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FURTHER DEVELOPMENT OF THE AN/DMQ-9 ROCKETSONDE

K. W. KIDD

THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION
BALTIMORE, MARYLAND 21204

CONTRACT NO. AF19(628)-4045

PROJECT NO. 6682

TASK NO. 668206

FINAL REPORT

JUNE 1965

PERIOD COVERED APRIL 1964 THROUGH APRIL 1965

PREPARED FOR

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS

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ABSTRACT

The AN/DMQ-9 rocketsonde is an expendable meteorological instrument package designed for use with the Arcas rocket vehicle to obtain vertical profiles of temperature and winds in the upper atmosphere between 80,000 feet and 200,000 feet. The instrument is of the transponder type and is compatible with the AN/GMD-2 Rawin Set ground equipment.

The purpose of this effort was to up-grade the existing design to provide for improved flight performance and ease of handling in the field. Flight tests conducted at the Air Force Eastern Test Range, Cape Kennedy, Florida indicate that the resulting instrument package is suitable for field use when the Rawin Set is supplemented with a parametric amplifier.

LIST OF CONTRIBUTORS TO THE PROJECT

J. R. Cosby	Chief Engineer, Instruments Section
K. W. Kidd	Project Engineer
W. P. Gleisner	Associate Engineer

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1. INTRODUCTION

This report describes work performed for the Aerospace Instrumentation Laboratory, Air Force Cambridge Research Laboratories, Bedford, Massachusetts, during the period April, 1964 through April, 1965 under Contract No. AF19(628)-4045 on further design improvements to the AN/DMQ-9 rocket instrument package. Previous work on this instrument was accomplished under Contracts No. AF19(604)-8433 and No. AF19(628)-1655. The intent of this contract was to upgrade the instrument as developed under the initial contracts to provide for improved flight performance and ease of handling in the field. Flight tests were conducted at Cape Kennedy, Florida at intervals during the course of the contract.

The AN/DMQ-9 rocketsonde is an expendable meteorological sounding device boosted into the upper atmosphere by the Arcas rocket vehicle to an altitude of approximately 200,000 feet. At apogee the instrument package is disengaged from the spent rocket motor by a gas generator separation device and descends to earth by parachute while utilizing radio telemetry to furnish meteorological data to the AN/GMD-2 Rawin Set ground equipment.

During descent, phase comparison of an 81.94 kc signal transmitted and received by the AN/GMD-2 equipment via the rocketsonde is used for computation of the slant range between the ground station and the sonde. Specifically, a 403 mc carrier amplitude modulated by the 81.94 kc ranging signal is transmitted from the ground equipment to the AN/DMQ-9 where it is received, detected, and amplified by the receiver components of the

sonde. The receiver output frequency modulates the 1680 mc carrier transmitted from the rocketsonde to the AN/GMD-2.

Temperature of the air through which the rocketsonde descends is sensed by a thermistor located at the forward end of the package and converted to a pulse repetition frequency by a blocking oscillator. A reference pulse repetition frequency is periodically generated to provide means for correcting for drift in the telemetry signal caused by environmental effects on the electronic components. The pulse signal also frequency modulates the 1680 mc carrier transmitted from the sonde to the AN/GMD-2.

Chronologically, the project consisted of a design phase followed with the construction of ten instrument packages incorporating the design changes. A portion of these instruments were expended in flight tests where operating deficiencies were observed. The remaining packages were reworked in the laboratory and then flight tested, still with less than complete success. It was felt however, that the remaining problems were of such a nature that they could be resolved without seriously affecting the design as worked out up to that time. Therefore, construction of a final group of twenty-five instrument packages was initiated and carried out concurrently with the final design effort to eliminate the last problem areas. The resulting sondes were delivered to Cape Kennedy where fourteen were expended in flight tests, the remainder being retained for future sensor testing. After the first three flights during which operational difficulties not related to sonde performance were cleared up, the remaining instruments were flown with good results.

2. DESCRIPTION OF THE ROCKETSONDE

The basic rocketsonde instrument package shown in Figures 1 and 2 consists of a 403 megacycle self-quenching super-regenerative receiver, a 1680 megacycle radiosonde transmitter, receiving and transmitting antenna assemblies, motor actuated sensor switches, electronic circuitry to properly modulate the transmitted carrier and a battery power supply. These components are contained within and supported by a mechanical structure of sufficient strength to withstand the stresses experienced by the sonde during flight. The assembly is packaged to fit in an ARCAS size 5 nose cone to which powdered lead-epoxy resin ballast is added to give the proper center of gravity.

The entire radiosonde assembly is mounted on an aluminum baseplate that fits within the parachute housing. Six indentations equally spaced around the outer surface of the baseplate engage locking balls which serve to retain the nose cone until separation at apogee. The power supply module is mounted within the confines of the baseplate. The remaining structure consists of a set of longitudinal members, secured to the baseplate, forming a skeleton framework to support the various subassemblies.

The 403 megacycle receiving antenna system is located directly above the power supply module. Four 1/2 inch wide steel strips making up the receiving elements are eyeleted to a glass epoxy disc and retained in a folded position by the nose cone. After the nose cone is discarded at apogee, these elements open to a position normal to the longitudinal axis

of the package. The battery pack is clamped against the receiving antenna deck. Easy access is provided to the battery area by removing the two screws by which the battery holder is attached to and forms an integral part of the structure.

The next section of the package consists of three modules: the 1680 megacycle cavity oscillator (encapsulated in foam plastic), the self-quenching super-regenerative receiver, and the blocking oscillator and 81.94 kc slant ranging signal amplifiers. The last two modules are shielded against r.f. interference. The lower disc to which these modules are attached comprises the etched circuit 1680 megacycle dipole antenna.

A scanning switch subassembly, consisting of a motor driven cam that actuates two snap-action switches, is located immediately above the electronic modules. The motor shaft rotates at 3 r.p.m. and the four lobe cam is of such design as to alternately switch between reference and temperature with a dwell of approximately 4.5 seconds on either, plus an "off" time of approximately 0.5 second preceding each switching operation.

A sensor mounting plate is located at the forward end of the instrument package to accommodate a plug-in type sensor assembly. Electrical connections are provided by two sub-miniature banana plugs which will mate with sub-miniature jacks having a nominal hole diameter of 0.104 inch. A 6-32 tapped hole in the mounting plate provides means for securing the sensor assembly to the instrument.

The spacers to which the sensor mounting plate is attached allows sufficient space between it and the ballast in the nose cone for an Atlantic Research Corporation mylar film bead thermistor mount.

The electronic circuitry consists of a 403 megacycle self-quenching super-regenerative receiver which receives and detects the 81.94 kc amplitude modulated carrier from the Rawin Set AN/GMD-2 transmitter. The 81.94 kc signal is in turn retransmitted on a 1680 megacycle carrier (FM) to the Rawin Set where phase comparison of the outbound and incoming modulation permits direct measurement of slant range. Switching between the meteorological sensor and reference resistor is accomplished with cam actuated snap-action switches and the signals derived therefrom are used to frequency modulate the 1680 megacycle transmitter at a rate of from approximately 20 to 200 cycles per second. Power for the sonde is obtained from a silver oxide-zinc battery pack in conjunction with a DC to DC converter.

A block diagram of the circuit is shown in Figure 3. The schematic, Figure 4, indicates all components referenced in the following detailed description.

Self-Quenching Super-regenerative Receiver

The 403 megacycle signal received by the sonde is inductively coupled from the antenna to the input tank of the super-regenerative detector Q1. Trimmer capacitor C2 is the only adjustment necessary to tune the receiver to the specific operating frequency of the Rawin Set transmitter. The

quench voltage, a saw-tooth signal approximately two to three volts in amplitude at the collector of Q1 and having a frequency of approximately 400 kc, is generated within the detector stage itself. This frequency is determined principally by C5 and the distributed parameters of the circuit. The effect of the quench signal is to alternately drive the detector into and out of self-oscillation.

The initial portion of the self-oscillating condition may be considered a sampling period at which time the amplitude of the 81.94 kc modulation on the 403 megacycle carrier influences the performance of the stage during the remainder of that particular quench cycle. Thus, over a number of quench cycles the collector current of the super-regenerative detector consists of components at the modulation frequency (81.94 kc), the quench frequency (400 kc) and the carrier frequency (403 mc). These latter two frequencies are appreciably attenuated from the desired 81.94 kc signal by means of components L2 and C8, and L5 and C10 respectively.

81.94 kc Amplifiers and Modulator

The super-regenerative detector is followed with an amplifier, Q2, having an output tank, C12 and L6, tuned to resonance at 81.94 kc. The overall gain of this stage is approximately 15. A portion of the 81.94 kc signal appearing across the tank is tapped off and further amplified by a factor of approximately 10 in Q3. No further amplification takes place through Q4 which serves as an impedance matching element between Q3 and the transmitter modulator Q5.

The modulator, an emitter follower in parallel with cathode resistor R17 of the 1680 megacycle cavity oscillator, changes the effective cathode bias of the r.f. oscillator as a function of the 81.94 kc signal. As a result, the oscillator produces a frequency modulated carrier having a deviation of approximately 175 kc for the 81.94 kc ranging signal at threshold 403 megacycle input to the sonde receiver.

Blocking Oscillator

The blocking oscillator, Q7, is a transistorized (2N2905A PNP silicon epitaxial), relaxation oscillator which utilizes half of the primary windings of transformer T1 for feedback. The other half of the primary is connected to the 1.5 volt supply. The combination of low supply voltage and high reference resistance, R22, in the sensor loop, results in a maximum power dissipation in the temperature measuring thermistor of approximately 6 microwatts. Reference frequency is a function of the inductance of the transformer, the reference resistor, and capacitor C19. If required, padding capacitor C20 is added to give a reference frequency of approximately 190 cycles per second.

Buffer stage Q6, connected as an emitter follower isolates the blocking oscillator from the 1680 megacycle oscillator. The output of this stage, approximately 0.75 volts peak negative pulses about 85 microseconds wide, is applied to the grid of the transmitter to shift the carrier frequency at the repetition rate generated by the blocking oscillator. (The trailing edge of the modulating pulse has a positive overshoot of approximately 1.5 volts in amplitude, but this is not significant).

1680 mc Transmitter

The 1680 mc transmitter V1 is, with the exception of a sub-miniature coax cable fitting for the antenna output jack, a standard 6562 single tuned cavity oscillator as used in other radiosonde applications. Grid resistor R18 is selected to give a plate current of approximately 30 ma. The transmitter is frequency modulated by both the 81.94 kc ranging signal and meteorological intelligence as described above. To prevent environmental factors from affecting the transmitter, such as severe frequency shifts or complete failure, the tube is potted in a foam-in-place resin.

Power Supply

The primary power source for the instrument consists of four Eagle-Picher type 1515 silver oxide-zinc cells that will provide approximately three hours of operation. A freshly activated battery pack has an initial output voltage of about 7 volts which decreases to 6 volts after the first few minutes of use. The full 6 volts potential is used for the transmitter filament, the switching motor and as the input to a DC-DC converter. A 1.5 volt connection feeds the blocking oscillator. A two-pole, double-throw power switch is provided.

The DC-DC converter supplies the operating voltages for the remainder of the circuitry. Oscillation of the transistorized converter is initiated by starting resistor R23 in the otherwise symmetrical configuration. The frequency of oscillation is approximately 1 kc as transistors Q8 and Q9 alternate operation in an on-off condition. Feedback is provided by the base to emitter transformer windings. The square wave voltage produced by

this circuit is stepped up by the transformer and the output is rectified by the full wave bridge consisting of CR1, CR2, CR3, and CR4. Final filtering by C25, R26, and C26 provides a substantially ripple-free plate supply of approximately 118 volts which is used for the transmitter directly and also as the source from which zener diode VR1 provides a nominal 10 volt supply for the receiver, 81.94 kc amplifiers and buffer stages. Filter components L7, C28, and C29, mounted on the rear of the receiver case, attenuate DC-DC converter noise on the 10 volt line.

Antennas

The receiving antenna is a configuration of four, half wavelength elements spaced 90 degrees apart on the mounting board. These elements feed half wavelength segments of sub-miniature coaxial cable in such a manner as to produce the equivalent effect of two mutually perpendicular dipole antennas.

The transmitting antenna is an etched circuit, centerfed dipole made up of two 152° segments of copper - one on each side of the base material. A length of sub-miniature coaxial cable connects the radiating elements to the 1680 mc oscillator.

3. SUMMARY OF REDESIGN EFFORT

Mechanical Design Changes

In the package configuration developed on the previous contract sufficient ballast weight was added to the payload structure to insure that the center of gravity of the vehicle-payload assembly was well forward of the minimum requirement of 36.5 inches from the tail. The resulting suspended weight on the parachute was approximately six pounds. In order to reduce the suspended parachute load, weight was removed from the instrument structure and attached to the nose cone using epoxy molding compound with powdered lead filler. The suspended parachute weight was thereby reduced to 3.3 pounds. This redistribution of weight was also deemed beneficial to reduce loading on the structure during the times the payload experiences in-flight shock and acceleration forces and to reduce the thermal mass of the descent package.

For the first flight test units the amount of powdered lead-epoxy resin ballast added to the nose cone gave a total nose cone weight of approximately 1.9 pounds and the resulting center of gravity of the assembled flight vehicle borderlined on 36.5 inches. Subsequently, additional ballast was added to the nose cone bringing its weight to 2.6 pounds and moving the flight vehicle center of gravity forward to 37.0 inches.

The approximate descent rate of the instrument package as calculated from flight test data is as follows:

Altitude ($\times 10^3$ feet)	Average Velocity (ft/sec)
202	500
190	384
178	300
170	250
158	187
150	157
138	120
130	100
118	75
110	63
98	48

In addition to redistributing the weight, several other mechanical design changes were incorporated in the present unit. The most important of these was the conversion of the electronic circuitry to printed circuit construction for increased reliability and ease of fabrication. A change in one of the primary structural members in the battery portion of the package permits the member to be removed easily to facilitate insertion of the battery pack in the instrument. Other minor design changes improve the ease with which various subassemblies may be attached to or removed from the structure.

Transmitter

The 1680 megacycle r.f. oscillator is the standard 6562 cavity-tuned pencil triode used in other radiosonde applications with the exception that

it is provided with a sub-miniature coaxial fitting for the r.f. output rather than the normal slip-on connector. This permits the use of a standard coaxial fitting on the feed line to the antenna. The transmitter is potted in a rigid polyurethane foam-in-place liquid resin to prevent its operating characteristics from being affected by environmental factors imposed during flight.

Sensor Switching

One of the deficiencies in the design of the AN/DMQ-9 at the conclusion of the previous contract was the presence of commutator noise in the meteorological audio frequency data. This interference appeared on the AN/TMQ-5 strip chart recorder as a repeating noise pattern which in some cases completely obscured the meteorological data. Considering the fact that the sensor current is on the order of 10 microamps, the presence of a sliding contact in the signal path is undesirable. To eliminate this condition, a special cam was designed to actuate two sub-miniature snap action switches, one for reference and one for temperature. The motor used to drive the cam is the same one that had been used with the commutator switching on all previous AN/DMQ-9's. The snap action switches chosen for this application have gold contacts as recommended for improved reliability in dry-circuit operation.

Meteorological Signal

The blocking oscillator circuit remained essentially unchanged from the previous contracts. For the last twenty-five instruments, a standard calibration curve was used rather than plotting each sonde's audio curve

from its individual calibration data. The standardized curve derived from the twenty-five instruments is as follows:

Sensor Resistance (K ohms)	Average Frequency (cps)	Highest Frequency (cps)	Lowest Frequency (cps)
0	190.0		
10	174.3	175.2	173.1
25	155.3*	156.0	154.1
40	140.3	141.1	139.1
60	124.4**	125.0	123.5
75	115.1***	116.0	114.5
100	102.7	103.7	101.8
200	73.0	73.6	72.5
300	58.1	58.8	57.6
400	49.3	50.6	48.8
500	43.1	43.6	42.9
600	38.8	39.0	38.4
800	33.2	33.6	32.8
1000	29.5	29.8	29.2
1200	27.0	27.8	26.8
1400	25.0	25.4	24.9
1600	23.7	23.9	23.1

* 1 point discarded

** 2 points discarded

*** 1 point discarded

Following the first flight tests where the meteorological pulse signal was very noisy, changes were made to the buffer stage between the blocking oscillator and the transmitter grid. These changes, consisting of reducing the emitter resistor R20, increasing coupling capacitor C16, and adding bias stabilizing resistor R27, had the effect of increasing the negative pulse amplitude at the grid of transmitter from approximately 0.5 volt to about 0.75 volt axis to peak. In addition the fall time of the trailing edge of the pulse was improved so as to reduce apparent changes in pulse width, as seen by the AN/GMD-2 receiver, caused by fluctuations in the pulse amplitude. The noise problem was not brought under control however until the blocking oscillator circuit board was shielded from r.f. radiation, a requirement which was not apparent until the entire instrument package was operated at elevated temperatures.

The only change made in the temperature measuring circuit was the addition of a precision carbon film resistor in shunt with the bead thermistor. This was necessary because of the typically wide variation in bead resistance at low temperatures. While the blocking oscillator may operate reliably with sensor resistances as high as approximately 1 megohm, the bead may have a resistance as high as 1.6 megohms at -65°C. The shunt resistor assures proper operation of the blocking oscillator regardless of the value of the bead.

Receiver

To take advantage of advances in the state of the art in the design of super-regenerative receivers for radiosonde use, a transistorized self-

quenching receiver as developed under Contract No. AF19(628)-2834 for the AN/AMQ-21 Multichannel Radiosonde was adapted for use in the AN/DMQ-9. Typical bandwidth characteristics of the receiver are shown in Figure 5. The AGC performance of the receiver was determined by varying the level of an 81.94 kc modulated 403 mc carrier applied to the input of the receiver and measuring the output peak to peak 81.94 kc voltage used to modulate the sonde transmitter. For input signal from 10 microvolts to 570 microvolts, approximately 35 db, the receiver output changed only 3 db; for an input signal range of 50 db, the receiver output changed 6 db.

To improve the stability of the receiver and to assure satisfactory operation of the super-regenerative detector stage with normal variations in circuit parameters, the supply voltage to the receiver was increased from 6 volts to approximately 10 volts prior to the final series of flight tests. The higher voltage was obtained with a zener diode voltage regulator circuit operating from the nominal 115 volt B+ generated by the DC-DC converter.

Antennas

Some effort was devoted to possible alternate 400 mc receiving antennas to simplify its method of construction and to facilitate handling the instrument in the field. In the time allotted however, none of the changes resulted in an antenna having performance equivalent to that of the existing design so it was retained.

The 1680 mc etched circuit bow-tie dipole antenna was modified slightly by increasing the sector angle from 150° to 152° to provide a better impedance match for the 50 ohm output of the 1680 mc oscillator.

4. SUMMARY OF FLIGHT TESTS

As mentioned in the introduction, several groups of flight tests were conducted at the Air Force Eastern Test Range, Cape Kennedy, Florida. The first series of tests were carried out in September, 1964 when seven instruments were flown. Only one of these produced a temperature recording that could be evaluated and the indicated temperature profile was not in agreement with a temperature profile obtained earlier with a non-transponder rocketsonde. Various other difficulties were encountered during these tests including interference from other radiosonde signals and problems with the Rawin Set operating in automatic tracking mode. The significant observation of the tests however was that excessive noise was present in the meteorological pulse telemetry signal.

Following these tests, changes were made in the modulating pulse shape as described previously and three instruments were test flown at Cape Kennedy in October. Unfortunately, two of the three flights were unsuccessful because of parachute deployment failures probably due to low launcher elevation angles dictated by unfavorable wind conditions. Successful parachute deployment was obtained in the other flight, however, a noisy telemetry signal was again received for the first ten minutes of descent after which the signal cleared up. The AN/TMQ-5 record was evaluated showing agreement to within 1.5°C of an overlapping balloonsonde flight.

The concluding series of flight tests were conducted in April, 1965 when fourteen instruments as described in Section 2 of this report were flown. Following the first three flights during which time adjustments

were made to the Rawin Set to insure optimum performance, ten AN/DMQ-9's were successfully tracked in the automatic mode from launch, through ascent and payload deployment at apogee and during descent using a parametric amplifier. The flight records were evaluated by Cape Kennedy Weather Station personnel and the data obtained was disseminated per normal rocket-sounding procedures.

The last flight was conducted without benefit of the parametric amplifier and as in the previous ten flights the instrument was tracked in the automatic mode throughout the flight. The signal level indicated by the Rawin Set receiver panel meter was low however, varying between 2 to 5 microamps at apogee and between 2 to 15 microamps later in the flight. The resulting AN/TMQ-5 record was of marginal quality for approximately the first two minutes after separation, but was suitable thereafter to be evaluated by the normal procedures. It should be noted that no useable range data were obtained due to the marginal signal strength.

5. CONCLUSIONS

Results of the program indicate that the AN/DMQ-9 rocketsonde is now satisfactory for use at sites where the Rawin Set is provided with a parametric amplifier. The circuit design and features of construction are such that the instrument may be manufactured with confidence that the performance will duplicate that demonstrated in the final flight tests. The package is easy to handle in the field in preparation for flight.

To satisfy a need for operation witnout the use of a parametric amplifier on the Rawin Set receiver, additional design effort is required on the transmitting antenna. Examining the space available, it appears practicable to develop an antenna having suitable characteristics to be mounted forward of the timing motor. No changes would be required in the remainder of the instrument package.

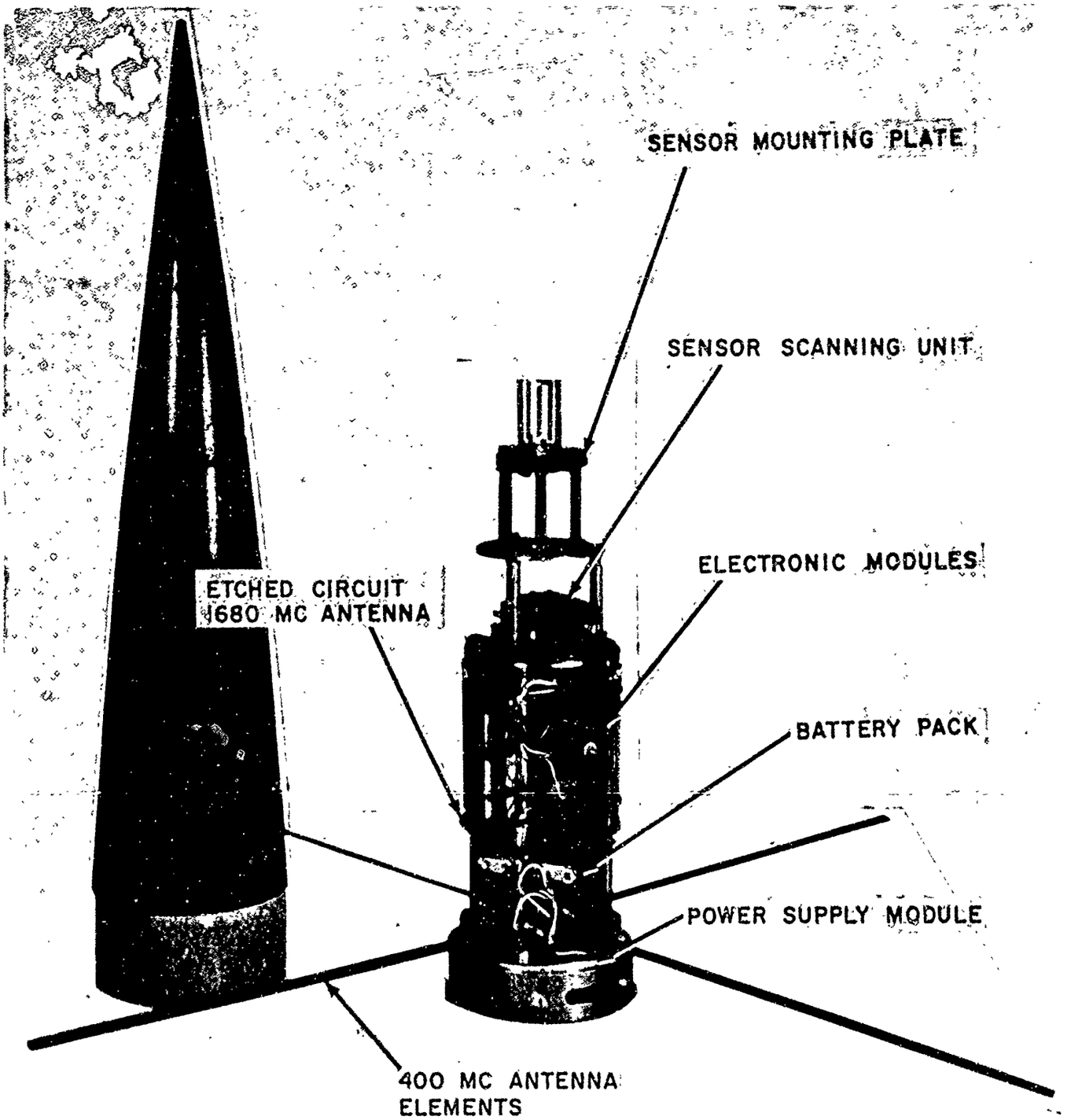


FIGURE 1

AN/DMQ-9 ROCKET INSTRUMENT PACKAGE

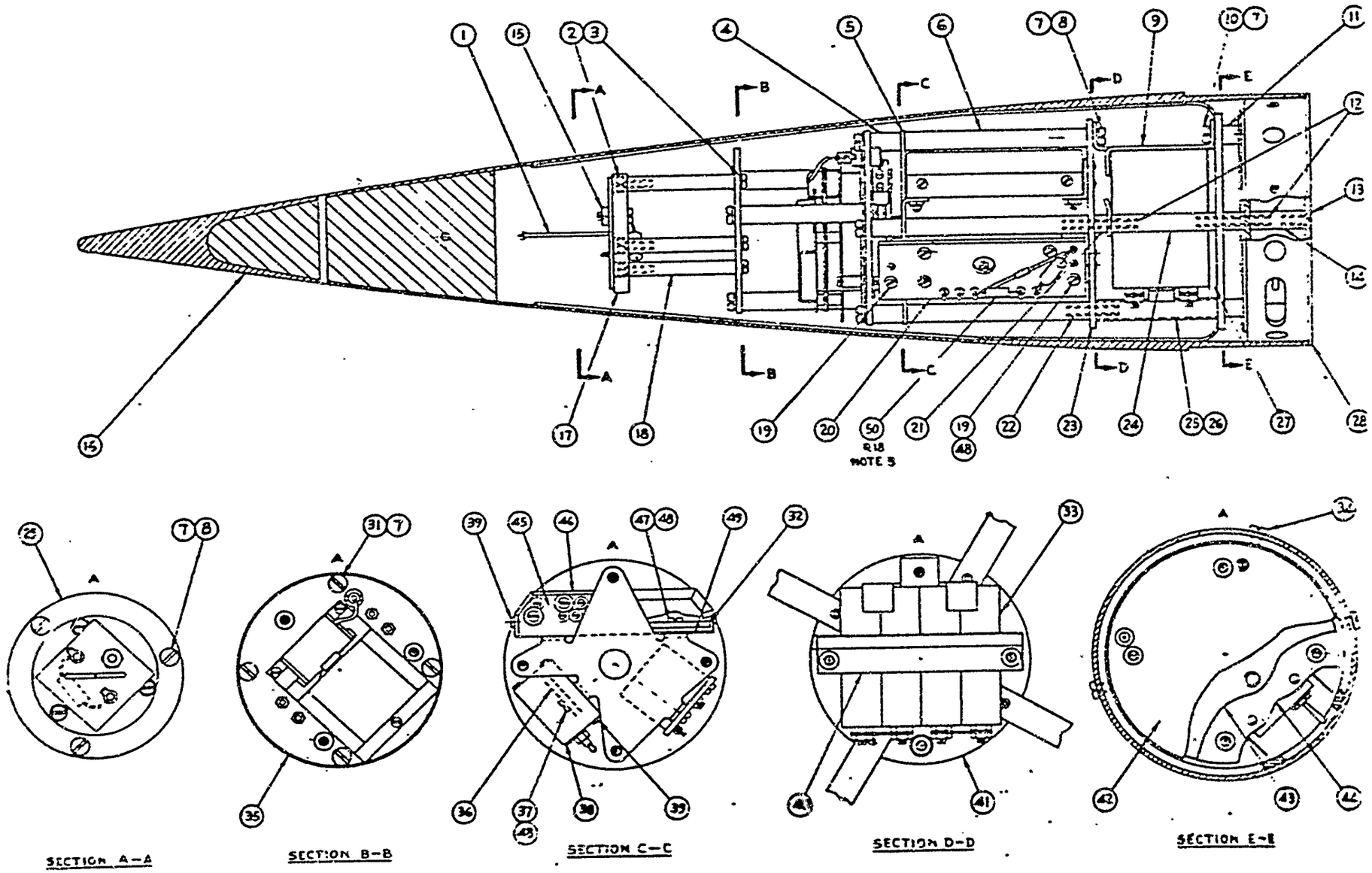


FIGURE 2

ASSEMBLY DRAWING

QTY. REQ'D	ITEM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION		NOTES
X	52	C1148991	WIRING DIAGRAM, AN/DMQ-9		
X	51	D1147640	SCHEMATIC, AN/DMQ-9		
1	50	RC20GF---J	RESISTOR, FIXED, COMP	MIL-R-11	3
1	49	B1148727	INSULATOR SHELF		
4	48	MS35649-44	NUT, HEX, 4-40		
4	47	MS35233-16	SCREW, PAN HD, 4-40 X 1/16		
1	46	C1148036	COVER		
1	45	C1148725-1	CASE ASSEMBLY		
1	44	D1147744-1	POWER SUPPLY ASSEMBLY		
1	43	C1147549	INSULATOR, DISK		
1	42	C1147620-1	SHIELD ASSEMBLY		
1	41	C1147761-1	ANTENNA BOARD ASSY		
1	40	B1147295	PLATE, BATTERY HOLDER		
10	39	A-500985-6	SCREW, SHEET METAL, NO.2		
1	38	C1147476	COVER, RECEIVER		
2	37	—	SCREW, RD. HD. 4-40 X 5/8	BLACK PLASTIC	
1	36	C1147747-1	RECEIVER ASSEMBLY		
1	35	C1147676-1	PLATE AND MOTOR ASSY		
3	34	MS35233-41	SCREW, PAN HD, 8-32 X 1/4		
4	33	A1144925	BATTERY		
1	32	C1147745-1	PRINTED CIRCUIT BOARD ASSY		
4	31	MS35233-47	SCREW, PAN HD, 8-32 X 1·		
	30				
1	29	C1147511	PLATE, MOUNTING		
1	28	C1147565-1	BASE ASSEMBLY		
1	27	B1147664	PAD, CUSHIONING		
2"	26	C1136665-001	INSULATION SLEEVING		
1	25	B1147297-2	POST		
2	24	B1147297-3	POST		
1	23	C1147608-1	ANTENNA BOARD ASSY		
1	22	B1147477-2	STUD, CONTINUOUS THREAD		
2	21	B1147298-3	SPACER, SLEEVE		
1	20	C1147461-1	TRANSMITTER ASSEMBLY		
2	19	MS35233-14	SCREW, PAN HD, 4-40 X 5/16		
3	18	B1147518	POST		
1	17	B1148753-1	PLATE, MOUNTING, ASSY		
1	16	D1147705-1	NOSE CONE ASSY		
1	15	MS35649-64	NUT, HEX, 6-32		
4	14	B1147297-4	POST		
4	13	MS35249-52	SCREW, FLAT HD, 8-32 X 1/2		
5	12	B1147477-1	STUD, CONTINUOUS THREAD		
4	11	B1147298-2	SPACER, SLEEVE		
1	10	MS35233-48	SCREW, PAN HD, 8-32 X 7/8		
1	9	B1147296	BRACKET, BATTERY HOLDER		
4	8	MS35233-43	SCREW, PAN HD, 8-32 X 3/8		
9	7	MS35338-80	WASHER, LOCK, NO. 8		
4	6	B1147297-1	POST		
1	5	B1147609-1	BRACKET ASSEMBLY		
4	4	B1147298-1	SPACER, SLEEVE		
6	3	MS35338-79	WASHER, LOCK, NO. 6		
6	2	MS35233-30	SCREW, PAN HD, 6-32 X 1/2		
1	1	B1148864	THERMISTOR MOUNT ASSY	ATLANTIC RES	
-1	LIST OF MATERIAL OR PARTS LIST				

FIGURE 2A

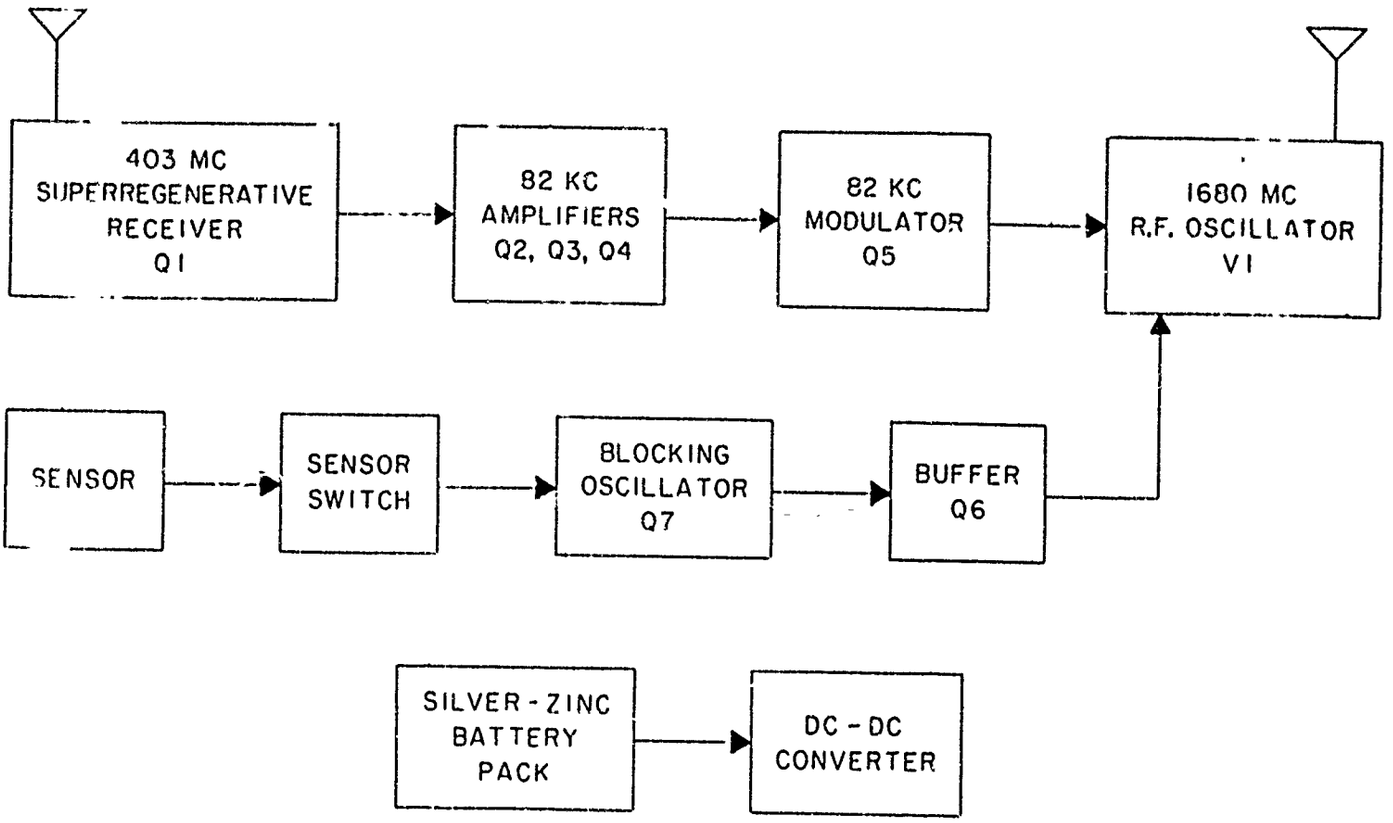


FIGURE 3

BLOCK DIAGRAM

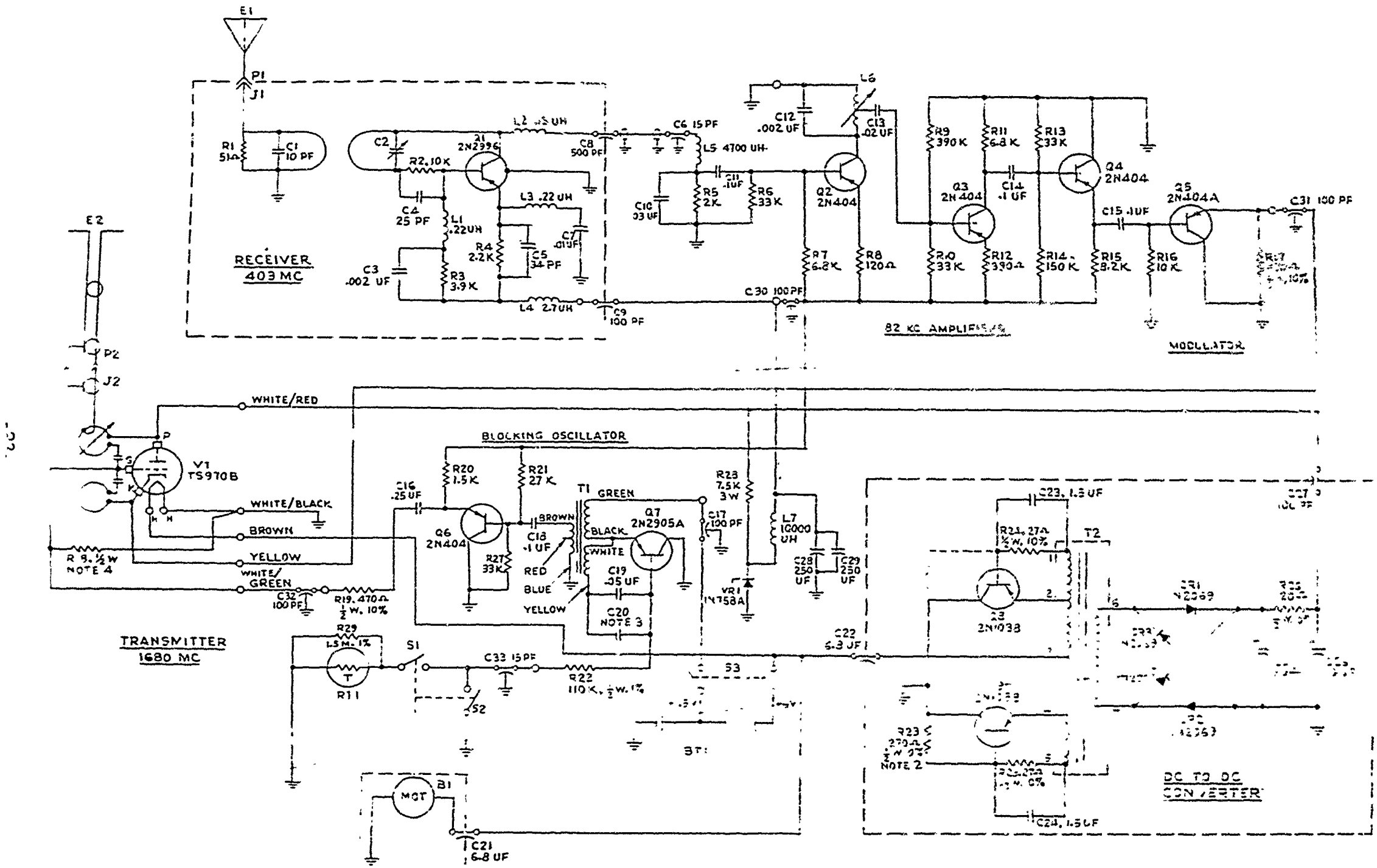
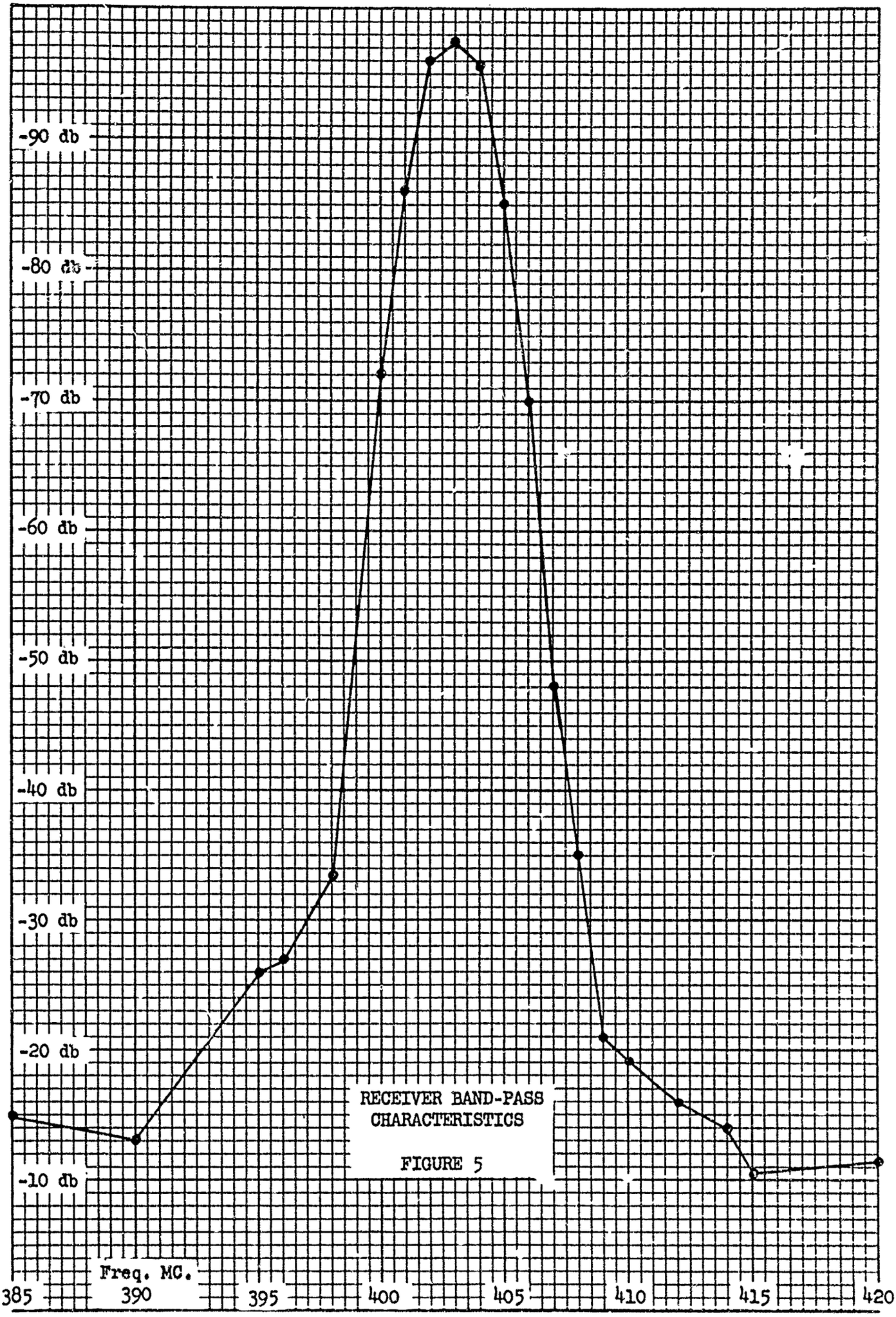


FIGURE 4

SCHEMATIC DIAGRAM



RECEIVER BAND-PASS CHARACTERISTICS

FIGURE 5

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