AD/A-003 356

BLACK BRANT IV A ROCKET PROBE RECEIVER EXPERIMENT

Wayne O. Miller

Aerospace Research, Incorporated

Prepared for:

Air Force Cambridge Research Laboratories

February 1974

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFCRL-TR-74-0237	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: AD/A 003 356	
4. TITLE (and Subtitle): BLACK BRANT IV A ROCKET PROBE RECEIVER EXPERIMENT	5. TYPE OF REPORT & PERIOD COVERED: Final - 1 July 1972 through 31 December 1973
	6. PERFORMING ORG. REPORT NUMBER: Pub. No. 534
7. AUTHOR(s): Wayne O. Miller	8. CONTRACT OR GRANT NUMBER(s): F19628-72-C-0340
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Aerospace Research, Inc., 130 Lincoln Street, Boston (Brighton), MA 02135	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 4603-14-01
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Cambridge Research Laboratories (LI), L. G. Hanscom Field, Bedford, MA 01730	12. REPORT DATE: February 1974
	13. NUMBER OF PAGES: 23
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Electronic Systems Division, Air Force Systems Command, USAF, L. G. Hanscom Field, Bedford, MA 01730	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

A - Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Contract Monitor: Richard B. Harvey
Ionospheric Physics Laboratory

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Black Brant
rocket probe receiver
signal propagation
ARCAS
meteorological rocket

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the design, fabrication, test, and launch of two rocket probe receiver packages to measure the propagation of ELF and VLF signals in the ionosphere. The second phase of the program included the study and design of a miniaturized receiver package to be electrically the same but with physical and environmental characteristics of an ARCAS meteorological rocket. The results of the program, including the trip report, are summarized.

TABLE OF CONTENTS

1.0 INTRODUCTION

The objectives of Contract F19628-72-C-0340 are twofold; first to design, build, and launch two rocket-borne receivers to measure propagation of ELF and VLF signals in the ionosphere, and second, to perform a feasibility study to analyze the suitability of the ARCAS rocket for use in VLF propagation experiments.

The ELF/VLF rocket payloads were designed to be similar mechanically and electrically to the payloads provided by Aerospace Research, Inc. to AFCRL under former contracts; these rockets have performed successfully. The addition of the ELF receiver caused the complete mechanical and electrical redesign, however the basic modular concept and simple circuit design was incorporated into the new design.

The feasibility study concerning the use of ARCAS rockets was instituted to determine whether an inexpensive meteorological payload with only minor modifications could be used in propagation experiments where large amounts of data would be taken over a wide range of conditions.

2.0 TECHNICAL DISCUSSION - Black Brant IV A

The major components of the equipment are the rocket-borne payload package, the ground-based receiver package, and the ground control station.

The experiment measured propagation effects through the upper atmosphere on signals in the ELF and VLF spectra. Signals were received simultaneously by ground-based receivers and rocket-born receivers. The signals received by the rocket payload were telemetered back to the control center so that these signals, along with those received by the ground station, could be tape recorded for subsequent data reduction. Two identical sets of receivers, operating from crossed loop antennas, were used at the ground station so that signal direction could be determined by comparing signal strengths from each loop. Five receivers were used in each set, one for the 10 to 150 Hz band, and four tuned to specific stations in the 16 to 24 kHz region.

2.1 ELECTRICAL DESIGN

2.1.1 ROCKET PAYLOAD PACKAGE

A Black Brant IV A rocket was used to loft the payload package. Since it was a fairly large rocket, the payload size and weight allowances were generous. For the experiment, the most important factor was that the nose section be made of fiberglass, allowing a loop antenna of useful size to be installed in the nose. At VLF and ELF ranges, antenna area is very important for good reception; even for a ground based station, no practical antenna is ever too large.

Two widely separated bands of signals were to be received. Best reception of the 10 to 150 Hz band called for an antenna with a large number of effective turns, operating untuned, so as to obtain best S/N with a realizable preamplifier. Best reception of the 16 to 24 kHz band required the antenna to be resonated at band center, and loading was convenient to flatten the sensitivity over the band. Effective number of antenna turns was less critical since either a moderate impedance (bipolar) or high impedance

(FET) input preamplifier could give optimum S/N. Practical considerations made the bipolar preamplifier more attractive.

In any case, S/N could not be simultaneously optimized for both frequency ranges by feeding a single preamplifier through a single transformer. One obvious solution was to use two orthogonal loops (one for each band), each feeding a separate transformer and preamplifier. This was an electrically satisfactory solution, as reception in each band could be optimized. However, the two loops would be somewhat cumbersome mechanically.

Ways of utilizing a single loop for effective dual band reception were considered. The method used, shown in Drawing B444-3003, used two cascaded input transformers and a filter network to drive a single bipolar preamplifier. By using two transformers, one of which was used only for the 10 to 150 Hz band, reception can be nearly optimized at both bands.

Therefore, a single loop of the largest practical size was used in the rocket nose. The loop was shielded and balanced to minimize electrostatic pickup. The effective area of this loop was about 300 square inches. For maximum signal strength, the antenna should have good Q at the lowest frequency of interest. Good Q down to 10 Hz is difficult to obtain with a small loop, but the shield cross-section was made fairly large, (about 1 square inch) to allow a lot of copper in the antenna to maximize Q. The largest convenient size wire, 14 gauge stranded, was used to minimize the space taken up by the wire insulation. The antenna was wound full, about 100 turns, with a predicted inductance of about 10 MHy. The self-resonant frequency was well above 24 kHz. A separate single turn winding was incorporated to provide a convenient means for coupling in a test signal.

As mentioned, the preamplifier used a dual transformer input circuit. Refering to Drawing B444-3003, coupling of the antenna to the amplifier in the 10 to 150 Hz band was accomplished mainly by T1. T1 had a primary inductance of about 100 MHy and an impedance step up of 1000:1. T2 contributed a small additional stepup. The secondary of T1 was loaded by C2 and R1 to provide a critically damped resonance of 200 Hz. At the 16 to 24 kHz band, coupling was provided entirely by T2, which had a primary inductance of about 10 MHy and an impedance step up of 4:1. T1 was entirely bypassed by C2. The combination of T2 and the antenna were tuned to resonance at 20 kHz by C1 and loaded by R2.

The preamplifier had two stages, biased for minimum noise and using dc and feedback for bias and gain stabilization and low output impedance. The preamplifier gain was fixed at 40 dB over the entire band.

The preamplifier output contained all signals of interest in both frequency bands. To separate the desired signals, the preamplifier output was fed to an ELF amplifier and to four tuned narrow band VLF amplifiers, as shown in Figure 1.

Each VLF amplifier was tuned to one of the active VLF transmitters. The VLF receiver schematic is shown in Drawing C444-3001. Three single tuned stages, using high Q tank circuits, were used to provide the necessary gain and selectivity. Each receiver incorporated a high/low gain switch to compensate for signal dropoff at high altitudes.

The ELF receiver used active R-C filters to provide a 10 to 150 Hz bandpass characteristic. Two integrated circuits provided the necessary gain stages. The schematic is shown in Drawing B444-3004.

The signals to be telemetered back to the ground were not very adaptable to the usual multiple SCO telemetry format. To obtain a reasonably efficient use of standard telemetry hardware and practices, a system using both SCO and direct modulation was chosen. The four selected VLF signals directly modulated the FM telemetry transmitter. The ELF signal modulated a 30 kHz, 7-1/2% bandwidth SCO, which in turn also modulated the transmitter. Using this arrangement, the deviation of the telemetry transmitter was several times the highest modulating frequency, thus allowing a good telemetry signal-to-noise ratio. The 30 kHz SCO frequency was chosen to be above the VLF band so that there was no possibility of interference or cross-coupling into the VLF channel, either within the rocket package or through the telemetry link. Conversely, the 30 kHz SCO band was below any harmonics of the VLF signals, thus precluding cross-coupling of the VLF signals into the SCO channel under

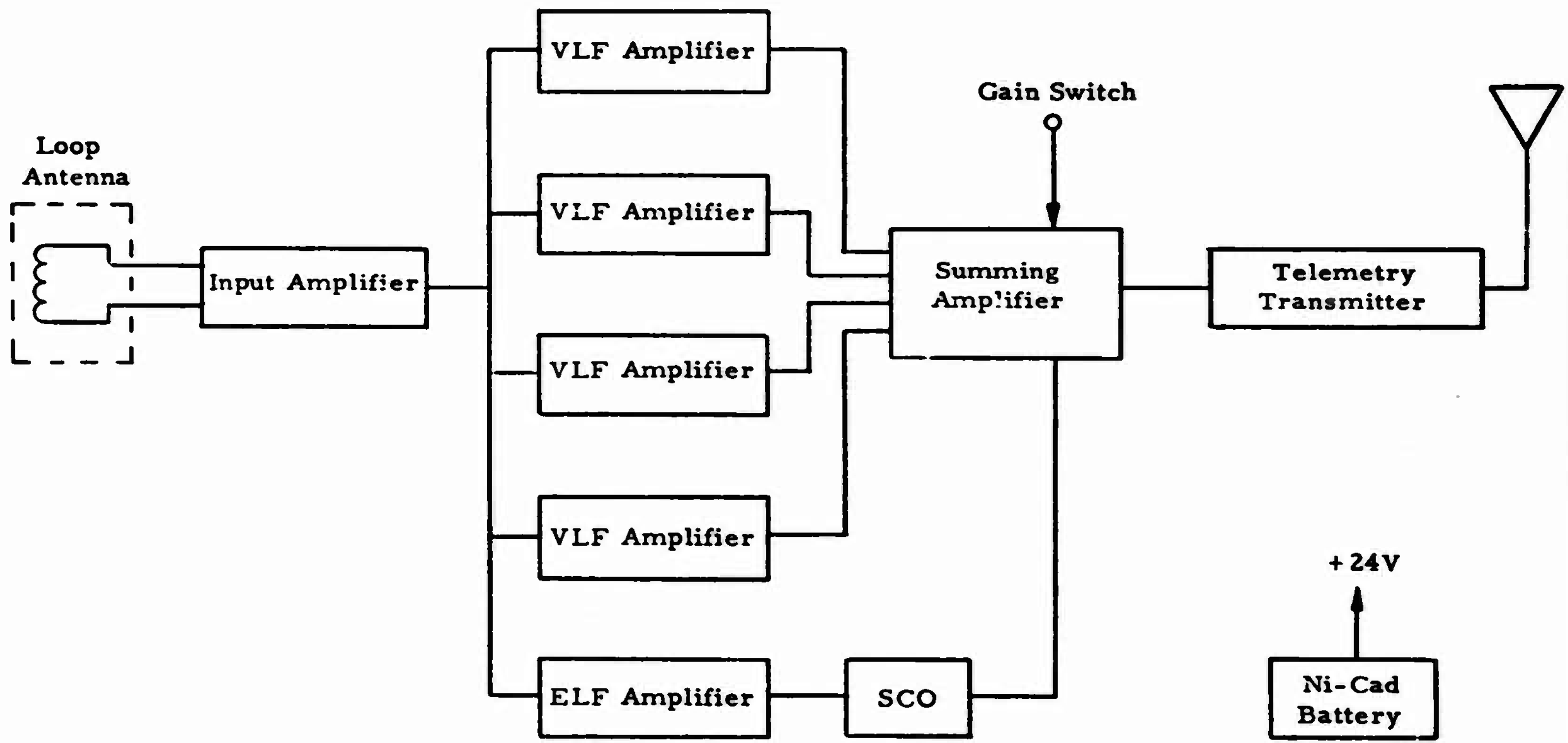


Figure 1 - Rocket Payload Block Diagram

possible overload conditions. The SCO channel also provided a convenient indication of proper telemetry operation.

At the telemetry ground station, the recovered VLF signals were recorded directly on magnetic tape. The ELF signal was recovered by a standard telemetry 30 kHz discriminator and then recorded.

To prepare the rocket receiver signals for telemetry, the four VLF receiver ouputs were summed through individual level setting controls to establish approximately equal levels, then passed through a limiter stage so as to avoid over-deviating the telemetry transmitter. The ELF amplifier output, set to an appropriate level, modulated the 30 kHz SCO. The constant amplitude SCO output is summed with the summed and limited VLF signals to provide the composite modulation to the telemetry transmitter. The summing circuits are shown on the schematic of the output card, Drawing D444-3002.

A 40 second delay timer circuit was also incorporated on the output card and was used to switch the VLF receivers from low to high gain 40 seconds after the launch. The timer was "held off" by returning the timer input to a negative supply through the umbilical. Opening or grounding the line, as occurs at launch, starts the timing cycle. If the timer has prematurely started for some reason, such as an intermittent contact, it would be instantly reset by returning the input negative again. The receivers and telemetry transmitter were powered by a single 24 volt Ni-Cad rechargeable battery of 1.2 ampere hour capacity.

2.1.2 OMEGA AMPLIFIER

While the payloads were being assembled at ARI, a final determination of which VLF stations would be monitored during the flight had to be made by AFCRL scientists. Evaluation of the locations and directions of incoming received signals (Drawing 444-5001), indicated that too few stations might be operating to yield sufficient data to satisfy the experiment. In addition, NSS was not transmitting to permit installation of new equipment. The scientists at AFCRL inquired into the possiblity of re-tuning to receive the Omega stations in the 10 kHz to 12 kHz range. This was accomplished by two changes. First, the antenna tuning was changed to permit the output to be flat over the entire range of 10 kHz to 24 kHz; this was accomplished by changing capacitors on the baseplate terminals. Second, a set of VLF amplifier cards had to be tuned to this frequency range. The range was beyond the tuning capability of the indicators normally used in these amplifiers and a new indicator was selected which was mechanically and electrically suitable. Once installed in amplifiers, these indicators allowed tuning over the Omega range. In order to cover the 2 kHz bandwidth required with one amplifier, the tank circuits were loaded, resulting in somewhat less gain in the amplifiers. Since the gain reduction was within the compensation range in the output mixer amplifier, this loss was not significant.

2.1.3 GROUND CONTROL STATION

A control box was provided for convenient test and control of the rocket payload through the umbilical. The control box allowed operation on internal or external power, high or low VLF receiver gain, and provided recharging of the payload battery.

2.1.4 GROUND RECEIVERS

The ground-based receivers were electrically identical to those in the rocket payload. Two complete and identical sets were used; these were fed by a pair of crossed loops to allow estimating direction of signal arrival. For this purpose, the amplifier gains were carefully matched between channels. To provide better signal pickup, one meter diameter loops were used which were wound to give the same inductance as the rocket loop.

2.2 MECHANICAL DESIGN

2.2.1 GENERAL

Compared to other rockets commonly used for scientific experiments, the Black Brant IV A rocket provides a relatively easy ride. The maximum linear acceleration is 37 G compared with acceleration of well over 100 G for other types of rockets. The anticipated vibration would not exceed 5 G and would be random noise in nature. No fixed frequency vibrations which might occur at a natural resonance of some part of the payload were expected. The payload was, however, tested for these resonances to make certain that no severe vibration amplification would take place in the payload. The payload did not have to be protected from temperature since the nose tip and fiberglass nose cone would absorb the effects of heating by air friction. The payload was constructed as two major sub-assemblies - antenna and electronic housing. Drawing E444-2006 is an overall pictorial of the payload. The baseplate joined the two sub-assemblies. In addition to holding the sub-assemblies together, the base plate was used to support electronics necessary to interface the antenna signals with the electronics housing. This circuit consisted mainly of an impedance matching network (resistors, capacitors, and transformer) which are mechanically rugged and could be mounted in an exposed manner without fear of damage. This baseplate is the means by which the payload was attached to the rocket. A series of twelve 1/4" - 28 bolts around the circumference were used to hold the payload to the aluminum skin sections. The only other support provided the payload was located at the top of the antenna. As shown, a round plate (made of epoxy glass for electrical reasons) was connected to the top of the antenna flanges by bolts. Around the outside edge of this fiberglass ring were four nylon tipped steel set-screws.

After the payload was installed in the nosecone the set-screws were tightened against the inside walls of the nosecone to provide stability for the antenna structures. Previous payloads of this type built by ARI have shown that no additional support between the antenna and nosecone would be required.

2.2.2 ANTENNA

Since the signal received is directly proportional to the area within the circumference of a loop antenna, it was necessary to make the antenna as large as possible. In order to do this the antenna was made in two sections, following the contour of the nosecone. For aerodynamic reasons, the nosecone sloped from its tip at an angle of $5^{o}30"$ until the diameter of 10.125" was reached. By taking advantage of the angled section, the antenna area could be increased by about 35%. The angled section and rectangular section were welded together as were all other parts, so that no metal buildup occurred in the wire channel.

The main antenna parts were built from aluminum extruded channel which was fabricated and welded. Since the antenna was wound using #14AWG wire it was felt that if the antenna structure had any sharp angles there might be difficulty in making the wire lay flat in the channel while winding. For this reason all sharp angles were designed with large radii corners. This permitted easy winding of the antenna while causing no appreciable reduction in antenna area. Flat aluminum plates were used as covers to complete the electrical shielding. These plates were secured with flat head machine screws at small intervals. After the antenna wire was wound in the channel the entire assembly was potted with RTV to reduce the noise from the vibrating wires. The antenna lead wires were brought out through a rubber grommet on the base of the antenna and were secured to the impedance matching circuitry on the base plate.

2.2.3 ELECTRONIC HOUSING

The VLF electronic housing was constructed with a shell and two doors, one on the front and one on the rear of the housing. With the doors removed each card could simply be pulled out since connectors and card edge pins were used to fix the cards in place rather than soldering the connections to the interior. Access to the wiring section was gained by removing the rear door. It was sssumed that access to the wiring would not be required often after final assembly and therefore it was decided to attach the batteries to the rear door.

The upper compartment of the housing was divided into two sections. The left section contained the input card; the wires for the input signal from the antennas were run through an opening drilled in the antenna baseplate to the input cavity in the wiring section so that the connecting wiring was as short as possible. The right section of the upper compartment was not used unless additional SCO's needed to be mounted here.

The center compartment contained the four VLF and one ELF receiver cards which were mounted vertically in order to relieve the stress from the weight of the inductors against the cards. The card input was in the upper section of the center compartment while the output from the cards was in the connecting pin at the lower section of the compartment so that the input and output wires do not cross. Since the input and output signals were the same with approximately 100 dB in gain between, some crosstalk and oscillation difficulty might be experienced if the wires were too close to one another.

The next compartment contained the timer, output and clipper card; the input on one side and output on the other as a precautionary measure even though there was no gain present.

Running from front to back in this section was a shielded aluminum tube of 3/8" diameter. The tube was used to run the coaxial cables that connected the output of the ELF receiver card to the SCO (mounted on the front door with the T-M transmitter). The SCO output also ran through the tube and connected as an input to the summer card. The output to the T-M transmitter ran in the tube to prevent crosstalk and connected to the T-M transmitter on the front panel.

The bottom compartment contained all dc switching and wiring. There was a printed circuit card with the latching relays plus all diodes and resistors required for external dc measurements. This card had the umbilical cord protector components to provide for faulty umbilical disconnect.

All four compartments in the VLF electronic housing were shielded from one another by metal separators which served as card supports. Power to the VLF electronic housing and the telemetry section was provided through the umbilical cable connector located behind the VLF batteries.

3.0 ARCAS DESIGN STUDY

3.1 PURPOSE

The objective of the ARCAS design study was to evaluate the feasibility of modifying the existing Black Brant VLF receiver experiment for use in an ARCAS meteorological rocket. Analysis of the modification showed the major differences as follows: (a) the ARCAS payload would use a single side-band VLF amplifier instead of the multiple narrow band amplifiers used in the Black Brant payload, (b) the receiving loop would be replaced by a ferrite antenna because of size and space requirements, and (c) a horizontal antenna would be added to receive signals from that mode.

In addition, the ARCAS payload would be similar to a standard meteorological payload because it would be ejected from the rocket at apogee and fall back to earth by parachute. The data transmission would be by standard 1680 MHz radiosonde and would be activated by a pressure switch at a pre-determined altitude.

3.2 DESIGN

Since standard meterological packages are commonly flown in rockets of this type, the reasonable approach seemed to be to take an existing payload and salvage the ejector, power supply, radiosonde, and parachute. This would mean that the VLF experiment would have to occupy the space formerly housing the meteorological instruments. Study of the existing meteorological payload indicated this to be a sound theory since the payload was well designed and yielded maximum payload space.

By use of "state of the art" integrated circuit amplifiers, an amplifier which would provide the gain necessary to yield usable data from the very small signals to be received by the ferrite antenna was designed and tested. A method for mounting this amplifier and the ferrite antenna was designed. After completion of amplifier design, work was started on the design of the horizontal loop antenna. The best design was found to be a loop wound and taped to the inside of the cylindrical housing. This antenna had a very low gain because of its size and the small number of turns which could be wound in the space. This was because the output open circuit voltage of a loop is directly proportional to both the number of turns and the area enclosed by a loop. The gain of the amplifier cannot be increased to compensate for this because of the poor signal-to-noise ratio of the antenna.

3.3 CONCLUSIONS

Since it was important to the experiment to measure both the vertical and horizontal signals, and since it was not possible to construct a horizontal antenna to accomplish this, the following conclusions were drawn:

1. The experiment as outlined was not feasible using ARCAS rockets. A larger vehicle must be used.
2. The ARCAS could be used for an experiment using only a vertical antenna.

4.0 TRIP REPORT - BLACK BRANT IV A

During the period 11 October through 25 October 1973, personnel of Aerospace Research, Inc. and AFCRL were present at Eglin Air Force Base for checkout and launch of two Black Brant IV A rockets. The following is a brief summary of the activities prior to launch as well as the two launch efforts.

11 Oct 1973	Departed Boston for Eglin Air Force Base, Florida via Atlanta. The equipment in ten crates was supposed to be held at Eastern Airlines Air Freight because of size limitations, however it had been forwarded to Pensacola. Upon arrival in Pensacola, a truck was obtained to pick up the material.
12 Oct 1973	Launch meeting. The build-up area, site A-11, was assigned to obtain bench space and unpack and setup equipment.
13 Oct 1973	Finished tuning of ground receiver and set it up with outside antennas. Monitored VLF stations at 1000 hours and 2200 hours to determine received signal levels.
14 Oct 1973	Monitored VLF transmissions at 1000 and 2200 hours.
15 Oct 1973	Checked tuning of payload cards and retuned some because of change in frequency of NAA transmitter site. Monitored VLF transmissions at 1000 and 2200 hours.
17 Oct 1973	Set up the SCO's on the bench. Rewired the payloads to accept "A" style SCO. The TM transmitter problem turned out to be the transmitter itself. The circuits were designed for a Conic FM transmitter, but we had to change to a Dorsett transmitter which was supposed to be an exact replacement. However, the Dorsett turned out to be be a PM transmitter instead of FM. This required some component changes in the output card which were done, and gave us the TM output level desired. Monitored VLF transmissions at 1000 and 2200 hours.
18 Oct 1973	Reassembled first payload for ground tests. Checked station reception and adjusted output card to equalize channels. Also started assembly of second payload.

Monitored VLF transmissions at 1000 and 2200 hours. Also checked night reception of payload.

19 Oct 1973 — Finished assembly of second payload and made adjustments. Monitored VLF transmissions at 1000 and 2200 hours. Also checked night reception of second payload.

20 Oct 1973 — Made final checks on first payload and completed final assesmbly for flight. Set up ground receiver at receiver site B-4A and checked operation. Mated first payload with rocket vehicle and hung it on the launch rail. Got equipment set up in the block house and checked operation of payload. Made final preparations for 2200 hours lauch. At T - 90 minutes the launch was scrubbed by range safety because of insufficient dispersion data on the Black Brant IV A.

21 Oct 1973 — Monitored VLF transmissions at 1000 and 2200 hours.

22 Oct 1973 — No launch because of federal holiday.

23 Oct 1973 — Did new horizontal and vertical checks on payload still hanging on rail.

Rocket was launched at 2205 hours. Vehicle ignition good but something happened at time of gain change (T + 35 seconds) to cause loss of signal on the 24 kHz channel. Other than this the flight went as planned.

24 Oct 1973 — Lunch meeting to discuss the first flight. It was decided that the most probable cause of the problem was an over-deviation of the 30 kHz SCO by the ELF channel causing the SCO frequency to interfere with the 24 kHz signal. To correct this, we reduced the gain for the ELF and 24 kHz cards and changed to a 70 kHz SCO.

Ground tests were completed on the second payload and did final assembly for flight. The payload was then mated with the rocket vehicle and hung on the launch rail.

Rocket was launched at 2207 hours. Vehicle ignition good and no payload failures. Received all data as planned.

After launch all equipment was assembled and packed.

25 Oct 1973 — In the morning the equipment was transported to Pensacola at Eastern Air Freight. ARI personnel left Pensacola at 1230 hours for the flight back to Boston.

5.0 CONCLUSION

The Black Brant IV A experiments were successful except for loss of the 24 kHz channel during the first flight. The on-site fix involved gain reduction in the ELF amplifier and a change in the SCO frequency from 30 kHz to 70 kHz. These changes resulted in good performance without the sacrifice of the ELF data (the option of removing the ELF preamplifier had been discussed at length on-site). However, it was still necessary to prove that the field evaluation of the problem had been correct. Upon return to Aerospace Research, Inc. a test program was conducted to attempt to recreate the failure mode. This was accomplished with the following explanation:

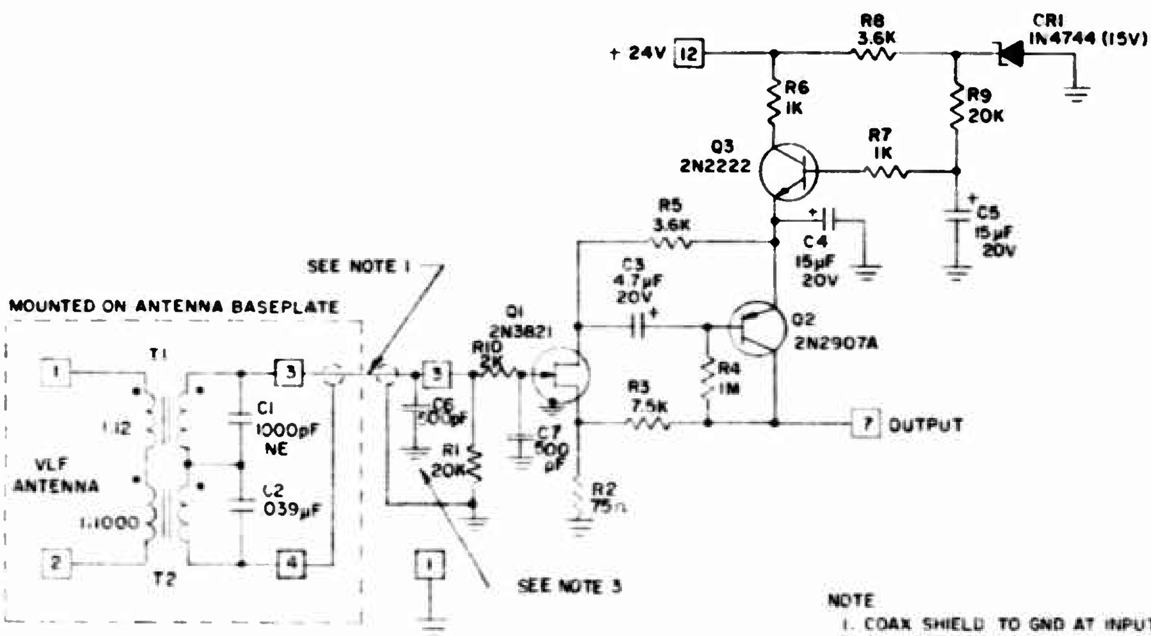
1. The extent of the magnetometer effect (a large copper antenna cutting the earth's magnetic field lines) was not anticipated.
2. The ELF amplifier would further amplify the signals induced in the antenna by this effect. (3 Hz while outside the bandwidth is only down by about 6 dB in an amplifier with 70 dB of gain).
3. Since signals of this nature were not expected to be received, the limiter was not fast enough to respond to them. The limiter had been included so that the SCO could not be driven out band.
4. It was possible to get 6V spikes out of the ELF amplifier before the limiter came into play.
5. These 6V spikes are sufficient to drive a 30 kHz SCO into the 24 kHz range.

These findings indicate that field analysis of the problem was accurate and the corrective action taken was in fact the proper course to follow.

If payloads of this nature are flown again, a redesign of the limiter or a permanent change to a 70 kHz SCO would correct the situation.

The preliminary analysis of the data indicated that it represented the real events of the observed phenomena and that no additional interference was present. Detailed data reduction will be undertaken by AFCRL.

The ARCAS feasibility study unfortunately did not result in an acceptable payload for the purpose intended. As mentioned previously, there was no practical way to deploy an antenna which would yield useable signals.



NOTE
1. COAX SHIELD TO GND AT INPUT CARD ONLY
2. ALL RESISTORS ARE ±5%, 1/4W.
3. MOUNTED ON J1 INPUT CARD CONNECTOR

REQD.	REQD.	ITEM	PART NO.	DESCRIPTION
				LIST OF MATERIALS

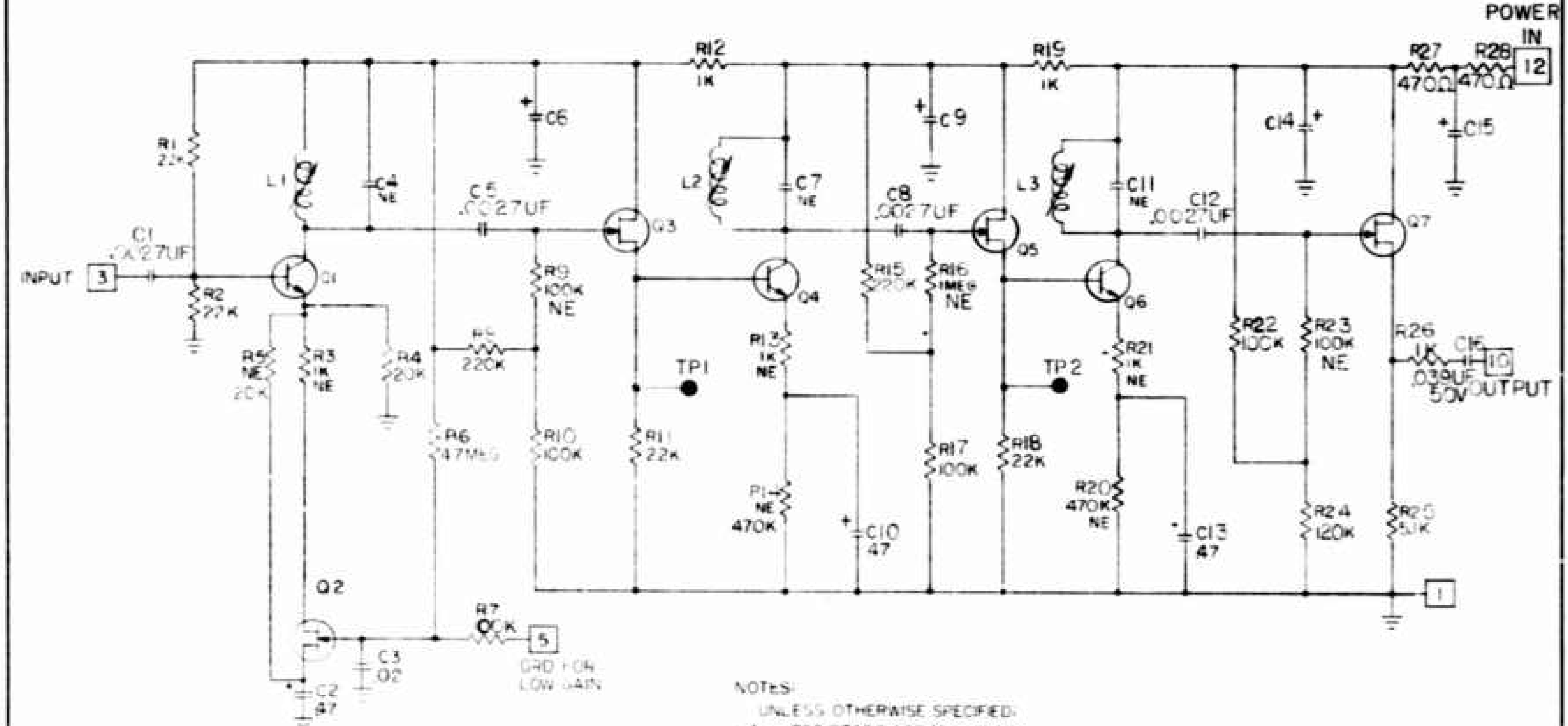
INPUT CIRCUIT
B.B. IVA ROCKET EXPERIMENT

AEROSPACE RESEARCH INC
BOSTON, MASS.

SIZE: B DWG. NO.: 444-3003 REV.: B

SCALE SHEET 1 OF 1

REVISIONS



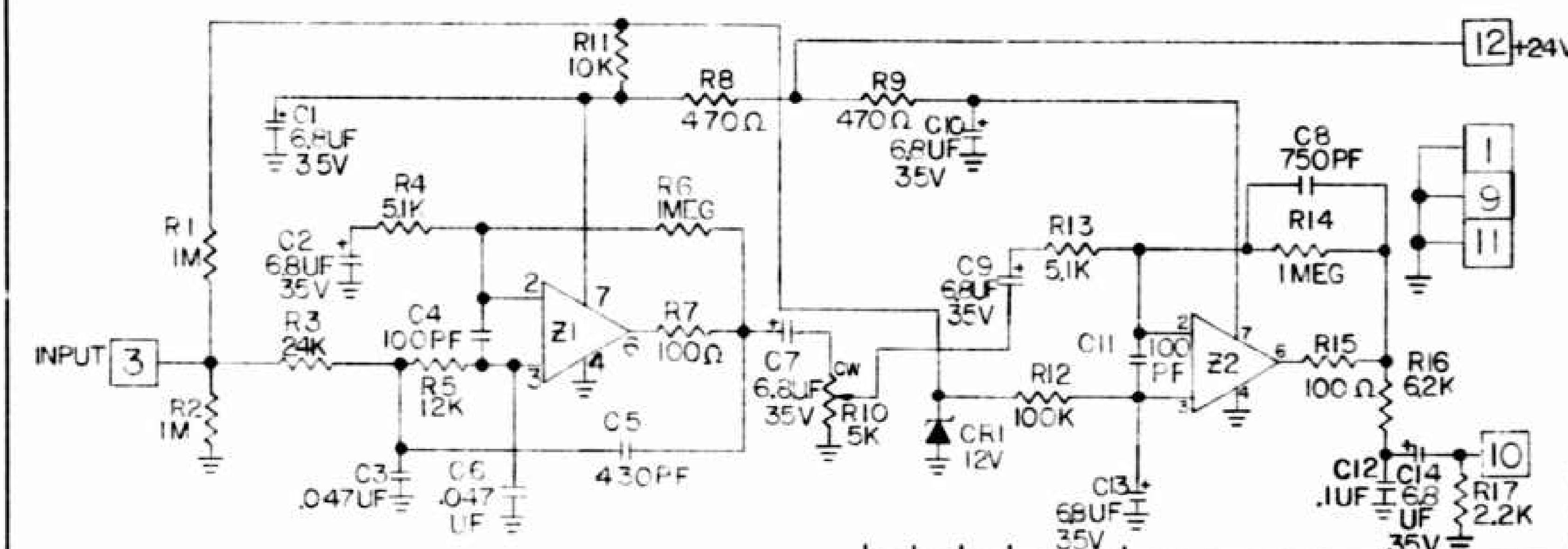
NOTES:

UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE 1/4W, ±10%
2. ALL NPN TRANSISTORS ARE 2N2222
3. ALL CAPACITORS ARE 6.8 UF, 35V
4. L1, L2, L3 TEXC T-9730
5. ALL FETS ARE 2N4393.

RECEIVER CIRCUIT SCHEMATIC- BB IV A VLF ROCKET EXP		AEROSPACE RESEARCH INC		
NEXT ASSY 444-2001	SIZE C	DWG NO 444-3001	REV -	

NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL OP AMPS ARE LM207.
2. ALL RESISTORS ARE 1/4W.

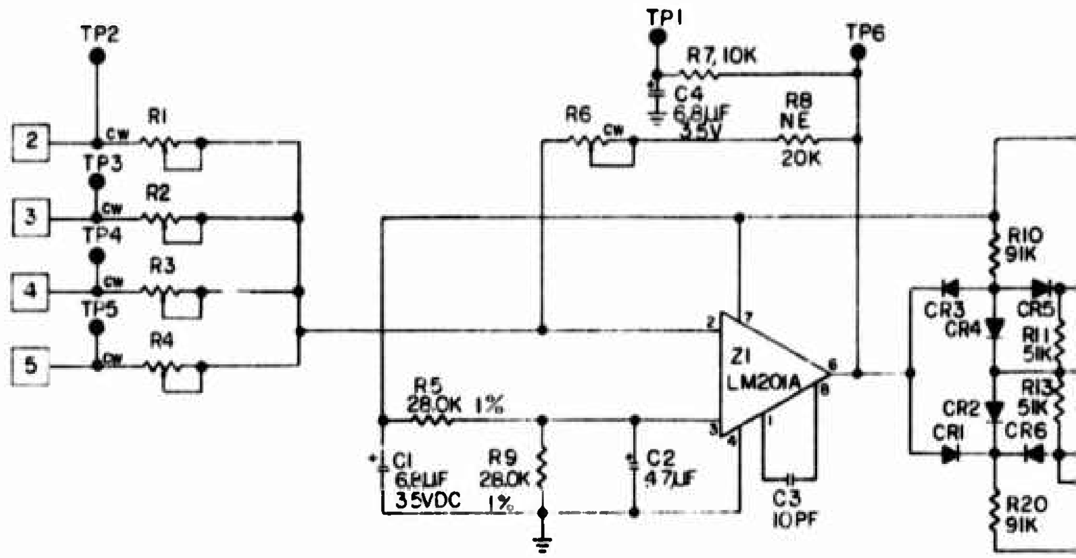


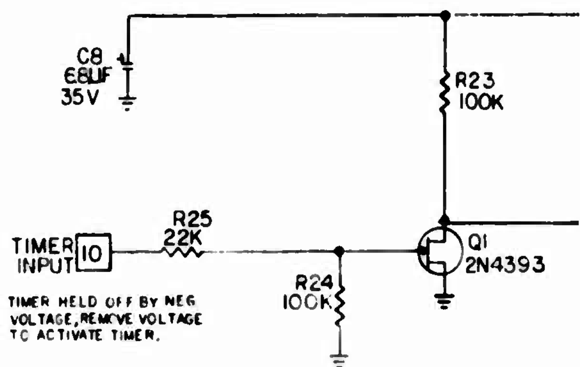
LIST OF MATERIALS

ELF AMPLIFIER
SCHEMATIC
BB IVA ROCKET EXP

AEROSPACE RESEARCH INC
BOSTON, MASS.

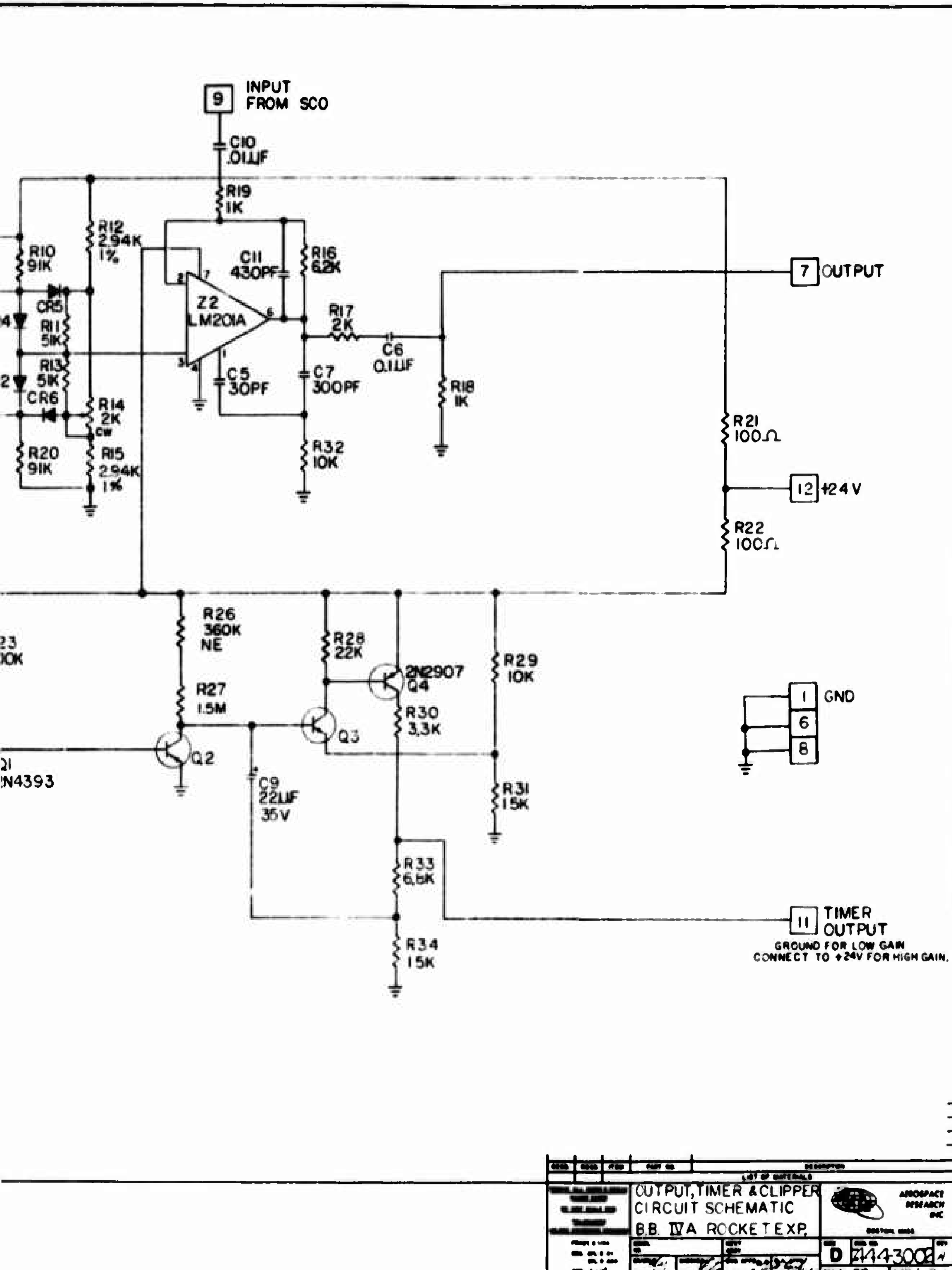
SIZE B | DWG NO. 7444-3004 | REV –
SCALE ∞ | SHEET 1 OF 1





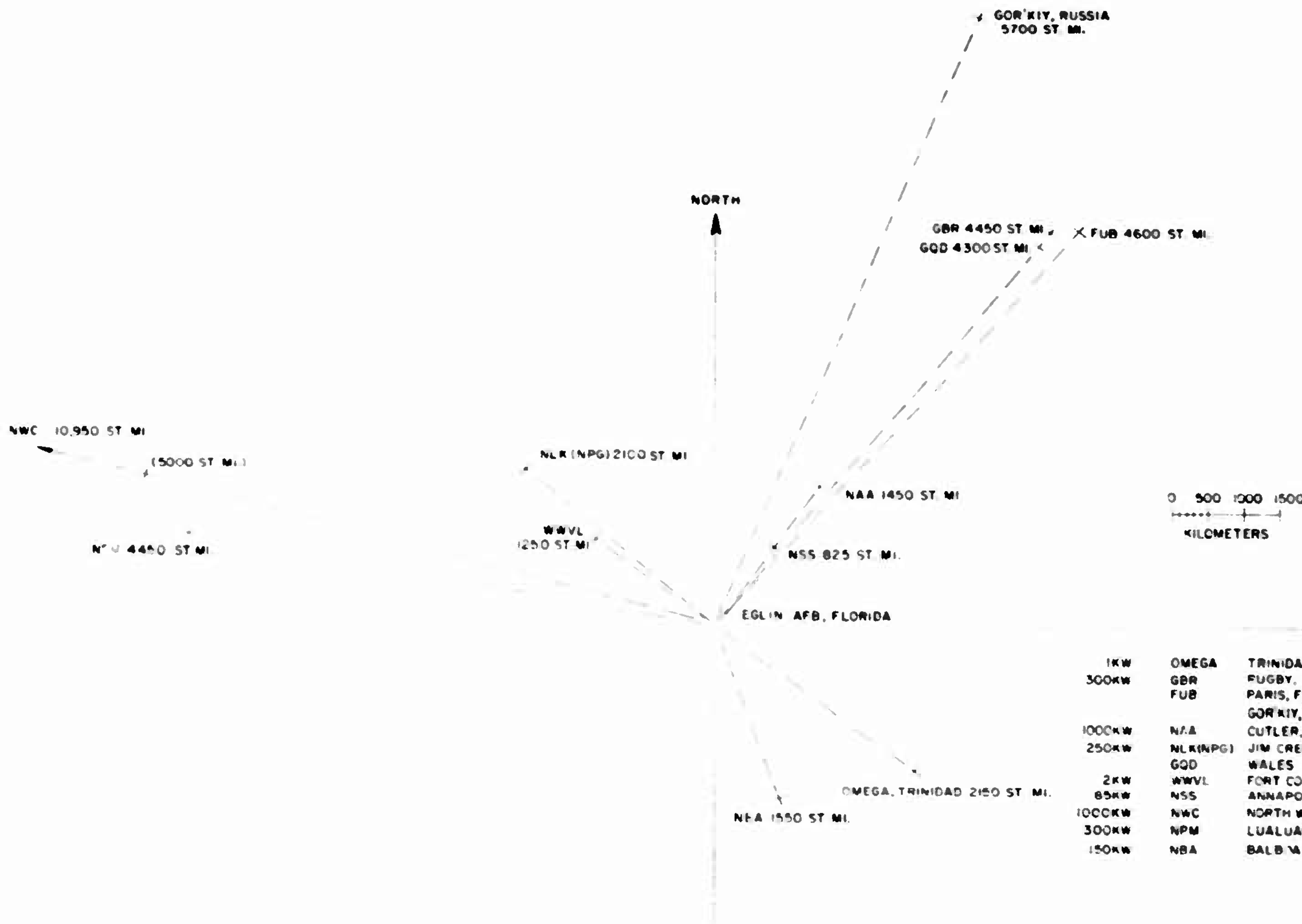
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL VARIABLE RESISTORS ARE HELITRIM * 58PR10K.
2. ALL RESISTORS ARE ±10%, 1/4W.
3. ALL DIODES ARE 1N4154.
4. ALL TRANSISTORS ARE 2N2222.

A



9 INPUT FROM SCO
C10 .01µF
R19 1K
R12 2.94K 1%
R10 91K
C11 430PF
R16 6.2K
Z2 LM201A
CR5
R11 51K
R13 51K
CR6
R14 2K CW
R20 91K
R15 2.94K 1%
C5 30PF
C7 300PF
R32 10K
R17 2K
C6 0.1µF
R18 1K
7 OUTPUT
R21 100Ω
12 +24V
R22 100Ω
R26 360K NE
R27 1.5M
Q2
Q1 2N4393
R28 22K
2N2907 Q4
Q3
R30 3.3K
R29 10K
R31 15K
C9 22µF 35V
R33 6.6K
R34 15K
1 GND
6
8
11 TIMER OUTPUT
GROUND FOR LOW GAIN
CONNECT TO +24V FOR HIGH GAIN.
OUTPUT, TIMER & CLIPPER CIRCUIT SCHEMATIC
B.B. IVA ROCKET EXP.
AEROSPACE RESEARCH INC
D 4443002

12



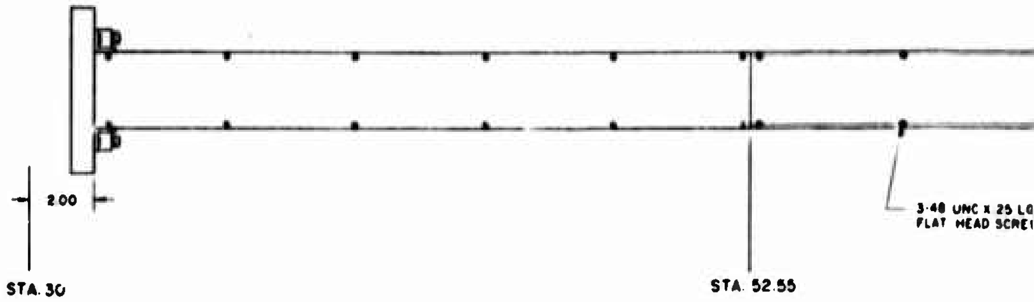
1KW	OMEGA	TRINIDAD, WEST INDIES	12.0KHz
300KW	GBR	RUGBY, UNITED KINGDOM	16.0KHz
	FUB	PARIS, FRANCE	16.8KHz
		GOR'KIY, RUSSIA	17.1 KHz
1000KW	NAA	CUTLER, MAINE	17.8KHz
250KW	NLK(NPG)	JIM CREEK, WASHINGTON	18.6KHz
	GQD	WALES	19.0KHz
2KW	WWVL	FORT COLLINS, COLORADO	20.0KHz
85KW	NSS	ANNAPOLIS, MARYLAND	21.4KHz
1000KW	NWC	NORTH WEST CAPE, AUSTRALIA	22.3KHz
300KW	NPM	LUALUALEI, HAWAII	23.4KHz
150KW	NBA	BALBOA, CANAL ZONE	24.0KHz

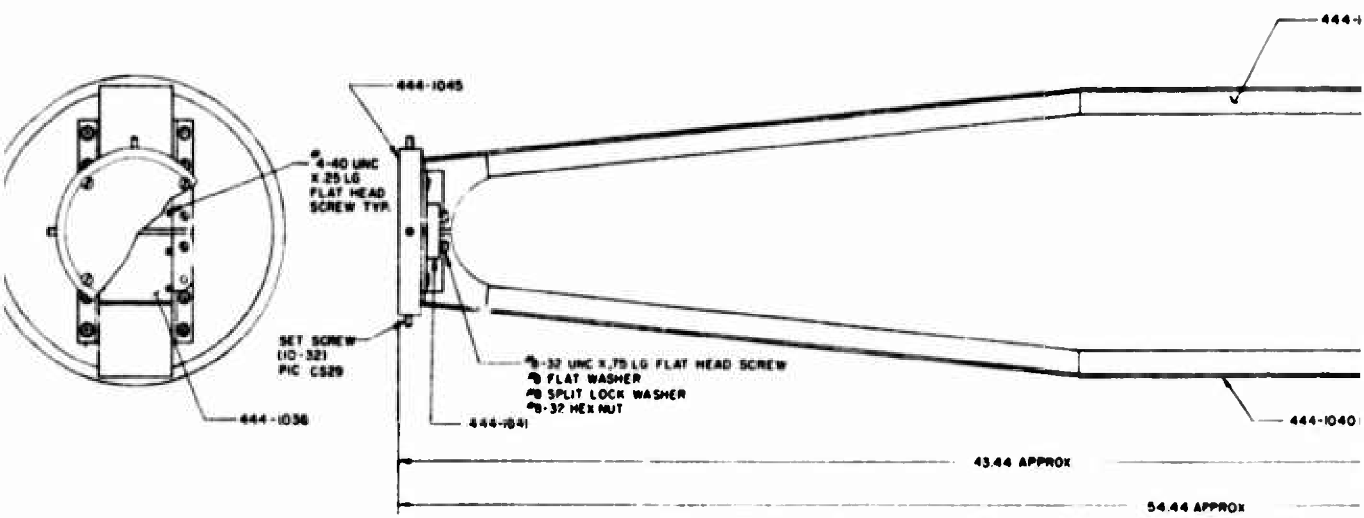
LIST OF MATERIALS

GREAT CIRCLE CHART
VLF TRANSMITTER STATIONS
EGLIN AFB, FLORIDA

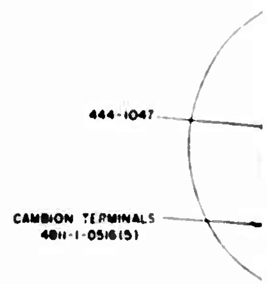
AEROSPACE RESEARCH INC
BOSTON, MASS.

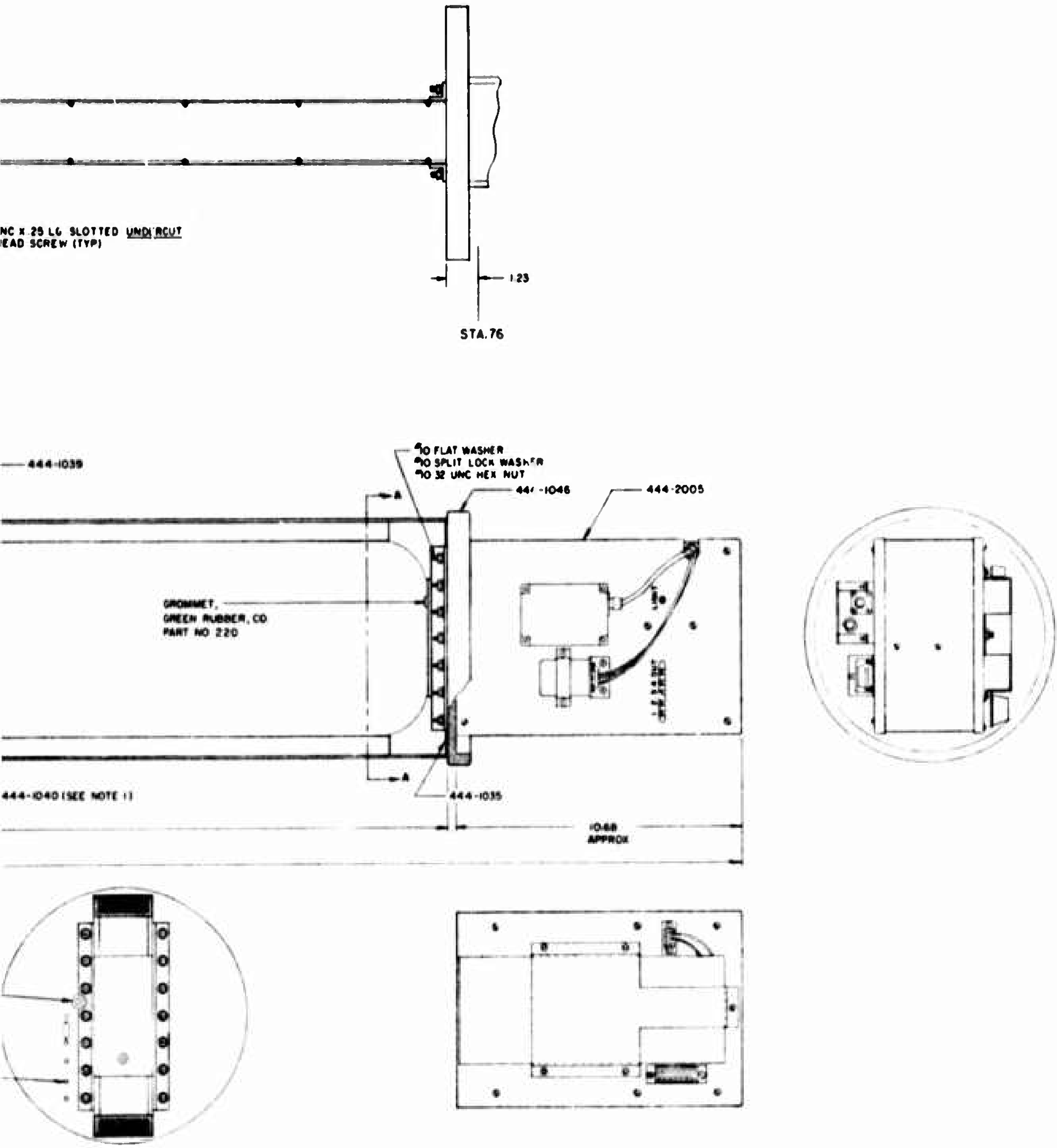
C 444-5001





NOTES:
1. AFTER ASSEMBLING SIDE PLATES (444-1040) TO ANTENNA WELDMENT (444-1039), FILE CHAMFERED EDGES ON SIDE PLATES TO INSURE EDGES OF MOUNTING SCREWS DO NOT PROTRUDE BEYOND CHAMFER.





SECTION A-A

QTY PER DASH NO	REV	CODE IDENT	PART OR IDENTIFYING NO	ARI PART NO	NOMENCLATURE OR DESCRIPTION	NOTE	ITEM NO

PARTS LIST

KEY: V—VENDOR ITEM—FOR PROCUREMENT OR PART NUMBER SEE SPECIFICATION CONTROL OR SOURCE CONTROL DRAWING. F—FEET I—INCHES B—BULK AR—AS REQUIRED

UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING.

DO NOT SCALE DWG

DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±
DECIMALS
2 PLACE ±
3 PLACE ±

SURFACES
MICRO INCHES

DR | DATE
CHK
APPD
APPD

FINISH

MATERIAL

NEXT ASSEMBLY | MODEL

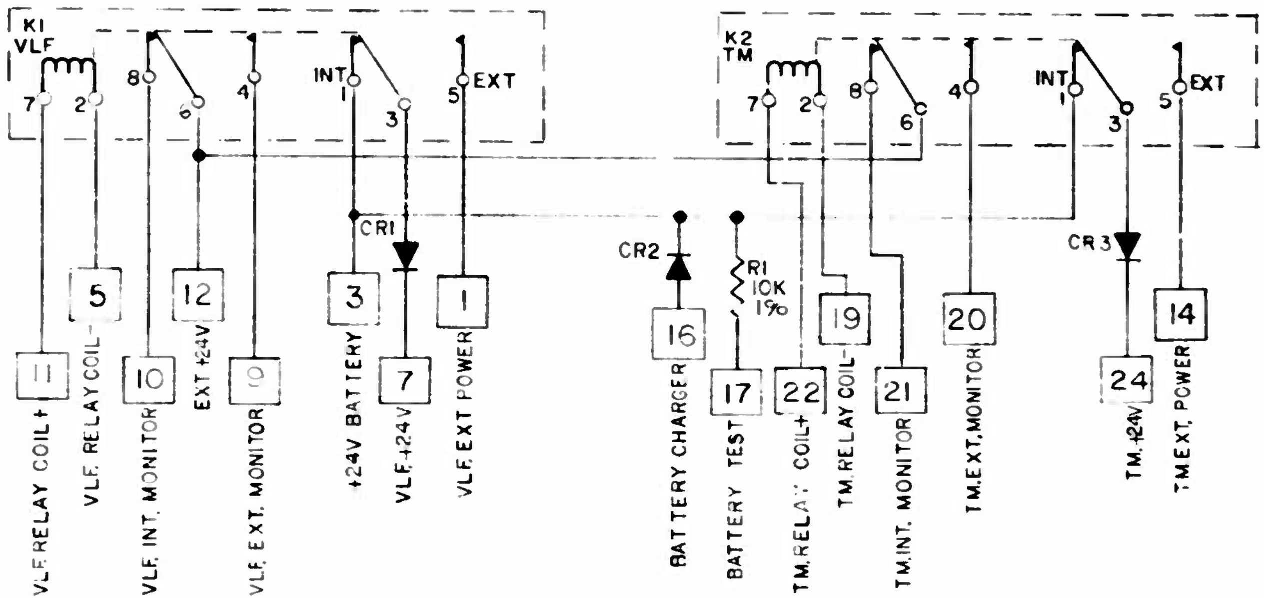
AEROSPACE RESEARCH INC

ANTENNA LOOP & ELECTRONICS PACKAGE ASSEMBLY BLACK BRANT IV-A ROCKET EXPERIMENT

SIZE	CODE IDENT	
E	24432	444-2006

SCALE | SHEET 1 OF 1

73



REQD.	REQD.	ITEM	PART NO.	DESCRIPTION

LIST OF MATERIALS

REMOVE ALL BURRS & BREAK SHARP EDGES
DO NOT SCALE DWG
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACT ±1/64
DEC 2PL
3PL ±.005
ANG

DC CONTROL CARD SCHEMATIC
BB IV A ROCKET EXP.

ARI AEROSPACE RESEARCH INC.
BOSTON, MASS

MODEL NO.
NEXT ASSY
DRAWN
DATE
CHECKED
DATE
ENG APPD
DATE
PROD APPD
DATE

SIZE B
DWG NO. 444-3007
REV —
SCALE ∞
SHEET 1 OF 1

REV | REVISIONS | APP