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BLACK BRANT IV LF/VLF ROCKET PROBE EXPERIMENT

Aerospace Research, Incorporated

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13. ABSTRACT Contract F19628-69-C-0088 was awarded to Aerospace Research to build two rocket payloads for use with the Black Brant IVA rocket. These payloads were to be similar in electrical and mechanical configuration to rocket payloads previously built by Aerospace Research on Contract F19628-69-C-0045. Since data on the transmission of the VLF signals at an equatorial site was desired, the rocket range operated by the Brazilian Air Force at Natal, Brazil, was chosen as the launch site.
Effective 12 November 1969 the basic contract was subsequently extended to modify and refurbish the two rocket payloads to be compatible with the re-designed nose cone; the modified vehicle was designated the Black Brant IVB, Mod. 1. The Churchill Research Range, Ft. Churchill, Manitoba, Canada operated under the sponsorship of the Canadian Research Council was selected as a launch site because of its close proximity to the North Pole. A discussion of the modifications to the VLF payload package will be found in Section 3.0 while Appendix C is an account of the field trip to the Churchill Research Range

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BLACK BRANT IV

LF/VLF ROCKET PROBE

EXPERIMENT

Aerospace Research, Inc.
130 Lincoln Street
Boston (Brighton), Mass. 02135

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TABLE OF CONTENTS

Appendix A - Field Trip to Barreira Do Inferno Range, Natal, Brazil 5 June 1969 - 20 June 1969

Appendix B - Field Trip to Barreira Do Inferno Range, Natal, Brazil 24 August 1969 - 10 September 1969

Appendix C - Field Trip to Churchill Research Range, Churchill, Manitoba, Canada 8 August 1970 - 22 August 1970

Appendix D - Circuit Schematics

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Purpose

Contract F19628-69-C-0088 was awarded to Aerospace Research to build two rocket payloads for use with the Black Brant IVA rocket. These payloads were to be similar in electrical and mechanical configuration to rocket payloads previously built by Aerospace Research on Contract F19628-69-C-0045. Since data on the transmission of the VLF signals at an equatorial site was desired, the rocket range operated by the Brazilian Air Force at Natal, Brazil, was chosen as the launch site.

Effective 12 November 1969 the basic contract was subsequently extended to modify and refurbish the two rocket payloads to be compatible with the redesigned nose cone; the modified vehicle was designated the Black Brant IVB, Mod. 1. The Churchill Research Range, Ft. Churchill, Manitoba, Canada operated under the sponsorship of the Canadian Research Council was selected as a launch site because of its close proximity to the magnetic North Pole. A discussion of the modifications to the VLF payload package will be found in Section 3.0 while Appendix C is an account of the field trip to the Churchill Research Range.

1.2 Design Considerations (Basic Contract)

Because Aerospace Research had not previously fabricated a payload for the Black Brant IV rocket, the Air Force Cambridge Research Laboratories supplied complete mechanical specifications and environmental requirements. Since the payload would probably sit on the launcher in the Brazilian sun for many hours prior to launching, it was especially important that this payload be fully temperature compensated as it would probably be launched with the payload at slightly elevated temperature; the temperature would naturally increase during the flight. The Black Brant IV produces a maximum 37 G's linear acceleration in contrast to the much higher G forces which had been experienced in Exos rockets but it was felt that the payload should be constructed as sturdily as possible to withstand any kind of shock and vibration that the rocket might produce. On previous Exos flights there had been some problem with the AGC in the receivers. This payload was designed to have six fixed gain receivers with a switch to change the gain of the receivers by 20 dB at a given altitude to be specified by the project scientists. Our output was to be compatible with a standard FM transmitter tuned to 234 MHz, and the VLF signals were intended to directly deviate the transmitter.

1.3 Projected Schedule (Basic Contract)

The effective date of the contract was 24 September 1968 and it was desirable to fire the rockets about June because of decreased noise in the Amazon region. The projected schedule called for the following:

a. Mechanical prototype to be completed by 1 January 1969. The electrical prototype had already been completed since it was substantially the same as the payload produced on the previous contract (F19628-69-C-0045).

b. The production of the payloads was to be completed during the month of January with testing of the payloads to be done in the months of February and March. April was to be spent in environmental testing and integration testing of the combined payloads.

c. The payloads were scheduled to be shipped in early May to allow six weeks to transport the equipment to Brazil. The schedule was later substantially modified because of mechanical design changes which will be discussed in Section 2.0.

2.0 PERFORMANCE OF WORK (BASIC CONTRACT)

2.1 Review of Electrical Design

The nature of this system is that it has a receiving antenna shaped to fit inside the nose cone; this is followed by a tuning network. The output of the antenna tuning network is fed into an input amplifier which is a broad band type intended mainly for impedance matching. The output of the broad band amplifier is fed to six receiver cards, each card having approximately 60 to 80 db of gain. The outputs of the receiver cards are fed into an output card which consists of an operational amplifier summing network. Each input to the summer is controlled by an individual gain adjustment pot for fine adjustment and equalization ot the gains at the output stage. There is also an overall gain adjustment pot to adjust the size of the signal that is fed to the FM telemetry transmitter. The output then goes directly to the FM telemetry transmitter.

In the original design the antenna tuning network had been a complicated network consisting of six inductors and six tuned tank circuits. The object of this complicated tuning network was to produce a tuned circuit which had six peaks. Each of these peaks were to occur at frequencies where the VLF stations were. Previous payloads using broad band tuning techniques had proved to be noisy and it was felt that this multiple tuned type circuit would eliminate some excess extraneous noise. It proved impossible however to manufacture inductors with the necessary high Q's at this low frequency. Using the best inductors available, it was found that there was actually a loss of signal in the tuning network and we, therefore, decided to revert to our broad-band tuning.

To compensate for this, we would attempt to make the receiver cards with as narrow a band width as possible. Our objective was to have the bandwidth less than 100 Hz. In actuality some cards had a bandwidth of 60 Hz. The receiver gain switch (in order that the receiver cards could increase their gain by 20 db on an altitude of about fifty thousand feet) had not been in the original payload although the receiver card had the electrical requirements necessary to do this. It was, therefore, necessary to build a timer circuit in order to accomplish the timing and switching function. A flip-flop type circuit fed by two unijunction oscillators was designed. Each of the unijunction oscillators had a long time constant with adjustable resistors so that the time could be changed. It was found by a projected trajectory that the switch would be accomplished at about 36 seconds into the flight. It proved to be no problem for the unijunction oscillators and this portion of the circuitry was finalized.

It was originally thought that the output might be going into a subcarrier oscillator before going in an FM transmitter. The subcarrier oscillator would have required a 0 to 5 volt RF signal. Deviating the transmitter directly required a much smaller signal. Since AFCRL installed a buffer amplifier between our signal and the input of the transmitter, only about a half volt to one volt was necessary. We, therefore, changed our output slightly by adding the series resistor and changing the value of the gain control so that we could vary our gain within the specified limits necessary for proper deviation of the transmitter.

2.2 Review of Mechanical Design

The original intention was to use the payload in the same mechanical configuration as the design under the prior contract. At this time we had been told that the payload would fit into a nine and one-half inch diameter circle and be covered with a skin section to bring the rocket to its 10-1/8 inch outside diameter. This nine and one-half inch diameter was confirmed by Government prints which were supplied to ARI for design and fabrication use. Approximately six weeks later after both payloads had already been fabricated, it was discovered that there had been an error in the original drawing. The Government had intended that ARI use an 8-1/2 inch diameter payload rather than a 9-1/2 inch diameter payload. In the original 9-1/2 inch payload, the electronics housing had been designed so that the input card was at one end of the box, the six receivers were in the middle, and the output was at the opposite end. All cards were easily accessible and could be removed by sliding them out of their cavities after desoldering the connections.

Since all printed circuit cards had been fabricated and mostly tested by the time this oversight was discovered, it was felt that some attempt should be made to modify their present configuration to the new chassis even though some mechanical inconvenience was involved. It was subsequently determined during the tests and the firing of the rockets that it might have been more practical at that point to discard some of the cards and start over with a new mechanical design. However, we did keep the cards we had assembled and tried to fit them into the 8-1/2 inch box.

This caused two problems in terms of tests. First, it was necessary to have two decks of cards; the lower deck contained the receiver cards while the upper deck contained the input cards, the timer section and the output card. In order to get in and change the gains of the receivers (which was necessarily performed at the launch site) the upper deck had to be removed which meant considerable disconnecting of wires and removal of cards. The second major drawback was that the input card and the output card were now very close to each other. While as much shielding as possible, both electrostatic and magnetic, was used, we still had serious problems with the input and output feeding into each other and causing oscillations.

It was felt however that these oscillation problems could be solved by adequate shielding of wires and judicious placement of the wires and connecting cables. The antenna design was similar to what we had expected from the previous payload. The final mechanical drawing of the payload showed the antenna to have an overall height of 42 inches of which 21 inches was straight rectangular sections and the remaining 21 inches were slanted at an angle of 5-1/2° in order to fit into the angle of the nose cone. The antenna was constructed of extruded aluminum panel welded at the corners so that no weld would build up inside. The entire assembly was potted with RTV so the wires would not shake or move around. The extrusion was then covered with metal plates, fastened with screws every four inches. The output from the antenna came through a hole in the bottom with a rubber grommet in the panel. The two leads were fastened to connectors on the base plate of the antenna where it was tuned in the broad-band configuration.

2.3 Building of the Subassemblies

All mechanical and electrical parts used in this payload were constructed at Aerospace Research. The mechanical parts were fabricated in our machine shop and consisted of the chassis housing, both the old and new style, and the antenna. The base plates used to mount to the skin of the rocket, and the skin of the rocket were provided by AFCRL. All of the printed circuit cards were fabricated in our printed circuit laboratory. The fabrication of the mechanical and electrical parts of the assembly took approximately one month and were completed on schedule. As soon as all parts had been manufactured and assembled, the payload was considered ready for test.

2.4 Test (VLF Payload)

Before any testing could begin, it was necessary that all receiver and other cards be ready and tuned. The input cards required no tuning and were functionally tested to ensure that their amplifiers were working properly. The output cards also required no tuning or calibration at this point. They were checked to confirm that they amplified and mixed properly. Each of the receiver cards contained three tuned circuits which had to be tuned so that the narrowest possible bandwidth was obtained. The inductors used were a high Q toroid especially manufactured to ARI specifications for this program. To assure that the cards would be temperature stable, they were tuned with a combination of polystyrene and mica capacitors. The polystyrene capacitors have a negative temperature coefficient and it was anticipated that this would offset the positive coefficient of the inductors. It was found that by using 80% polystyrene and 20% mica we were able to exactly offset the temperature drift of the inductors. Each of the cards was tuned and on the average they were found to have a Q on the order of two to three hundred which was within design considerations.

When all cards had been tuned, it was decided to make a preliminary gain adjustment. Since AFCRL staff members had departed on a preliminary field trip to the launch site to determine what type of signals and signal strength would be received, actual data on the approximate field strengths of the stations to be received was available. We, therefore, calculated necessary gains and made preliminary adjustments to the receiver cards so that final gain adjustment in the field would not be a drastic change from that used during test. After preliminary gain adjustment, the cards were temperature cycled over the 0 to 70° C range. The purpose of this test was to confirm that all cards still operated properly over this temperature range and also to determine the shift in the center frequency of the tuned circuitry. It was found that most of the cards had a temperature shift of less than 10 Hz over the range and we were most pleased with these results.

Because the payload would be subjected to severe mechanical stress it was felt that the package should be tested for shock and vibration, testing was conducted at the AFCRL environmental test facilities. The payload was run through a vibration test of 20 to 20,000 Hz at a 5 G level. It was also run through a random noise test for five minutes at a 5 G lev 1 using an artificial signal as it is not possible to receive any VLF stations inside the environmental test laboratory. The payload was not given a formal shock test since information indicated that the lift-off shock would only be in the order of 5 G's. We had previously shocked the payload more severely during preliminary tests and felt that it could easily stand the 5 G shock.

The payload was then set up in a wooded area behind AFCRL to completely electrically test as a system. Since Aerospace Research is located in the heart of the urban area, it is extremely "noisy" at VLF frequencies. It is very difficult to receive any signals there except the very strongest (NAA). We had previously received NAA within the plant with our payload but it was felt that further tests should be conducted in an electrically quiet area. The wooded area behind AFCRL was found to be very quiet electrically and was selected for further electrical testing. Using our payload to receive signals and a BRR3 receiver as a comparison, we found that we were able to receive signals at AFCRL that were not or had not ever been received with the standard commercially available VLF receivers. The stations NAA Cutler, Maine; NSS Annapolis, Maryland; NBA Canal Zone; and GBR England were received each day and it was felt that the package was ready to receive the same signals in Brazil since the signal levels from some of these stations would be higher. It was hoped that even in Brazil we might possibly be able to receive the station from North West Cape, Australia.

Because of the delay in receiving the mechanical parts from AFCRL, i.e. the nose cone did not arrive until the last week of April and because of slippage as a result of mechanical rework and changes previously mentioned, only about two weeks was available to perform integration testing of the entire payload. In order to begin, the package had to be completely assembled. Two days were spent modifying the mechanical parts of the payload to change the dimensions of the mounting flanges of the antenna, and to change the method of mounting the upper antenna support designed to keep the antenna from vibrating inside the nose cone. When this was accomplished payload final assembly was completed.

The payload was again set up in the wooded area at AFCRL approximately a quarter of a mile from the receiving site set up in the telemetry station in the main building at AFCRL. The plan was to receive the real signals, feed them to the telemetry, see if the telemetry signal could be received and then see if we could recover our signal back at the telemetry station receiving site. This was considered an operational functional test which was adequate in view of the short time remaining before scheduled launch. We found that we were able to receive and recover our signals at the telemetry, although there were still some difficulties adjusting the level of signal so that the transmitter was not over-deviated. It was found that in the high gain mode, which would not occur in the flight until the signals were much lower, we over-deviated the transmitter to the point where the signals from the environmental sensors were lost.

There was some question whether the S-band beacon used to track the payload by radar during the flight would interfere with our signals as had occurred on other flights. The assembled payload was taken to a screen room so that no outside interference would cause problems to check the beacon and received signals. It was found that the beacon would not cause any harmful interference. Therefore, the telemetry group removed the timer switch which had been installed in the payload. The switch had been designed to shut off the beacon shortly after launch so that it would not interfere with our payload. Since there was no interference, it was felt that the beacon could stay on the entire flight. The magnatometer contains a square-wave generator. It was felt that possibly one of harmonics from the square-wave generator could cause payload interference. This was checked by moving a magnet around the outside of the payload to activate the magnatometer and see if it would cause any interference with our signals. It did not and it was felt that there would be no interference problems between the telemetry payload and the VLF payload.

At this point we proceeded with the mechanical environmental tests of the payload. Because of the delay in delivery of the hardware a test fixture had not been completed which would mount the payload directly to the shaker table. A temporary arrangement was provided by AFCRL which enabled us to complete the tests. The payloads received the same shock and vibration tests previously performed on the VLF payload itself. There appeared to be no change in signal as received by the telemetry station and it was felt that the payload was ready.

The next few days were spent packing the payloads, and the necessary support and test equipment which would be used at the field site. Since it was likely the equipment would be exposed to high humidity, all parts were carefully wrapped and sealed so that no damage would be done to the payload prior to the later arrival of the launch party on site. The payloads and all support equipment were shipped from AFCRL the first week in May. The month before the field trip was spent arranging passports and other necessary details so that everything would be in order for the trip. All clearances and shots were obtained and all necessary paperwork was accomplished.

3.0 MODIFIED PAYLOAD - BLACK BRANT IVB

3.1 Design Considerations

The modification to the Black Brant IVB vehicle consisted of the addition of fins to the second stage of the rocket. The resulting extension in overall rocket length allowed the use of a longer VLF receiving antenna. Since the received signal strength is proportional to the area of the antenna, the increased area would allow reception of a weaker signals. The change in rocket thrust was not expected to be significant so no mechanical redesign of the payload was required.

Although the rocket launchers at the Churchill Research Range were equipped with protective shells to maintain payload temperature during prelaunch checkout, it was necessary to completely temperature compensate the payload in view of temperature extremes which would be encountered during flight. As calculated during prior flights, it was expected that the payload would be subjected to a maximum of 37 G linear acceleration and approximately 5 G vibration.

3.2 Program Schedule

The projected launch date was established for the latter part of June 1970. In order to alleviate any potential problems with interface and integration testing, it was decided to accelerate the schedule as follows:

a. Mechanical and electrical prototype to be completed by mid-December 1969.

b. Payload production to begin in early January 1970 and be completed no later than the end of March.

c. Environmental and integration testing of combined payloads to be conducted during April and May.

d. Shipment of payloads and support equipment to be accomplished on or about 1 June, allowing two weeks transit time to the Churchill Research Range.

3.3 Review of Electrical Design

3.3.1 Antenna and Input Card Assembly (Dwg. No. 334-3006)

Since it was decided to make the receiving antenna a balanced loop, the input transformer on the input card was substituted for one with a center tapped primary. The antenna was changed to a new inductance of 6.7 mH in order that the impedance match between the antenna and the input circuit would remain the same. No further changes were required in the input card circuitry.

3.3.2 Receiver Card Assembly (Dwg. No. 334-3007)

The original design of the receiver card called for three gain stages; the first and third stages were relatively wideband while the second stage, a high Q stage, provided most of the gain and was actually where the bandwidth of the receiver was determined. In this configuration, it was difficult to tune the card because the majority of the gain was in one stage. There was also the possibility that more overall gain in the narrow band condition would be required as the result of having to broadband the card to receive FSK signals since there were no stations transmitting regularly scheduled CW broadcasts.

It was decided to divide the gain equally among the three stages by making the inductors - L1, L2, and L3 - 3 mH coils having a minimum Ω of 250 at 20 kHz. The values of L1, L2 and L3 had been 1 mH, 5 mH, and 1 mH respectively. The change in inductors, combined with the substitution of Q3 and Q7 from normal bi-polar to field effect transistors (FET), resulted in the possibility of approximately 40 dB gain per stage, and a maximum of 120 dB gain in the very narrow band position. The bandwidth of the modified card was found to be about 50 to 60 Hz. Another positive feature of the modified coils is that they are slug tunable, which made it possible to solder a fixed capacitance and to fine tune the inductor rather than resorting to the hit -and-miss placement of small capacitance.

The 20 dB switch was maintained so the gain of the payload would be switched by 20 dB as before. The switching mechanism, Q2, was changed to a FET to allow fewer transients in the switching cycle. It had been noticed that at times during a switch from high to low gain, a transient appeared, making that portion of the data unusable; the use of the new switch corrected the problem and the transient was no longer observed.

3.3.3 Output, Timer, and Clipper Card Assembly (Dwg. No. 334-3008)

Because of space and mechanical considerations, the gain switch, timing control, output mixer, and clipper circuits were combined into a single printed circuit assembly. No interference was experienced, and in fact, the modification seemed to improve the overall performance. The original clipper circuit consisted of a simple zener diode cutoff across the output operational amplifier. Although the circuit worked reasonably well, the output level could not be changed without changing the selected zener diodes. Because of their very low voltage, they were expensive and difficult to obtain.

It was therefore decided to replace the circuit with one which was variable. It was necessary to vary the output level since different telemetry transmitters will deviate differently depending upon the input signal, so that it is convenient to be able to control the output in order that the level of deviation can be changed easily.

The circuitry illustrated in Dwg. No. 334-3008, starting at Pin 6, Z1, and going to Pin 6, Z2, is the clipper circuit. This is basically a diode clipper using the operational amplifier, Z2, to provide a reference controlled by a 2k potentiometer, R22, which determines the maximum level of output signal. An LM201A was chosen as Z2 for its characteristics at this frequency. Since an LM201A had been selected for Z2, it was also decided to utilize an LM201A for Z1 instead of a 709. The LM201A requires only one compensation capacitor, C3, between Pins 1 and 8 instead of four compensation components (two resistors and two capacitors) required to compensate the 709. Therefore, the LM201A was less likely to oscillate and should provide better amplification in the circuit.

3.3.4 Low Pass Filter (Dwg. No. 334-3009)

During discussions concerning the best utilization of the telemetry link which would transmit the VLF signal, some mention was made of the possible adverse effects of harmonics. It was felt that the second and third harmonics would be present in sufficient amplitude to be objectionable. Since at higher frequencies a smaller amplitude would deviate the transmitter in a similar manner to a lower frequency, the harmonics would contribute enough to the deviation to reduce the quality of the signals.

The first harmonic in question was 32 kHz (double 16), only 8 kHz above 24 kHz, the highest frequency of interest. A 6-pole Butterworth filter was designed in order to attenuate this frequency enough to be negligible. The six poles resulted in a rolloff of 36 dB/octave so that the 32 kHz harmonic would be attenuated approximately 8 dB.

The filter, shown in Dwg. No. 334-3009, is of the active type using equal capacitors. The operational amplifiers, Z1, Z2, and Z3 provide the filter with associated resistors and capacitors. Operational amplifier, Z4, is used as a power supply to provide plus, minus, and ground to the other operational amplifiers - this is required since the system must operate from the single 24 V battery. The filter as designed had a gain of approximately 12 dB. Since the circuit was intended to have zero gain in the filter, a voltage divider (R1/R2) was included. Z1, Z2, and Z3 were LM201A, chosen because of operational stability and sufficient gain, while Z4 was an LM207, a good moderately priced general purpose operational amplifier.

Since the interior of the VLF electronics housing had not been originally designed to accommodate the filter assembly, provisions were made for mounting the circuit card in a shielded enclosure and bolting the enclosure to the front door of the housing.

3.4 Review and Modifications of Mechanical Configuration

As previously mentioned, one of the advantages of the Black Brant IVB, Mod. 1 configuration was the opportunity to increase the antenna length through an additional sixteen to eighteen inches of available space. It was also decided that the VLF payload and the housekeeping sections would each have their own telemetry link. This would avoid the situation which had been encountered before where crosstalk between channels caused some distortion of the received signal in the subcarrier channels in the housekeeping payload when the VLF payload switched to the high gain mode. With the inclusion of a second telemetry section, the VLF payload and the housekeeping payload would be separate and distinct entities which could be checked and tested individually.

After calculation of space requirements for the additional telemetry section, it was determined that the VLF receiving antenna could be increased in length by ten inches. The modified antenna would be approximately fifty-two inches long; the new area would be $.267m^2$ versus $.18m^2$ resulting in an increased area of 68% which was significant in view of the strength of the output signal being directly proportional to the area of the receiving antenna.

It had been found in previous payloads that the antenna wires shifted within the antenna structure and caused noise bursts when subjected to vibration. This was corrected by potting the antenna structure after winding with RTV to maintain rigidity. The potting compound also ensured antenna inductance stability since the vibration and loosening of the windings might cause some small inductance change.

Since the VLF payload would now have its own telemetry link, it was important to utilize the link in full measure. It was determined that the advantage of a separate link would be somewhat diminished by the addition of any subcarrier oscillators, therefore the entire telemetry channel would be used for deviation by the VLF signal and there would be no possibility of crosstalk or interference from any other circuitry on the link. Housekeeping data which might be required could be obtained from the housekeeping section directly.

Because the VLF electronic housing had to be redesigned in order to fit into the separate skin section required for the additional telemetry, it was decided that a more efficient system for mounting the printed circuit cards should be devised. As discussed in Section 2.0, the cards were mounted in two decks with the input and output near each other.

Figure 1 is a detailed view of the interior of the VLF electronic housing. The 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 assumed 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 contained the magnetic latching relay used to switch the power in the payload.

The center compartment contained the six VLF 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 did not cross. Since the input and output signals were the same with approximately 100 dB in gain between, some crosstalk and oscillation difficulty had been experienced in previous payloads because the wires were too close to one another.

The lower compartment contained the timer, output, and clipper card; the input was on one side and the output on the other as a precautionary measure even though there was no gain present. The output was fed directly to the telemetry transmitter input in the telemetry section through a coaxial cable running through the side of the housing.

All three compartments in the VLF electronic housing were shielded from one another by metal separators which also served as card supports. The shielding coupled with the wiring changes seemed to have corrected the oscillation problems. The telemetry transmitter was connected to the VLF housing by a shielded cable. The transmitter was mounted on a separate baseplate which acted as a heat sink; the plate was also used to mount the batteries to power the transmitter. Both the electronics housing and the telemetry baseplate were mounted inside the 10-1/8 inch outer skin of the rocket. Power to the VLF electronic housing and the telemetry section was provided through the umbilical cable connector located behind the VLF batteries as shown in Figure 2.

3.5 Fabrication of Subassemblies

Figure 3 is a photograph of the payload showing the nose cone with interior payload instrumentation. All mechanical parts and electronic assemblies used in the payload were either fabricated by Aerospace Research, Inc. or provided to ARI by AFCRL through Northeastern University. Northeastern University supplied the outer skin, antenna baseplate, and telemetry mounting plate in order to maintain continuity in the total mechanical integration of the rocket. All other subassemblies including the antenna, VLF electronic housing, and printed circuit cards were fabricated by Aerospace Research, Inc.

3.6 VLF Payload Testing

Before the payload could be tested as a unit, it was necessary to tune all receiver cards. The tuning procedure went very smoothly since the capacitance values had been predetermined. A combination of 80% polystyrene and 20% mica capacitors were again used; these had been found to compensate for the positive temperature drift of the inductors. The selected capacitors were mounted on the cards and final tuning was accomplished by use of the inductors. This proved to be a simple method which allowed the cards to be tuned within a very short time.

The input and output cards, and clipper and gain switch timer sections were checked for operation. When all cards were functioning properly, they were assembled into a housing and subjected to an operational check. The payload exhibited much improved performance characteristics since signals were received which had not previously been observed and no oscillation was present even though the tests were conducted at maximum gain. Gain settings were adjusted and the payload was set up in the flight configuration for signal strength based upon the signal readings received in Boston.

Tests were continued at AFCRL, L. G. Hanscom Field, which is an area less subject to outside signal interference than the ARI plant location. The payloads continued to perform well in the high gain mode with no apparent oscillations. The telemetry section was attached to the payload, signals were transmitted to a receiving site on the opposite side of the field, and the VLF was demodulated from the received telemetry signal. Since there was no interference within the VLF electronic payload, it was felt that interference testing with the housekeeping payload could be started.

During the course of the integration tests, some minor interference was noted which was apparently caused by one of the magnatometers in the housekeeping section oscillating at a frequency within the receiving spectrum of the VLF. Since there were no stations on this frequency, the problem was not considered significant.

After completion of integration tests, the payloads were ready for environmental testing which was conducted at the AFCRL environmental test laboratory. The tests included drop tests of 40 G and 50 G which approximated the predicted first stage ignition impulse. Also included were vibration tests with a random noise at the 5 G level, and also 3 G and 5 G shake tests of a frequency scan from 20 Hz to 2000 Hz at a rate of 2 octaves/minute. No abnormalities were noted except some small noise transients which were caused by shifting of the windings on the inductor bobbin during the drop test. These disappeared when the short pulse was removed and did not seem to cause any shift or change in frequency or gain.

During May 1970 information was received that delays associated with the maintenance of the rocket launcher at Churchill Research Range would result in a postponement of the scheduled June launch. This was subsequently confirmed and the launch was rescheduled for mid-August. As a result of the delay, the completed payloads were put in storage after environmental testing to await final checkout prior to shipment to the range. The payloads were removed from storage during July and final electrical, mechanical, and environmental tests were conducted to verify operational performance. The payloads functioned properly and were packed and shipped to the Churchill Research Range for the initiation of launch activities. A description of the field trip is included as Appendix C to this report.

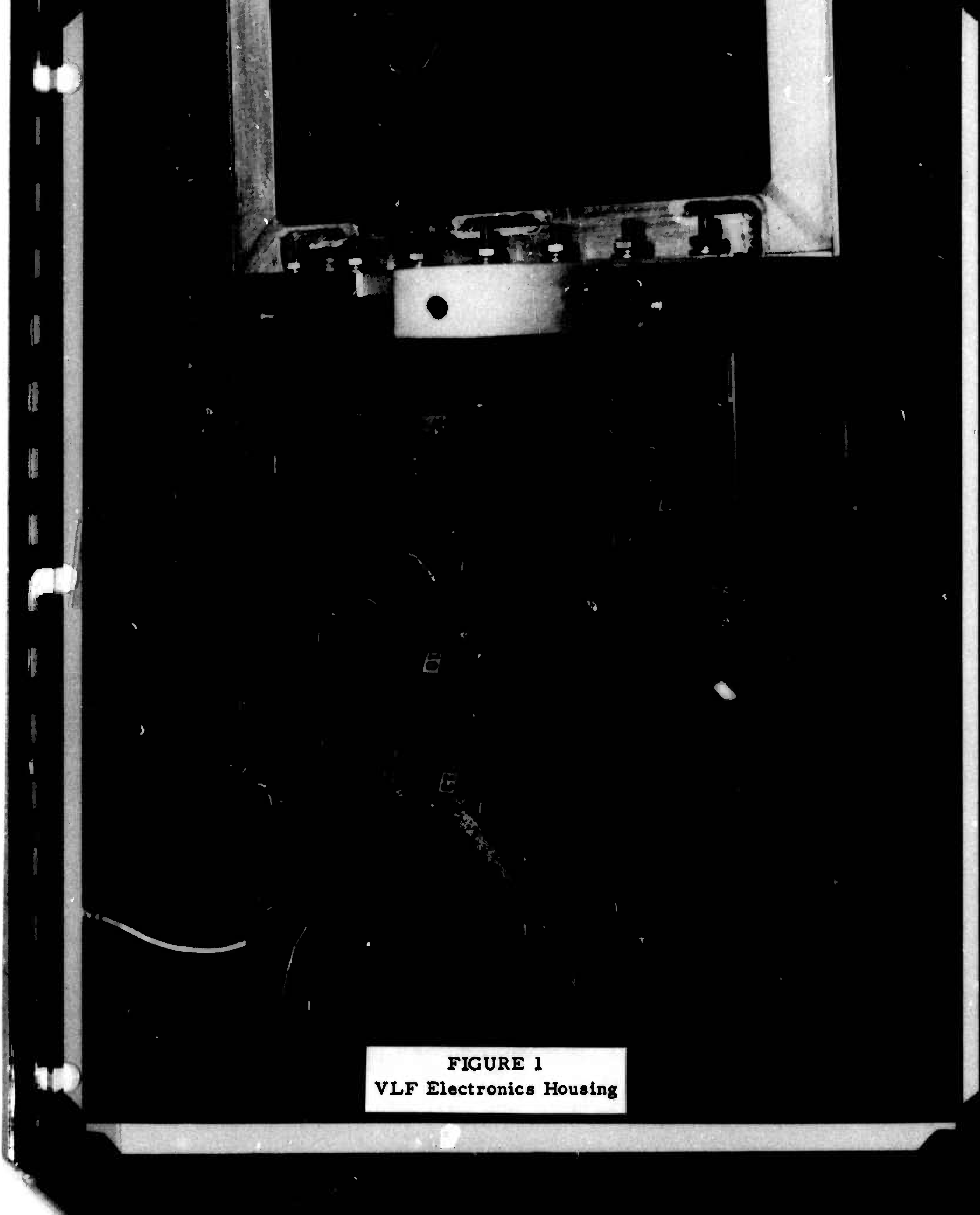


FIGURE 1
VLF Electronics Housing

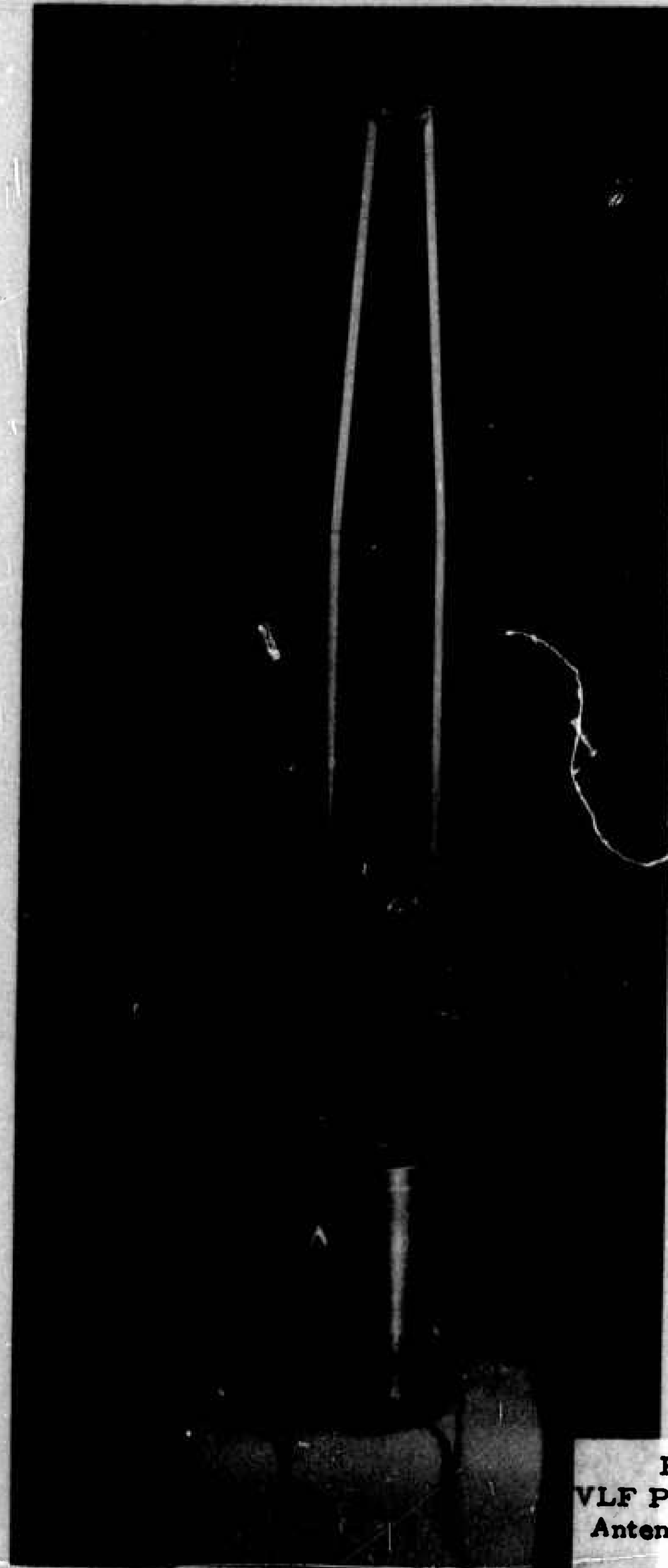


FIGURE 2
VLF Payload and Loop Antenna - Assembled

FIGURE 3
VLF Payload - Nose Cone
and Interior Instrumentation

APPENDIX A

Field Trip to Barreira Do Inferno Range
Natal, Brazil

5 June 1969 to 20 June 1969

1.0 Introduction

In accordance with the requirements of Contract No. F19628-69-C-0088, the field party, comprised of personnel of AFCRL (CRPE) and Aerospace Research, Inc., left Boston on 5 June 1969 to complete preliminary testing and final calibration of Black Brant IV payload to be launched from Natal, Brazil later in June.

2.0 Description of the Barreira Do Inferno Site

The Barreira Do Inferno site is a rocket range operated by the Brazilian Air Force at Natal, Brazil. The site was originally selected because of its proximity to the geomagnetic equator. The range has been in existence for approximately ten years and is very well staffed with capable people willing to do their best to assist user groups in any way they can. The facilities are complete and modern with sufficient work space for two field parties at the same time. A portion of an air-conditioned preparation building was assigned to us for ground base test equipment and workbench facilities for the completion of the calibration of the payloads.

3.0 Description of Pre-launch Activities

The full field party arrived in Natal on 8 June 1969. Since the equipment had been shipped approximately six weeks earlier, we first unpacked all the equipment to check for damage. After all equipment was found to be in working order, we proceeded with calibration and testing. The first order of business was to measure the field strengths of the received signals in Natal. Since it is impossible to accurately estimate the field strengths of the stations during factory checkout, it was necessary to wait until we were on site to make final gain adjustments on the package. In order to do this more precisely, it was necessary to make readings over a period of days to get good average readings. The equipment has fine adjustment controls to allow for slight variations on the day of flight but the average field strength must be known in order to set the gains within the range of the fine adjust.

The calibration of the package and the gain adjustments were completed on Thursday, June 12 and we began horizontal and vertical checkout. A preliminary launch date of Sunday, June 15 for the first package, and Monday, June 16 for the second package was established. For horizontal and vertical checks, the payload was completely assembled in full flight configuration and mounted to the rocket motor. The horizontal checks were conducted with the rocket motor mounted on the launch rail. During the horizontal checks, it was found that when the payload was taken outside the building, there was a great increase in signal level. This rise in signal level later was found to be caused by attenuation of the signal by the preparation building; all testing after that was conducted outside. The vertical check showed some unexplained phenomena which at the time were attributed to the close proximity of the payload to the large iron launch rail. It was assumed that the metal was causing interference with the magnetic pickup of the loop antenna, causing the antenna to lack a null. It was decided that the payload was in "go" condition except for readjusting the gains outside. The payload was then dismantled and the gains readjusted in preparation for the launch on Sunday.

4.0 Description of Launch

On Sunday morning at 5:00 a.m., the countdown was begun for a flight launch time of 11:05 a.m., local time. This time was selected by comparing the maintenance and transmission schedules of all six VLF stations to be received during flight. The countdown proceeded smoothly with no holds and the payload appeared ready, although the same discrepancies noted in the horizontal and vertical checks were again present. The project scientists felt that there were no problems since this was again due to the close proximity of the metal launch rail; the firing was ordered to proceed on schedule. At 11:05 a.m. precisely the vehicle was launched. The flight of the vehicle was slightly less than the predicted value but within acceptable limits. The apogee was about 350 miles which is suitable for this type of experiment and the rocket was considered to have performed well.

5.0 Description of Post-launch Activities

Preliminary investigation of the data received from our package showed that at the instant of liftoff something had caused the signal to disappear. A short time later a signal had come back on the channel, but it was noise and appeared to bear no resemblance whatever to the data that was being received at the ground station which functioned perfectly throughout. About the 38 second mark into the flight, we observed the gain switching taking place in the normal predicted manner. A preliminary look at the subcarriers which contain the mechanical flight data accelerometer, magnatometer, two temperature gauges and the combustion chamber pressure showed that although the data was readable, it was covered with a considerable amount of noise and interference believed to be caused by the VLF receiver overdeviating the transmitter and causing cross-talk in the internal channels. The data, however, was retrievable and it appeared that there were no abnormal mechanical problems with the payload.

The remainder of the day, Sunday, was spent in speculation as to the probable causes of malfunction. We attempted to examine all possibilities which might cause a failure mode such as this based on experience in tests in Boston and Brazil. It was finally concluded by the majority of those present that it was possibly or most probably the random failure of an operational amplifier in the output stage. Although this did not appear to be the complete solution, it was the most reasonable explanation for the failure. It was, therefore, decided that since it was a random failure we should proceed to test the second payload and finalize its calibration so that it could be fired on Monday at 11:05 a.m. Since the primary objective of the experiment was to get data during the daytime, it was decided that rather than launch the second vehicle at night as originally planned, we would again try to obtain the data in a day shot.

During the late evening on Sunday and during Monday, we found that the second payload which should have been identical to the first, was behaving in a rather extraordinary manner. It appeared to oscillate on the high gain channels which was a situation that had never been experienced before with this payload. We tried many combinations of rewiring as best we could with the facilities available. We then discovered that the problem was not something that was internal to the VLF receiver payload, but rather an interface problem between the VLF payload and the telemetry input. We, therefore, decided that the best solution would

would be to isolate our signal from the telemetry. We installed isolating transformers at the output of our signal. This seemed to help a great deal and solved the problem. We then proceeded to remate the package and at this time it again showed signs of oscillation.

By this time the launch date had been changed to Tuesday at 11:05 which allowed another day to modify the payload. We discovered that although the isolation transformer helped a great deal, it did not completely alleviate the problem. Tuesday morning the project scientists decided to cancel the second shot, return all equipment to Boston for complete repairs and checkout, and attempt to return in August before the rainy season to fire the second rocket. The next few days were spent packing all equipment for return to Boston for the repair of the second payload. The full field party left Brazil and returned to Boston on June 20, 1969.

APPENDIX B

Field Trip to Barreira Do Inferno Range
Natal, Brazil

24 August 1969 to 10 September 1969

1.0 Introduction

In accordance with Contract No. F19628-69-C-0088, a field party comprised of personnel from AFCRL (CRPE) and Aerospace Research, Inc. left Boston on 24 August 1969 to complete field tests and final calibration of a payload to be fired from Natal, Brazil early in September, 1969. Because of the difficulties encountered on the first trip, and also because it was necessary to be sure that the atmospheric noise caused by thunderstorms was not at such a high level as to make the received signals unreadable, it was decided that the field party should go in two groups. The first group would leave about one week in advance of the main field party to check both the noise levels and the performance of the packages. The advance field party, consisting of two men from AFCRL and one man from Aerospace Research, was to radio AFCRL via short-wave the status of the packages and the noise and inform the remainder of the field party whether or not they should proceed for the launch.

2.0 Pre-launch Activities

In order to ensure that all equipment would arrive safely, the advance field party carried all equipment and the payload which had been in Boston for testing as excess baggage. It was necessary, however, to get the remainder of the equipment which had been stored in Brazil since June out of storage, unpacked and checked to be sure that it was functioning properly. All equipment was unpacked, checked, and found to be in working order. The first few days the advance field party was there, it rained. We were informed by the Brazilian meteorological staff that this time of year in Brazil was the beginning of the rainy season and that we could expect two or three days of rain followed by a couple of weeks without rain. The rain would gradually increase in intensity until it rained all the time. It was our intention to launch the rocket as soon as possible in order to avoid the rainy season.

By the end of the day, Tuesday, all the equipment was set up and working. Since it was raining, there was a great deal of atmospheric noise. There was some concern that if the rain continued we might not be able to fire because the noise seemed somewhat excessive; the signals, however, were still readable through the noise. There were periods the next day when it did not rain and the noise level seemed to decrease markedly during these dry periods. It was assumed that if it were not a rainy day and there were no local disturbances, conditions would be acceptable for firing.

Both payloads and the ground station seemed to be working perfectly at this point; therefore, it was decided by the advance field party that the full-field party should proceed to Brazil for launch. On Wednesday afternoon, we made radio contact with AFCRL to this effect. During the interval between Wednesday and Sunday when the full field party arrived, the advance party continued to make extensive tests on the payloads and to monitor the daily noise level. After the third day it did not rain and the noise level went way down so that conditions seemed very favorable for a launch.

When the full field party arrived on Monday morning, we began setting the test equipment to the final configuration required for the flight. All equipment was set up so that we could get the maximum amount of data from the equipment. It was decided that a Visicorder would be used to monitor one channel for the whole flight, both with the ground station and the rocket receiver. When all equipment was set up and ready, we took the payload to the iron launch rail to be sure that none of the phenomena observed in June took place again. The payload was set next to the large iron launch rail and rotated to ir· ıre that it still had a null; the null was present and the payload appeared to work perfectly. The iron seemed to have almost no effect on the receiver as it had on the previous field trip.

Everything appeared to be in working order so horizontal and vertical checks for the payload were scheduled on Thursday, September 4. We arranged the horizontal and vertical checks to take place at approximately 11 o'clock since the launch was scheduled for Saturday at 11:10 a.m. We wanted the vertical and horizontal checking to take place at the same time of the day so that we could see what signals were received when atmospheric conditions were at that time of the day. Everything proceeded smoothly in mating for the horizontal check. During the horizontal check we seemed to have an oscillation problem. It was discovered that the oscillation was caused by stray pickup of RF from the beacon transmitter feeding into the umbilical cable lines. This problem was corrected by switching the beacon transmitter to its internal battery power to eliminate stray RF signals. The launcher was elevated to the vertical position and the package checked to see that all signal levels rose as expected. In the horizontal position the plane of the antenna was positioned so that it could not receive very much and in the vertical position it was positioned so that the signal level was nearly maximum on all stations. We observed a signal increase in all channels and therefore considered the package operationally ready without further gain adjustments or calibrations. The launcher was lowered, the package was separated from the rocket, and the payload was left fully assembled. Figure B1 and B2 illustrate the rocket and launcher in the vertical check position and the launch position respectively.

3.0 Launch Activities

The on-station time for all launch personnel was 5:00 a.m. The mating of the payload to the rocket motor and the second stage motor to the booster proceeded so smoothly that there was about an hour of extra countdown. During this period another horizontal and vertical check was made to ensure that the payload was ready. The signal increases were still noted in all channels. Additionally, the absolute field strength measurements were recorded to be used in data reduction. At precisely 11:10 the rocket was launched; all preliminary indications from the mechanical sensors on board the flight indicated that we had had an almost perfect flight, with apogee occurring at just about or a little above the predicted value.

4.0 Post-launch Activities

We continuously monitored one channel during the flight for a constant check of events. On the channel selected all signals seemed to disappear after 36 seconds of flight. At first this caused alarm but then it was realized that this was real factual data at that point in the flight (approximately 25 miles altitude). The nature of the ionosphere was such that the signal was either absorbed or reflected. Upon sweeping the bands, it was found that all signals had disappeared. It wasn't until later when we reduced all the data we could that we found that although no signals were present, they had faded out slowly one after another at regular intervals which indicated that there was no possibility of instrument failure.

After informing all parties concerned at AFCRL and Aerospace Research of the successful launch, the equipment was packed for return shipment. All personnel left the field site and arrived in Boston on Wednesday, September 10.

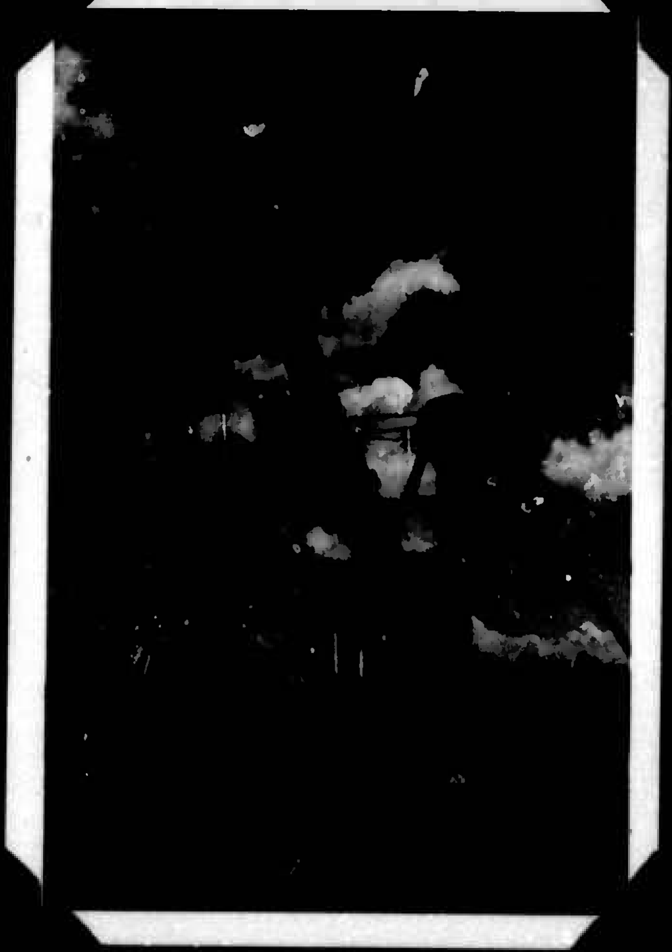


FIGURE B1
Rocket Launcher, Natal, Brazil
Vertical Check Position

FIGURE B2
Rocket Launcher, Natal, Brazil
Launch Position

APPENDIX C

Field Trip to Churchill Research Range

Churchill, Manitoba, Canada

8 August 1970 to 22 August 1970

1.0 Introduction

In accordance with the requirements of Contract F19628-69-C-0088, a field party comprised of personnel from AFCRL (CRPE) and Aerospace Research, Inc. left Boston 8 August 1970 to complete preliminary testing and final calibration of the Black Brant IVB, Mod. 1 payload to be launched from Churchill Research Range, Churchill, Manitoba, Canada on 18 and 19 August 1970.

2.0 Site Description

The Churchill Research Range is located in northern Manitoba in the town of Churchill. A housing facility known as Fort Churchill provides lodging for the range users. The launch facility, approximately eleven miles south of Fort Churchill, is situated on the shores of Hudson Bay so that projectiles fired from the range will fall harmlessly into the water. The surrounding area (Figure C1) is typically Arctic terrain, consisting mostly of scrub grass and a few small trees. The launch site was originally chosen because of its close proximity to the magnetic pole, and also because the frequency of intense Aurora Borealis at this latitude, approximately 58° north. The range itself is under the sponsorship of the Canadian National Research Council; Pan American World Airways acts as a subcontractor by providing personnel to operate the range. The range has all the latest and most complete facilities for launching sounding rockets, its primary mission. The preparation area consis[illegible] of one large building (Figure C2); permission was granted for access to anc[illegible] age of range support equipment necessary to perform launch preparation. All range personnel were very cooperative and helpful, and no difficulties were experienced as a result of shortage or lack of facilities.

3.0 Pre-Launch Activities

The field party arrived at Fort Churchill late in the day, 9 August 1970. No attempt was made to begin work until Monday morning, 10 August. As with previous payloads, it was impossible to calibrate the payloads and adjust gains for the field strengths to be experienced prior to arrival at the launch site. It was therefore necessary to immediately unpack all receiver equipment and payloads to begin a series of field strength measurements in order to determine what gain settings would be required for the flights. All equipment crates were unpacked and all equipment was found to be fully functional. The remainder of the day was spent in erecting outside antennas, beginning field strength measurements, and some assembly of the payloads.

On 11 August, a pre-flight conference was held where Mr. T. W. McGrath, general superintendant of the range, and Mr. D. Burrows, test conductor, were introduced. The minutes of the pre-flight conference, and Test Directive TD7004 are included at the end of Appendix C for information.

During the next three days all personnel were busy preparing the payloads for launch. After monitoring the VLF's signals for field strength for a period of several days, preliminary gain settings were made which were within the range of the outside adjustable gain setting equipment. To this point no problems had been experienced with the payloads. They had required only routine mechanical "nut-and-bolt" tightening, and there had been a minimum of electrical component failures; it was felt that the payloads would perform well.

Friday, [illegible] August, attempts were made to perform both vertical and horizontal instrumentation checks for both payloads. Figure C3 illustrates the test equipment setup inside the blockhouse. It was immediately apparent that since the actual launch rail was housed within a metal building, the h--- -ontal instrumentation check would yield very little since all of the signals would be shielded by the building. It was found, however, that interference checks could be made. During the first horizontal check it was determined that interference was being received from one of the magnatometers on board the housekeeping payload. Since the interference would not fall within one of the normally received channels, the problem did not appear to be significant. The rocket was then elevated to the vertical position (Figure C4). In the vertical position it was found that some additional interference was encountered from the housekeeping payload. All of these problems were found to be curable by removing the umbilical cables or setting the payloads to internal power. This indicated that the interference was random RF pickup on the umbilical cables, and therefore vertical checks would have to be performed on internal power.

Because of the time consumed in isolating the interference problems, horizontal and vertical checks were performed on only one payload on Friday, 14 August. It was decided to attempt the second payload horizontal and vertical checks on 17 August, leaving the completely checked payload on the launch rail in preparation for firing Tuesday, 18 August. Some additional signal strength monitoring and final gain adjustments to the package were performed over the weekend.

Since the first launch was due to take place at 1000, it was felt that it would be advantageous to conduct horizontal and vertical checks on that payload in the same time period. Accordingly Monday, 17 August, the designated "day" payload was elevated, and horizontal and vertical checks were conducted. At this time no problems were apparent and the payload was considered ready for flight. The "night" payload was then mounted and checked. It was found to be working well and was likewise declared ready for launch.

On Tuesday morning, 18 August all scientific and technical personnel were on station at 0800 in preparation for launch. It was learned that the meterorological report was not favorable for a launch that day; winds in excess of 50 knots were predicted, well above the wind tolerance for this vehicle. The countdown proceeded smoothly and at 1000 the VLF station came on in the special mode as previously arranged with the U.S. Navy with the signals being received in acceptable fashion. The launch was still in a "hold" status because of high winds. At 1015 it was determined that it no longer mattered if launch was accomplished during the window since the special VLF signals would not be available beyond the pre-established thirty minute period. A further meteorological forecast called for the winds to remain at the high level for as long as another twenty-four hours. It was decided to cancel the flight for the day, remove the day payload, and mount the night payload for a launch Wednesday evening, 19 August.

In order to make certain that all equipment was operating properly, a final vertical check was performed on the night payload Tuesday night, and operation was found to be satisfactory. By Wednesday night, 19 August, the winds were still high and it appeared as though launch could not be attempted. However, a simulated countdown was conducted with the exception of elevating the launcher since the winds were so high that the Range Safety Officer would not allow the launcher doors to be opened or the launcher to be elevated. Because there was a possibility of damaging the payloads with constant changing from the day to the night configuration and the meteorological forecast for Thursday morning, 20 August, did not show any signs of improvement, it was therefore decided to leave the night payload in place and attempt a launch Thursday night.

4.0 Description of Launch

On Thursday evening, 20 August, all personnel were on station at 1800 in preparation for scheduled launch at 2000. Since there were no longer any stations scheduled to shift to the special mode, no launch window was available. It was felt, however, because of problems arising when the terminator passes between the receiving and the transmitting sites that 2000, originally selected as the time for the special transmissions, would still be used as launch time. No problems with the payload other than those of interference through the umbilicals were experienced during preliminary testing and final horizontal and vertical testing. Approximately 2005, after a hold of some fifteen minutes to determine if there was a possibility of wind shift, the rocket was launched.

The first few seconds of the flight appeared to be normal as the rocket left the pad. Just prior to second stage ignition some increased vibrations were seen in the vibration accelerometers mounted in the housekeeping section. When the second stage fired, radar reported tracking multiple targets. At this time the project scientist noted a very high spin rate indicated by the number of nulls in the data which he was receiving. Reports were received from radar that the vehicle had achieved apogee after only a few minutes although it had been anticipated that apogee would be reached at slightly over seven minutes. At five minutes and two seconds after launch, impact occurred. The rocket reached final apogee of 58.24 kilometers and landed downrange about fifteen kilometers. The anticipated apogee had been predicted at 637 kilometers, therefore, the rocket had reached less than 10% of its predicted apogee.

5.0 Post-Launch Activities

Since this was the first launch of a Black Brant IVB, Mod. 1 vehicle and the modifications had been the addition of fins to the second stage, it seemed probable that perhaps the failure mode was related to the modification. During the next few hours, the mechanical engineers on site examined all available data from the payload including spin rates from internal magnatometers, those derived from the received VLF signals, the data from all mechanical sensors on board the vehicle, and all radar and telemetry data which had been gathered. It was determined that an on-site explanation and statement as to the failure mode was not possible without further in-depth analysis and study of the available information. Therefore it was decided to forward the data and the 16 mm film showing the radar screen during flight to Bristol Aerospace in Winnipeg for processing and further study. As the result of the rocket failure, Capt. V. Fields, USAF, AFCRL, acting project scientist, with the concurrence of Mr. C. Howard, AFCRL, mission controller, decided to cancel the second flight. Their feeling was that the rocket had definitely failed because of aerodynamic instability which was probably caused by the modification to the second stage. It seemed unwise to risk the second rocket which utilized the same design.

It should be noted that examination of the VFL data indicated that, although the flight was abbreviated and the payload had been subjected to extreme stress, the VLF instrumentation was fully operational and had performed well under severe environmental conditions.

All equipment was dismantled and packed for return shipment to Boston but only those items which would be required for immediate use were carried as excess baggage. The balance of the equipment was left in the custody of the Research Range until a determination could be made concerning a launch of the second rocket. The field party subsequently left Fort Churchill on Friday, 21 August, and arrived in Boston on Saturday, 22 August.

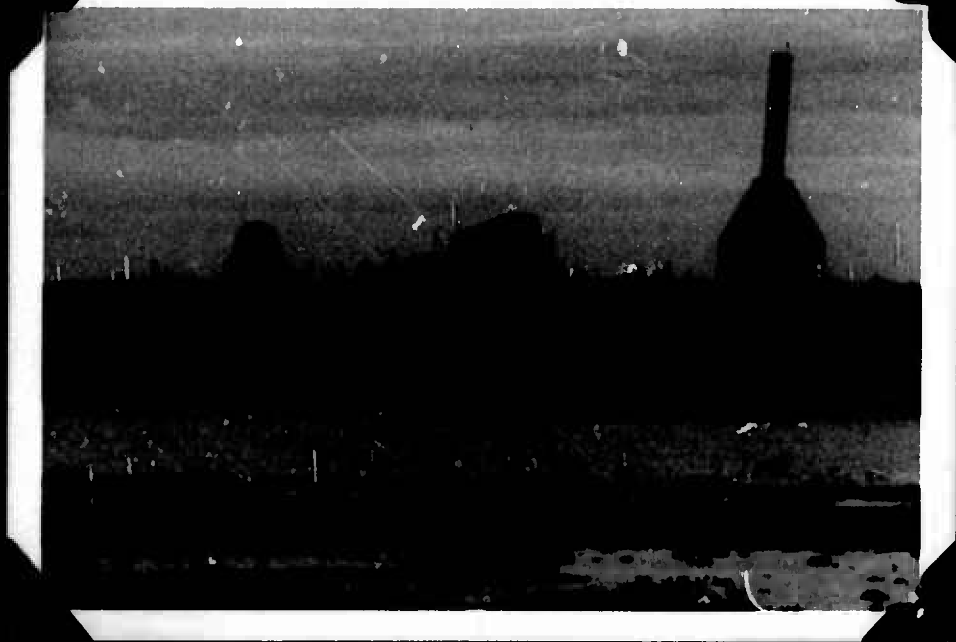


FIGURE C1
Launch Facility, Churchill
Research Range, Canada

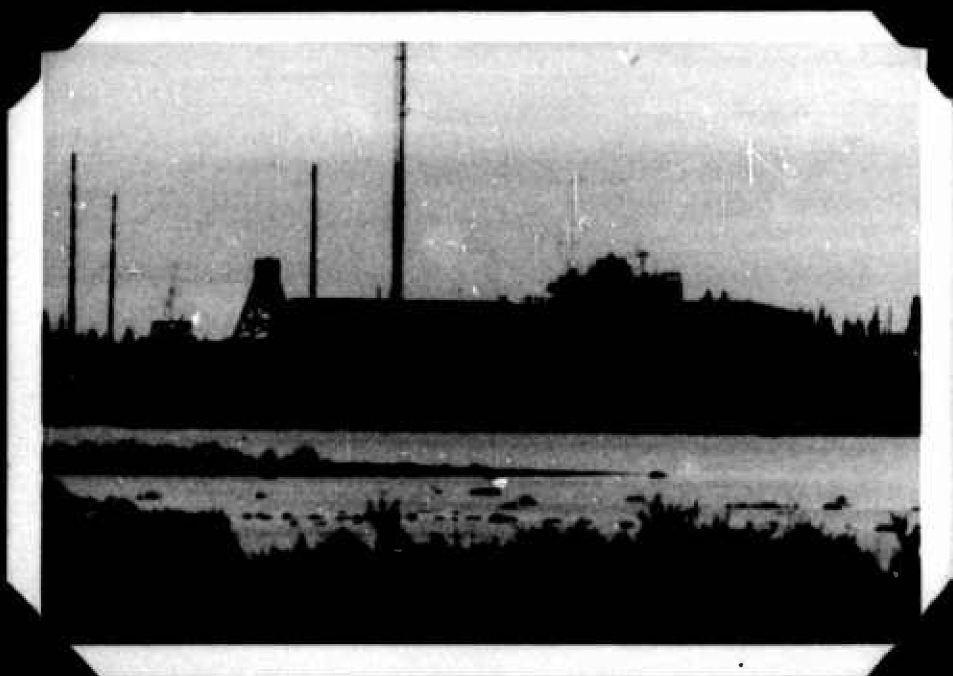


FIGURE C2
Launch Preparation Building,
Churchill Research Range, Canada

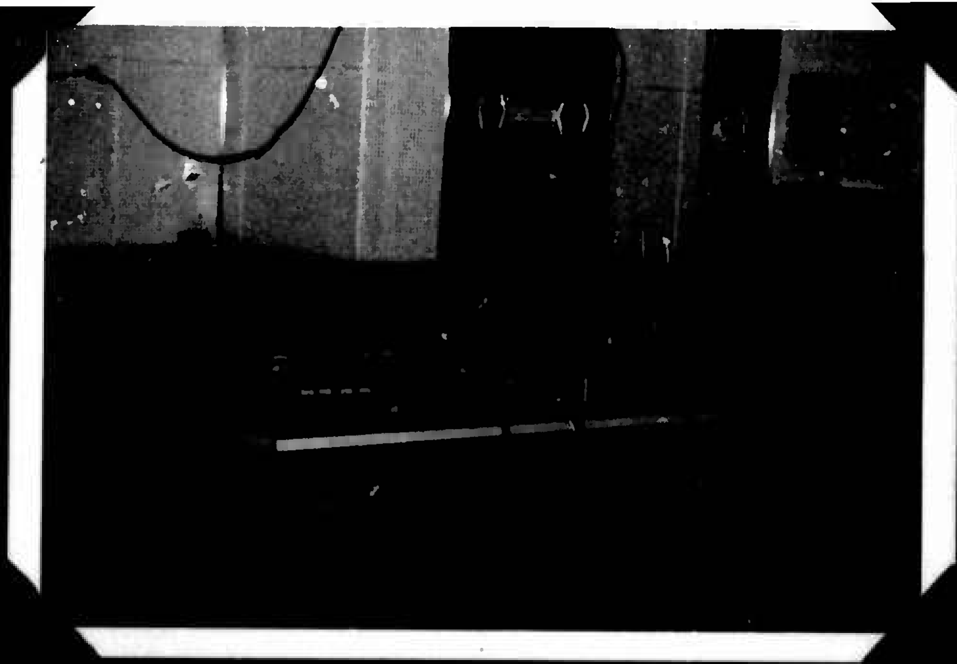


FIGURE C3
Blockhouse Test Setup, Churchill Research Range, Canada

FIGURE C4
Rocket Launcher, Churchill Res. Range, Canada - Vertical Check Position

PRE-FLIGHT CONFERENCE ON TD 7004

1. GENERAL

1.1 A Pre-Flight conference on TD 7004 was held at 1600 hours, 11 August 1970.

PRESENT WERE:

NRC

T. W. McGrath	General Superintendent

PAN AM

R. A. Pollock	Project Manager
D. Burrows	Test Conductor

USERS

R. Harrison (AFCRL)	Asst. Project Scientist
Capt. V. Fields, Jr. (AFCRL)	Asst. Project Scientist
C.D. Howard (AFCRL)	Mission Controller & Project Engineer
T/Sgt. R. Reed, Jr. (AFCRL)	Payload Instrumentation
W. Miller (Aerospace Res. Ltd.)	Payload Engineer
F. Dalton (Aerospace Res. Ltd.)	Payload Engineer
P. R. Parks (Oklahoma S.U.)	Telemetry Engineer
R. Healy (North Eastern Univ.)	Payload Integration
D. Juzkiw (Bristol Aerospace Ltd.)	Vehicle Engineer

1.2 Mr. McGrath welcomed the Users to the Range.

\+ 2. DISCUSSION OF THE OPERATIONAL REQUIREMENT

2.1 Mr. Howard explained that the rockets were being launched in conjunction with the U.S. Navy. The U.S.N. will begin a radio transmission on 18 July for two thirty-minute periods from 1500 to 1530Z and from 1700 to 1730Z. The only launch limitations being safety as soon as reception of the Navy's signal occurs, the rocket will be launched. Should the 1500Z signal not be received, the launch will occur on the 1700Z signal. The second rocket will be launched at 0100Z, 20 July, if the first is launched 18 July 1970. An alternative window for the second rocket will be 0300Z, 20 July. Should the first rocket not be launched on 18 July, it will be slipped to the windows of the second rocket. In this event, the second rocket will be launched by day at a time to be agreed.

\+ NOTE: All dates in Section 2. should read "August" vs. "July".

2.2 Horizontal and vertical payload checkouts; it was agreed would take place on 14 July 1970 (including beacon checks). It was also agreed that checks prior to that would require Range support for beacon checks only.

2.3 Mr. Burrows drew the attention of the meeting to Para. 2.5 of the T.D. It was explained to the Users that additional telemetry tapes would require tape replacement. Mr. Howard explained that he required two of each tape to take away. It was agreed that material replacement could and would take place after the fact and that A.F.C.R.L. would accept responsibility for ensuring it took place.

2.4 It was confirmed that the Range could not undertake data reduction or photographic support. Polaroid cameras will be made available to the User party. In reply to a direct question from Mr. Howard, Mr. McGrath stated that a data reduction system being worked out by N.R.C. should be ready late this year and can be used by A.F.C.R.L. in the future on a cost recoverable basis.

2.5 Mr. Howard stated that he was concerned that the DMER Partial Reflection Station might be on a frequency in conflict with the rocket experiments. He undertook to discuss this with the DMER technician, Mr. Erickson.

2.6 Mr. McGrath agreed to arrange a meeting with the D.O.T. Manager of the Ionosphere Station in order that the Ionogram requirement can be arranged.

2.7 It was accepted that Mr. Howard would act as Mission Controller and it was agreed that T/Sgt. Reed (Payload Instrumentation) would meet with the Range Telemetry Supervisor to discuss telemetry needs.

3. SAFETY

3.1 The Chairman explained that under the new Range concept, N.R.C. remains responsible for safety, but delegates implementation to the Contractor. Thus, general clearance to take visitors to the Range can be obtained from the General Superintendent, but during count-down, clearance to the Operations building from Check Point "C" must be obtained from the Test Conductor and that movement from the Operations building forward of Check Point "A" must be specifically approved by the Test Conductor. Under no circumstances can visitors be taken into the rocket preparation areas or launch bays.

3.2 Contractor direction on matters of safety must be accepted at the time, although, the matter may be appealed to the Chief of Operations subsequently.

Thomas W. McGrath

T. W. McGrath
General Superintendent

CHURCHILL RESEARCH RANGE

TEST DIRECTIVE
TD 7004

BLACK BRANT IV B

VEHICLE NUMBERS
A16-010-3
-4

VLF PROPOGATION

(AFCRL/HARVEY)

PREPARED: 27 July 1970

for PAN AM/CRR ELECTRONICS SUPPORT SUPT.

APPROVAL:

CHIEF OF OPERATIONS NRC/CRR

PROGRAM DIRECTIVE INDEX

- o0o -

PART II --- CRR RESPONSE TO THE OR

1.0 USER INFORMATION

Part II of the Program Directive provides general information to the Range User and constitutes a commitment of Range support to meet all requirements of the OR except those noted in Section 2.0 below.

1.1 Operations Command

Overall responsibility for rocket launches, acquiring data during the flight, processing of data and ensuring that safe operating conditions exist at all times is assigned to the General Superintendent, Churchill Research Range.

The NRC Chief of Operations is responsible for safety practices associated with any rocket launch. He may delegate a Launch Safety Officer (LSO) to act on his behalf. He is responsible for scheduling of all tests at the CRR.

At the Preflight Meeting, the Range User's senior representative will appoint a Mission Controller (MC) from his group. The MC will then act as the Range User's single point of contact for all activities during the countdown.

The Range's corresponding single point of contact is the Range Test Condcutor (TC).

During the preparation, prelaunch countdown and flight phases of the test, all liaison between the Range User group and the Range will be by the MC and the TC with the exception that the TC may request direct liaison on matters of detail between specific members of the User Group and specific Range personnel.

1.2 Range Master Countdown

The TC and the MC will hold a meeting to discuss details of the countdown and to complete a Data Disposition/Receipt Form.

1.3 Holds Late in the Range Countdown

Holds to await desired launch conditions are standard at T-180 or T-90 seconds. However, the Project Scientist may request a hold for this purpose (through the Mission Controller to the Test Conductor) at any time before T-10 seconds. The maximum duration of such a hold must be agreed between the Mission Controller and the Test Conductor at the time of writing the countdown. This hold cannot normally exceed three (3) minutes. Count resumption from these late holds is immediately on confirmation of Telemetry and Radar recorders being "ON".

1.4 Network Procedures

All Range Users who will be using Range voice networks are advised to refer to the Mission Controller's Book in the Blockhouse to inform themselves on voice net procedures and network terminals.

1.5 Radio Frequency (RF) Silence

The Range requires RF silence during periods when electro-explosive devices (EEDs) are being worked on. The area in which RF silence is enforced extends from Checkpoint Charlie to Mile 11. RF silence is announced on the ROC Net and is indicated by flashing lights on the Blockhouse, the Operations Building, Checkpoint Charlie and in the Payload Preparation Room. Interrupted warning tones are broadcast on the mobile radio net and in the Payload Preparation Area. During RF silence all transmitters must be turned off and vehicle radios must be switched to "STANDBY".

1.6 Data Delivery

Some quick look data may be signed for and collected at source. Other data may be obtained from the Data Library (Operations Office) before departure or data will be forwarded by registered air mail. The delivery time of all data is dependent upon Range workload.

1.7 Return Shipment of User Equipment

The Range User is responsible for pickup and delivery of all User equipment sent to the Range. The CRR will cooperate whenever possible in arranging for its transfer to and from the launch site by local commercial carrier. Range vehicles may be available to Range User groups for moving their own equipment when a qualified operator is assigned the vehicle.

1.8 Payload Transportation

The Range User is responsible for movement of the payload from the preparation area to the hazardous assembly area. The CRR will provide suitable vehicles for payload handling.

2.0 OR REQUIREMENTS WHICH CANNOT BE MET:

2.1 Documentary Photography

The request of paragraph 8.1 of the OR requesting documentary photography by the Range will not be met for lack of equipment and personnel. The Range Users will be allowed to take photographs in the hazardous areas as long as the equipment in use complies with all safety standards at the CRR.

2.2 Ionograms

The request of paragraph 8.3 of the OR requesting ionograms cannot be met by the Range. A standard sweep rate of one sweep every fifteen minutes is available during normal operation of the Department of Transport Ionosonde station. During normal working hours (8:00 a.m. - 4:00 p.m.), faster sweep rates are available if required. Copies of all ionograms are available at the following address:

Director of Telecommunications Regulations
Department of Communications
Burger Building
100 Metcalfe Street
Ottawa, Ontario

2.3 Transportation

The request of paragraph 8.6 of the OR for four motor vehicles will not be met. Vehicle availability is dependent on the number of User personnel on a program and the number of programs present on the Range at that time.

2.4 Reduced Radar Data

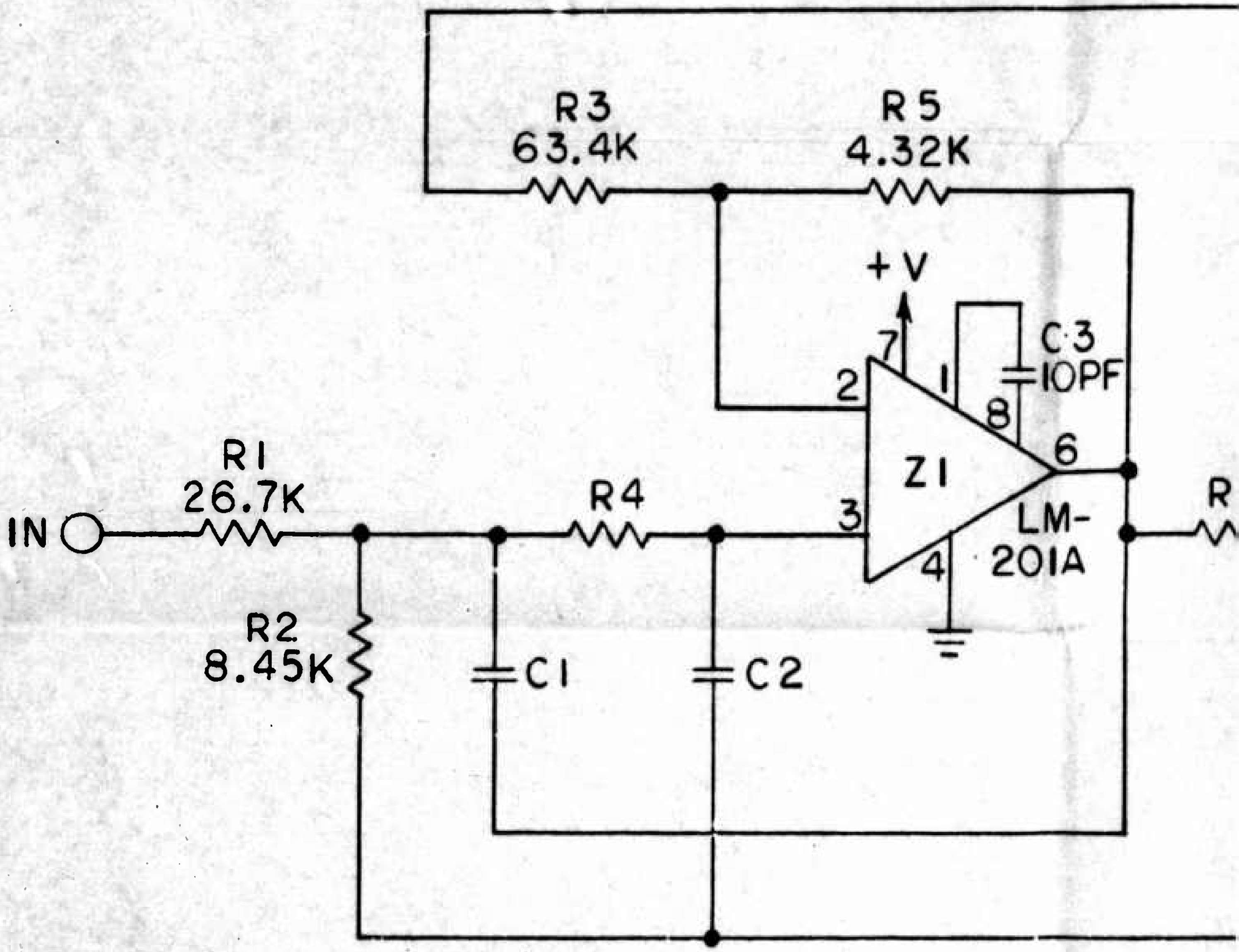
The request of paragraph 8.5.2 of the OR cannot be met. Tabulated radar data is no longer available at the CRR; however, the raw digital data will be provided on the Telemetry magnetic tape as a portion of the Telemetry station multiplex.

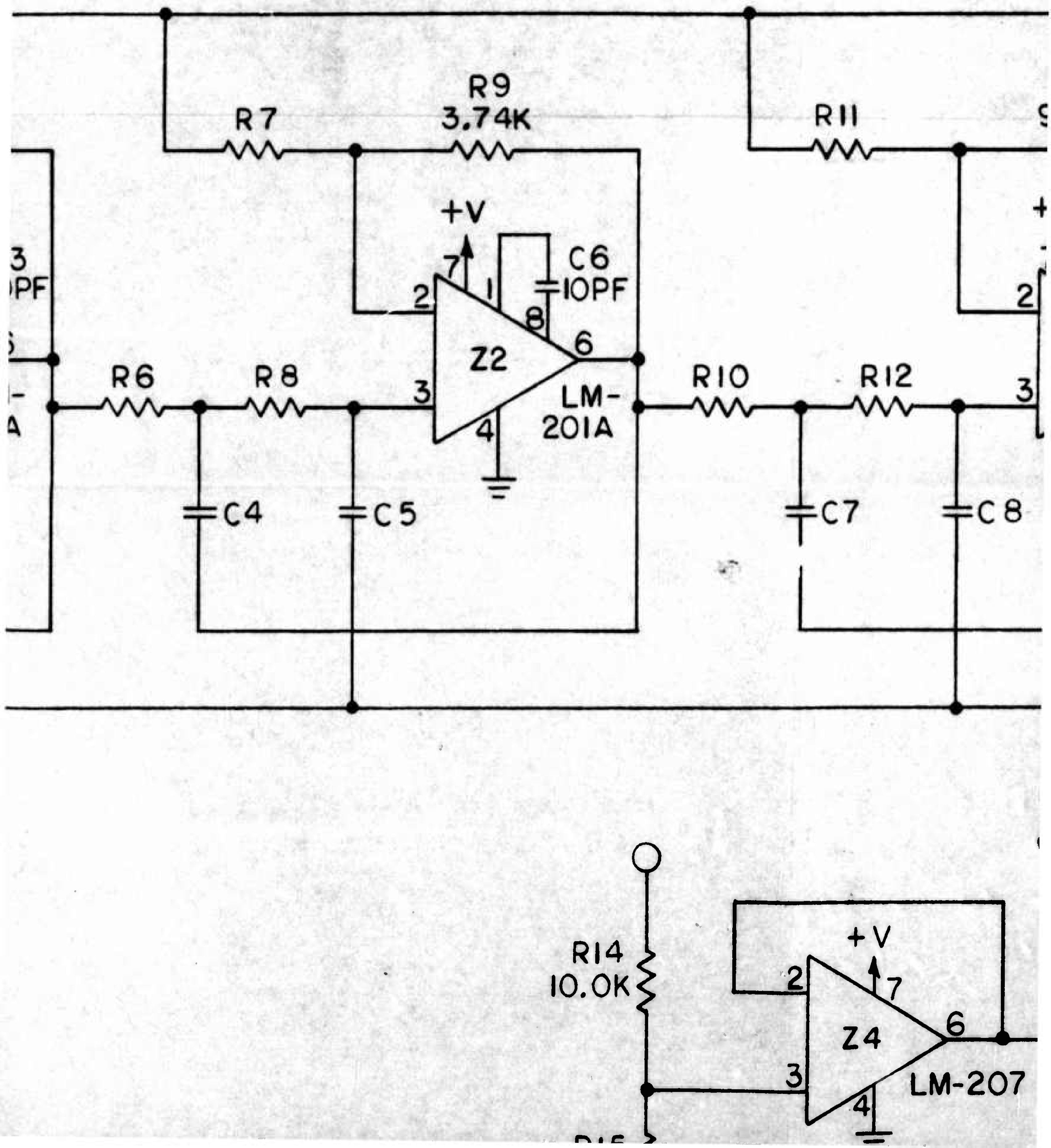
2.5 Telemetry Support

The request of paragraph 8.5.3 of the OR for stripouts from the magnetic tape as soon after flight as possible, will not be met. Standard Range support consists of one original magnetic tape, plus realtime paper records of horizontal and vertical instrumentation checks only, as an aid to payload diagnostics. Any additional telemetry records may be met by the CRR on a material replacement basis. Details of telemetry and radar support will be discussed at the Preflight meeting.

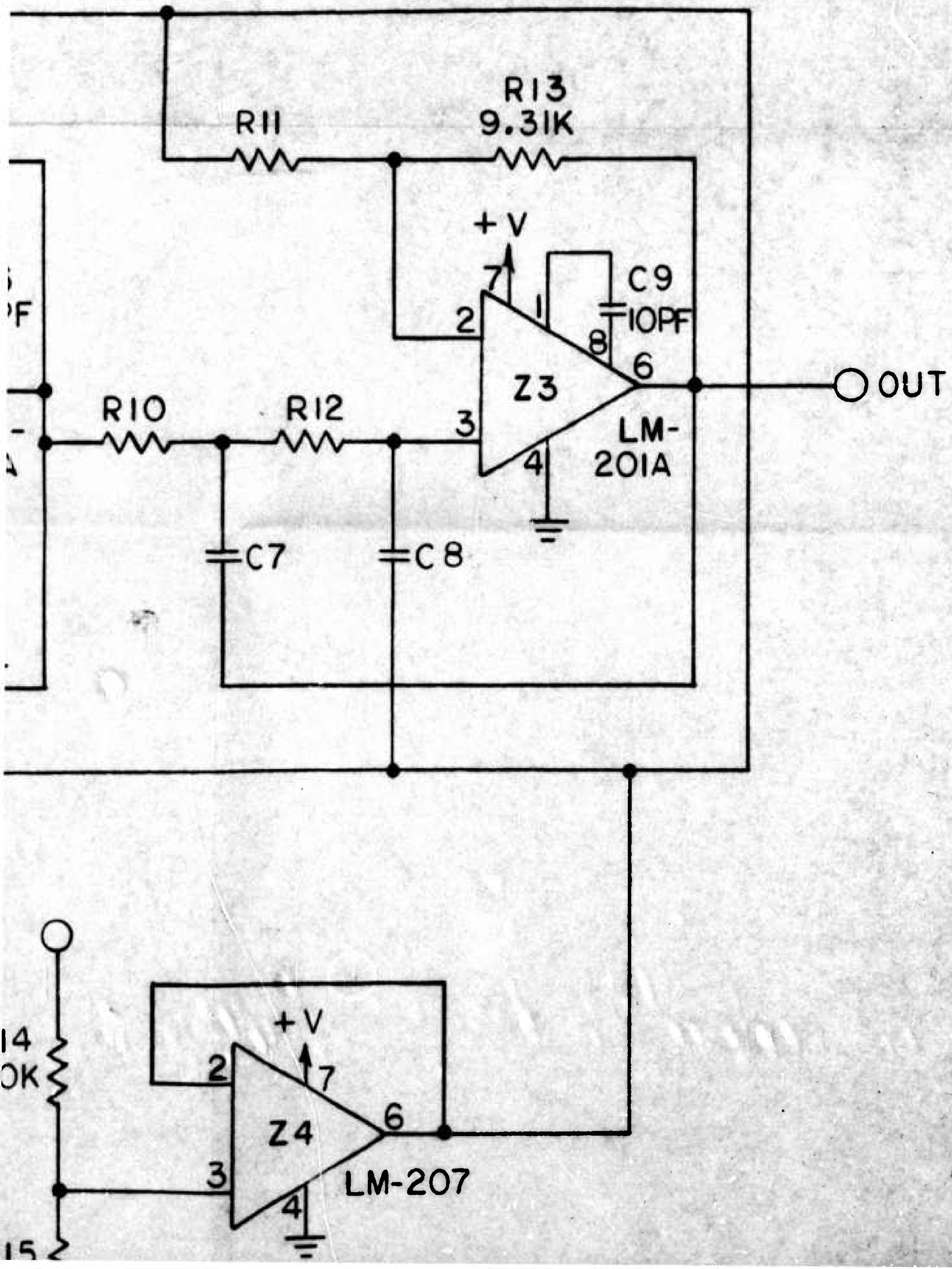
APPENDIX D

Circuit Schematics

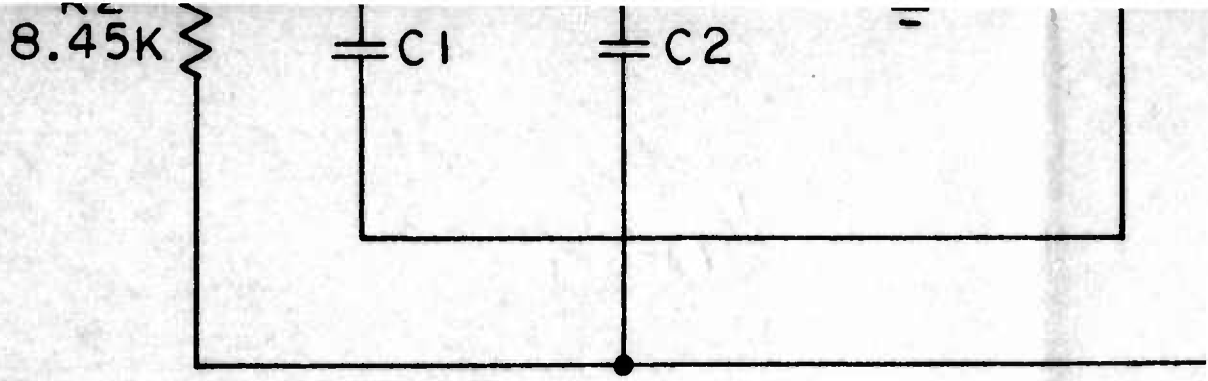

R3
63.4K
R5
4.32K
+V
C3
10PF
7
1
2
8
6
Z1
3
LM-
201A
4
R1
26.7K
IN
R4
R2
8.45K
C1
C2
R



R7
R9
3.74K
R11
+V
C6
10PF
Z2
LM-
201A
R6
R8
R10
R12
C4
C5
C7
C8
R14
10.0K
Z4
LM-207



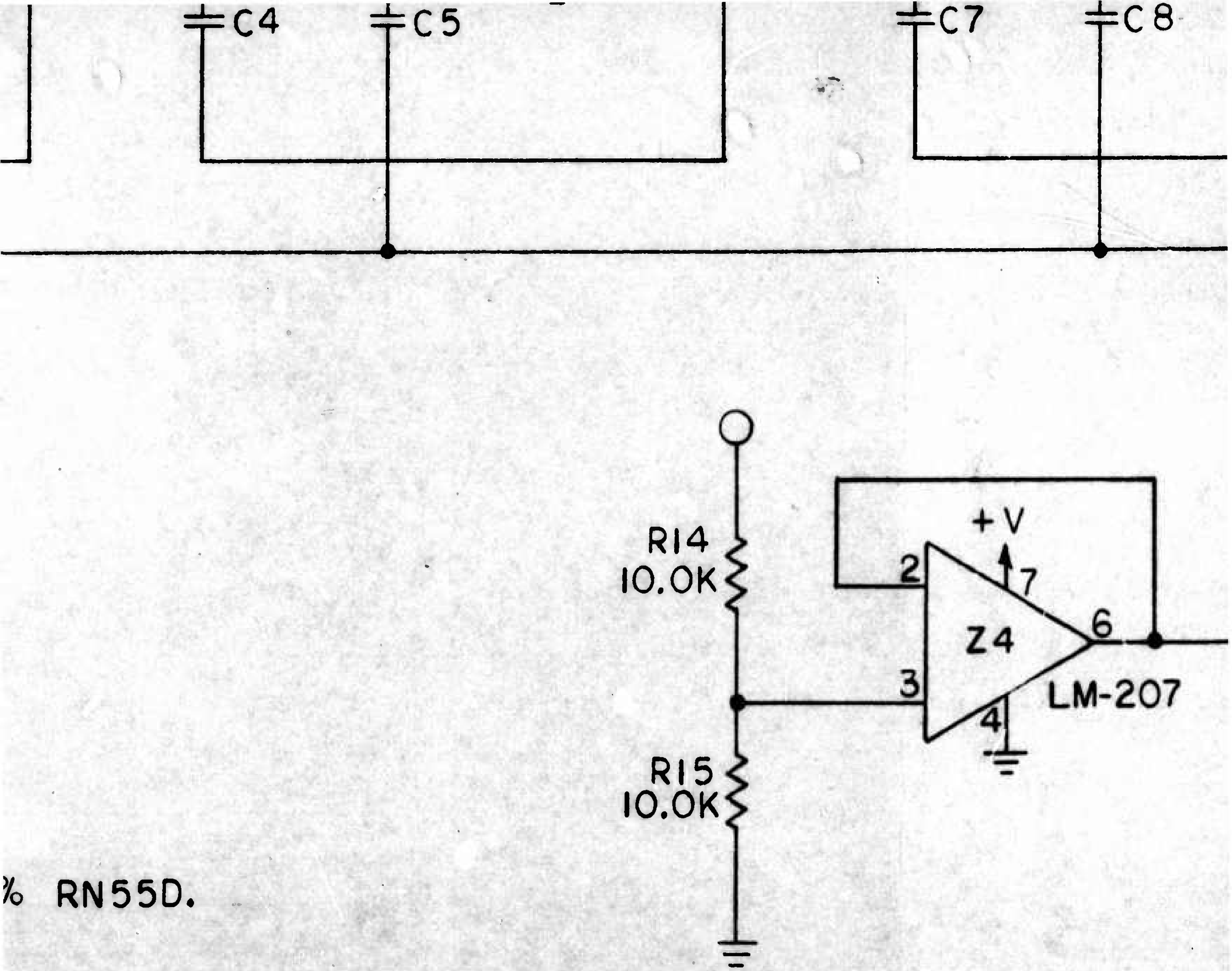
R13
9.31K
R11
+V
C9
10PF
Z3
LM-
201A
OUT
R10
R12
C7
C8
+V
Z4
LM-207



NOTES - UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE 6.34K.
2. ALL RESISTOR VALUES ARE IN OHMS ±1% R
3. ALL CAPACITORS ARE .001UF ±1%.

REV. | REVISIONS | APP



% RN55D.

REQD.	REQD.	ITEM	PART NO.	

REMOVE ALL BURRS & BREAK SHARP EDGES

DO NOT SCALE DWG.

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACT. ±1/64

DEC. ±PL.

±PL. ±.005

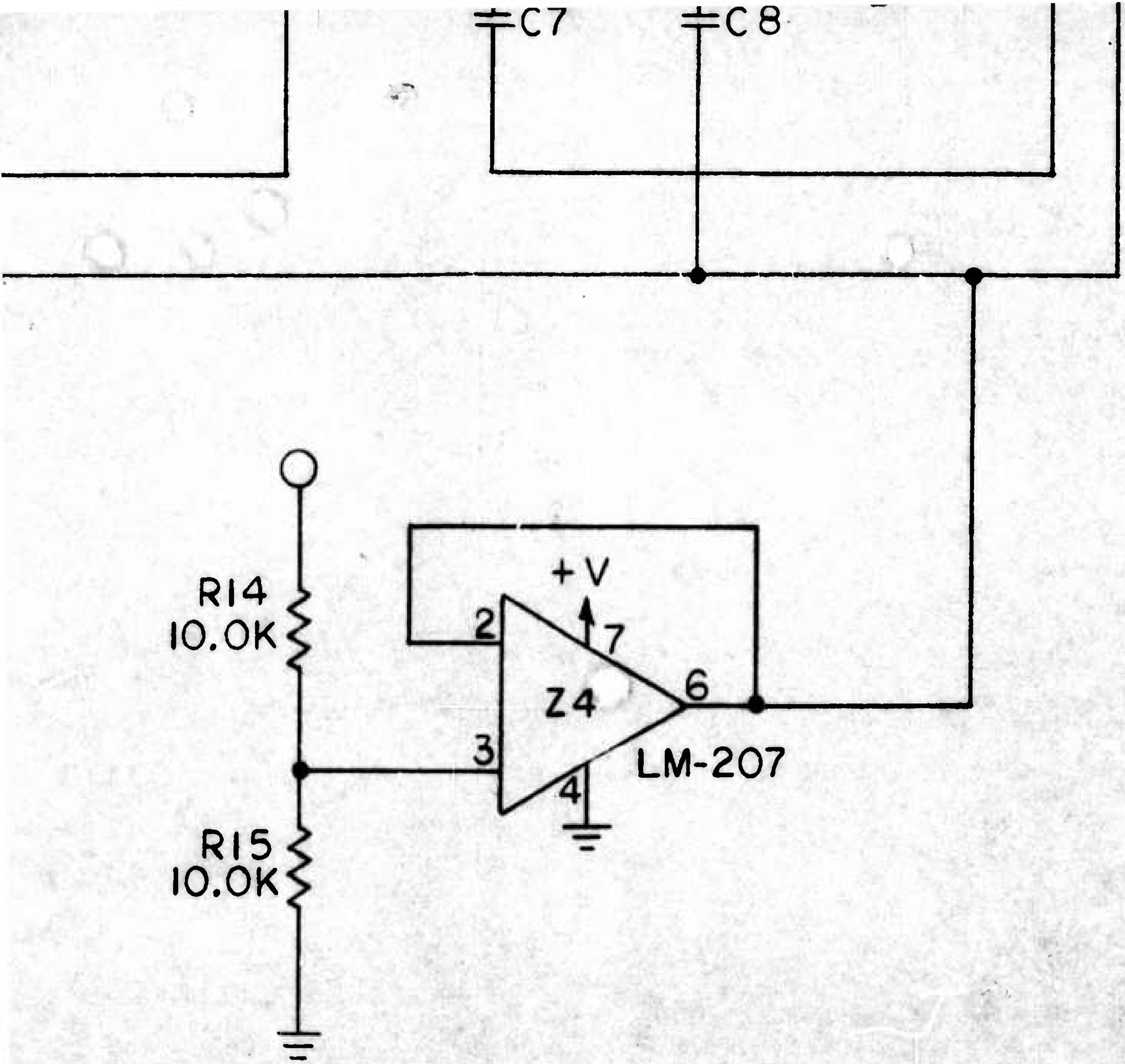
ANG.

6POLE BUTTERW
25KHz LOWPASS
SCHEMATI
BBIVB ROCKET

MODEL NO.

DRAWN C.A.P. CHECKED

DATE 5-28 72 DATE 6/1/72



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

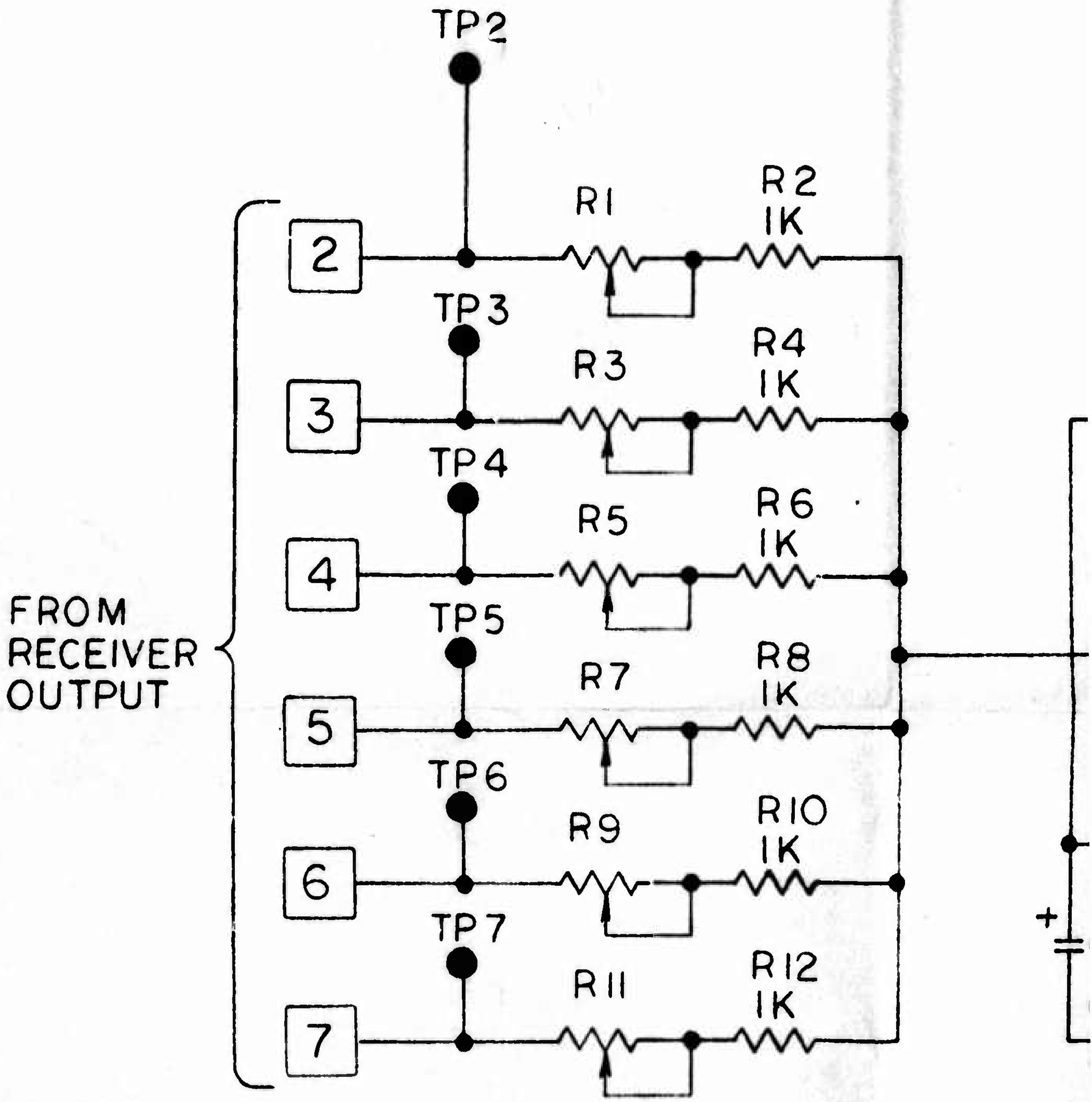
ANG.

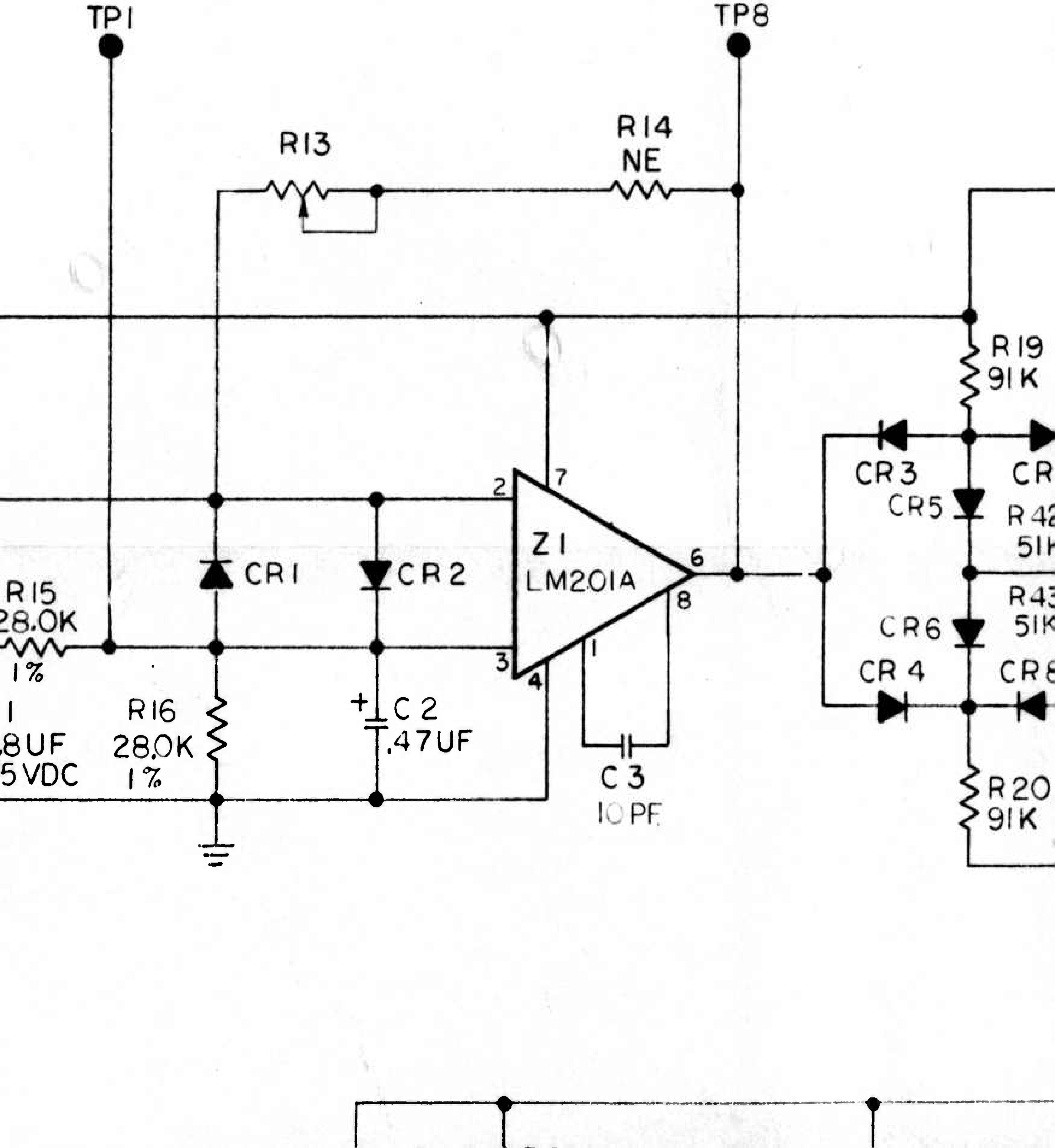
6POLE BUTTERWORTH
25KHz LOWPASS FILTER
SCHEMATIC
BBIVB ROCKET EXP.

AEROS[illegible] RESEA[illegible]

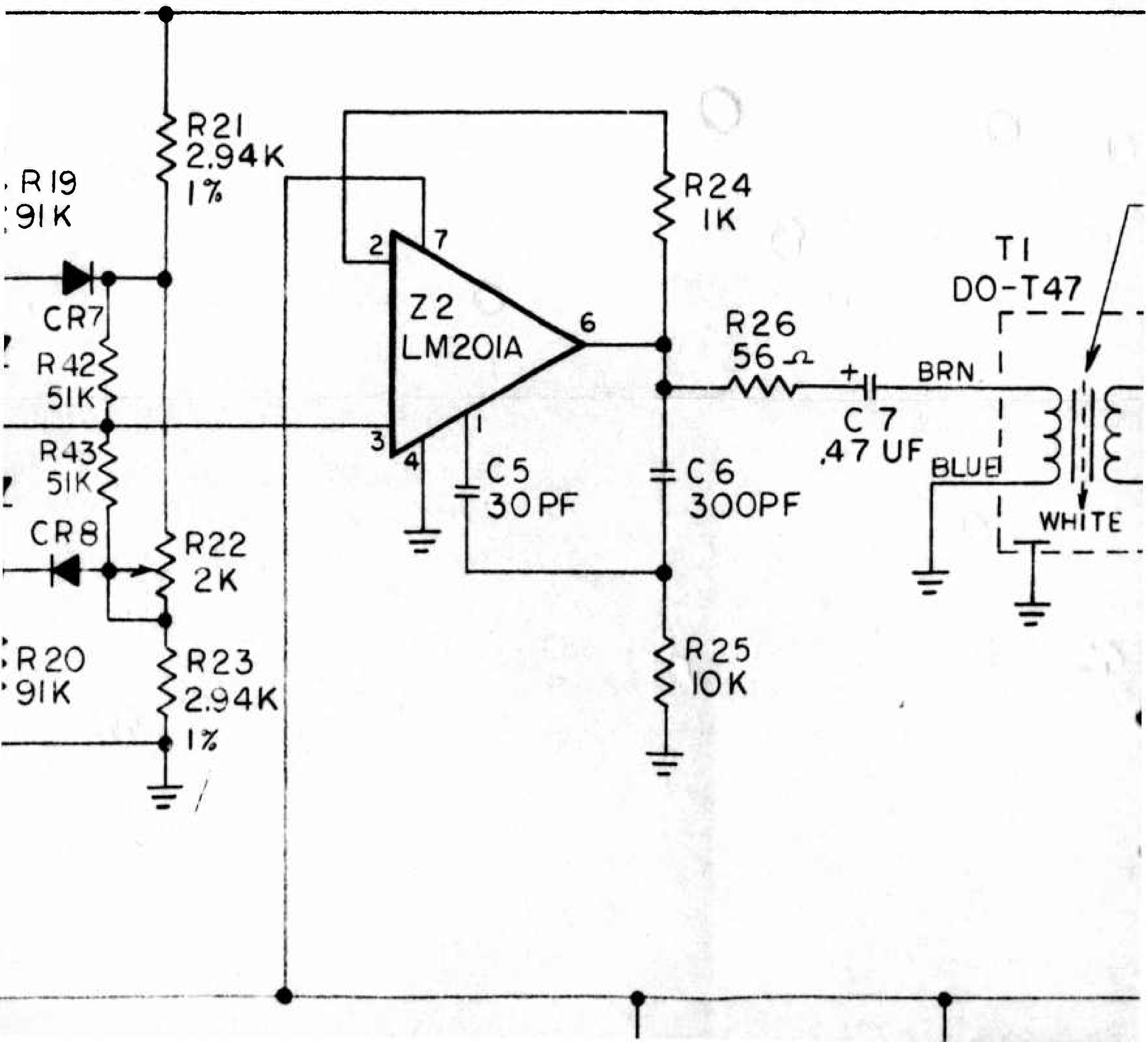
BOSTON, MASS.

MODEL NO.		NEXT ASSY.		SIZE C	DWG. NO. E334-300[illegible]
DRAWN [illegible] DATE 5-28 '70	CHECKED [illegible] DATE 6/1/70	ENG. APPD. [illegible] DATE 1 June '70	PROD. APPD. DATE	SCALE: ~	SHEET 1

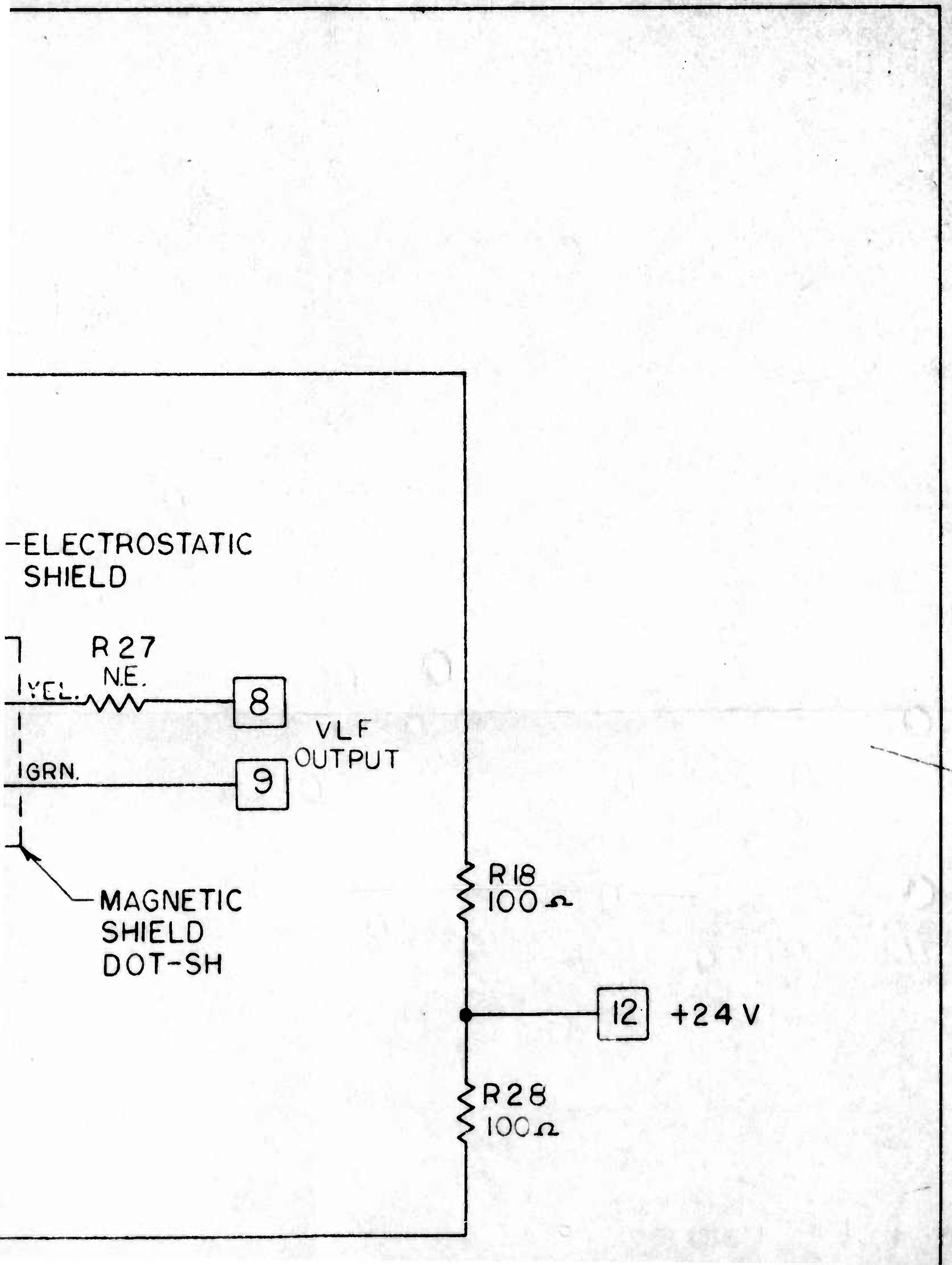

TP2
TP3
TP4
TP5
TP6
TP7
R1
R2
1K
R3
R4
1K
R5
R6
1K
R7
R8
1K
R9
R10
1K
R11
R12
1K
2
3
4
5
6
7
FROM
RECEIVER
OUTPUT
+



TP1
TP8
R13
R14
NE
R19
91K
CR3
CR5
R42
51K
Z1
LM201A
CR1
CR2
R15
28.0K
1%
R43
51K
CR6
CR4
CR8
R16
28.0K
1%
C2
.47UF
.8UF
5VDC
C3
10PF
R20
91K



R21
2.94K
1%
R19
91K
CR7
R42
51K
R43
51K
CR8
R22
2K
R20
91K
R23
2.94K
1%
Z2
LM201A
2
7
6
3
4
1
C5
30 PF
R24
1K
R26
56 Ω
C6
300PF
R25
10K
+
C 7
.47 UF
BRN
BLUE
WHITE
T1
DO-T47

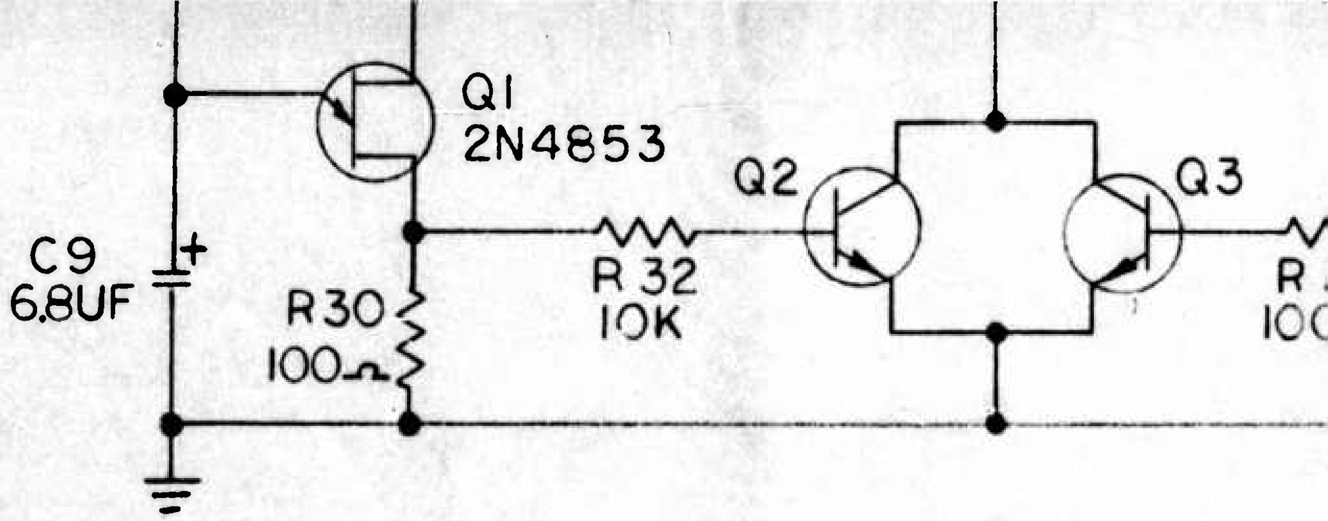


-ELECTROSTATIC SHIELD
R 27
N.E.
YEL.
8
VLF OUTPUT
GRN.
9
MAGNETIC SHIELD DOT-SH
R18
100 Ω
12
+24 V
R28
100 Ω

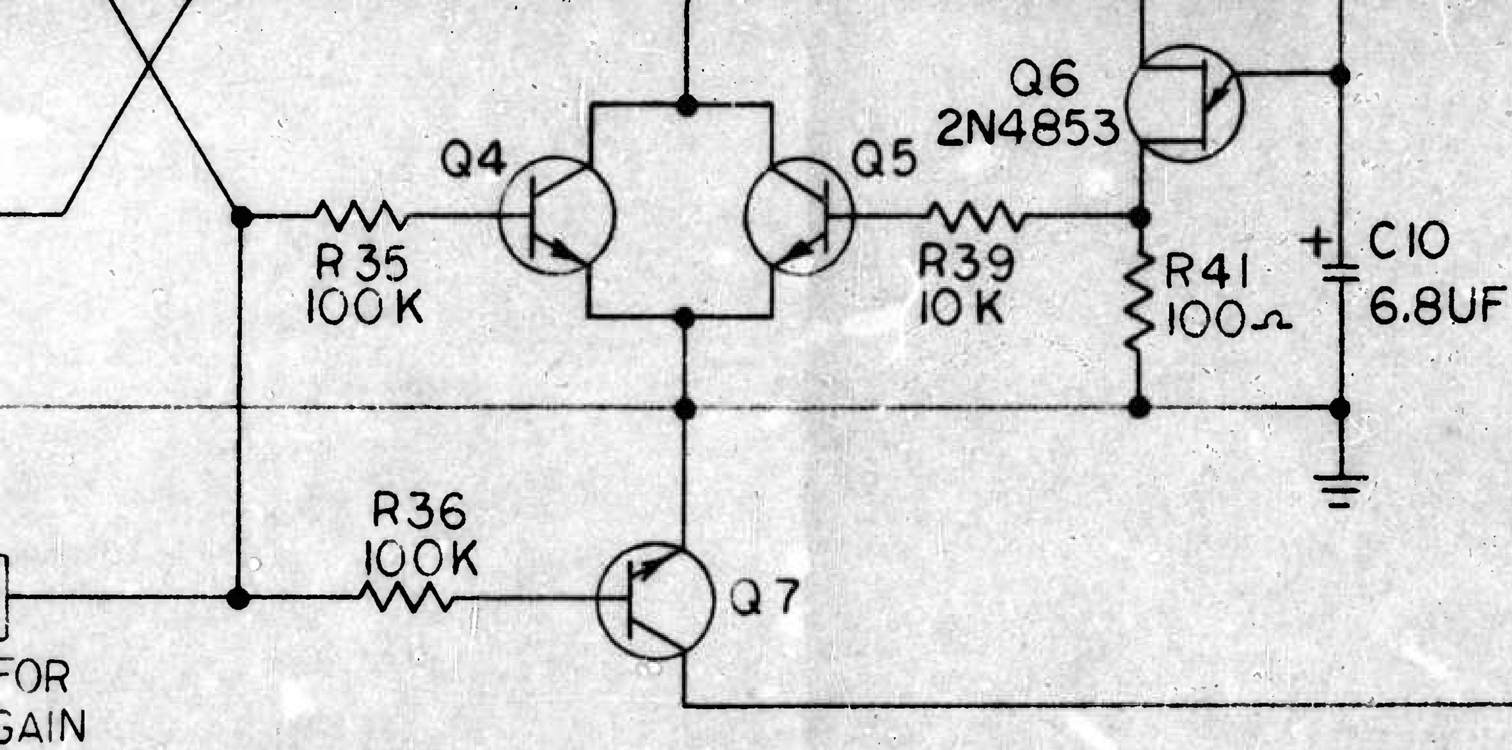
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL VARIABLE RESISTORS ARE HELITRIM #58PR10K.
2. ALL RESISTORS ARE ±10%, 1/4W.
3. ALL DIODES ARE 1N4154.
4. ALL TRANSISTORS ARE 2N3392.

APP	REVISIONS	REV.



HIGHEST COMPONENT DESIGNATION	
COMPONENT	
SYMBOL	NUMBER
C	10
CR	8
Q	7
R	43
T	1
Z	2



Q6
2N4853
Q4
Q5
R 35
100 K
R39
10 K
R41
100Ω
C10
6.8UF
R36
100K
Q7
FOR
GAIN

REQD.

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

REMOVE ALL BURRS & BREAK SHARP EDGES

DO NOT SCALE DWG.

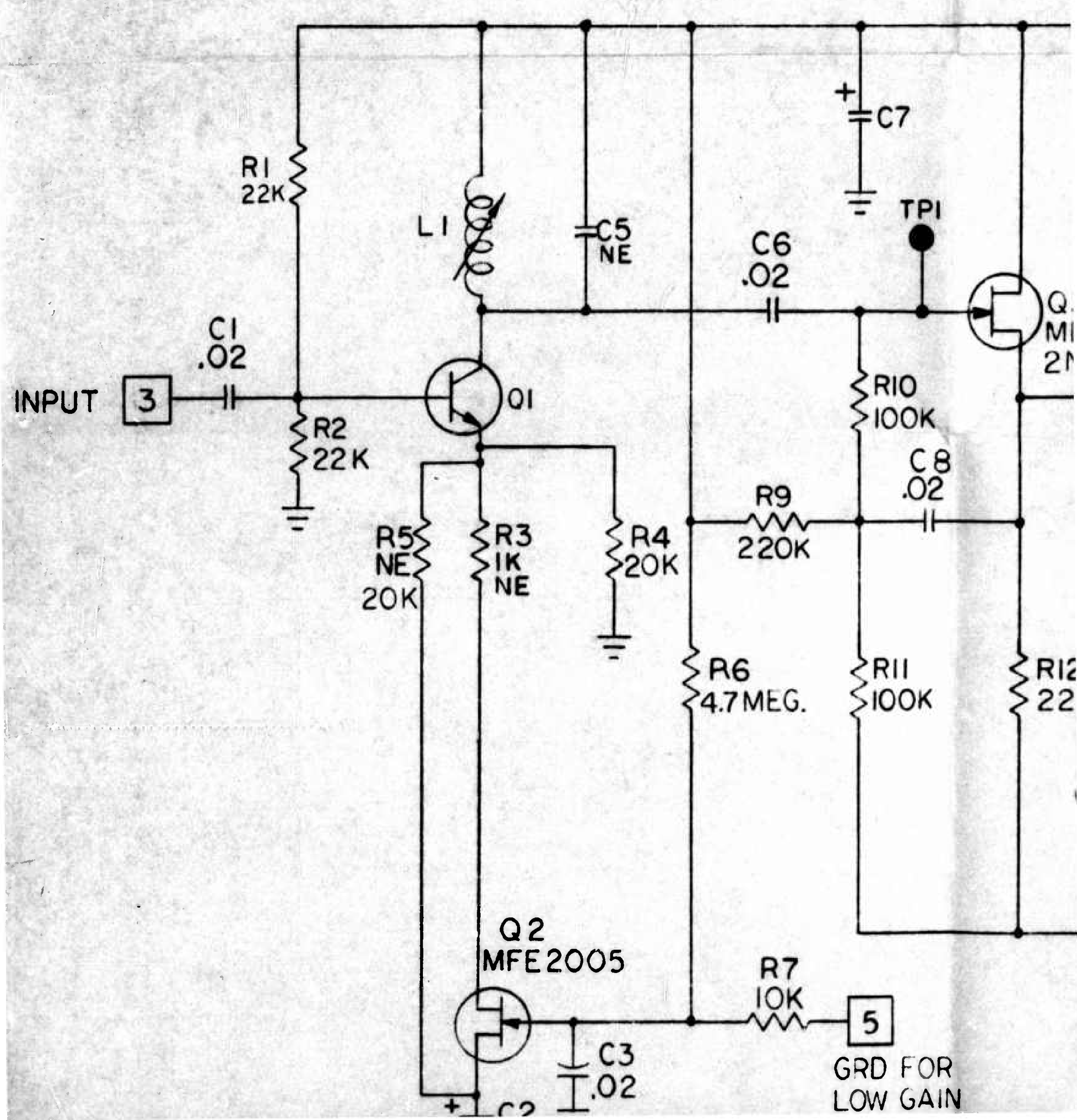
TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACT. ±1/64
DEC. 2PL.
3PL. ±.005
ANG.

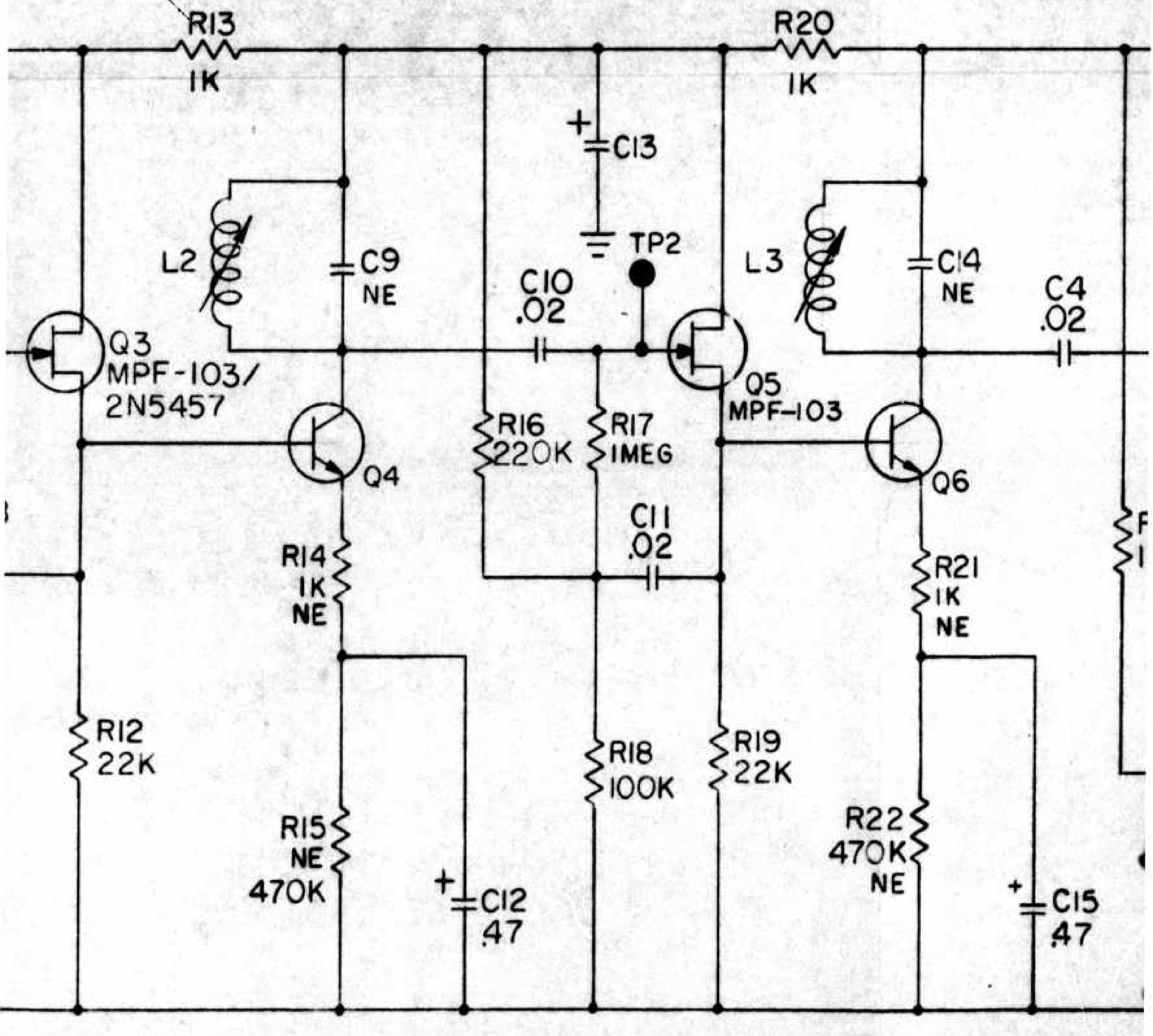
OUTPUT, TIMER & CLIPPER CIRCUIT SCHEMATIC
B.B. IV B ROCKET EXP.

AEROSPA
RESEAR
BOSTON, MASS.

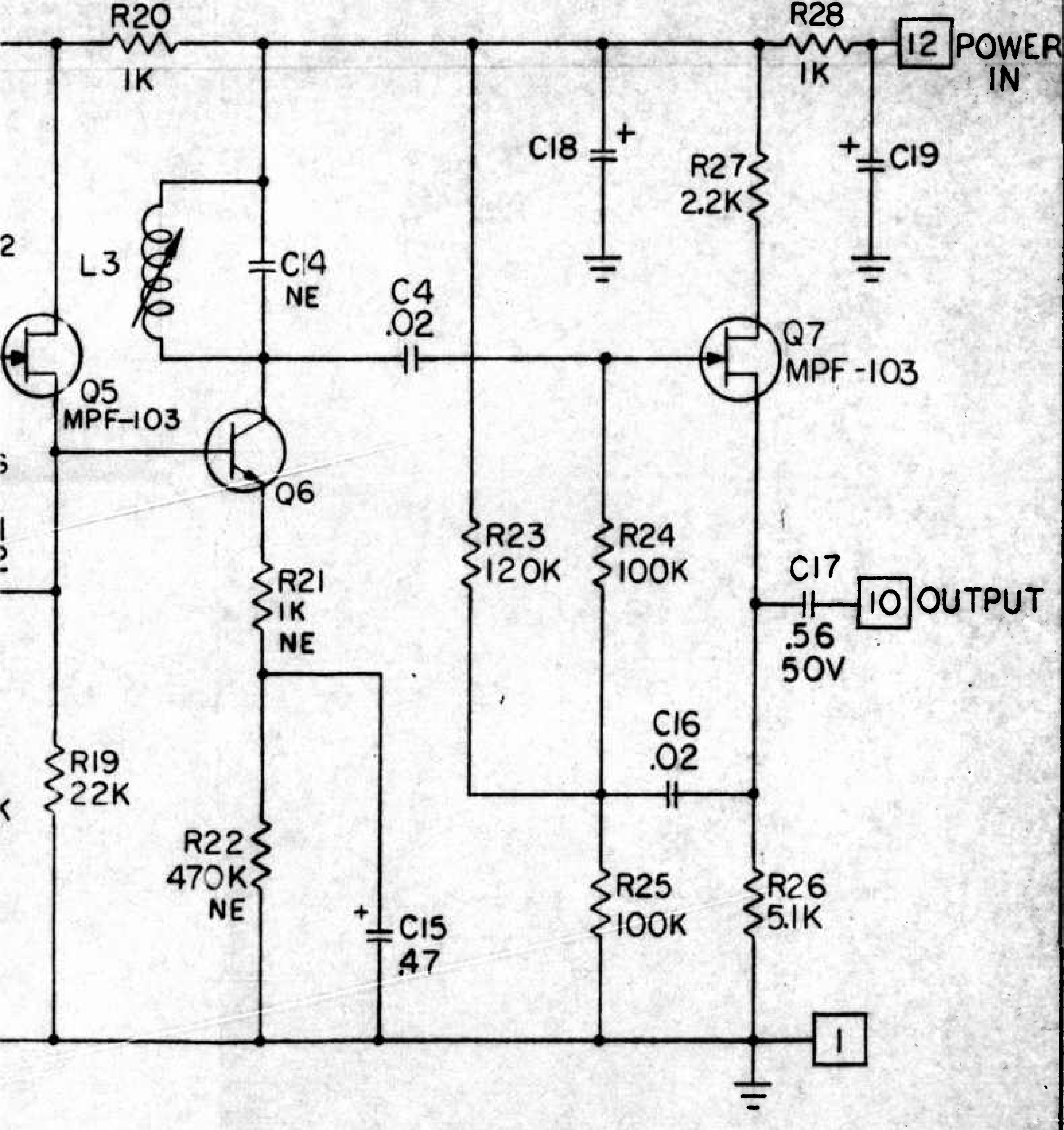
MODEL NO.	NEXT ASSY. 334-2008	SIZE D	DWG. NO. 334-3008
DRAWN / DATE	CHECKED / DATE 1-2-70	ENG. APPD. / DATE	PROD. APPD. / DATE
SCALE:	SHEET		



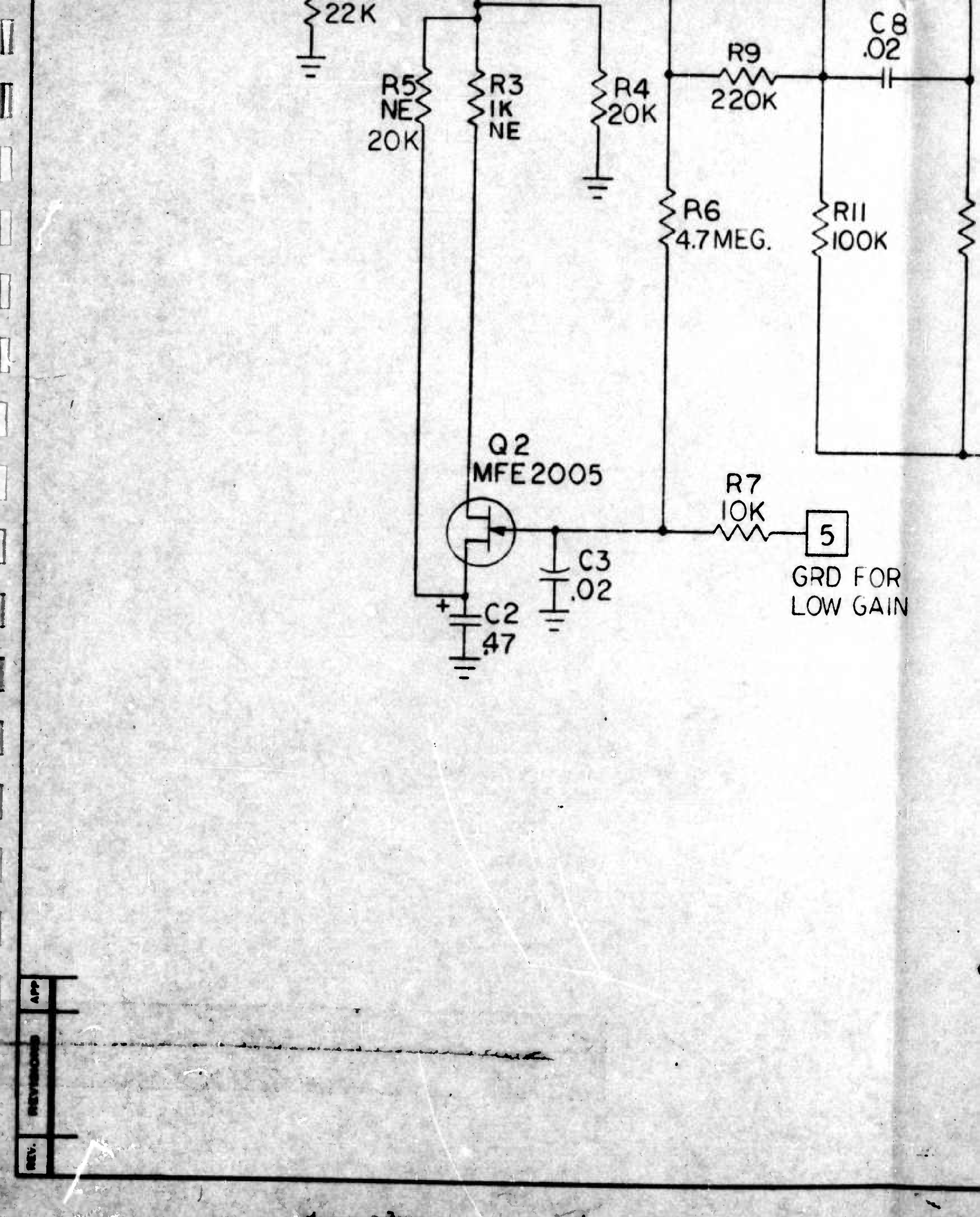
INPUT
3
C1
.02
R1
22K
R2
22 K
L1
C5
NE
Q1
R5
NE
20K
R3
1K
NE
R4
20K
C6
.02
C7
TP1
R10
100K
R9
220K
C8
.02
R6
4.7 MEG.
R11
100K
Q2
MFE2005
R7
10K
5
GRD FOR
LOW GAIN
C3
.02


R13
1K
R20
1K
C13
TP2
L2
C9
NE
C10
.02
L3
C14
NE
C4
.02
Q3
MPF-103/
2N5457
Q5
MPF-103
Q4
R16
220K
R17
1MEG
Q6
C11
.02
R14
1K
NE
R21
1K
NE
R12
22K
R18
100K
R19
22K
R22
470K
NE
R15
NE
470K
C12
.47
C15
.47

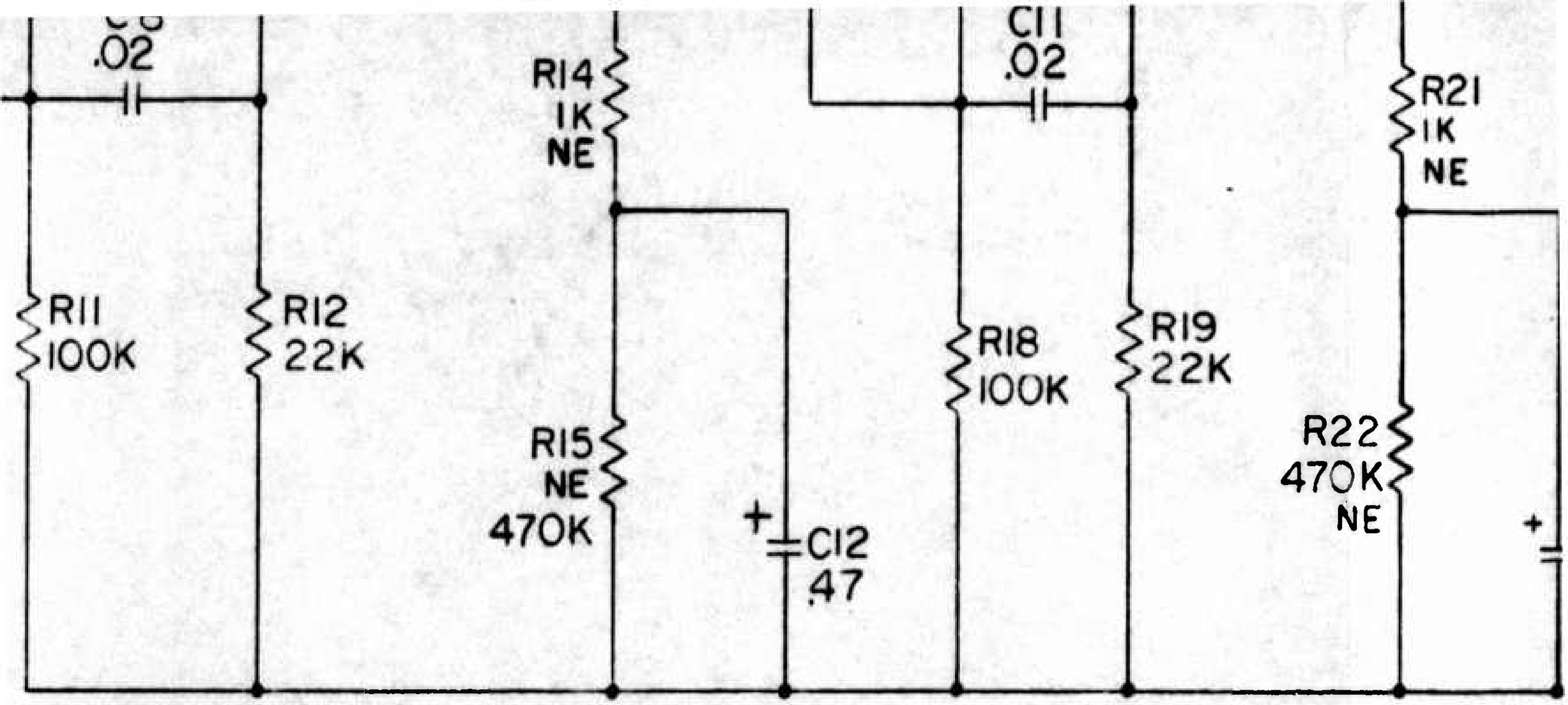
NOTES:



R20
1K
R28
1K
12 POWER IN
C18
R27
2.2K
C19
2
L3
C14
NE
C4
.02
Q7
MPF-103
Q5
MPF-103
Q6
R23
120K
R24
100K
C17
10 OUTPUT
R21
1K
NE
.56
50V
C16
.02
R19
22K
R22
470K
NE
R25
100K
R26
5.1K
C15
.47
1



22K
R5
NE
20K
R3
1K
NE
R4
20K
R9
220K
C8
.02
R6
4.7MEG.
R11
100K
Q2
MFE2005
R7
10K
5
GRD FOR
LOW GAIN
C3
.02
C2
.47
APP
REVISIONS
REV.



5

RD FOR
OW GAIN

NOTES:

UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE 1/4W, ±10%.
2. ALL TRANSISTORS ARE 2N3392.
3. ALL CAPACITORS ARE 6.8 UF, 35V.
4. L1, L2, L3 TENCO T-9730

REQD.	REQD.	ITEM	PART NO.

REMOVE ALL BURRS & BREAK SHARP EDGES

DO NOT SCALE DWG.

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACT. ±1/64

DEC. 2PL.

3PL. ±.005

ANG.

RECEI

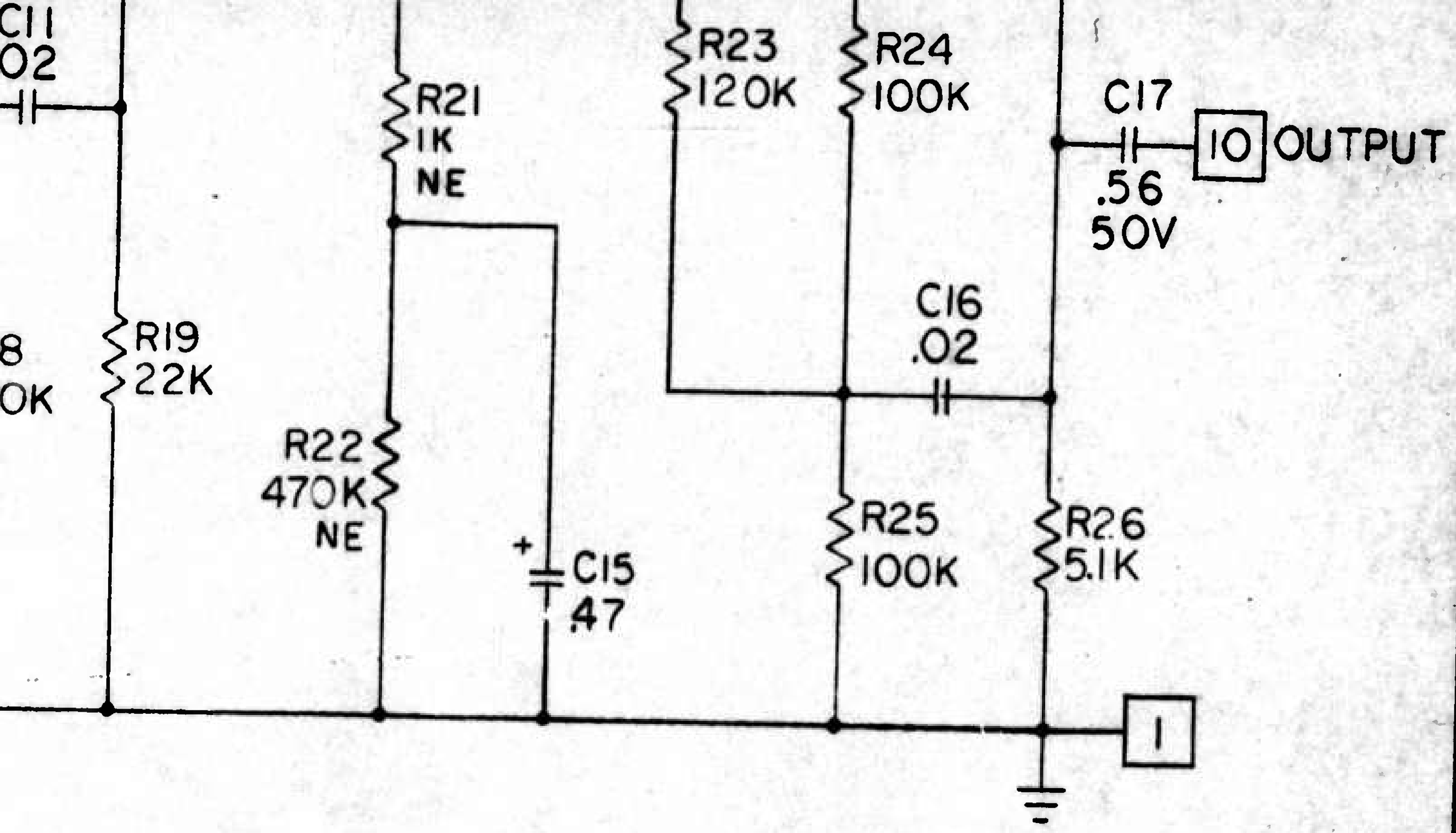
SC

BB IVB

MODEL NO.

DRAWN AJM

DATE 12-8-69



CIFIED:

/, ±10%.

2N3392.

.8 UF, 35V.

30

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.

RECEIVER CIRCUIT SCHEMATIC-

BB IVB VLF ROCKET EXP.

AEROSPACE RESEARCH INC.

BOSTON, MASS.

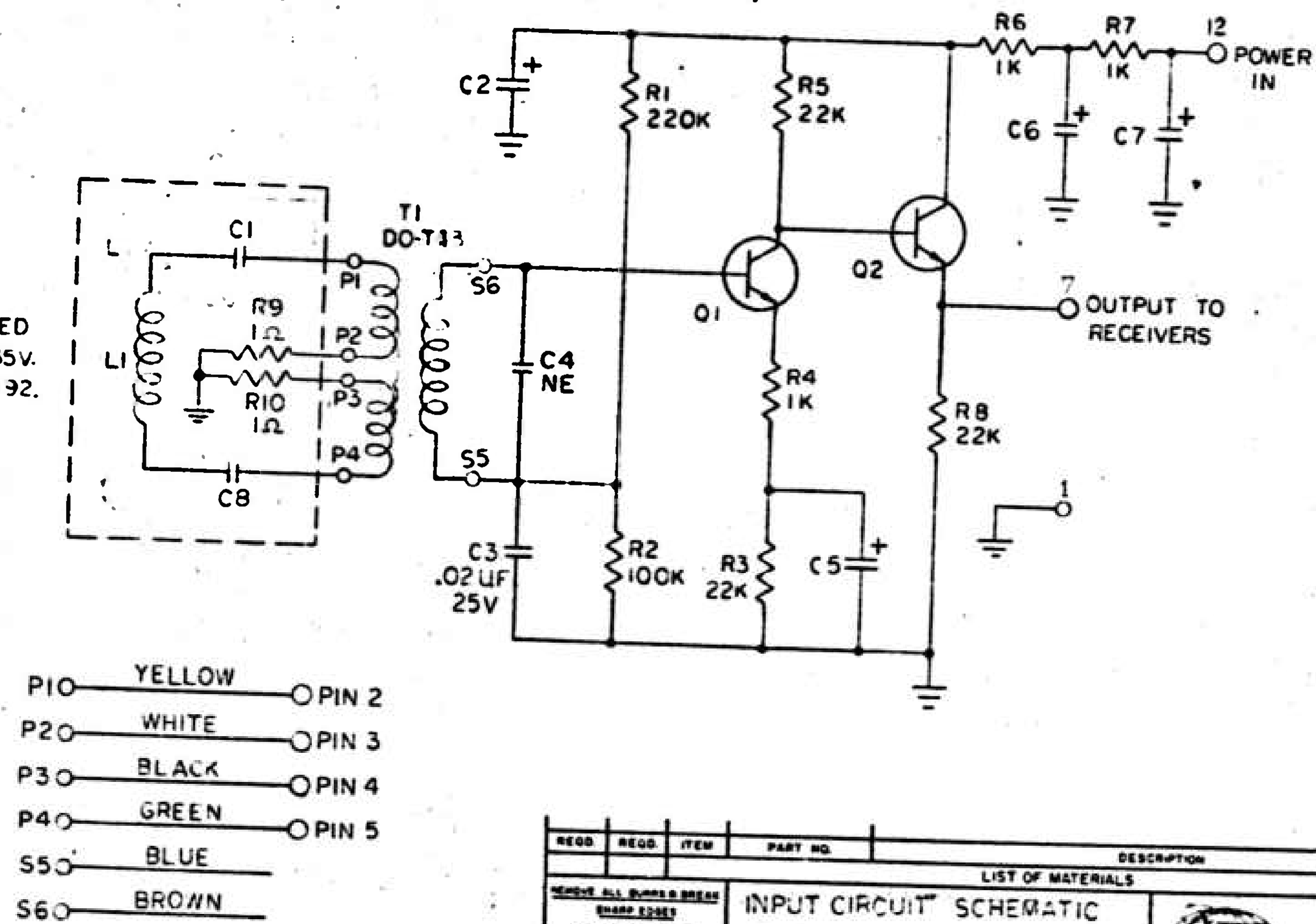
MODEL NO.	NEXT ASSY.	SIZE	DWG. NO.	REV.
		C	C334-3007	

DRAWN AJM	CHECKED P/H	ENG. APPD.	PROD. APPD.
DATE 12-8-69	DATE 1-3-70	DATE 1/1/70	DATE

SCALE: 4/1 — SHEET 1 OF 1

117

NOTES
UNLESS OTHERWISE SPECIFIED
1 ALL CAPACITORS ARE 6.8µf, 35V.
2 ALL TRANSISTORS ARE 2N3392.
3 ALL RESISTORS ARE 1/4 W.



XXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages
for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXX

LIST OF MATERIALS

REQD	REQD	ITEM	PART NO.	DESCRIPTION

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

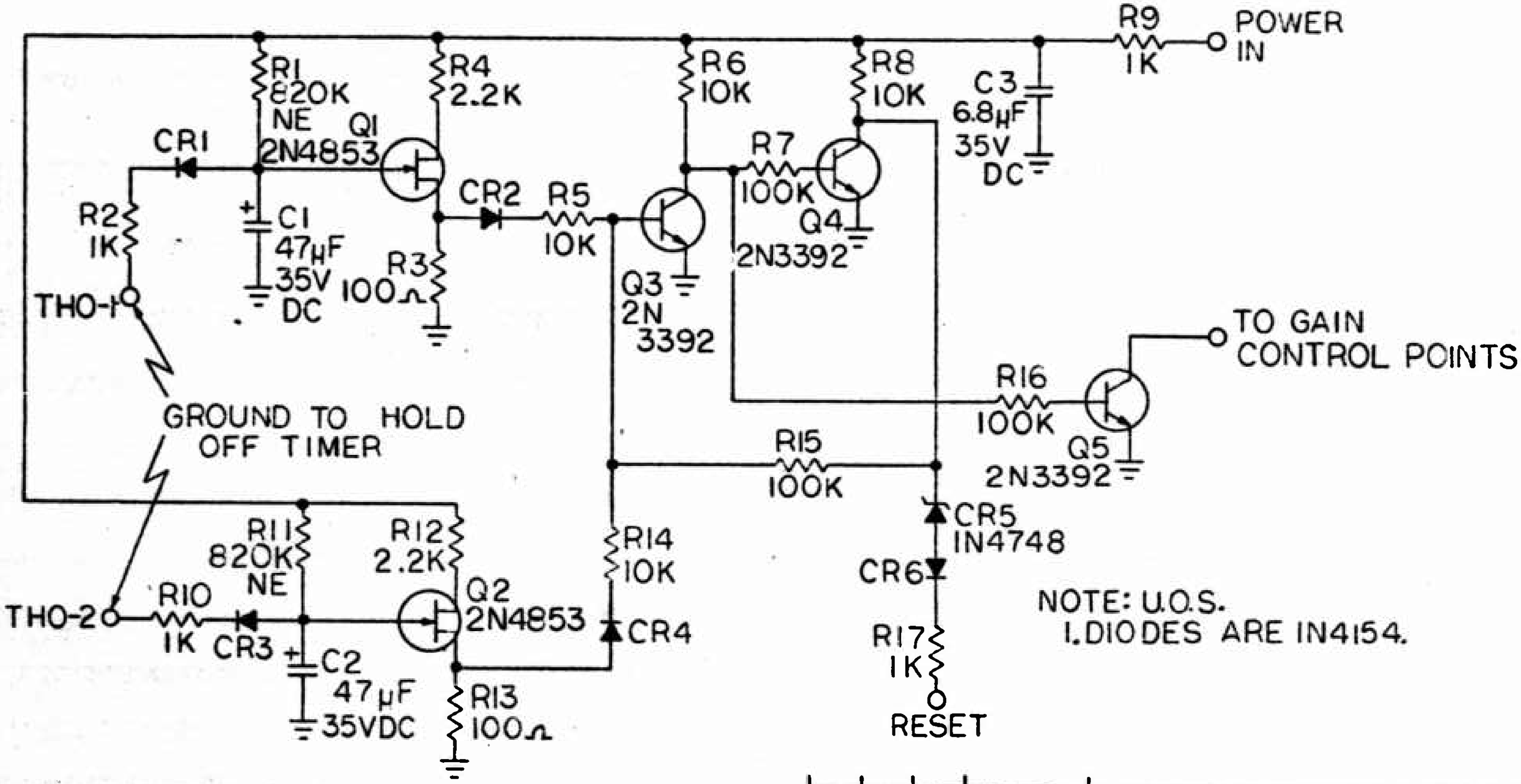
INPUT CIRCUIT SCHEMATIC
BE IV VLF ROCKET EXP

AEROSPACE RESEARCH INC
BOSTON, MASS

MODEL NO.		NEXT ASSY	
DRAWN	CHECKED	ENG APPD	PROD APPD
DATE	DATE 3-3-70	DATE	DATE

SIZE B | DWG NO. 334-3006 | REV
SCALE NA | SHEET 1 OF 1

REVISIONS



XXXXXXXXXXXXXXXXXXXXXXXXXX
See the following pages for greater detail.
XXXXXXXXXXXXXXXXXXXXXXXXXX

REV.	REVISIONS	APP.
A	ECO # 576	[illegible]
	I.S. 8-12-70	

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

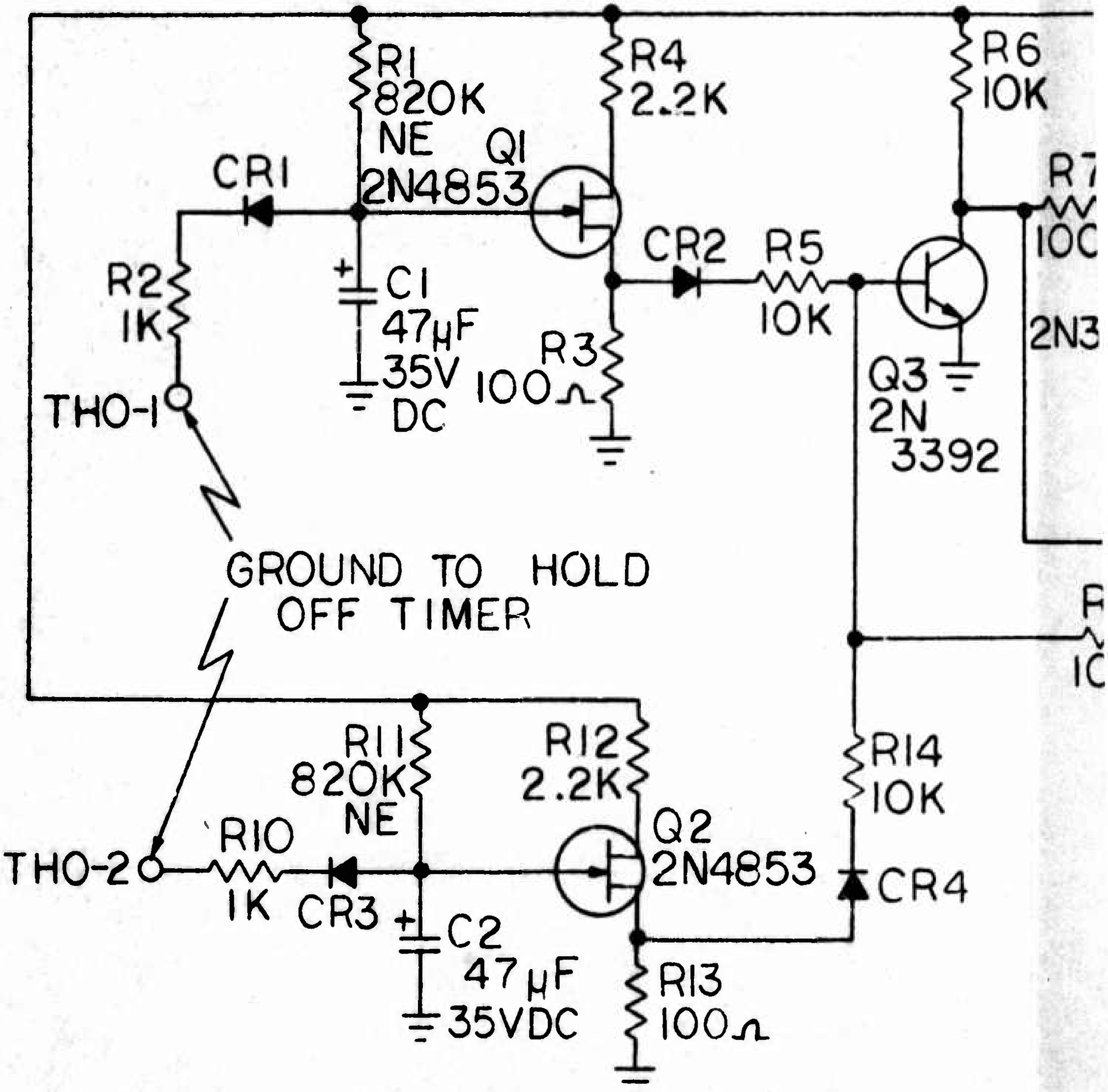
REMOVE ALL BURRS & BREAK SHARP EDGES
DO NOT SCALE DWG.
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACT ±1/64
DEC. 2PL.
3PL. ±.005
ANG.

TIMER CIRCUIT, SCHEMATIC – ANT. IMP. MEAS. EXP.

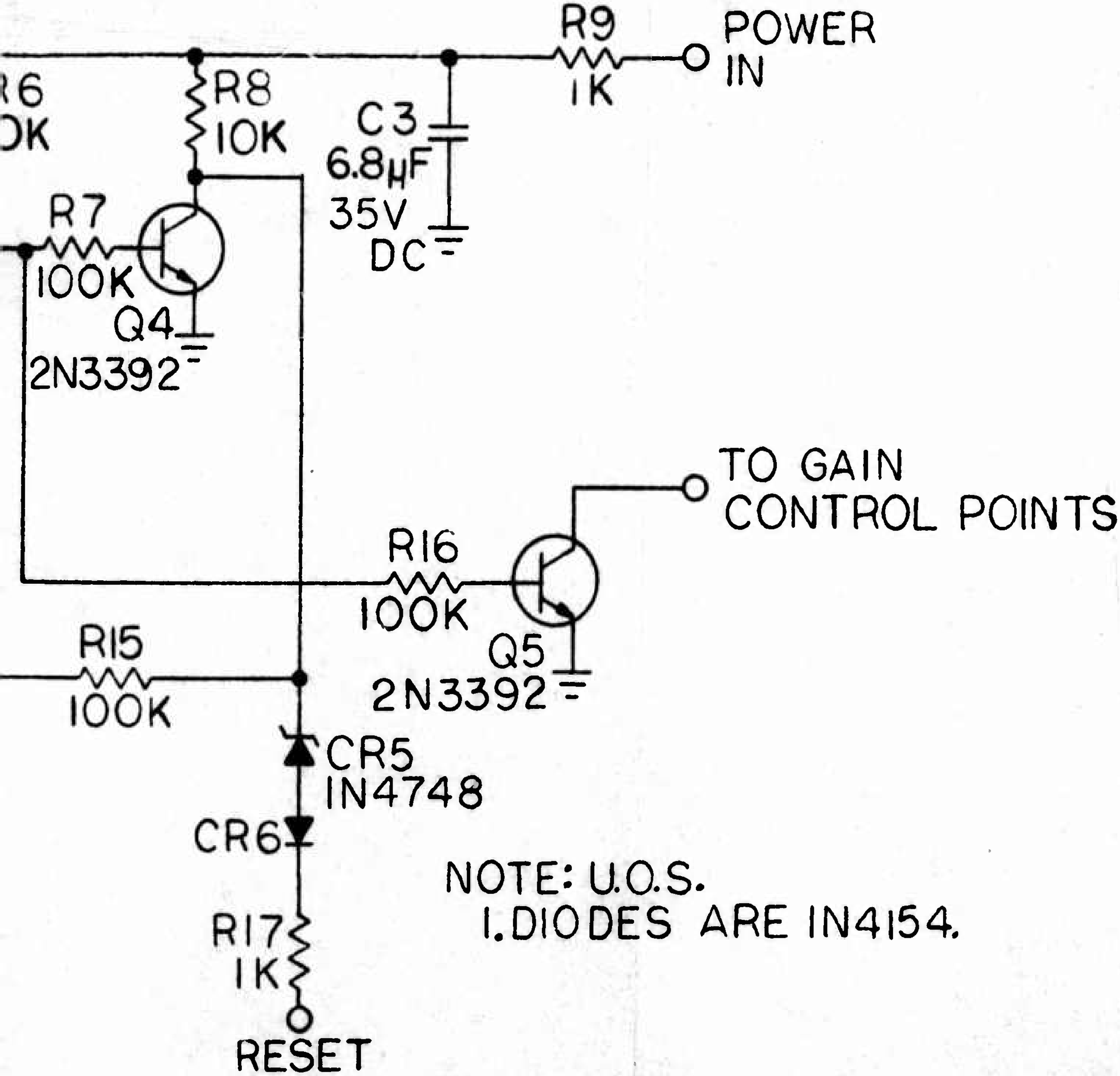
AEROSPACE RESEARCH INC.
BOSTON, MASS.

MODEL NO. | NEXT ASSY.
DRAWN PEB DATE 5-2-69 | CHECKED DATE | ENG. APPD. DATE | PROD. APPD. DATE

SIZE B | DWG. NO. E300-3020 | REV. A
SCALE: NA | SHEET 1 OF 1



REV.	REVISIONS	APP
A	ECO #596	
	1.S. 4-10-70	



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.

TIMER CIRCUIT, SCHEMATIC – ANT. IMP. MEAS. EXP.

AEROSPACE RESEARCH INC.
BOSTON, MASS.

MODEL NO.		NEXT ASSY.		SIZE	DWG. NO.	REV.
DRAWN PEB DATE 5-2-69	CHECKED MAL DATE 5-2-69	ENG. APPD. [illegible] DATE 5/6/69	PROD. APPD. DATE	B	300-3020	A
				SCALE: NA	SHEET 1 OF 1	

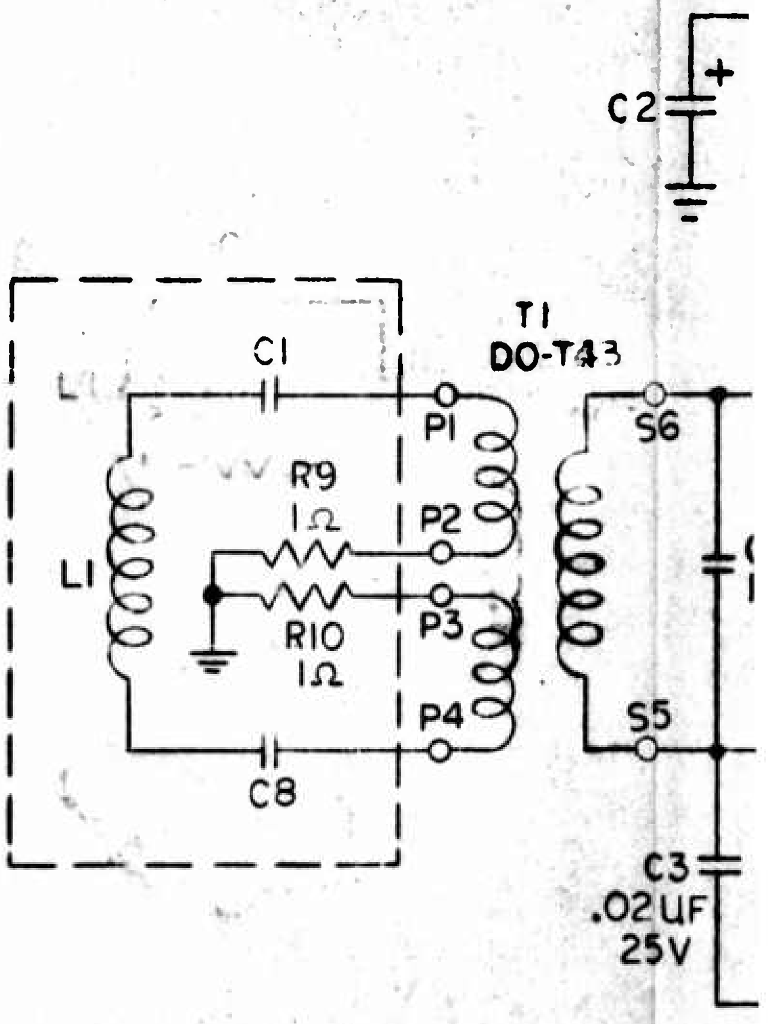
NOTES

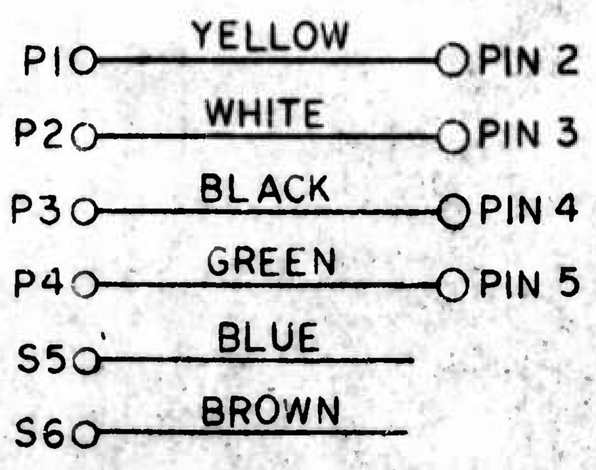
UNLESS OTHERWISE SPECIFIED

1 ALL CAPACITORS ARE 6.8μf, 35V.

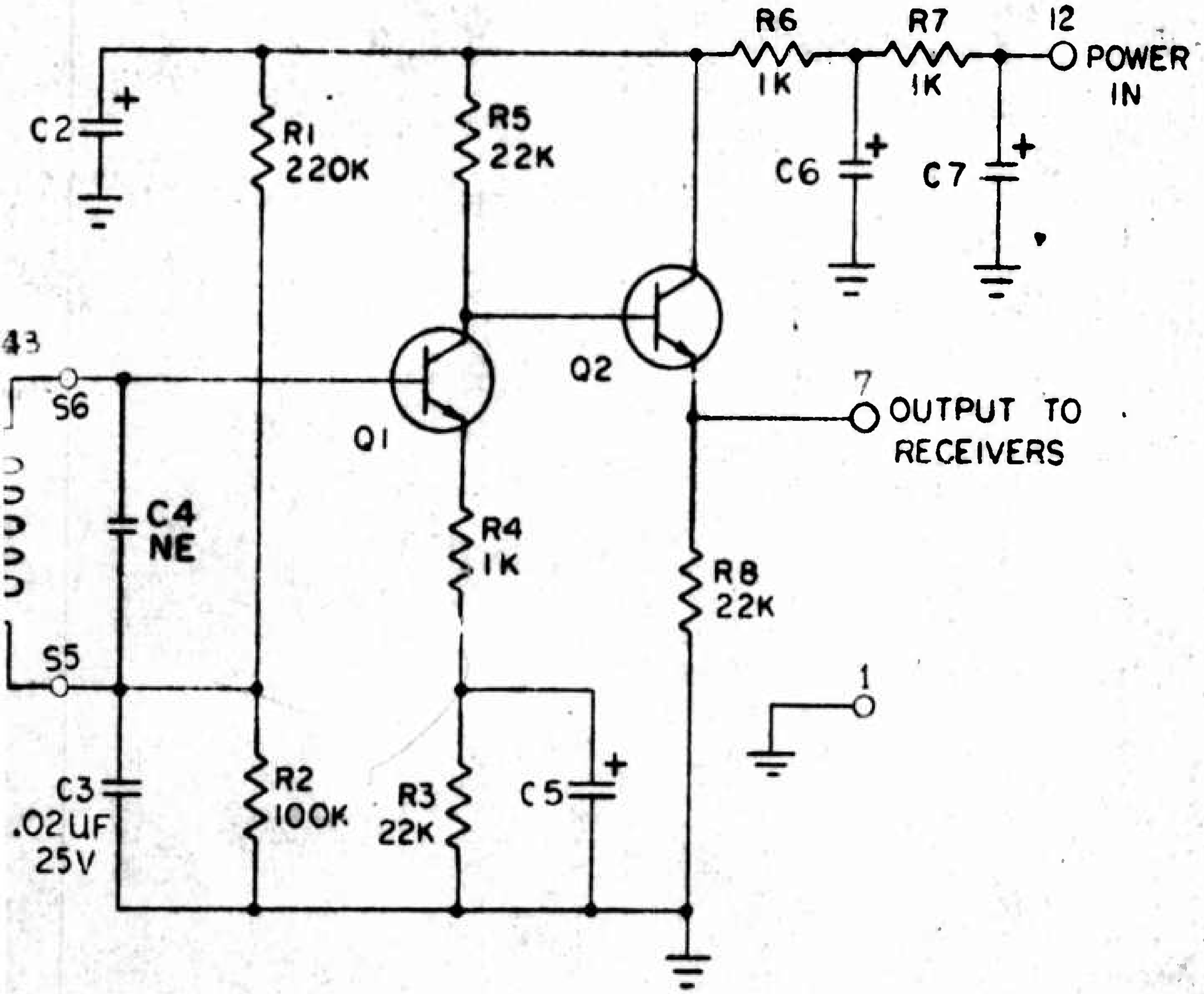
2 ALL TRANSISTORS ARE 2N3392.

3 ALL RESISTORS ARE 1/4W.





REV.	REVISIONS
A	



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

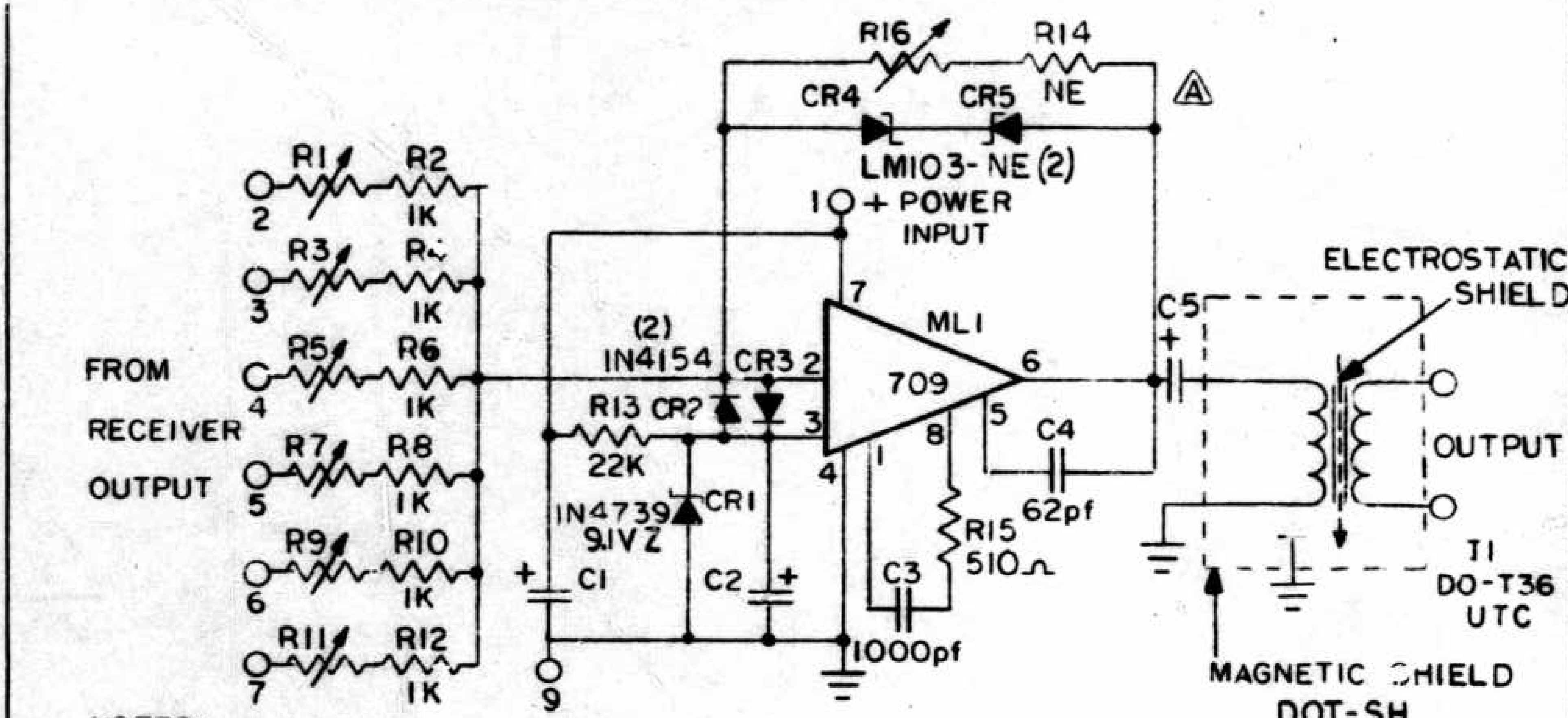
INPUT CIRCUIT SCHEMATIC
BB IV VLF ROCKET EXP.

AEROSPACE RESEARCH INC.
BOSTON, MASS.

SIZE	B
DWG. NO.	334-3006
SCALE	NA
SHEET	1 OF 3

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

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



NOTES:
UNLESS OTHERWISE SPECIFIED
1 ALL VARIABLE RESISTORS ARE HELITRIM # 58PR10K
2 ALL CAPACITORS ARE 6.8µF, 35VDC.

REV	REVISIONS	APP
A	PER ECO # 508	[illegible]
	MJC 7-29-69	
B	ECO # 596	[illegible]
	I.S. 4-10-70	

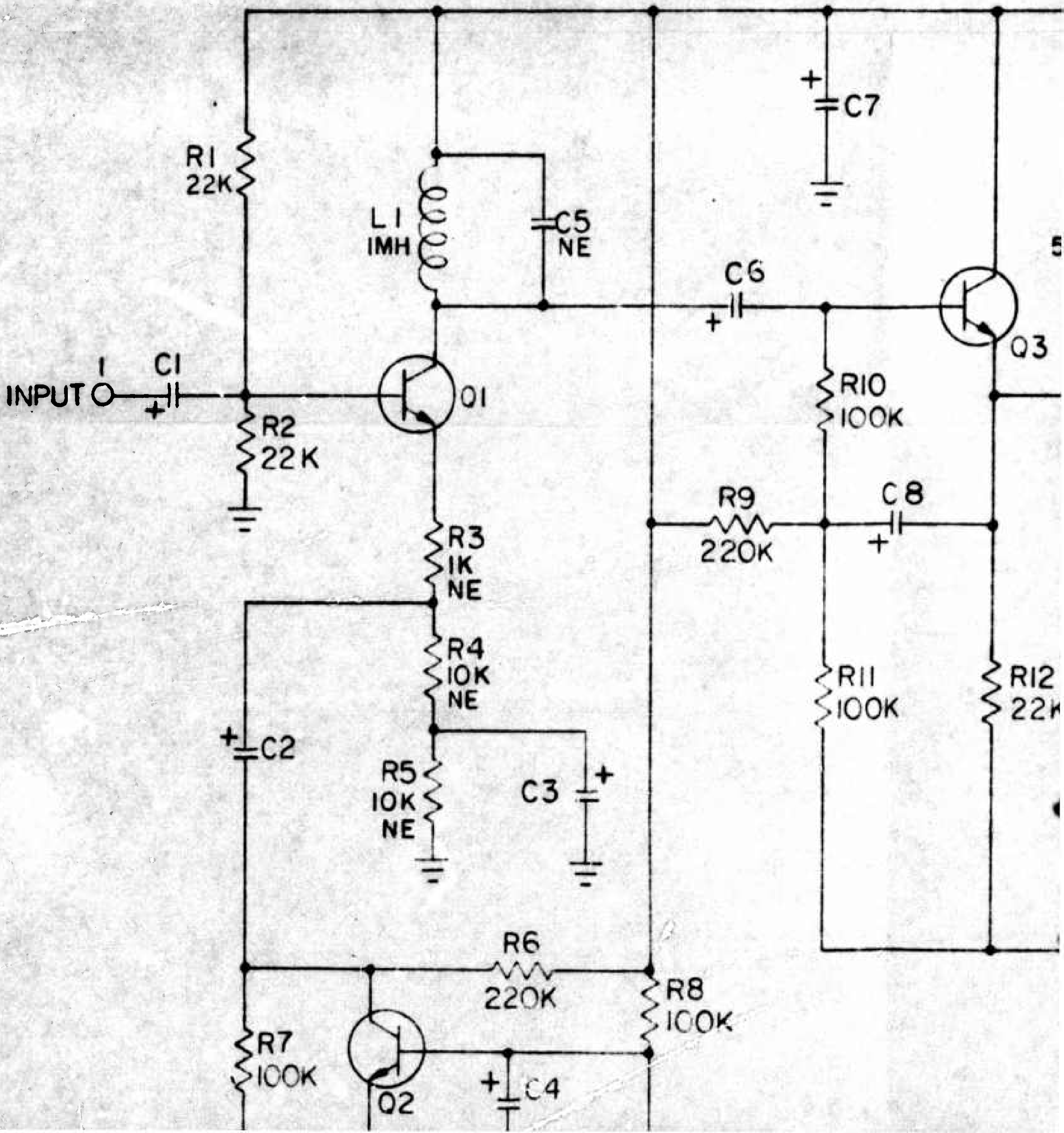
REMOVE ALL BURRS & BREAK SHARP EDGES. DO NOT SCALE DWG.
TOLERANCES: UNLESS OTHERWISE SPECIFIED. FRACT. ±1/64, DEC. 2PL ___, 3PL ±.005, ANG ___

OUTPUT AMPLIFIER CIRCUIT
SCHEMATIC –
BBIV VLF ROCKET EXP.

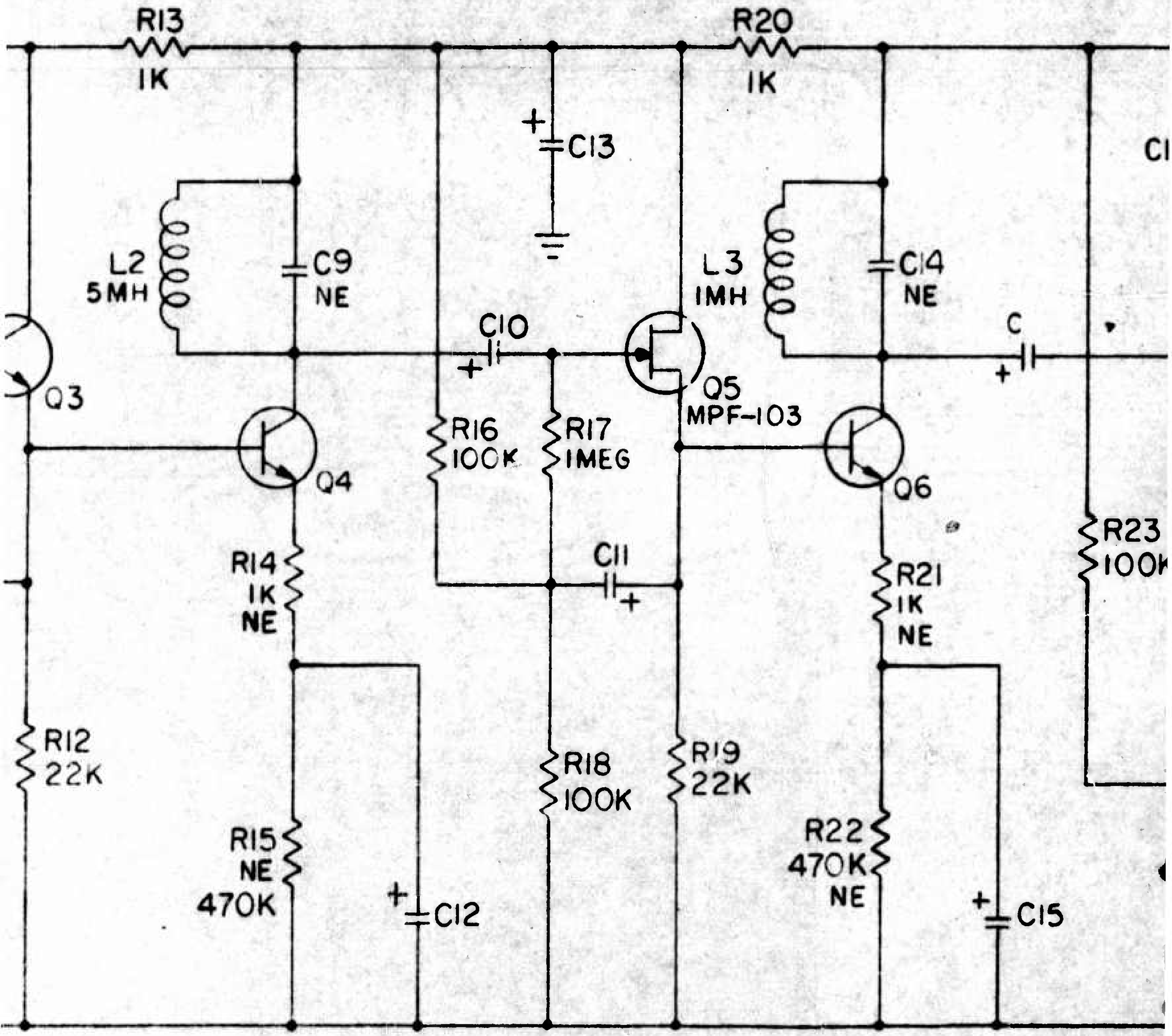
AEROSPACE RESEARCH INC.
BOSTON, MASS.

MODEL NO.	NEXT ASSY.	SIZE	DWG. NO.	REV.
DRAWN PB DATE 10-6-68	CHECKED [illegible] DATE [illegible]	A	300-3006	B
ENG. APPD. [illegible] DATE [illegible]	PROD. APPD. DATE	SCALE: [illegible]	SHEET 1 OF 1	

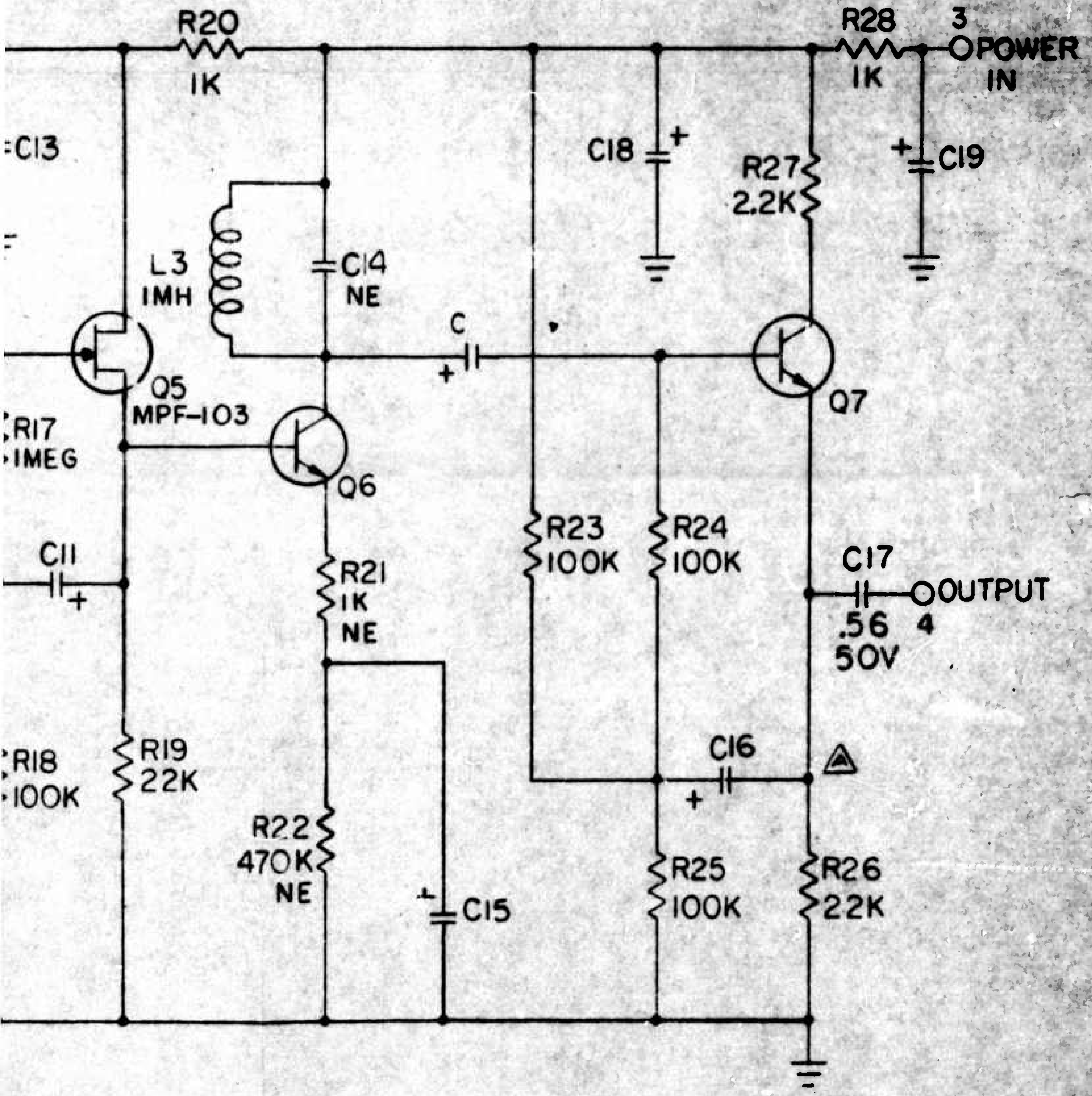
M



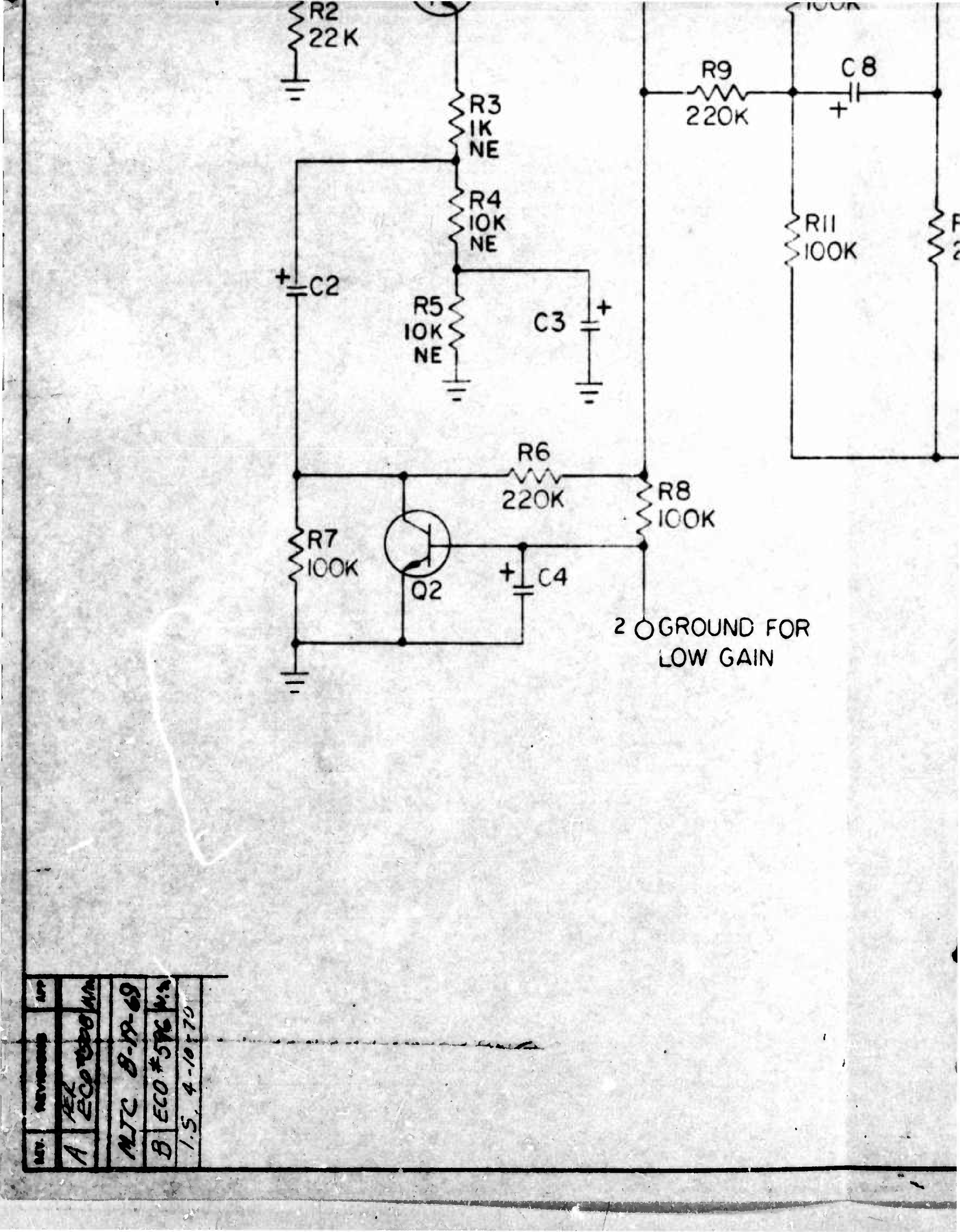
INPUT
1
C1
R1
22K
R2
22K
L1
1MH
C5
NE
Q1
R3
1K
NE
R4
10K
NE
R5
10K
NE
C2
C3
C6
C7
Q3
R10
100K
R9
220K
C8
R11
100K
R12
R6
220K
R7
100K
R8
100K
Q2
C4

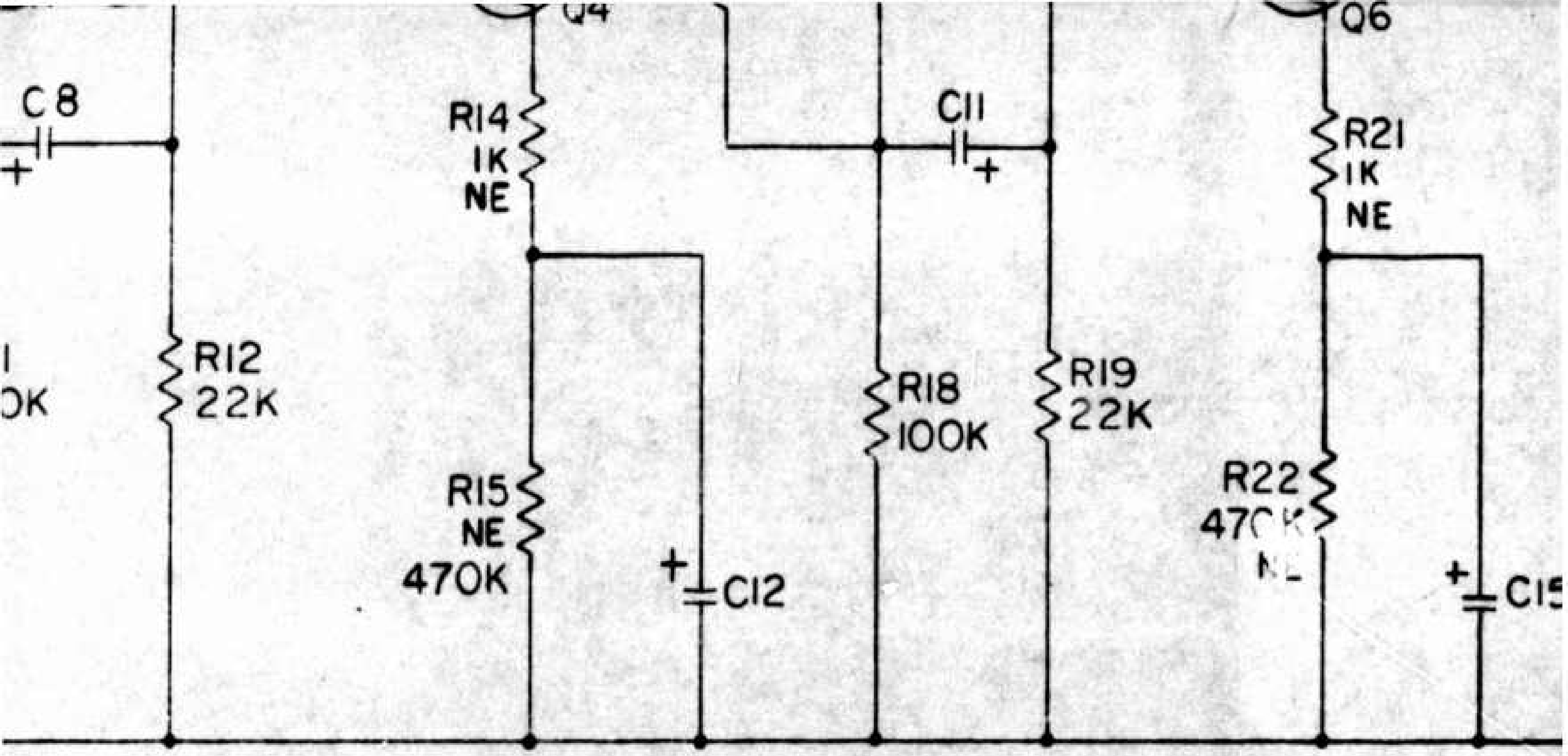

R13
1K
R20
1K
C13
L2
5MH
C9
NE
C10
L3
1MH
C14
NE
C
Q3
Q5
MPF-103
R16
100K
R17
1MEG
Q4
Q6
R23
C11
R14
1K
NE
R21
1K
NE
R12
22K
R18
100K
R19
22K
R22
470K
NE
R15
NE
470K
C12
C15

NOTES:



R20
1K
R28
1K
3
POWER IN
C13
C18
C19
R27
2.2K
L3
1MH
C14
NE
C
Q5
MPF-103
Q6
Q7
R17
1MEG
C11
R23
100K
R24
100K
R21
1K
NE
C17
OUTPUT
.56
50V
4
R18
100K
R19
22K
C16
R22
470K
NE
C15
R25
100K
R26
22K


R2
22K
R3
1K
NE
R4
10K
NE
R5
10K
NE
C2
C3
R9
220K
C8
R11
100K
R6
220K
R8
100K
R7
100K
Q2
C4
2 GROUND FOR
LOW GAIN
LTR.
REVISIONS
APP.
A
REL ECO
W.H.
MJC 8-19-69
B
ECO #576
W.H.
1.S. 4-10-70



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE 1/4W, ±10%.
2. ALL TRANSISTORS ARE 2N3392.
3. ALL CAPACITORS ARE 6.8µf, 35V.
4. L1, L3 ARE TOROTEL PC51-1.
5. L2 TENCO ARI T8528.

REQD.	REQD.	ITEM	PART NO.

REMOVE ALL BURRS & BREAK SHARP EDGES

DO NOT SCALE DWG.

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACT. ±1/64

DEC. 2PL.

3PL. ±.005

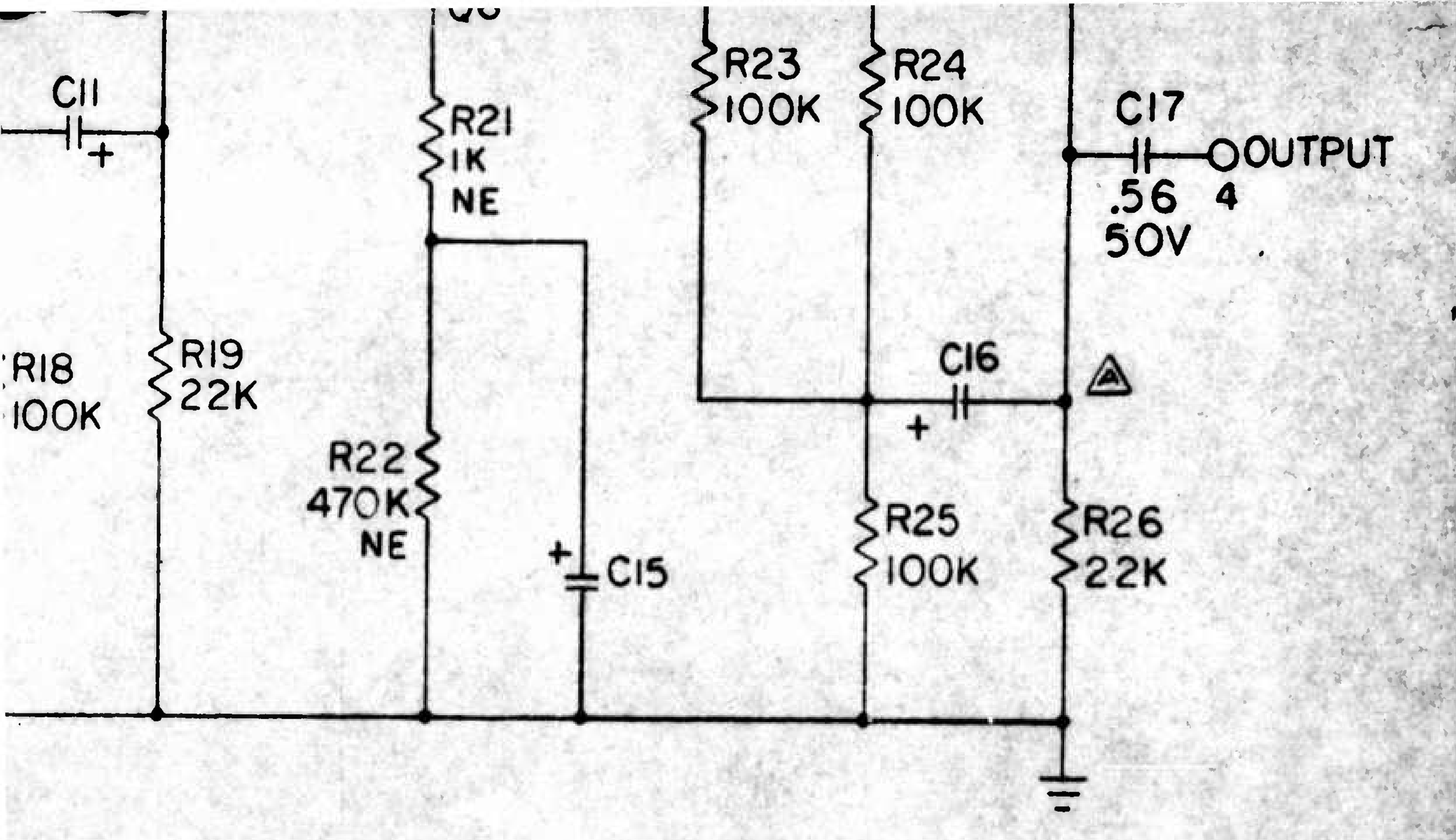
ANG.

RECEIVE
SCHE
BB IV VLF

MODEL NO.

DRAWN PB
DATE 10-7-68

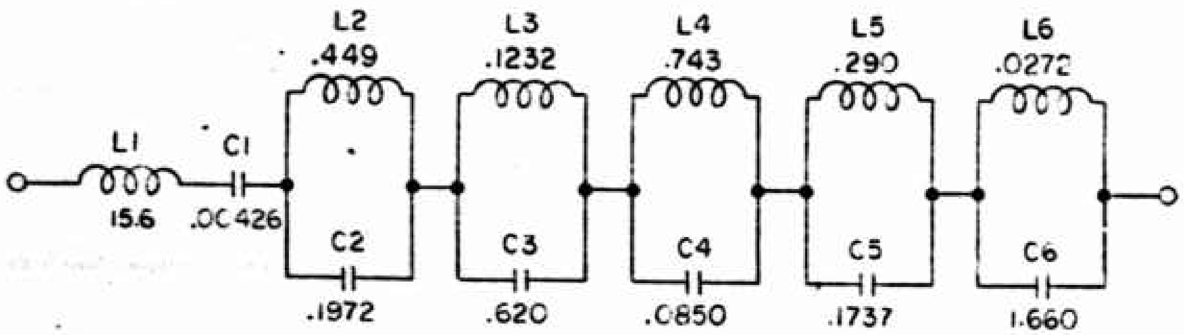
CHECKED
DATE 5-



SPECIFIED:
¼W, ± 10 %.
RE 2N3392.
6.8μf, 35V.
PC51-1.
28.

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.	RECEIVER CIRCUIT SCHEMATIC- BB IV VLF ROCKET EXP.		AEROSPACE RESEARCH INC. BOSTON, MASS.	
	MODEL NO.	NEXT ASSY.	SIZE C	DWG. NO. C300-3007	REV. B
	DRAWN PB DATE 10-7-68	CHECKED DATE 5-7-69	ENG. APPR. DATE	PROD. APPR. DATE	SCALE: SHEET



POLES	ZEROS
16.9 KHz	16.0 KHz
15.2 KHz	17.8 KHz
20.0 KHz	18.6 KHz
22.4 KHz	21.4 KHz
23.7 KHz	23.4 KHz
	24.0 KHz

NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL CAPACITORS ARE IN μf
2. ALL INDUCTORS ARE IN mh.
3. L1 IS THE ANTENNA INDUCTANCE

See the following pages for greater detail.

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

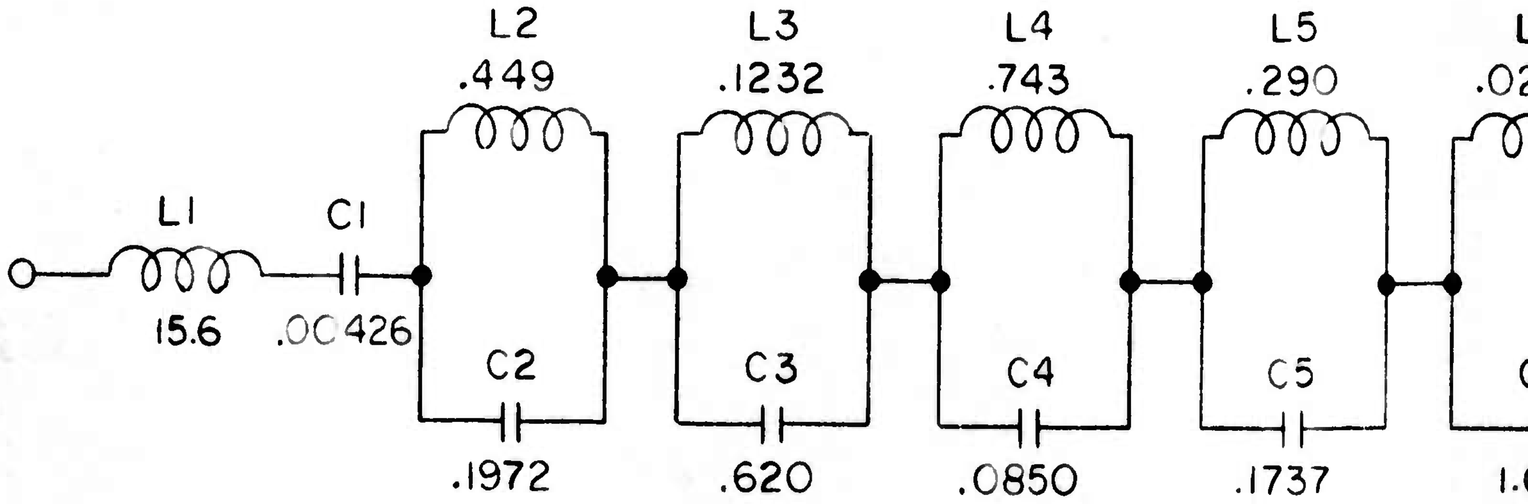
REMOVE ALL BURRS & BREAK SHARP EDGES
DO NOT SCALE DWG.
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACT. ±1/64
DEC. 2PL.
3PL. ±.005
ANG.

ANTENNA TUNING NETWORK
B3 IV VLF ROCKET EXP.

AEROSPACE RESEARCH INC.
BOSTON, MASS.

MODEL NO. | NEXT ASSY.
DRAWN I S | DATE 4 8 72
CHECKED | DATE
ENG. APPD. | DATE
PROD. APPD. | DATE
SIZE B | DWG. NO. 300-3022 | REV.
SCALE: — | SHEET 1 OF 1

REV. | REVISIONS | APP.

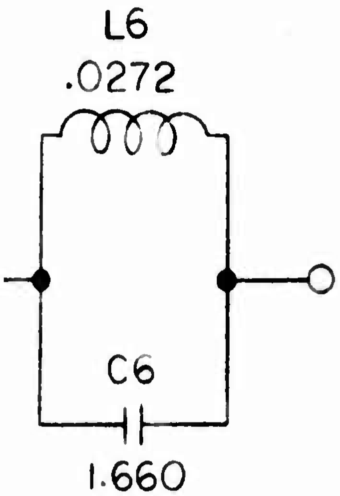


NOTES:

UNLESS OTHERWISE SPECIFIED:

1. ALL CAPACITORS ARE IN μf.
2. ALL INDUCTORS ARE IN mh.
3. L1 IS THE ANTENNA INDUCTANCE

REV. REVISIONS APP



POLES	ZEROS
16.9 KHz	16.0 KHz
18.2 KHz	17.8 KHz
20.0 KHz	18.6 KHz
22.4 KHz	21.4 KHz
23.7 KHz	23.4 KHz
	24.0 KHz

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.

ANTENNA TUNING NETWORK

BB IV VLF ROCKET EXP.

AEROSPACE RESEARCH INC.

BOSTON, MASS.

MODEL NO.

NEXT ASSY.

DRAWN I S DATE 4/8/70

CHECKED DATE

ENG. APPD. DATE 10 Apr. '70

PROD. APPD. DATE

SIZE B

DWG. NO. 300-3022

REV.

SCALE: ✗

SHEET 1 OF 1

M

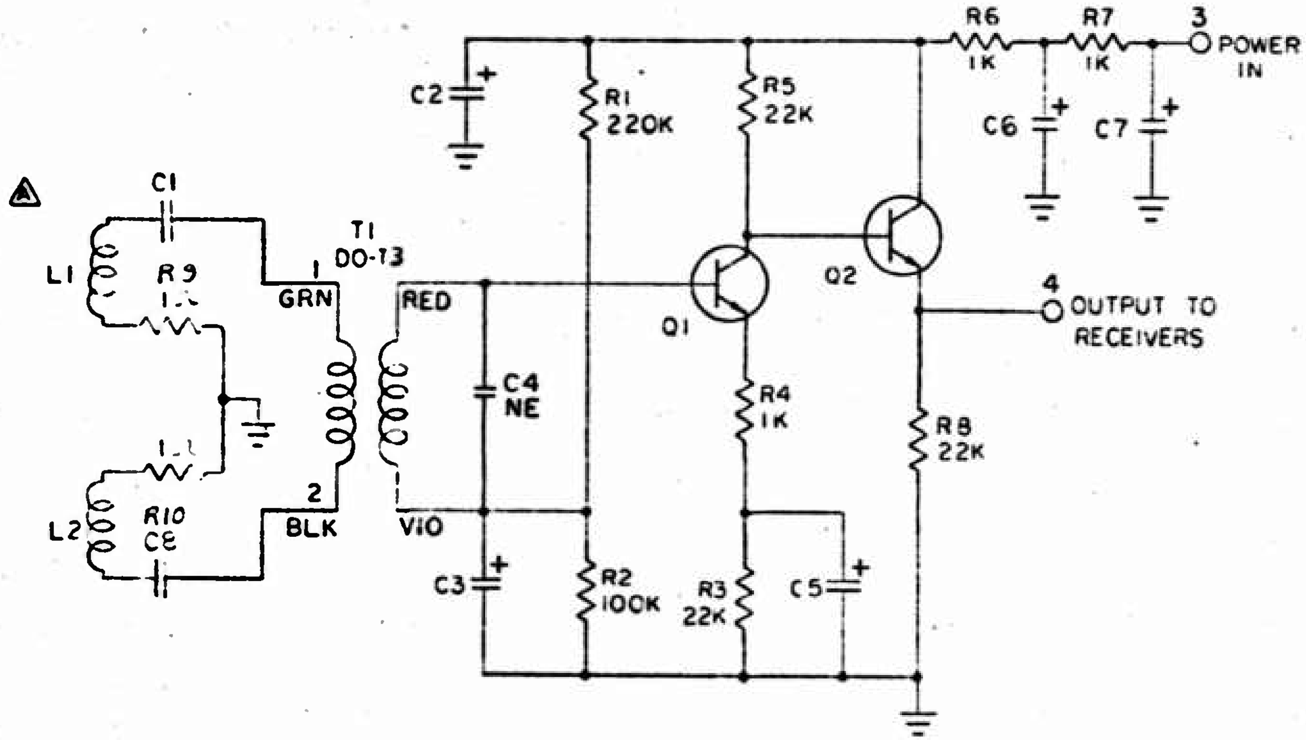
NOTES

UNLESS OTHERWISE SPECIFIED

1 ALL CAPACITORS ARE 6.8μf, 35V.

2 ALL TRANSISTORS ARE 2N3392.

3 ALL RESISTORS ARE 1/4W.



REV	REVISIONS	APP
A	ECO #508	
	MJC 8-19-69	
B	ECO #596	
	I.S. 4-10-70	

See the following pages for greater detail.

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

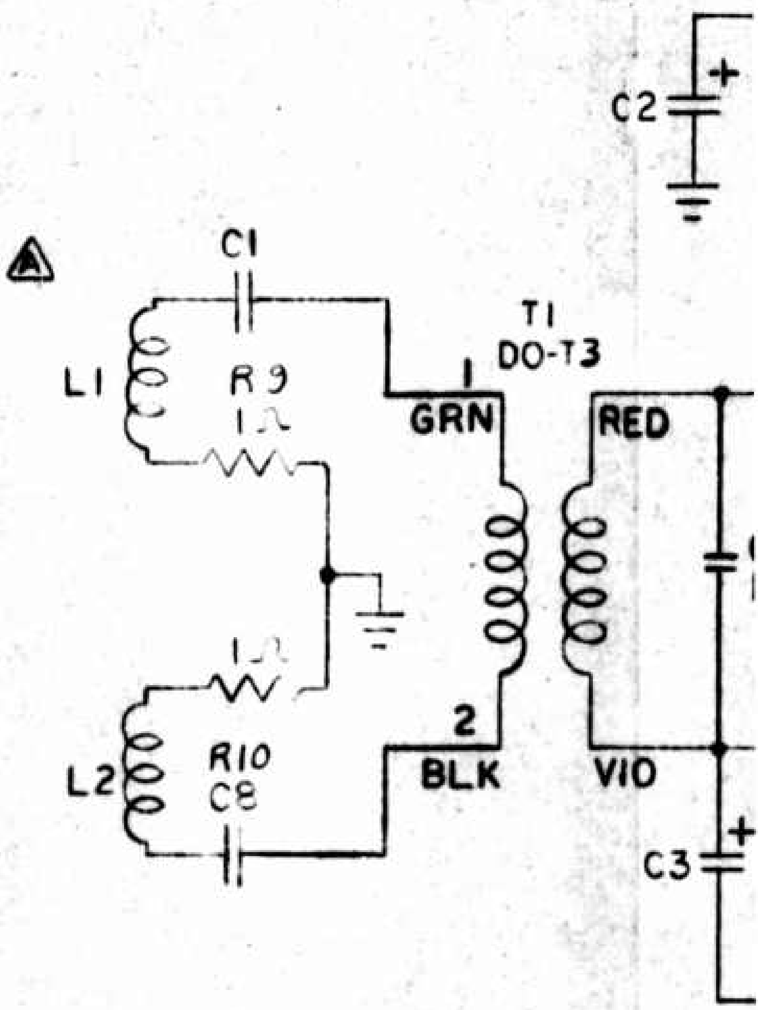
REMOVE ALL BURRS & BREAK SHARP EDGES
DO NOT SCALE DWG
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACT. ±1/64
DEC. .XX
.XXX ±.005
ANG.

INPUT CIRCUIT, SCHEMATIC— BBIV VLF ROCKET EXP.

AEROSPACE RESEARCH INC
BOSTON, MASS.

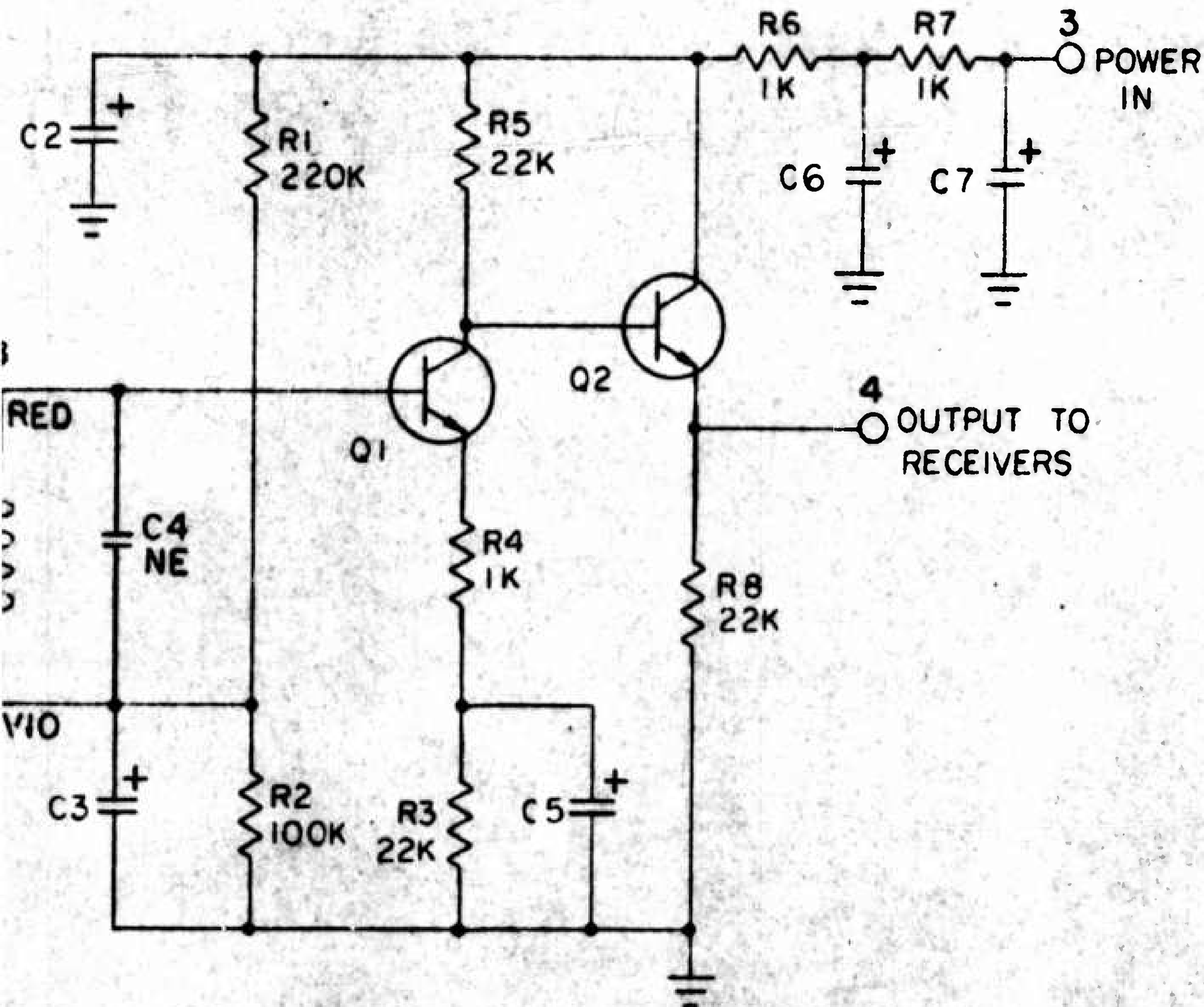
MODEL NO	NEXT ASSY.	SIZE	DWG NO	REV
DRAWN / DATE 10-7-68	CHECKED / DATE	ENG. APPD M.M. / DATE	PROD. APPD / DATE	B / 300-3008 / B

SCALE: NA SHEET 1 OF 1



NOTES
UNLESS OTHERWISE SPECIFIED
1 ALL CAPACITORS ARE 6.8μf, 35V.
2 ALL TRANSISTORS ARE 2N3392.
3 ALL RESISTORS ARE 1/4W.

REV	REVISIONS	APP
A	AER ECO #508	
	MJC 8-19-69	
B	ECO #596	
	I.S. 4-10-70	



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.

INPUT CIRCUIT, SCHEMATIC — BBIV VLF ROCKET EXP.

AEROSPACE RESEARCH INC.
BOSTON, MASS.

MODEL NO.		NEXT ASSY.	
DRAWN RB DATE 10-7-60	CHECKED DATE 5-7-67	ENG. APPD. M.M. DATE 7 May 67	PROD. APPD. DATE

SIZE	DWG. NO.	REV.
B	300-3008	B
SCALE: NA	SHEET 1 OF 1	