191 = 2.62%
T + 10 minutes	19/491 = 3.87%
Termination	19/509 = 3.73%

No data received from T + 213 to T + 295 seconds.

Low-High spare channel printouts 495 - 500

Number of temperature data jumps None

Humidity data jumps at:

T + 308 to T + 309 seconds	101
T + 309 to T + 310 seconds	041

Ranging Data

Number of range data jumps \geq 20 yards/second after T + 11 seconds:

12/606 = 1.98%

Maximum range data jump at T + 493 - 494 = 37 yards.

Coarse range data satisfactory except for times T + 2 through T + 9 seconds.

Number of significant angle data jumps None

A considerable number of zero data sets were evident on printout--appear to be extra-high reference pulses.

Balloonsonde Serial #17

Met Data

Good met data at T + 34 seconds
Good range data at T + 12 seconds

Termination time T + 783 seconds

Unusable met data vs. number of data sets considered at:

T + 5 minutes 14/266 = 5.26%

T + 10 minutes 48/566 = 8.48%

Termination 101/749 = 13.48%

Low-High spare channel printout 502 - 506

Number of temperature data jumps None

Humidity data jumps at:

T + 210 - T + 211 seconds 035

T + 211 - T + 212 seconds 023

T + 212 - T + 213 seconds 051

Ranging Data

Number of range data jumps \geq 20 yards/second after T + 12 seconds:

14/770 = 1.82%

Maximum range data jump at T + 203 - 204 seconds = 27 yards.

Coarse range data satisfactory.

Number of angle data jumps None

The following individual rocketsonde data was used to compile the rocketsonde summary sheet found at the beginning of this flight test sequence:

Rocketsonde Serial #19

Met Data

No usable met data received.

Ranging data satisfactory from T + 1 second except at:

T + 1 to T + 2 data jump of 66

T + 2 to T + 3 data jump of 75

Termination time T + 264 seconds

Ranging Data

Number of range data jumps \geq 20 yards/second considered from
T + 15 seconds:

$$6/248 = 2.42\%$$

Coarse range data satisfactory.

Number of angle data jumps

None

Maximum elevation angle

16.07° at T + 14 seconds

Rocketsonde Serial #3

Met Data

Good met data at

T + 28 seconds

Good range data at

T + 3 seconds

Termination time

T + 274 seconds

Unusable met data vs. number of data sets considered at termination:

$$23/246 = 9.35\%$$

Low-High spare channel printout

498 - 505

Maximum temperature data jump at T + 197 - 198 = 013.

Maximum humidity data jump at T + 114 - 115 = 037.

Ranging Data

Number of range data jumps \geq 20 yards/second after T + 16 seconds:

None

Coarse range data satisfactory.

Azimuth angle data jumps at:

T + 258	104.55 degrees
T + 259	103.96 degrees
T + 260	104.55 degrees
T + 261	105.83 degrees
T + 262	104.29 degrees
T + 263	103.12 degrees
T + 264	103.28 degrees

Maximum elevation angle of 17.33° at T + 15 seconds.

A considerable number of met data printout errors were in the 900 digits.

Rocketsonde Serial #4

Met Data

Good met data at	T + 3 seconds
Good range data at	T + 4 seconds
Termination time	T + 278 seconds

Unusable data sets vs. number of data sets considered at termination:

$$49/275 = 17.82\%$$

Low-High spare channel printout	501 - 504
---------------------------------	-----------

Temperature data jumps at:

T + 198 - 199 seconds	012
-----------------------	-----

T + 200 - 201 seconds	-012
-----------------------	------

Humidity data jumps at:

T + 165 - 166 seconds	-030
-----------------------	------

T + 166 - 167 seconds	+030
-----------------------	------

Ranging Data

Number of range data jumps \geq 20 yards/second after T + 16 seconds:

$$2/262 = .76\%$$

Maximum range data jumps at T + 258 - 259 = 31 yards.

Number of angle data jumps	None
----------------------------	------

Coarse range data satisfactory.

Maximum elevation angle	17.92° at T + 15 seconds
-------------------------	---------------------------------

Rocketsonde Serial #15

Met Data

Good met data at	T + 14 seconds
------------------	----------------

Good range data at	T + 3 seconds
Termination time	T + 291 seconds

Unusable met data vs. number of data sets considered at termination:

$$17/277 = 6.14\%$$

Low-High spare channel printout	505 - 507
Number of temperature data jumps	None

Humidity data jumps at:

T + 122 - 123 seconds	-060
T + 123 - 124 seconds	-064
T + 124 - 125 seconds	-028

Ranging Data

Number of range data jumps \geq 20 yards/second after T + 17 seconds:

$$3/274 = 1.09\%$$

Maximum range data jump at T + 242 - 243 seconds = 24.

Coarse range data satisfactory.

Number of angle data jumps	None
----------------------------	------

Maximum elevation angle of 18.77° at T + 16 seconds.

Rocketsonde Serial #2

Met Data

Good met data at	T + 3 seconds
------------------	---------------

Unusable met data from T + 15 through T + 23 seconds.

Good range data at	T + 0 second
Termination time	T + 274 seconds

Unusable met data vs. number of data sets considered:

$$63/271 = 23.25\%$$

Low-High spare channel printout	496 - 513
---------------------------------	-----------

Temperature data jumps at:

T + 165 - 166 seconds -017

T + 166 - 167 seconds +017

Humidity data jump at

T + 147 - 148 seconds 026

Ranging Data

Number of range data jumps \geq 20 yards/second after T + 16 seconds:

8/258 = 3.1%

Coarse range data satisfactory.

Maximum elevation angle of 19.30° at T + 15 seconds.

One set of unusable data was repeated three times (printout).

This again may be caused by extraneous high reference data pulses or just plain noise.

3. Flight tests of the Low Level Sonde System were conducted at AFCRL, Hanscom Field, in May 1968. Participants of this flight test sequence were:

Captain T. Smith

CREU-AFCRL

Captain G. Carning

CRER-AFCRL

Mr. R. Betz

Bendix ESD

Mr. J. Wills

Bendix ESD

Two balloonsonde flights were made, however, the serial numbers of the radiosondes were not recorded. Both flight tests were conducted with separate objectives. The first was made with low temperature coefficient resistor values of 15 K ohms, 112.4 K ohms and 900 K ohms to determine stability of the radiosonde circuitry. The second flight consisted of a balloonsonde configuration with a rocketsonde sensor package attached. The objective here was to make a comparison flight for correlation of temperature data between the two types of sensor mounting packages used. From the data acquired, it appears that the metallic mass associated with the rocketsonde sensor package configuration may be contributing to its slow response time. Subsequently, Bendix ESD provided a nylon shield, to be substituted for the metallic shield originally supplied, to AFCRL for evaluation.

FLIGHT #1 - Balloonsonde with lo-temperature coefficient
resistors installed in sensor mounts:

After T + 10 minutes

<u>Resistor Value</u>	<u>Printout Range</u>	<u>Ord. Variation</u>
15 K	891 - 902	11
112.4 K	500 - 506	6
900 K	119 - 122	3

After T + 45 minutes

<u>Resistor Value</u>	<u>Printout Range</u>	<u>Ord. Variation</u>
15 K	887 - 902	15
112.4 K	496 - 506	10
900 K	115 - 122	7

FLIGHT #2 - Flight made with both balloonsonde and rocket-
sonde sensor packages attached with ML-419
sensors installed:

<u>T + Min.</u>	<u>T + Sec.</u>	<u>Temp. (°C) Balloonsonde Configuration</u>	<u>Temp. (°C) Rocketsonde Configuration</u>	<u>Temperature Diff. (°C)</u>
0	0	+25.5	+25.5	+0
.15	9	12.3	14.0	1.7
.33	20	11.4	12.2	.8
.83	50	10.1	10.8	.7
1.67	100	9.3	9.9	.6
6.50	390	5.6	6.4	.8
10.0	600	---	---	---
13.33	800	-3.1	-2.4	-.7
19.53	1172	-17.1	-16.4	-.7
20.0	1200	---	---	---

In addition to flight testing of the low-level radiosonde, Bendix and AFCRL personnel performed the modification of the GMD data processor which was necessary to make it compatible with the system.

During checkout of the GMD, it was found that the coarse ranging system of the unit was not functioning properly.

One other incident worth mentioning here was that the GMD receiver would not operate in the automatic AFC mode. An on-the-spot analysis indicated the possibility of other equipments in the area operating on the same frequency causing interference.

Upon concluding the flight tests, the GMD unit was returned to normal operation.

4. Final Flight Testing of the Low Level Sounding System was conducted at Vandenberg Air Force Base, California (AFWTR). The participants of this test were:

Captain G. Canning	CREU-AFCRL
Mr. R. Betz	Bendix ESD
Mr. J. Wills	Bendix ESD

The objective here was to fly one balloonsonde with both sensor packages attached and to launch one rocketsonde. The rocket launch was not achieved due to problems encountered--first, with baselining the sonde and second, a leak developing in the launcher.

Results of this flight test verified the findings of the flight test of May, 1968. After installing an ML-419 temperature sensor in both sensor mounts, the rocket version was found to have a much slower response than the balloon version.

In addition, no usable met data was received until T + 38 seconds, and the spare channel data printout was intermittent.

Sample copies of a GMD data processor--teletype printout, and a computer processed data printout appear in Figures 30 and 31 respectively.

NOT REPRODUCIBLE

703	363	493	000447	2643	05637	0031
703	369	499	000454	2670	05708	0032
703	369	501	000456	2693	05715	0033
703	367	501	000463	2721	05717	0034
707	367	502	000475	2723	05717	0035
707	365	501	000430	2732	05717	0036
706	363	501	000436	2751	05717	0037
706	364	501	000496	2753	05715	0033
706	363	501	000507	2774	05714	0039
707	360	502	000527	2790	05723	0040
706	360	502	000533	2793	05733	0041
706	360	501	000543	2793	05730	0042
705	357	502	000555	2731	05725	0043
705	353	502	000567	2757	05726	0044
705	343	502	000537	2755	05736	0045
705	352	501	000593	2751	05736	0046
704	347	501	000593	2757	05720	0047
705	349	502	000603	2772	05690	0043
705	343	502	000617	2772	05664	0049
703	341	502	000629	2772	05650	0050
703	334	501	000623	2765	05633	0051
703	324	501	000635	2752	05616	0052
703	322	501	000652	2740	05601	0053
703	316	501	000649	2706	05591	0054
703	310	501	000672	2713	05536	0055
702	306	501	000675	2693	05534	0056
701	300	502	000637	2633	05533	0057
703	300	501	000703	2661	05570	0053
702	230	502	000707	2647	05540	0059
701	21	501	000717	2534	05514	0060
700	239	501	000705	2523	05493	0061
700	295	501	000730	2603	05433	0062
701	300	502	000741	2595	05430	0063
700	301	502	000754	2535	05431	0064
701	303	501	000760	2566	05431	0065
700	304	501	000770	2540	05470	0066
700	303	501	000733	2523	05463	0067
700	304	501	000735	2506	05461	0063
701	304	502	000803	2494	05465	0069
701	305	503	000815	2474	05463	0070
700	306	501	000823	2450	05463	0071
700	303	501	000837	2430	05457	0072
701	307	502	000854	2420	05456	0073
701	303	501	000856	2407	05463	0074
700	310	501	000879	2339	05466	0075
701	310	501	000839	2370	05465	0076
701	303	503	000903	2362	05457	0077
701	309	501	000910	2343	05456	0073
701	310	501	000930	2330	05460	0079

FIGURE 30. GMD Data Processor--Teletype Printout

NOT REPRODUCIBLE

ALTITUDE FEET	IN INCHES	SPEED KNOTS	TEMP DEG C	DEPT DEG C	PRESS KBS	Q4 PCT	AIR W/3	DENSITY W/3	TEMP DEG C	WIND KTS
100	231	22	21.0	18.3	975.87	94	15.54	1154.75	347	445
1075	233	22	20.8	18.1	975.21	94	15.34	1154.44	347	445
1100	236	22	21.0	18.3	974.14	94	15.51	1152.71	347	445
1125	235	22	20.7	17.9	973.28	94	15.15	1153.25	347	445
1150	233	22	20.3	17.5	972.42	94	15.16	1151.61	347	445
1175	235	22	20.7	17.3	971.56	94	15.11	1151.27	347	445
1200	235	22	20.3	17.5	970.70	94	15.15	1148.30	347	445
1225	235	22	20.9	17.9	969.85	94	15.25	1147.44	347	445
1250	233	22	21.0	18.0	969.02	94	15.27	1145.77	347	445
1275	232	24	20.7	17.7	968.17	94	14.99	1147.25	347	445
1300	235	25	20.4	17.9	967.31	94	15.15	1145.29	347	445
1325	236	22	20.7	17.5	966.45	92	14.51	1146.75	347	445
1350	236	22	20.7	17.5	965.60	92	14.79	1145.55	347	445
1375	237	22	20.7	17.5	964.75	92	14.77	1145.32	347	445
1400	236	21	20.7	17.4	963.89	92	14.76	1142.02	347	445
1425	235	23	20.0	17.2	963.04	91	14.54	1144.42	347	445
1450	237	24	20.4	17.5	962.18	91	14.35	1146.24	347	445
1475	245	25	20.5	17.5	961.34	90	14.16	1145.65	347	445
1500	242	27	20.9	18.7	960.49	90	14.11	1137.21	347	445
1525	243	25	20.5	18.3	959.64	90	14.30	1137.50	347	445
1550	240	26	20.7	18.5	958.79	90	14.35	1134.05	347	445
1575	245	26	20.4	18.4	957.94	90	14.73	1134.47	347	445
1600	241	27	20.9	19.1	957.10	90	14.92	1134.73	347	445
1625	246	27	20.7	18.1	956.25	90	14.35	1133.64	347	445
1650	242	27	20.4	18.0	955.40	90	14.47	1131.45	347	445
1675	243	27	20.0	18.3	954.55	90	14.34	1131.12	347	445
1700	240	29	20.4	18.7	953.71	90	14.22	1130.20	347	445
1725	243	31	20.7	19.0	952.87	90	14.24	1125.14	347	445
1750	246	31	20.5	18.5	952.03	90	14.03	1125.11	347	445
1775	247	31	20.6	18.6	951.18	90	14.35	1122.11	347	445
1800	248	32	20.9	18.5	950.34	90	14.02	1126.48	347	445
1825	242	24	20.2	18.4	949.49	90	14.92	1125.34	347	445
1850	249	24	20.1	18.2	948.64	90	14.31	1124.17	347	445
1875	242	25	20.0	18.3	947.79	90	14.92	1125.47	347	445
1900	246	28	20.3	18.6	946.94	90	14.11	1123.51	347	445
1925	245	22	20.0	18.1	946.09	90	14.76	1123.56	347	445
1950	247	33	19.9	18.0	945.24	90	14.43	1122.09	347	445
1975	244	24	18.9	18.3	944.39	90	14.45	1121.94	347	445
2000	252	25	20.1	18.4	943.54	90	14.47	1120.45	347	445
2025	245	24	19.3	18.3	942.69	90	14.01	1123.51	347	445
2050	246	24	19.9	18.2	941.84	90	14.95	1119.21	347	445
2075	253	25	19.7	18.0	940.99	90	14.33	1119.23	347	445
2100	245	20	19.4	18.9	940.14	90	14.32	1117.89	347	445
2125	250	20	18.7	18.9	939.29	90	14.08	1120.57	347	445
2150	253	23	18.5	18.7	938.44	90	14.09	1120.68	347	445
2175	250	23	18.0	18.0	937.59	90	14.57	1115.40	347	445
2200	244	23	19.3	18.7	936.74	90	14.64	1113.79	347	445
2225	250	22	19.4	18.3	935.89	90	14.34	1114.11	347	445

FIGURE 31. Computer Processed Data Printout

APPENDIX I
TELEDYNAMICS METEOROLOGICAL DATA PROCESSOR -
CHANGE-OVER PROCEDURE

APPENDIX I

TELEDYNAMICS MET DATA PROCESSOR - CHANGE-OVER PROCEDURE

After the data processor cabinet and receiver wiring changes have been completed, the system may be converted to operation compatible with the Low Level Radiosonde by the substitution of a number of cards and connectors and by changing the positions of the appropriate switches. The change-over procedure is given below:

1. Check out the normal data processor operation with the system sonde simulator.
2. Turn off power.
3. Substitute the modified printed circuit cards for the original cards in the following locations:

a. Data Drawer:

J1, J30, Add J5

b. Control Drawer:

J102, J103, J105

Substitute J106 with modified card J215

c. Processing Drawer:

J203 J208 J222

J204 J209 J226

J205 J210 Add J218

J206 J211

Insert card J106 (removed from Control Drawer in paragraph 1.b) into card slot J215.

Substitute modified VCO Card for original VCO Card.

Substitute the modified program connectors P93 and P193 for the original connectors.

5. Change the jumper on the Program Card, J103 so that the processor will accept three data channels.
6. If there is no card in slot J133, insert the system spare in the J133 card slot.

7. Change the rotary switch inside the Processing Drawer from the "NORMAL" position to the "Low-Level" position.
8. Set the Reference Frequency Range switch to the "190" position.
9. Set the "Time Interval" switch to the "6" position.
10. Set switches in the GMD Receiver as follows:
 - a. "Normal - Low Level" switch to "Low Level".
 - b. "CF - INV" switch to "INV"
 - c. "AM-FM" switch to "FM"
 - d. "Broad-Sharp" switch to "Sharp"
11. Turn on power and proceed with the data processor check-out utilizing the "Low-Level Sonde Simulator".

APPENDIX II
SONEX METEOROLOGICAL DATA PROCESSOR -
CHANGE-OVER PROCEDURE

APPENDIX II

SONNEX MET DATA PROCESSOR - CHANGE-OVER PROCEDURE

After the data processor cabinet and receiver wiring changes have been completed, the system may be converted to operation compatible with the Low Level Radiosonde by the substitution of a number of cards and connectors and by changing the positions of the appropriate switches. The change-over procedure is given below:

1. Check out the normal data processor operation with the system sonde simulator.
2. Turn off power.
3. Substitute the modified printed circuit cards for the original cards in the following locations:

a. Control Drawer:

J102, J103, J105

b. Processing Drawer:

J203	J208	J219
------	------	------

J204	J209	J222
------	------	------

J205	J210	J226
------	------	------

J206	J211	Add J216
------	------	----------

J215	Add J217
------	----------

Substitute modified VCO card for the original VCO card.


4. Substitute the modified program connectors P93 and P193 for the original connectors.
5. Change the jumper on the Program Card, J103, so that the processor will accept three data channels.
6. If there is no card in slot J133, insert the system spare #2339 in the J133 card slot.
7. Set the Reference Frequency Range switch to the "190" position.
8. Set the "Time Interval" switch to the "6" position.

9. Set switches in the GMD Receiver, as follows.
 - a. "Normal - Low Level" switch to "Low Level"
 - b. "CF - INV" switch to "INV"
 - c. "AM-FM" switch to "FM"
 - d. "Broad-Sharp" switch to "Sharp"
10. Turn on power and proceed with the data processor check-out utilizing the "Low Level Sonde Simulator".

APPENDIX III

TEI-751 PRELIMINARY TESTING OF CARDS USED IN MODIFICATION
OF
TELEDYNAMICS AND SONEX MDPS FOR THE LOW LEVEL SOUNDING SYSTEM

APPENDIX III

APPROVAL	DATE	 Environmental Science Division BALTIMORE, MARYLAND 21204	ENGINEERING SPECIFICATION
PROJECT ENGINEER <i>R. J. Hernandez</i>	<i>3/21/69</i>		TYPE Test Specification
ENGRG MANAGER <i>W. L. Smith</i>	<i>3/21/69</i>		NUMBER TEI - 751
PRODUCT ENGINEER			TITLE Preliminary Testing of Cards Used in Modification of Teledynamics and Sonex MDPS for the Low Level Sounding Systems
			RELEASE NO.

REVISION SHEET

RECORD OF REVISION STATUS FOR EACH SHEET

[illegible][illegible]

RECORD OF REVISION STATUS FOR ADDED SHEETS

[illegible]

SHEET 010 CONT. ON 020

[illegible]

4.3 Frequency Multiplication

This test will confirm that the frequency range of the VCO (multiplied) will be 1,000 Hz to 20,000 Hz for an input frequency range of 200 Hz to 4,000 Hz.

- 4.3.1 Connect the output of the Set-Reset flip-flop in Paragraph 4.2 to the frequency multiplication circuitry as shown in Figure 2.
- 4.3.2 Set Sonde Simulator frequency to a 4 KHz \pm 10 cps square wave (steady signal). The output of the VCO shall read 20 KHz \pm 40 cps. Record Sonde Simulator frequency vs. VCO frequency by referring to the following chart:

<u>Sonde Simulator</u> <u>(Continues Signal)</u>	<u>VCO</u>
4 KHz \pm 10 Hz	20 KHz \pm 40 Hz
2 KHz \pm 5 Hz	10 KHz \pm 40 Hz
1 KHz \pm 3 Hz	5 KHz \pm 40 Hz
500 Hz \pm 3 Hz	2.5 KHz \pm 25 Hz
250 Hz \pm 3 Hz	1.25 KHz \pm 20 Hz

4.4 Channel Drop-Out Detector

- 4.4.1 Connect the Channel Drop-Out Detector Card J209 as shown in Figure 3.

- 4.4.2 Observe waveforms at TP2 and TP3 with input frequency set to 200 cps and 4 KC. See Figure 4.

4.5 Missing Channel Detector

- 4.5.1 Connect the Missing Channel Detector Card as shown in Figure 5.

- 4.5.2 With the Sonde Simulator operating normally, TP3 will remain at zero volts.

- 4.5.2.1 Switch Missing Channel switch on the Sonde Simulator to the "ON" position. TP3 will go to + 5 volts after the channel has been missing for 50 msec and will be reset by the .3 second one-shot. See Figure 6.

4.6 Fall-Out Detector During Reference Gate

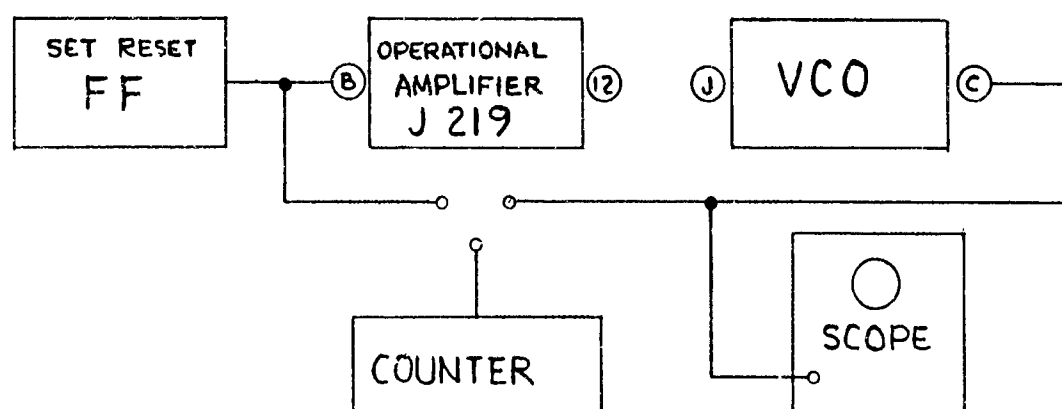
[illegible]

FIGURE 2

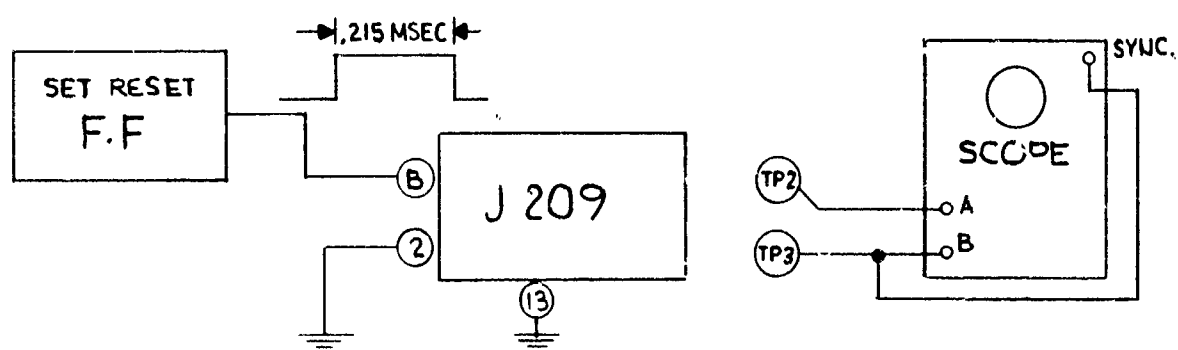


FIGURE 3

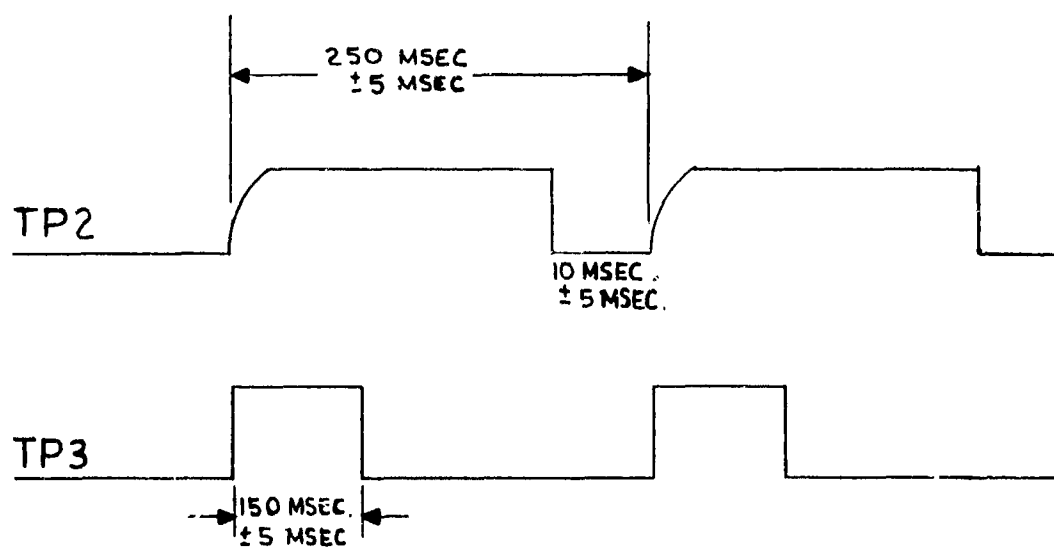
[illegible]

FIGURE 4

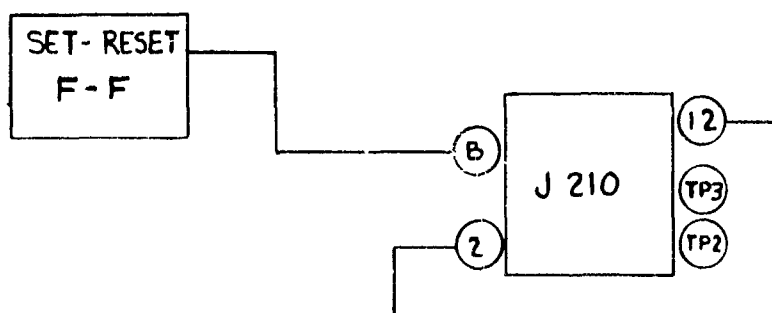


FIGURE 5

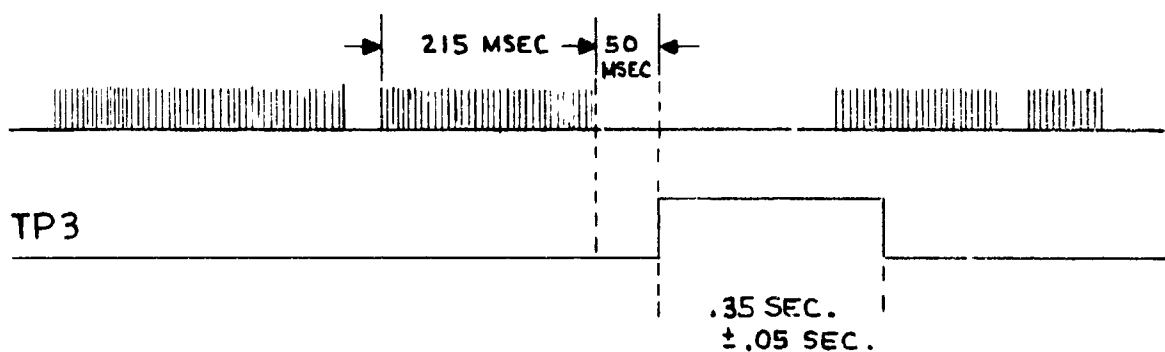
[illegible]

FIGURE 6

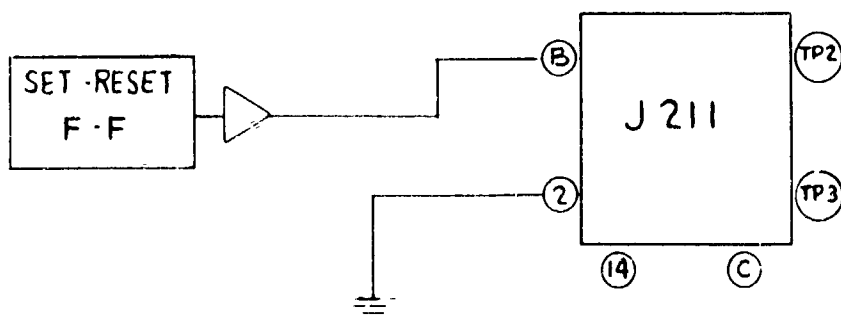


FIGURE 7

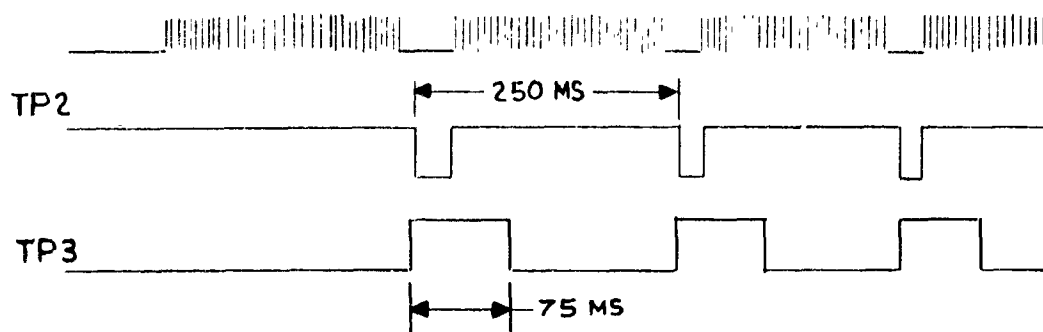
[illegible]

FIGURE 8

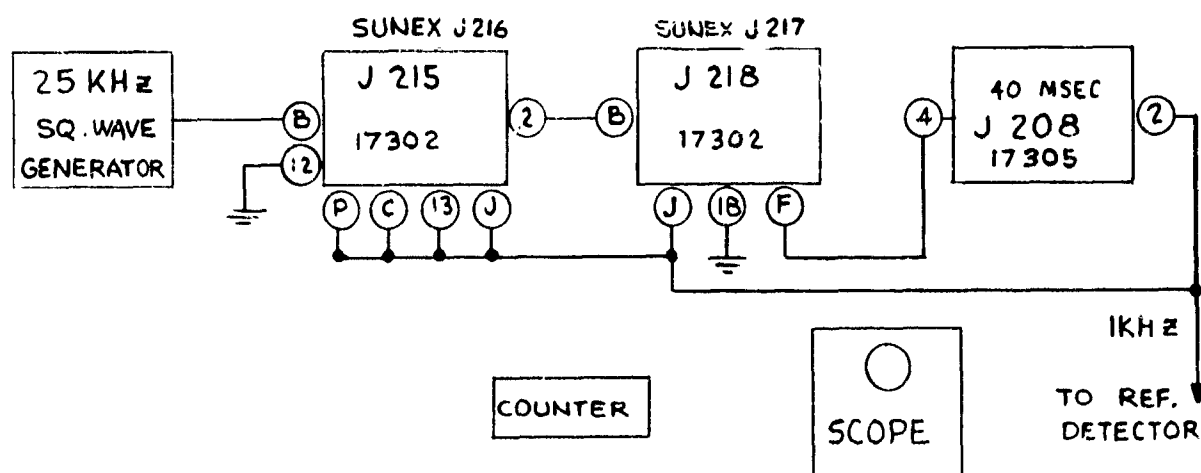


FIGURE 9

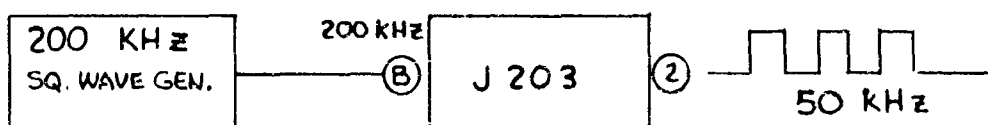
[illegible]

FIGURE 10

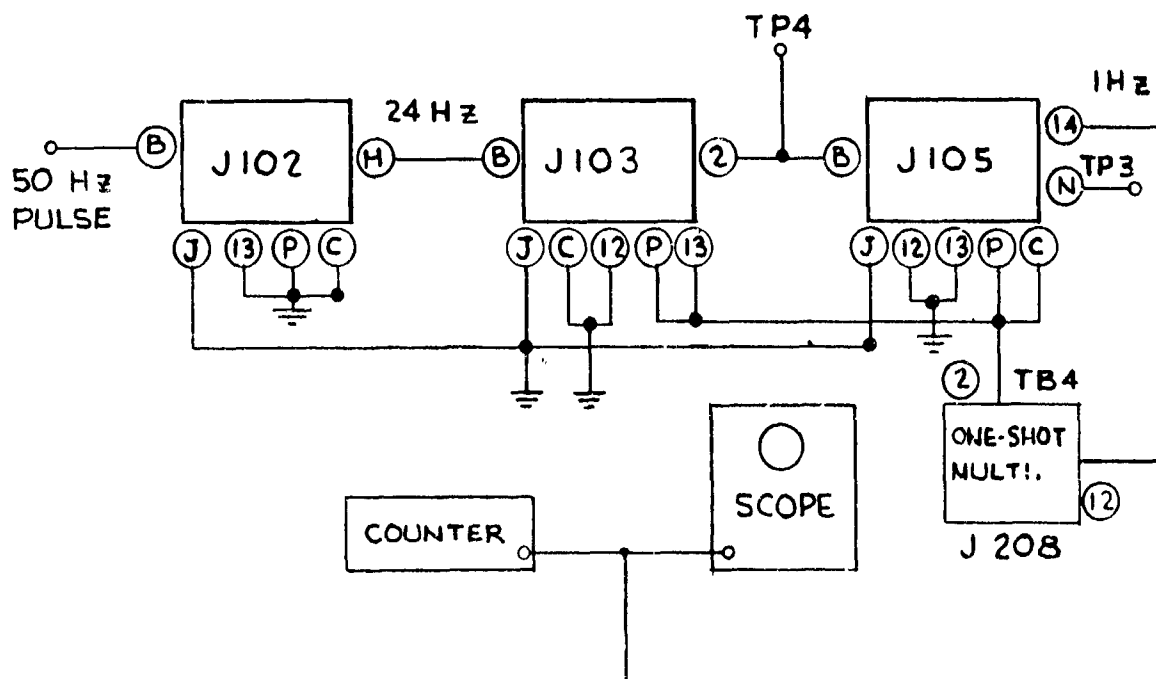



FIGURE 11

APPENDIX IV
ES-2412658 GMD-4 MODIFICATION
FOR
LOW LEVEL SOUNDING SYSTEM

APPENDIX IV

APPROVAL	DATE	 Bendix Environmental Science Division BALTIMORE, MARYLAND 21204	ENGINEERING SPECIFICATION	
PROJECT ENGINEER			TYPE	Test Specification
ENGRG MANAGER			NUMBER	ES 2412658
PRODUCT ENGINEER			TITLE GMD-4 Modification for Low Level Sounding System	
			RELEASE NO.	DATE

RECORD OF REVISION STATUS FOR EACH SHEET

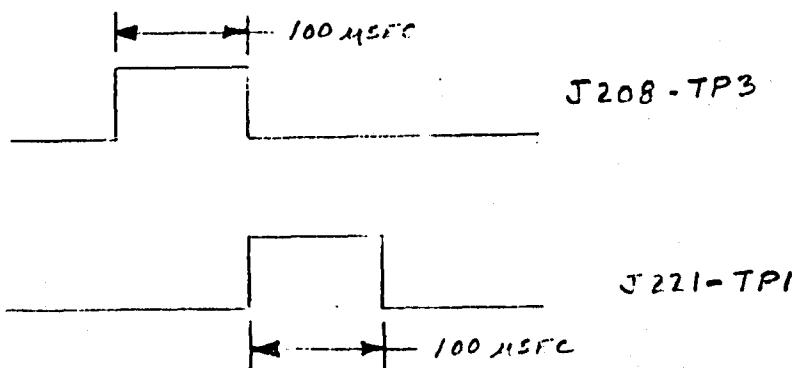
[illegible][illegible]

RECORD OF REVISION STATUS FOR ADDED SHEETS

[illegible]

[illegible]

- 4.2.2.14 Connect the scope to J208, pin 2. Observe 40 usec pulses at a 1 KHZ rate.
- 4.2.2.15 Connect "A" input of scope to J208, TP3 and "B" input to J221, TP1. Sync Scope on positive edge of signal at J208, TP3. The relationship between pulses shall appear as follows:



A timing diagram showing a single rectangular pulse. The pulse width is indicated by a horizontal double-headed arrow above the pulse, labeled "100 μSEC".

J208 - TP3

A timing diagram showing a single rectangular pulse. The pulse is high for a duration of 68 MSEC, as indicated by a dimension line below the pulse.

J 220-TIP/

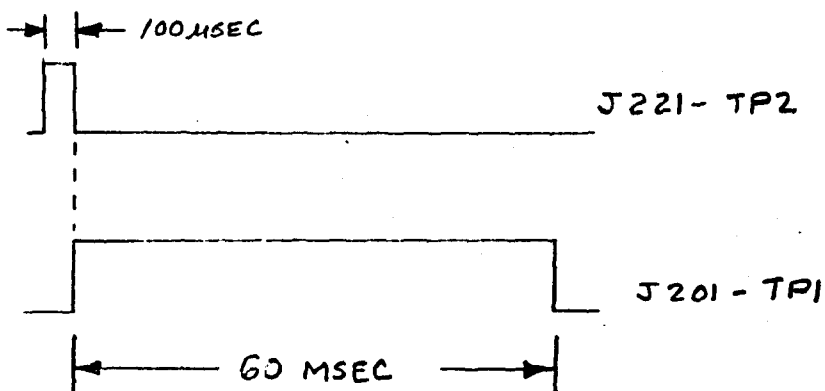
[illegible]

With S201 set to the 180 position, the pulse width at J220-TP1 will be 70 msec.

With S201 set to the 170 position, the pulse width at J220-TP1 will be 74 msec.

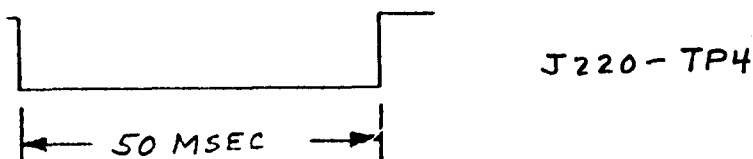
With S201 set to the 160 position, the pulse width at J220-TP1 will be 79 msec.

4.2.2.17 Sync scope on the trailing edge of the pulse at J238-TP4. Connect the "A" input to J221-TP2 and the "B" input to J201-TP1. The waveforms shall appear as follows at a rate of once per second.

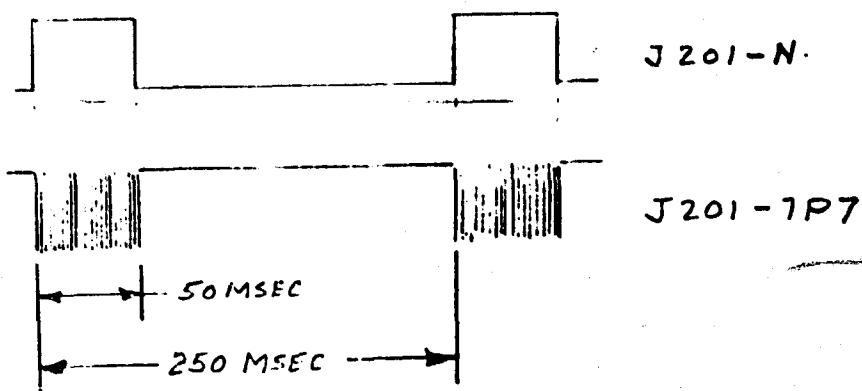


[illegible]

- 4.2.2.18 Connect scope to J203 - TP4. Observe a 50 KHZ square wave.
- 4.2.2.19 Sync scope on the trailing edge of the pulse at J201 - TP1. Observe J220 - TP4 for the following pulse once per second.



- 4.2.2.20 Monitor J221 - TP3. A positive pulse shall occur once per second and shall have a duration of 100 msec \pm 20 usec.
- 4.2.2.21 Sync the scope on the positive edge of the pulse at J208-F. Connect input "A" to J201-N and input "B" to J201 - TP7. The waveforms shall appear as shown below:





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[illegible]

-
- Timing diagram showing two traces:
- J202-TP3**: A sequence of pulses labeled R, H, T, SPARE, and R.
 - J211-TP3**: A single pulse.
 - A scale bar indicates **75 MSEC**.

- 4.2.2.35 Observe the print-out to confirm a zero in the spare channel location.

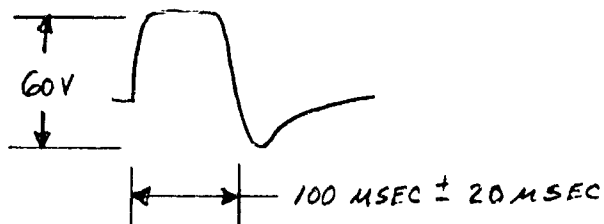
[illegible]

4.3 Simulated Met Data System Test

4.3.1 Description

This test will utilize a low level radiosonde or a modified AMQ-9 radiosonde to transmit simulated met data. The met data section of the sonde will be replaced by the Sonde Simulator so that known data will be transmitted.

- 4.3.1.1 Connect the equipment as shown in Figure 4.
- 4.3.1.2 Turn on AMQ-9 radiosonde.
- 4.3.1.3 Monitor pin 6 of V1008 in the receiver. The output shall appear as shown below:



- 4.3.1.4 Monitor met data at J202 - TP3 in the data processor to confirm proper pulse width and format.
- 4.3.1.5 Repeat paragraphs 4.2.2.30 through 4.2.2.35.

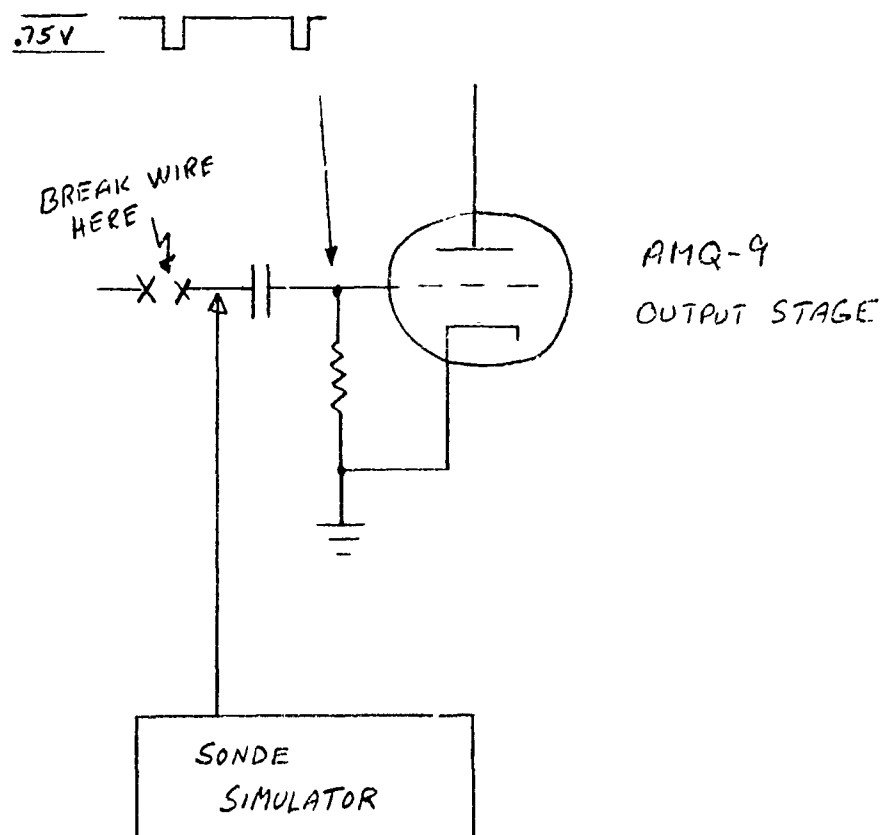
[illegible]


Figure 4.

APPENDIX V

ES-2410806 TEST SPECIFICATION

LOW LEVEL RADIOSONDE

APPENDIX V

APPROVAL	DATE	 Environmental Science Division BALTIMORE MARYLAND 21204	ENGINEERING SPECIFICATION		
<i>R.A. Ramsey</i> PROJECT ENGINEER	7/7/69		TYPE		
ENGRG. MANAGER <i>W.E. Throckmold</i> PRODUCT ENGINEER	3/20/69		NUMBER	ES-2410806	
			TITLE	TEST SPECIFICATION LOW LEVEL RADIOSONDE	
		REVISION SHEET		RELEASE NO.	DATE

RECORD OF REVISION STATUS FOR EACH SHEET

010	020	030	040	050	060	070	080	090	100	110	120	130	140	150	160	170	CHECKED	APPROVED	DATE	ECN NO.
A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		<i>P.R.</i>	<i>7/7/69</i>	

180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	CHECKED	APPROVED	DATE	ECN NO.
A	A	A																		

RECORD OF REVISION STATUS FOR ADDED SHEETS

																	CHECKED	APPROVED	DATE	ECN NO.



TYPE

NUMBER ES-2410806

[illegible]

This specification describes the specifications and testing procedures for the prototype models of the Low Level Radiosonde.

2.1 Temperature - The radiosonde shall be capable of operating over the temperature range of +140°F to 0°F without degradation in performance.

	<u>Minimum</u>	<u>Nominal</u>	<u>Maximum</u>
a.	-4.0V	-4.5V	-5.0V
b.	-12.0V	-13.0V	-14.0V
c.	-17.0V	-18.0V	-19.0V

3.1 Electrical

3.1.1.1 Tuning Range - The receiver shall be tunable over the frequency range of 400 to 406 MHz.

3.1.1.2 Sensitivity - The sensitivity over the range of 400 to 406 MHz shall be 50 microvolts or less.

3.1.1.3 Selectivity - The receiver selectivity at minimum supply voltage (see 2.2) shall be at 50 db down at 391 and 415 MHz from that at 400 and 406 MHz with the receiver set to 403 ± 1.0 MHz.

3.1.2 Meteorological Pulse Generator

3.1.2.1 Reference Frequency - With the reference resistor connected to -4.5 volts, the meteorological pulse generator frequency shall be identified as the reference frequency, and shall be between 3900 and 4100 cps.

[illegible]

3.1.2.2 Data Frequencies

- a. With the reference resistor connected to -4.5 volts through a $28.7K \pm 1K$ resistor, the frequency of the meteorological pulse generator shall be $4/5$ that of the reference frequency.
- b. With the reference resistor connected to -4.5 volts through a $446K \pm 7K$ resistor, the frequency of the meteorological pulse generator shall be $1/5$ that of the reference frequency.

3.1.2.3 Pulse Length - The pulse length of the meteorological pulse generator shall be 50 usec \pm 15 usec.

3.1.2.4 Reference Frequency vs. Voltage - The change in reference frequency shall not exceed ± 60 HZ when the supply voltage is varied over the range given in paragraph 2.2.

3.1.3 Clock Generator

3.1.3.1 Frequency - The clock generator frequency shall be 4.0 HZ \pm .1 HZ with the supply voltage set to -4.5 volts. At supply voltages of -4.0 volts and -5.0 volts, the frequency shall be 4.0 HZ \pm .25 HZ.

3.1.4 Met Data Blanking Pulse - The met data blanking pulse shall be between 18 and 25 milliseconds in length when the supply voltage is varied between -4.0 volts and -5.0 volts.

3.1.5 Transmitter

3.1.5.1 VSWR - The voltage standing wave ratio, as measured at the input to the transmission line, shall not exceed 1.25 as referred to a 50 ohm impedance, when measured in the unit. This is a design test only.



TYPE

[illegible]

- | <u>REASON FOR CHANGE</u> | <u>MAXIMUM CHANGE</u> |
|---|-----------------------|
| a. Power Supply variation
(-12V to -14V) | 10 degrees |
| b. Change in received signal
strength between 200 microvolts
and 20 MV. | 15 degrees |

- 4.1.1 Connect Commutator module C and Met Data Generator module D as shown in figure 1.
- 4.1.2 Set all test tool switches to position 1 and the sensor decade resistance box to zero ohms. Set decade resistance box (R32) to 27K and decade capacitance box (C20B) to 500 pf.

SHEET 050 CONT. ON 060

[illegible]

- 4.1.3 Adjust C20B on module D for an output frequency of 4 KHZ \pm 50 H%.
- 4.1.4 Set S2 to position 2. The output frequency shall not differ by more than \pm 2 HZ from the frequency of 4.1.3.

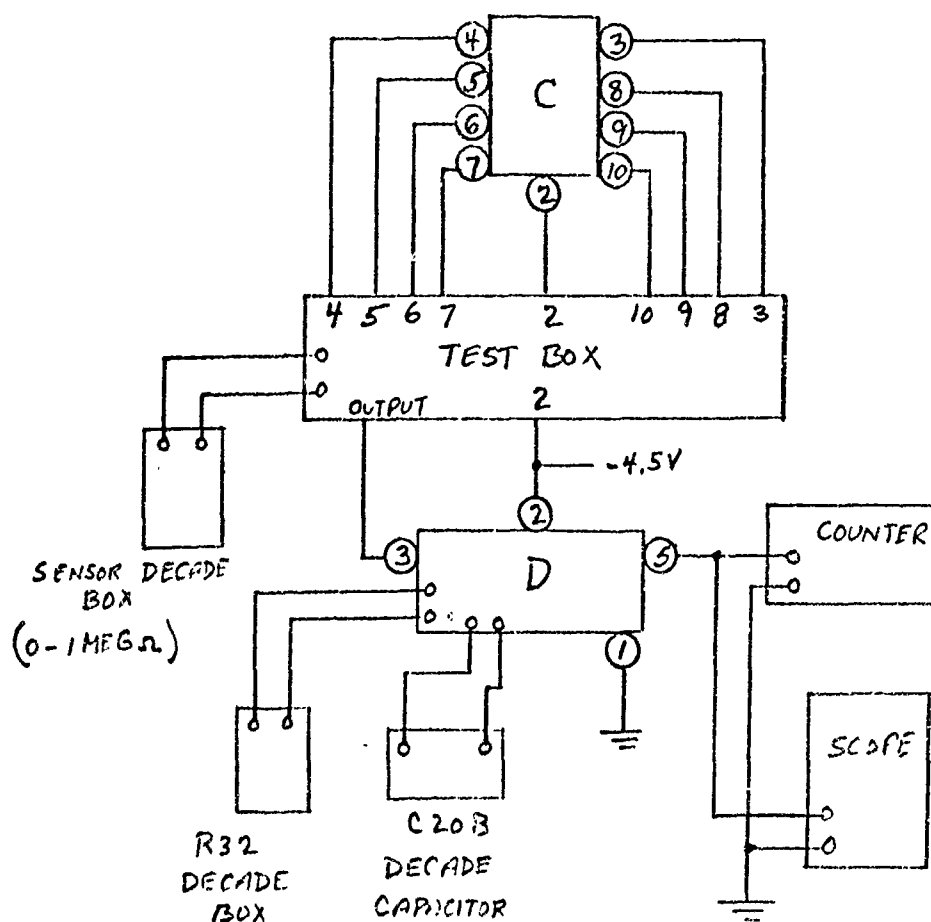


FIGURE 1

TYPE

NUMBER ES-2410806

[illegible]

4.1.6.2 With the test tool switches set to the positions shown in Table III, the measured frequencies shall not differ from each other by more than 5 HZ.

TABLE III

<u>Test</u>	<u>S1</u>	<u>S2</u>	<u>S3</u>	<u>S4, S5</u>		<u>S7</u>	<u>S8</u>	<u>S9</u>
				<u>S6</u>				
Leakage	2	2	2	2		2	1	1
"	3	2	2	2		1	2	1
"	4	2	2	2		1	1	2
"	4	2	1	2				

Note: Compliance on the data sheet.

4.1.7 Frequency response.

Set the test tool switches to the following positions:

<u>Sl thru S6</u>	<u>S7</u>	<u>S8</u>	<u>S9</u>
Position 2	1	2	2

With the sensor decade box set at zero ohms, note the reference frequency. It shall be $4000 \text{ Hz} \pm 50 \text{ Hz}$. The frequency is adjusted by varying the value of C20B (capacitance box). Increase the setting of the sensor decade box until the frequency equals eight-tenths of the reference frequency. Record resistance value. Record resistance values corresponding to frequencies of .5, .2, and .1 of the reference frequency. The resistance values shall fall within the tolerance shown in Table IV.

TABLE IV

<u>FREQUENCY (% of REF.)</u>	<u>RESISTANCE</u>
100	0
80	28.7K ± 1K
50	112.6K ± 3K
20	446K ± 7K
10	995K ± 15K

SHEET 080 CONT. ON 090

[illegible]

- 4.1.8 If the resistances do not fall within the tolerances of Table IV, adjust R32 in module D by observing the following rules:
- a. If the resistances are too high, decrease R32.
 - b. If the resistances are too low, increase R32.
- Repeat 4.1.7.
- 4.1.9 After response curve has been adjusted to specified tolerances, proceed as follows:
- a. Install closest 5% resistor for R32.
 - b. Install closest 5% capacitor for C20.
 - c. Run a response curve and record sensor resistor values on the data sheet. The resistance values shall be within the tolerances shown in Table III. Record the reference frequency. Repeat at supply voltages of -4.0 and -5.0 volts.
- 4.1.10 Pulse width
- Record the pulse width of the met data generator at the reference frequency. It shall be 50 usec \pm 15 usec. Record on the data sheet. Repeat at supply voltages of -4.0 and -5.0 volts.
- Commutator Clock, Decoding, and 20 MSEC Pulse Generator
- 4.2.1 Connect module A and B as shown in figure 2. Connect a decade resistance box in place of R18 and set it to 39K. Connect a decade resistance box in place of R23 and set it to 15K.

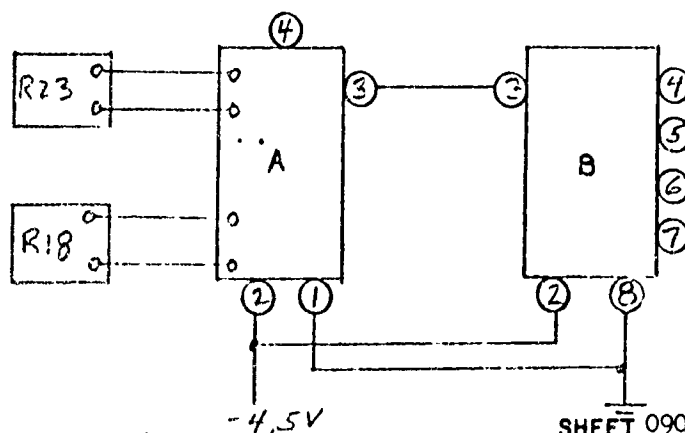


FIGURE 2

TYPE

NUMBER ES-2410806



FIGURE 3

- 4.3.3 Observe an 81.94 KHZ sine wave at the output (pin 4) of the amplifier. Adjust coil L6 for maximum output signal. Vary the frequency of the sine wave generator above and below 81.94 KHZ to assure that the circuit is peaked to 81.94 KHZ. Note compliance on the data sheet.

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ES-2410806

NUMBER ~~XXXXXXXX~~

[illegible]

5.0 RadioSONDE Tests - These tests shall be performed with the radioSONDE completely assembled.

5.1 Modulation

With the signal generator set to 403 ± 1 MHz and 25% amplitude modulated by a 81.94 KHZ sine wave, set the signal generator output level to 1 MV. The signal generator shall be directly coupled to the receiver. Adjust the amplitudes of the ranging and net data signals to obtain a composite waveform at the input to the transmitter as shown in figure 4.

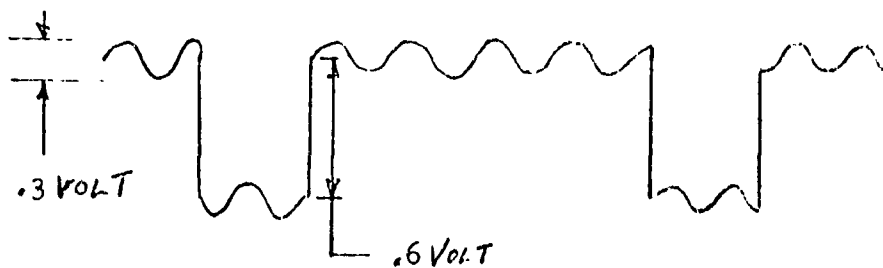
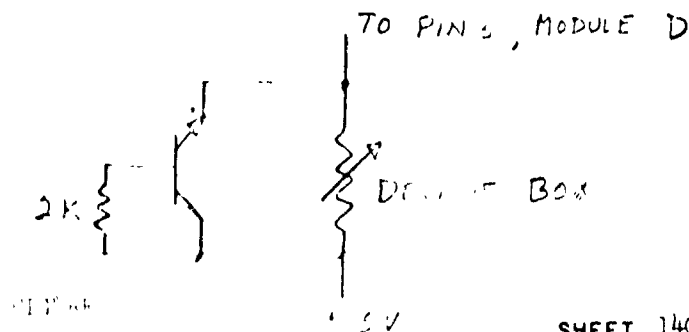
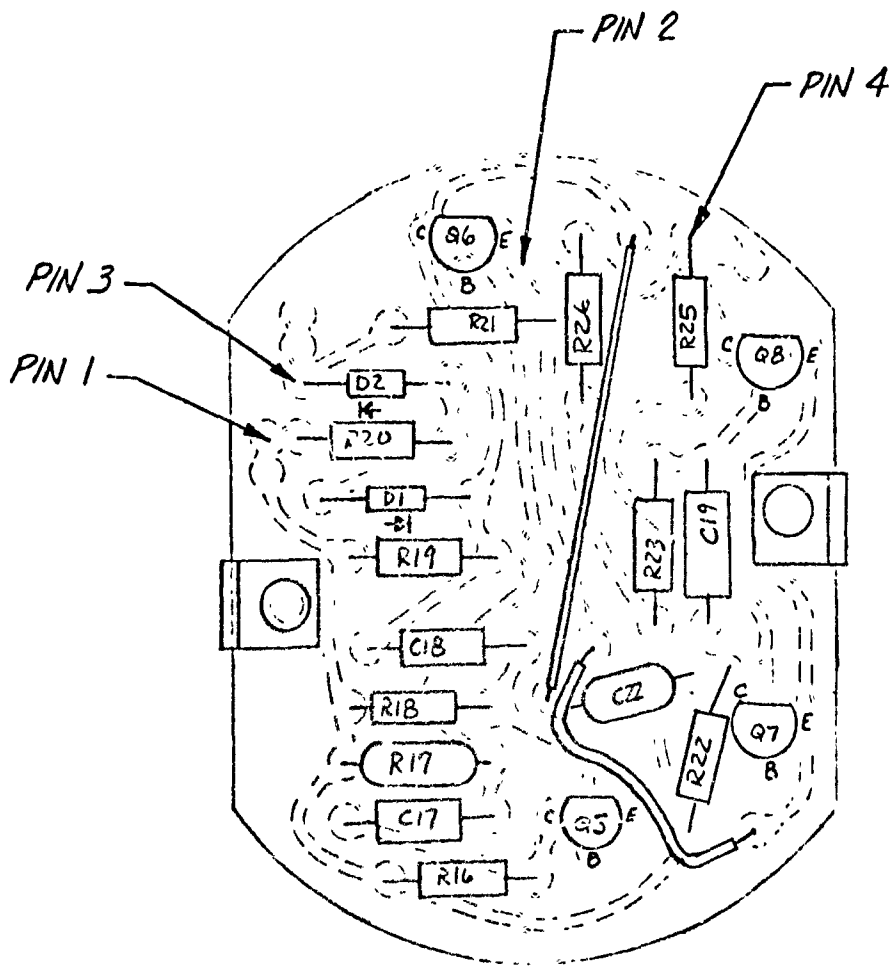


FIGURE 4

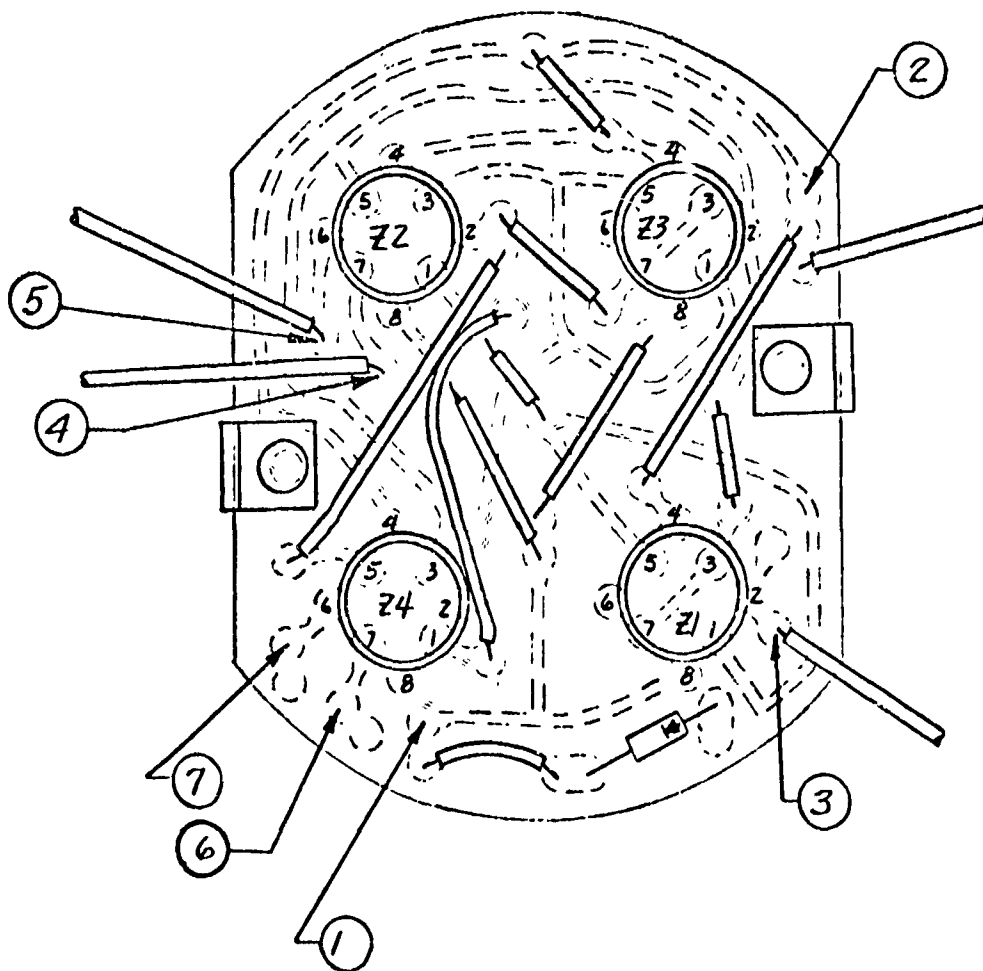
5.2 Met Data Generator Response

Disconnect the wire at pin 3 of the met data generator module "D". Connect to the circuit shown in figure 5. Record resistance values vs. ratio on data sheet no. 5 for voltages of 4.5, 4.0, and 5.0 volts. This test is to be performed with the transmitter operating.

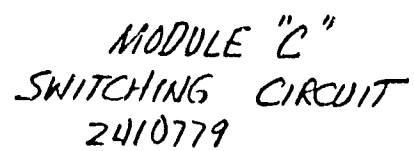


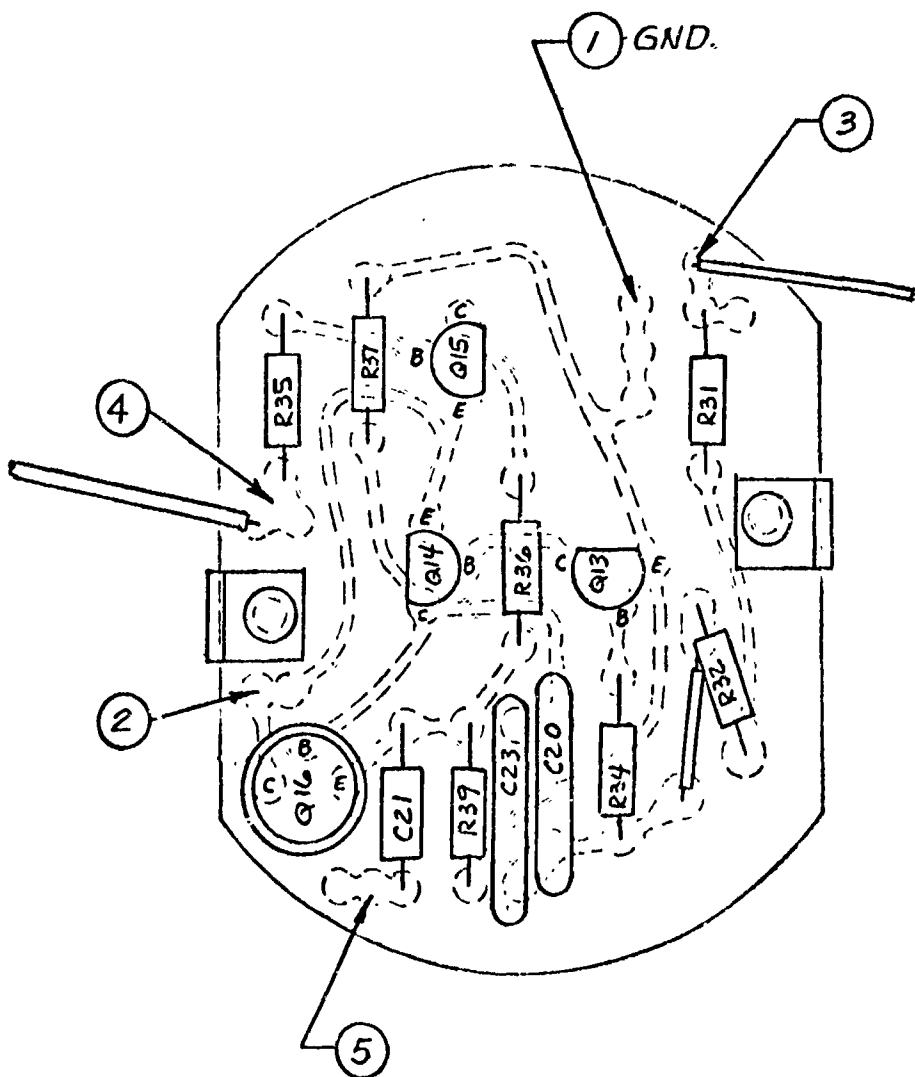
[illegible]

MODULE "A"
COMMUTATOR CLOCK MODULE
2410780

[illegible]

MODULE "B"
COMMUTATOR CIRCUIT
2410778

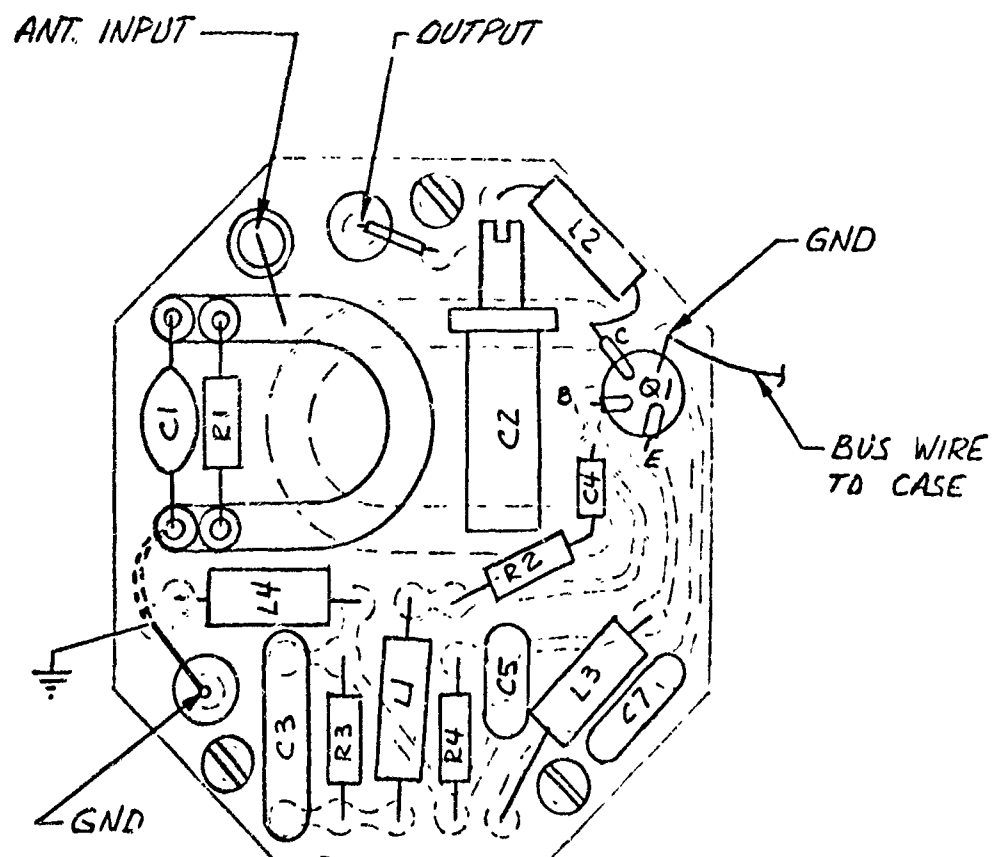
[illegible]

[illegible]

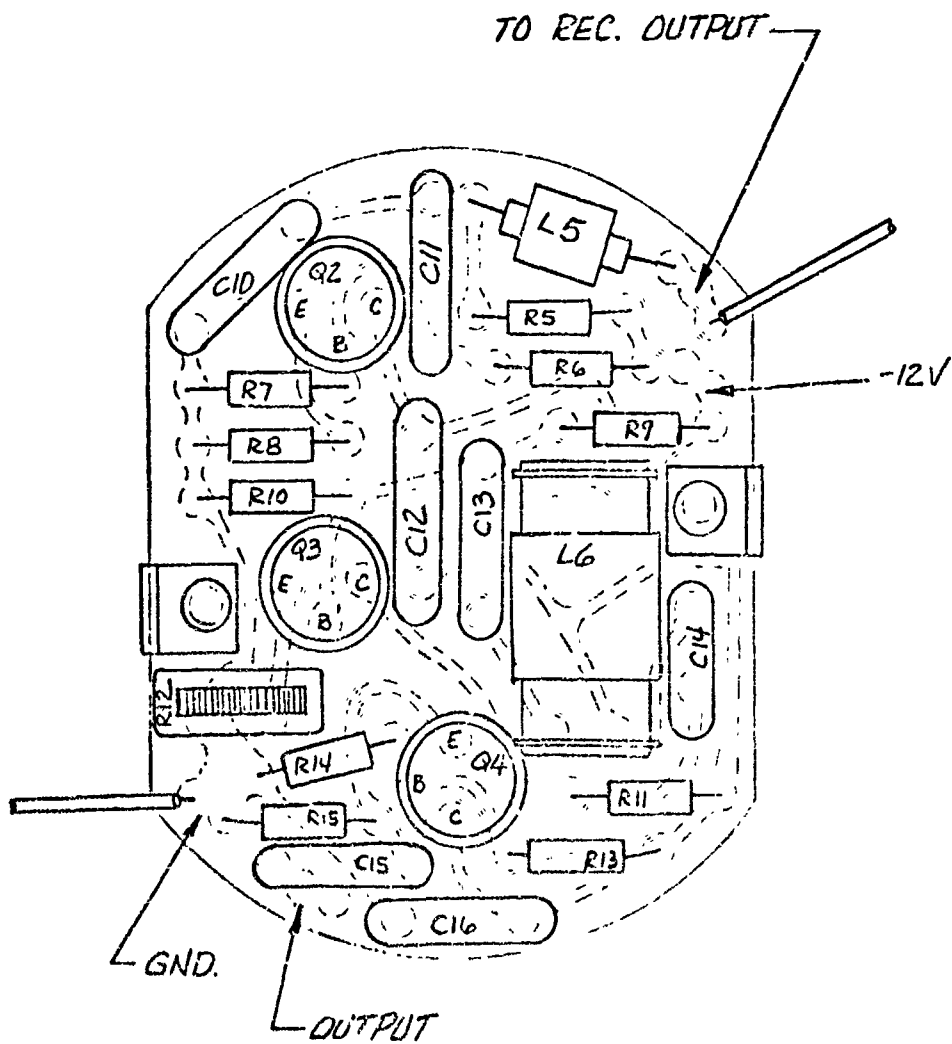
C20 }
C23 } SELECT AT TEST
R32 }

MODULE "D"
MET PULSE GENERATOR
2410777

REV. A



MODULE "E"
RECEIVER ASSY
2410781

[illegible]

MODULE "F"
82KHZ AMPLIFIER
2410776

Unclassified

Security Classification

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13. ABSTRACT <p>The results of a program to develop, design and fabricate a low-level telemetry subsystem to operate in the lower 1,000 meters of the atmosphere and compatibly interface with a modified Rawin Set AN/GMD-4 is presented herein. The subsystem has been designed to provide a detailed analysis of the temperature, humidity and wind structure of the lower atmosphere, employing standard radiosonde sensors and transponder techniques, and consideration has been given for the use of modular construction to facilitate updating as new techniques and equipments are developed. The telemetry device is adaptable for use as a balloonsonde designed for data acquisition on ascent, or as a rocketsonde providing data acquisition on descent, upon deployment of a parachute and a sensor mounting package.</p> <p>Utilized in the design of this telemetry device are: a solid state and integrated circuit commutator, with a sampling rate of one cycle per second, and a solid state microwave transmitter. The relatively high sampling rate of one every second provides a more complete synopsis of the atmospheric construction than have previous balloon borne or rocket sounding telemetry devices.</p>		

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DD FORM 1473

REPLACES DD FORM 1473, 1 JAN 64, WHICH IS
OBSOLETE FOR ARMY USE

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Rocketsonde						
Balloonsonde						
ML 419 Temperature Sensor						
ML 476 Humidity Sensor						
AN/GMD-4 Data Processor						
Teledynamics Meteorological Data Processor						
Sonex Meteorological Data Processor						
Cricket Rocket						
Radiosonde						
Low Level Sonde						
152						