ITT INDUSTRIAL LABORATORIES

A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

3700 East Pontiac Street
Fort Wayne, Indiana 46803
Area Code 219
Telephone 743-7571
TWX 241-2065

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HIGH RESOLUTION NIGHTTIME

CLOUD-COVER RADIOMETER

QUARTERLY REPORT XVII

OCTOBER 1, 1965 TO JANUARY 1, 1966

Contributors

P. C. Murray, W. H. Wallschlaeger, R. Harber,
P. R. Sargent, J. Whitacre, P. Eagle, R. Miller

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Planetary Radiations Branch
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland

Approved by

K. L. DeBrosse, Manager
Space and Physical Science Dept.

Dr. C. W. Steeg Jr., Director
Product Development

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1.0 INTRODUCTION

Quarterly Report XVII covers work done on the High Resolution Infrared Radiometer under Modification 22 of Contract NAS 5-668 during the period from 1 October 1965 to 1 January 1966. Design reviews were held at ITT and at NASA during this interval. A Design Review Report has been made part of this report and also indicates the effort for the first half of this reporting period.

Following the Design Reviews, is a period devoted to design cleanup and finalization, the beginning of fabrication, parts procurement, test equipment modifications, and the generation of procedures and specifications.

2.0 DESIGN REVIEW

An initial Design Review was held at ITTIL on November 8, 9, and 10. In attendance for the project group were:

W. H. Wallschlaeger

P. C. Murray

P. R. Sargent

R. A. Harber

R. V. Annable

R. L. Miller

Representing Quality Assurance were Paul Eagle (Reliability) and J. Whitacre (Quality Control). From other groups were mechanical engineers H. S. Romanowski and J. Crawford and electrical engineers R. Foote and L. T. Hunkler.

A more formal review took place at NASA on November 15 and 16. In addition to W. Wallschlaeger, P. Murray, P. Sargent, and R. Harber of ITTIL were representatives from ORI, G. E., and various branches of NASA, GSFC.

The following sections give a brief explanation of the various electrical, optical, and mechanical elements of the HRIR much as they were presented during the reviews. In the appendix of this report are drawings and schematics which will be referred to in the course of the explanations. The sections covered are electronic design, optical design, mechanical design, and electronics packaging. For each block or assembly, under an area called Design Considerations, there are appropriate check lists.

2.1 Electronics Design

There are many differences between the electronics of Nimbus A and those designed for Nimbus B. There now will be three low impedance video outputs including one for real time readout and two for recording. Multiplexed with each output are the marker pulses and a seven voltage step calibration signal. The preamplifier and video amplifier have been redesigned while the chopper radiation correction signal is now produced in a completely electronic fashion. To effect a gain change for day to night signal level changes, the detector bias is switched by a relay controlled by the satellite cosine pot.

2.1.1 Preamplifier

The preamplifier provides low noise amplification of a signal from a high impedance source (the PbSe detector and load resistor). It features high input impedance, a low noise figure and a small amount of voltage amplification.

2.1.1.1 Operation

The circuit is shown in drawing No. 4708379. The first two stages combine for high power gain and a voltage gain of unity. Q1 is operated as a source follower, the output of which is bootstrapped to Q2, an emitter follower. This arrangement reduces the effects of the gate to source capacitance (31 pf), and the gate to drain capacitance (9 pf) of Q1. The total input capacitance is reduced to approximately 3 pf allowing operation at the 1500 cps chopping frequency.

The voltage amplification is provided by the third stage, Q3, and is approximated by the expression $YfsR_L/(YfsR16 +1)$, where R_L is the effective load resistance caused by R14, R15 and the input resistance of the video amplifier. The term gfs is the gate to drain transconductance. R16 provides some temperature stability, while judicious selection of resistor and sensistor values for R15 and R14 will further increase stability.

2.1.1.2 Design Considerations

a. Gain: The designed gain was 2.92:1 considering R_L = 2.3 k and yfs = 3600 μmhos. The measured gain was 2.7:1 at 25 degrees C.

b. Period: Not applicable.

c. Temperature Stability: −0.26 db at 50 degrees C, −0.22 db at 0 degrees C with respect to 25 degrees C value.

d. Noise Figure: Designed for best possible value for source impedances from 1 megohm to 3 megohms with 3 db highest acceptable. Actual: Measured less than 2 db over this range.

e. Input Impedance:

1. Designed for highest possible value.

2. Measured to be 58 megohms at 1500 cps.

2.1.2 Cell Bias Supply

The cell bias supply provides d-c current through the 3 megohm load resistor to the detector cell. The photoconductive change in resistance of the detector is seen at the junction of the detector and load resistor as a modulated 1500 cps signal. (Chopping frequency = 1500 cps.) The magnitude of this signal is directly proportional to the biasing voltage. It is because of this property that the cell bias is the initial choice as a means of changing the system gain for day-night operation.

2.1.2.1 Operation

The bias supply is merely a resistive attenuator with decoupling capacitors. It is powered from the -18 volt full time regulator directly during the night and has an additional series attenuator during the day. The switching is shown on the block diagram. The day-night override relay, when activated, causes a return to the night mode.

2.1.2.2 Design Considerations

a. Gain: The nighttime cell bias will be set between -3 volts dc and -18 volts dc to a value as near as possible to the optimum indicated by Eastman-Kodak data. For the daytime mode, the amount of attenuation will be increased by about 20 db. The actual figure will be arrived at after daytime testing of the instrument has been accomplished.

b. Period: Not applicable.

c. Temperature Stability: The attenuation is accomplished by passive resistive components. Any drift will be a function of the -18 volt regulator.

d. Noise Figure: Not applicable.

2.1.3 Cell Temperature Controller (4708379)

The purpose of this circuit is to accurately measure and control the temperature of the PbSe detector cell over the wide range of ambient casting temperatures. It has been shown previously that (1) the cell will cool to a maximum of approximately -85 degrees C with no external heat injected, and (2) that cell cooling is directly dependent on ambient temperature. Thus it becomes necessary to provide some means of closely controlling cell temperature at a mean value of about -78 degrees C.

2.1.3.1 Circuit Operation

A measurement of temperature is required both for external telemetry purposes, and to provide a reference for control. The primary measurement device is a miniature glass bead thermistor mounted on the radiation patch adjacent to the cell mounting stud. The actual circuitry will be discussed under "Telemetry Systems".

Control is accomplished by applying power to a micro-zener diode mounted on the radiation patch at the opposite end from the thermistor. By mounting at this point, sudden temperature changes are damped by the thermal delay through the patch material. Power is supplied to the diode in an "on-off" fashion, turning "on" when the thermistor voltage reaches a threshold point, and turning "off" when the voltage again drops below the threshold. In actual practice, a "hysteresis" effect is present, causing a small cycling of cell temperature. This is due to the circuitry, and also to the thermal lag in the patch.

Transistor Q5 serves as a high gain threshold amplifier, with the threshold set by CR1. As the voltage at base 1 reaches the zener voltage of CR1, current through Q5 (b), R24, and CR3 increases rapidly. At the peak point current of CR3, the diode switches to its high voltage state, turning on Q6. When Q6 is turned on, current is allowed to flow through the patch diode in series with current limiter R25. As the diode dissipates power, the temperature drops, reducing the thermistor voltage and the voltage at base 1 of Q5. As the tunnel diode current reaches the valley point current, the diode again switches to its low voltage state, turning off Q6. Some hysteresis is present due to the peak-to-valley current ratio of the tunnel. diode. At 25 degrees C, this hysteresis amounts to about 45 millivolts (TM voltage) or about 0.5 degree C in cell temperature. Current through the diode is limited to approximately 6.5 ma by R25, so that it injects on the order of 35 milliwatts of heat into the patch.

2.1.3.2 Design Considerations

a. Gain: Not applicable.

b. Period: Not applicable.

c. Temperature Stability: Temperature compensation is provided by adding CR2 in series with CR1, as the change in forward voltage is equal and opposite to the change in reverse voltage. A 1N4566A compensated zener diode has been tried with success and will probably be used in place of the series diodes. The 1N4566A has a stability of 0.005 percent/degree C, or 0.25 percent over the 0-50 degree range. Using the 1N4566A diode, the following results were obtained.

Temp.	Turn on (E_{TM})	Turn off (E_{TM})	Hysteresis
0^oC	1.582 V	1.511 V	71 MV
25^oC	1.577 V	1.534 V	43 MV
50^oC	1.570 V	1.532 V	38 MV

The change in hysteresis with temperature can be attributed to the current level changes in the tunnel diode.

d. Noise Figure: Not applicable.

e. Other: None.

2.1.4 Video Amplifier

The function of the video amplifier is to provide amplification, frequency shaping, gain adjustment and less than 600 ohms driving impedance.

2.1.4.1 Operation

The circuit diagram is shown in drawing No. 4708380. The four transistors are directly coupled to reduce the number of parts. The frequency response is controlled by the ratio of the feedback elements R12, C3 and R9, R10, R11, C2. Movement of the potentiometer wiper (R15) affords a gain variance of better than 7 db. R18 sets the output impedance to 511 ohms, a value maintainable over the extremes of the gain variation.

2.1.4.2 Design Considerations

a. Gain: A variation of 2:1 or 6 db was desired. The actual value is 7.4 db or 2.34:1. The minimum 1500 cps gain with the preamp is 270:1 so that an 8 mv detector signal causes a 6 volt p-p signal at the video amplifier output.

b. Period: Not applicable.

c. Temperature Stability: Measured with the preamplifier, the gain variations with respect to the 25 degrees C value were -0.18 db at 50 degrees C and -0.32 db at 0 degrees C.

d. Noise Figure: Not applicable.

e. Other: Bandwidth - Measured with the preamplifier and a source impedance of 2.5 megohms, the high and low frequency 3 db points were 530 cps and 4000 cps.

2.1.5 Quadrature Filter

The quadrature filter is the mixing point for the video and the correction signals. The input is a two-phase video signal and the output is corrected in a single phase by the addition of the correction signal.

2.1.5.1 Operation

The circuit diagram is shown on drawing No. 4708385. The quadrature filter consists of a demodulator, filter and modulator. The demodulator, composed of T1 and Q1 synchronously rectifies the video signal. The filter, L1, L2, C1 and C2 has a cutoff frequency of approximately 600 cps and removes the 1500 cps ripple. The correction signal is fed in at R1. It causes the rectified filtered signal to be entirely negative. T2 and Q2 remodulate this single polarity signal at 1500 cps for further processing in the logarithmic amplifier. The FI-0049 field effect transistors have a zero offset voltage and were chosen for handling the 1600:1 dynamic range of this signal.

2.1.5.2 Design Considerations

a. Gain: Approximately a 10 db loss due to a 2:1 insertion loss and the rectification and filtering constant 0.637 Ep.

b. Period: Not applicable.

c. Temperature Stability:

50 degrees C -0.06 db } with respect to 25 degrees C gain
0 degrees C +0.10 db }

d. Noise Figure: Not applicable.

e. Filter bandwidth: System bandwidth is 350 cps and is set by the output filter. This filter is set to cutoff at 600 cps so there is no effect on system. Actual exact cutoff value is not important as long as it is near 600 cps.

2.1.6 Logarithmic Amplifier

The logarithmic amplifier reduces the dynamic range of the signal by providing low gain for high signals and high gain for low signals. The dynamic range of signals from the detector is about 1600:1.

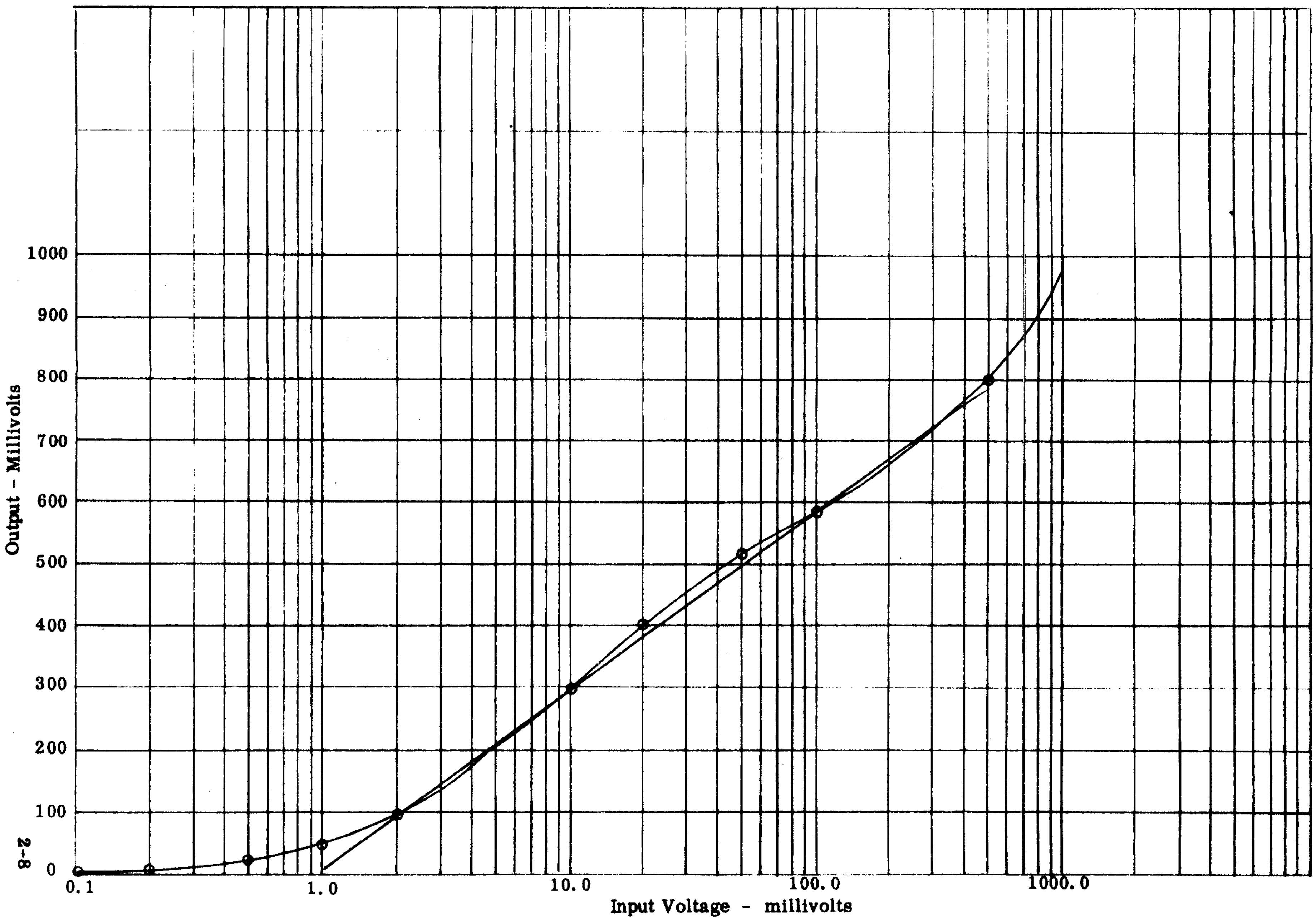
2.1.6.1 Operation

The logarithmic amplifier circuit diagram is shown in drawing No. 4708385. It consists of three operational amplifiers each with two definite gain modes. Consider the first stage amplifier built around Q3. The four diodes in series with R15 and the collector of Q3 are germanium (1N277s). The d-c current through these diodes partially bias the silicon feedback diodes shown between terminals 1 and 2 and 4 and 5 on the diode module.

The low signal gain of the amplifier is set by the ratio of R13 to R43. As the signal increases, the feedback diodes become more conductive until the gain becomes the ratio of R13 paralleled with R9 and R12 to R43. The output stage, Q6 etc., serves as a driver for the three output amplifiers and provides gain adjustment of about 6 db.

2.1.6.2 Design Considerations

a. Gain: The design objective was to reduce the dynamic range of the signal from 1600:1 to 150:1 or less. The 150:1 corresponds to the range of target temperatures between 190 degrees K and 340 degrees K. The dynamic range of the output can be adjusted by varying the video amplifier gain and the output stage of the log amplifier. The dynamic range can then be reduced between 16:1 and 50:1. The graph illustrates the gain characteristic of the amplifier.



Output - Millivolts
1000
900
800
700
600
500
400
300
200
100
0
0.1
1.0
10.0
100.0
1000.0
Input Voltage - millivolts

b. Period: Not applicable.

c. Temperature stability: Due to the many non-linear elements involved in this circuit, the design goal was to achieve a variation of ± 1 db or less between 0 degrees C and 50 degrees C with respect to the 25 degrees C value. The circuit diagram shows the many tailor points included for this purpose. The following table demonstrates the stability of the breadboarded amplifier.

Ambient Temperature	0°C	10°C	25°C	40°C	50°C
Input Signal (Millivolts)	Gain in db				
0.2	35.04	34.80	34.32	33.98	33.64
0.5	33.80	33.90	33.66	33.44	33.18
1.0	33.80	33.86	33.78	33.54	33.26
2.0	33.52	33.62	33.52	33.24	32.96
5.0	32.54	32.54	32.38	32.04	31.74
10.0	29.68	29.54	29.50	29.26	29.04
20.0	26.18	26.06	26.02	25.80	25.52
50.0	20.48	20.42	20.34	20.18	20.00
100.0	15.54	15.52	15.42	15.30	15.20
200.0	10.36	10.42	10.38	10.34	10.22
500.0	3.96	4.08	4.08	4.08	4.08
1000.0	-0.44	-0.34	-0.20	-0.16	-0.12

d. Noise figure: Not applicable.

2.1.7 Output Amplifier, Demodulator, and Low-Pass Filter

The output amplifier provides the power drive necessary to obtain a 6 volt signal across a 600 ohm termination. The demodulator synchronously rectifies the 1500 cps signal and the information bandwidth is set by the low-pass filter. The necessary bandwidth for a field of view of 7.2 milliradians and a 48 rpm scanning rate is about 350 cps.

2.1.7.1 Operation

The circuit schematic is shown on drawing No. 4707700. The amplifier operation is similar to class AB push-pull, i.e., the transistors are biased partially on to prevent crossover distortion. Temperature stability is achieved by the judicious use of sensistors. C6 tunes the primary and eliminates distortion and inefficiency due to switching spikes etc.

In the demodulator section, field effect transistors Q10 and Q11 operate as switches which are opened by a negative gate to source voltage and closed by a zero or positive gate to source voltage. Under normal operation Q10 is closed when a negative going signal appears at terminal one of T2 and Q11 is closed when a negative signal is present at terminal 3. A negative rectified signal then appears at the junction of the sources of Q10 and Q11. The "on" resistance of the CM602 is a maximum of 50 ohms which causes only a small loss in efficiency.

2.1.7.2 Design Considerations

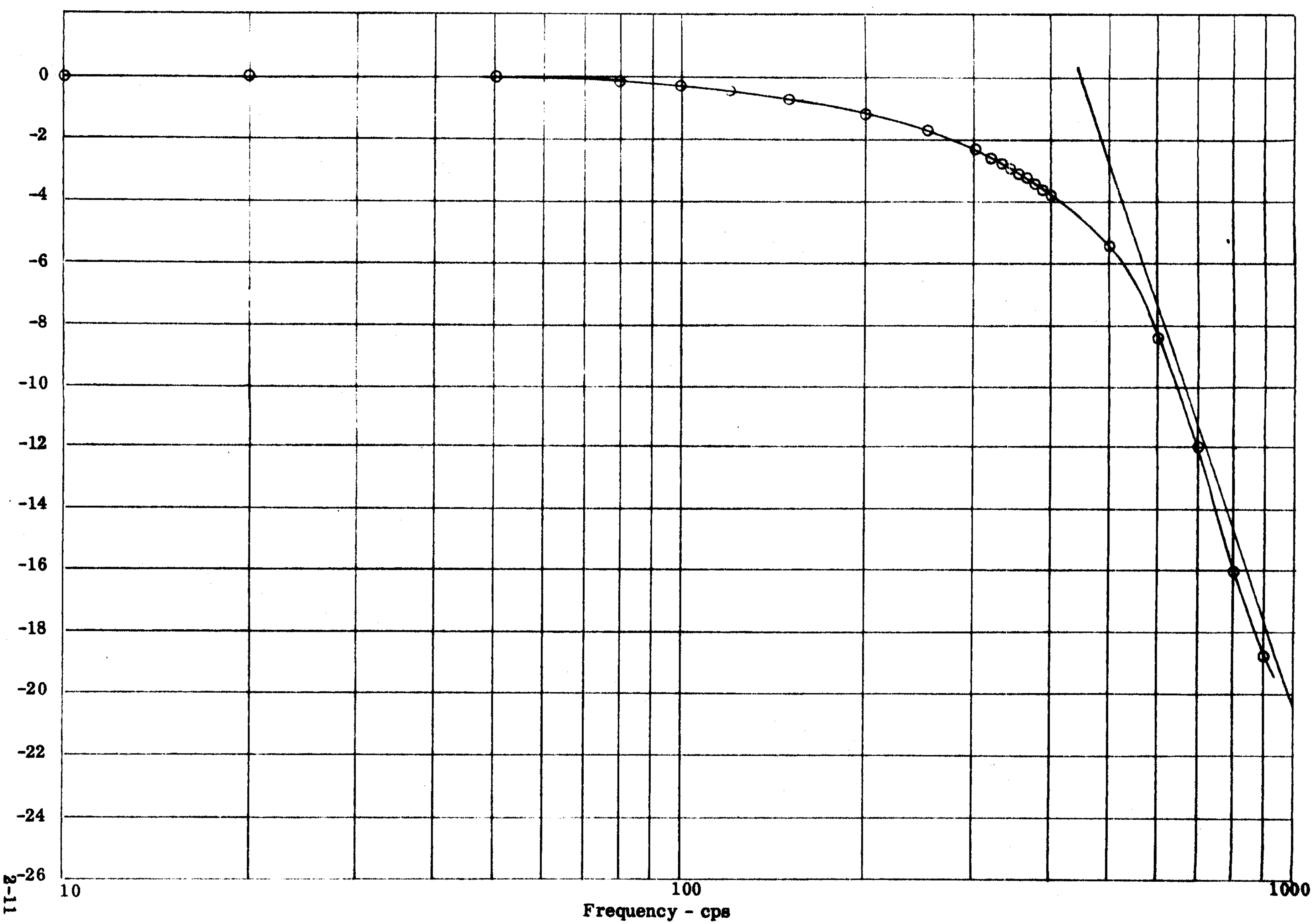
a. Gain: The gain as measured is 6.5 volts d-c per volt rms. The system frequency response is shown on the graph. Since other video chain elements have an effect on system response, the total system rather than just the low-pass filter response is measured.

b. Period: Not applicable.

c. Temperature stability: No data available as yet.

d. Noise figure: Not applicable.

e. Other: Delay - The filter has a nearly constant delay over the frequency range from 0.1 cps to beyond cutoff. The measured value is about 1.6 milliseconds.


0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
10
100
1000
Frequency - cps

2.1.8 Marker Generator (4708378)

The function of the marker generator is to provide a series of seven marker pulses, each 6 msec long and separated by 6 msec, once each scan during the space "look" preceding the earth scan. Total pulse train width is to be 78 msec ± 1 msec, and pulse amplitude is to be 5.75 volts ± 0.025 volts.

2.1.8.1 Operation

Timing is initiated by a magnetic pickup mounted on the motor mount adjacent to the large scan gear. A steel slug is mounted on the gear at a position corresponding to the proper mirror position. As the slug passes the pickup pole piece, a positive and negative pulse is generated, one at the leading edge and one at the trailing edge. This pulse is fed to an amplifier stage (Q2) where it is amplified and inverted.

The negative going pulse is used to trigger a 78 msec monostable multivibrator (Q4-Q6), which in turn gates on a free-running multivibrator (Q8-Q11). This multivibrator is adjusted for a frequency which yields the proper pulse width and spacing.

After amplitude limiting by CR10, the pulses are fed through CR16 to a complimentary emitter follower Q18. CR16 acts as a subtraction element to eliminate a residual -0.4 volt base line caused by leakage through R32, R39, and R42. The pulses are fed out through a 568 ohm resistor giving an equivalent output impedance of nearly 600 ohms.

2.1.8.2 Design Considerations

a. Gain: Not applicable.

b. Period: The two primary design criteria are the gate pulse width and the astable frequency. If the frequency can be set accurately, the gate pulse can have a rather "sloppy" tolerance. The limits of the astable frequency can be determined by:

$$f = \frac{1}{t} \quad \text{where } t = \frac{T}{6.5}$$

or:

$$f = \frac{6.5}{T} \quad \text{where } T = \text{pulse train length.}$$

Using this relation, the frequency is determined to be 83.3 cps ± 1 cps for 78 msec ± 1 msec pulse train duration. This is adjusted by R31 and R39 (4708378).

The gating pulse may be any length between 78 msec and 84 msec, which corresponds with the leading edge of the eighth pulse. This pulse width is adjusted by R14 and R17.

c. Temperature stability: Temperature compensation of the astable is provided by sensistor R44, and for the monostable R19. The emitter follower Q18 inherently has a nearly zero temperature coefficient due to the complimentary design. Results of temperature tests are tabulated below.

Temp.	Frequency	Period	Amplitude
0^oC	84.0 cps	80.8 ms	-5.5 V
25^oC	83.5 cps	79.8 ms	-5.6 V
50^oC	83.4 cps	77.8 ms	-5.6 V

Using these test results, preliminary specification can be set for the two adjustable values during board tailoring. These should be 83.3 cps $^{+0.5}_{-0.8}$ cps for the astable, and 80 msec $^{+4}_{-0}$ msec for the monostable. These take into account both the specified tolerances and the temperature stability.

d. Noise figure: Not applicable.

e. Other: The marker generator must also supply a positive-going pulse to the output multiplexer to open the marker mux-gate during the time pulses are being generated. This is available at Q6 collector and is fed out on pin D. This same pulse is inverted by Q17 and "ORed" with the calibration pulse to provide a video gate pulse to turn off the video mux-gate during pulse generation.

2.1.9 Calibration Step Voltage Generator (4708378)

In order to facilitate checkout of equipment and circuits processing the radiometer output with respect to linearity and distortion, a calibration signal is multiplexed into the video signal during a portion of the "backscan". This signal comprises a step voltage, 0-6 volts, in one volt steps.

2.1.9.1 Circuit Operation

Since the only accurate measure of angular scan position is the synchronizing pulse train, this is the logical point at which to begin the timing cycle of the calibration. The center of the "backscan" occurs approximately 950 msec after the first sync pulse, and this scan period extends about 95 msec either side of the center, or "straight up" position. Thus a delay of about 900 msec is introduced using a monostable multivibrator (Q1 - Q3) triggered from the leading edge of the marker gate pulse. The trailing edge of this delay pulse triggers a monostable gate circuit (Q5 - Q7) having a period of 1/3 of the backscan, or approximately 65 msec. This pulse is used to gate on a 100 cps free-running multivibrator for 6-1/2 cycles, much the same as in the marker generator.

These pulses are fed to the actual step voltage generator (Q13). Operation of this circuit is dependent on the fundamental expression:

$$V = \frac{Q}{C}$$

where:

C = capacitance in farads

Q = charge in coulombs

V = potential difference in volts

Since charge is a measure of current and time, the expression may be written:

$$V = \frac{It}{C}$$

where:

I = current in amperes

t = time in seconds

Since Q13 is essentially a constant current generator, and the value of C20 is a constant, we have:

$$V \quad \alpha \quad t$$

Now, if the circuit values are adjusted such that the period (t) of one positive-going pulse causes a voltage (V) of 1 volt, then each successive period (t) will cause an additional volt of potential to be added to the previous value, assuming negligible discharge between pulses.

Transistor Q16 serves a twofold purpose. It is a very high input impedance d-c amplifier to minimize capacitor discharge and thus minimize "droop" between steps. In addition, it has a very low output impedance, allowing the circuit output impedance to be determined by the series resistor R61.

Transistor Q14 is used to fully discharge C20 between scans. This transistor is turned off during the stepping period, and turned on at the completion of a staircase of 6 volts. Triggering is accomplished by inverting the 65 msec gate signal in Q19 and applying this level to the transistor gate electrode.

2.1.9.2 Design Considerations

a. Gain: The effective "gain" of the step voltage generator is dependent on the amplitude of the input pulses. Since these pulses are shaped by C18 and R50, gain, or step amplitude, is set by the potentiometer R50.

b. Period: The delay period from marker pulse to step voltage generation is set by adjusting the value of R9 and R2. The exact period necessary will be determined empirically.

The frequency can be determined in the same manner as in the marker generator, using:

$$f = \frac{6.5}{T}$$

Since we want the duration of the step voltage signal to be 65 msec, the frequency must be 100 cps. This is set by resistors R36 and R45. The imposed tolerance will be arbitrarily set at ± 1 cps.

The gating pulse length must be less than 64.6 msec to avoid generating a seventh step, and greater than 61 msec to allow least a 5 msec sixth step. This period is set by R16 and R25.

c. Temperature stability: Temperature compensation of the two monostable circuits is provided by sensistors R12 and R28, and for the astable, R48. Sensistor R52 compensates the step generator by varying the amount of degeneration to offset the change of transistor gain with temperature. Of particular concern is the temperature stability of the input capacitor C18, which largely determines the magnitude of the input current pulses. In this regard, a test was made of several types of capacitors at both temperature extremes. Results are shown in Table I. As can be seen, the Scionics Type SCM demonstrated excellent stability throughout the range, and was chosen for use in this application.

Results of other temperature tests are tabulated below:

Temp.	Relay	Gate	Freq.	6th Step
0°C	915 ms	66 ms	99.6 cps	-5.75 V
25°C	907 ms	65.5 ms	101.0 cps	-5.85 V
50°C	899 ms	64.4 ms	101.1 cps	-5.75 V

Using these test results, preliminary specifications can be set for the adjustable values during board tailoring. These should be 100.5 ± 0.5 cps for the astable, and 61.5 msec to 63.3 msec for the monostable gate. These take into account both the specified tolerances and the temperature stability.

d. Noise figure: Not applicable.

e. Other: The step voltage generator must also supply a positive going pulse to the output multiplexer to open the calibration mux-gate during the time steps are being generated. This is available at Q7 collector and is fed out on pin M. This same pulse is inverted by Q19 and "OR ed" with the marker gate pulse to provide a video gate pulse to turn off the video mux-gate during step generation. This operation is performed by Q10, CR12, and CR14.

Table I Capacitor Temperature Stability Comparison

Temp. (^{o}C)	Scionics SCM 30 D	Hopkins P15P5D	Hopkins 1P2D	Sprague 114P1041R352	Good-All CP09A1KC104K	Cornell-Dubilier	Plastic Cap. AM2-104	T. I. SCM6
-30	0.1000	0.0915	0.0095	0.1020	0.0940	0.1000	0.0975	0.0833
-10	0.1000	0.0950	0.0930	0.1010	0.0945	0.1050	0.0987	0.0850
+10	0.1020	0.0970	0.0950	0.1020	0.0945	0.1022	0.0995	0.0880
+20	0.1000	0.0980	0.0960	0.1050	0.0942	0.1030	0.1005	0.0900
+40	0.1000	0.0985	0.0975	0.1000	0.0945	0.1030	0.1005	0.0930
+60	0.0960	0.1100	0.0990	0.1000	0.0950	0.1035	0.1005	0.0970

2.1.10 Output Multiplexer (4707700)

The purpose of this circuit is to receive information from the marker generator, step-voltage generator, and video demodulator, and properly channel this information into the proper linear time slot on a single output line. This multiplexer is duplicated three times to provide the required three isolated output lines.

2.1.10.1 Circuit Operation

Transistors Q2, Q3, and Q4 act as an on-off series switch according to the d-c potential applied to the gate electrode. The three modes of signal information are applied to the drain electrodes of each gate, while all source electrodes are tied to a common output line, pin B. The gate signals are derived from the information source circuits as previously described in the marker and step-voltage generator discussions. These pulses must be positive going for turn on, zero volts providing full-on operation at zero volts source voltage. The resistance of the CM602 transistor is nominally 35 ohms, which results in negligible loss when working into a 50,000 ohm load. The diode-resistor combination in each gate line enhances switching operation and prevents feedback of transients. The sequence of switching is shown in Figure 1.

2.1.10.2 Design Considerations

a. Gain: Not applicable.

b. Period: The periods involved in the switching sequence were discussed in previous blocks.

c. Temperature stability: Results of temperature tests are tabulated below. During this test a steady d-c voltage was fed to all gates through 221 ohm isolation resistors, and the output was terminated in 47K.

Ein	Eo (0°C)	Eo (+25°C)	Eo (+50°C)
-0.5 V	0.494	0.499	0.485
-1.0 V	0.996	0.991	0.990
-1.5 V	1.490	1.491	1.488
-2.0 V	1.987	1.989	1.992
-3.0 V	2.988	2.989	2.983
-4.0 V	3.974	3.982	3.973
-5.0 V	4.972	4.964	4.971
-6.0 V	5.964	5.960	5.960

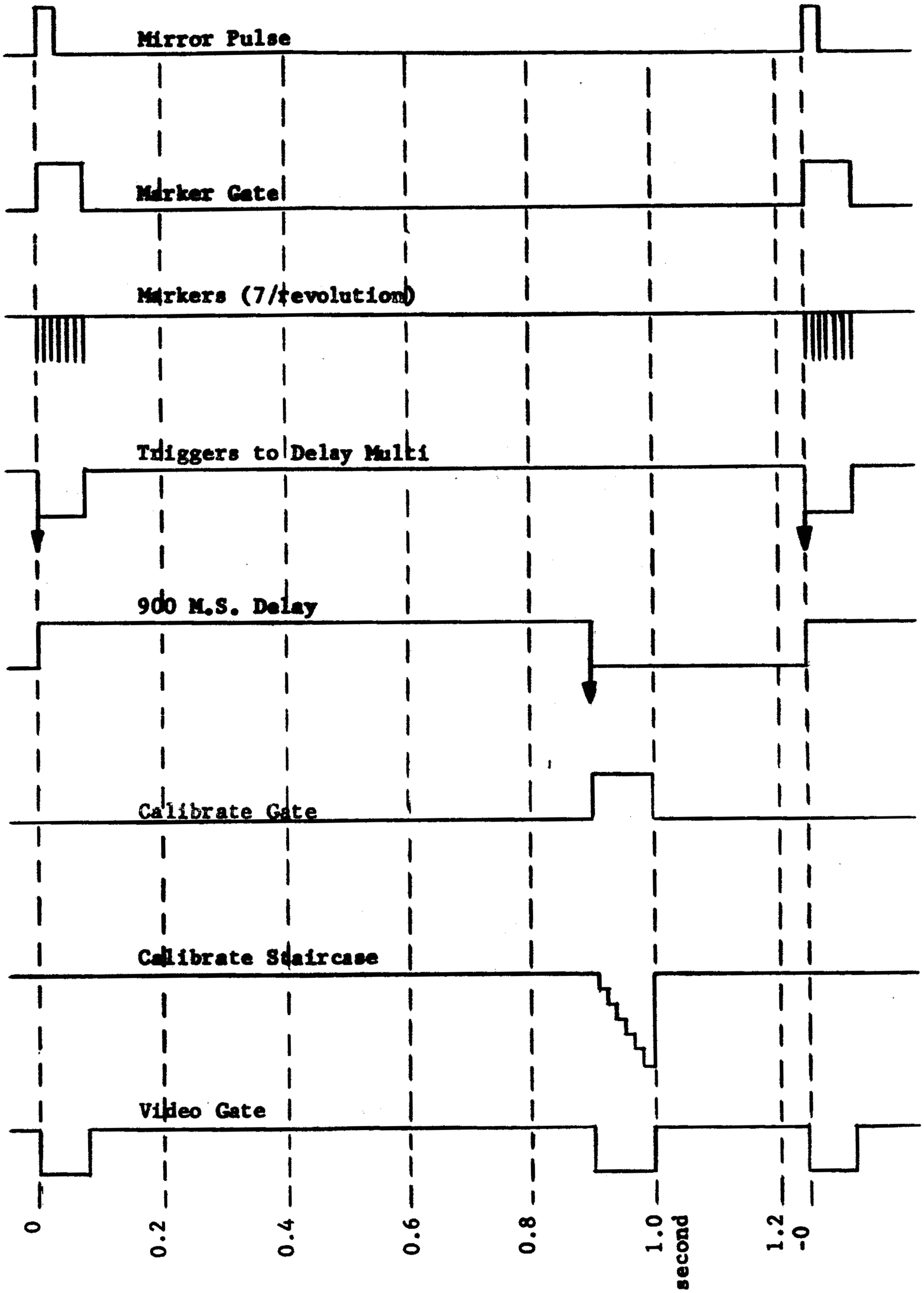


Figure 1 Timing Chart for Nimbus B HRIR

d. Noise figure: Not applicable.

e. Other: One additional design criteria is the required gate voltage for turn-off condition. The CM602 has a nominal -7.5 volt pinch-off voltage rating (voltage required between gate and source for turn-off). Thus if the source is at zero volts (no signal) the required gate pulse is only zero to -7.5 volts. However, when the source is at -6 volts (full signal), a 13.5 volt pulse is required for turn-off. In all cases, the gate pulse was made a minimum of zero to -14 volts to assure proper pinch-off of the series gate transistors.

2.1.11 -18 Volt Regulator (4708364)

The purpose of this circuit is to provide a high degree of input and load regulation for the primary d-c power to all electronic circuits within the radiometer, and to prevent wide fluctuations in loading from feeding back to the spacecraft battery line.

2.1.11.1 Circuit Operation

The circuit operates as a conventional series regulator, using the zener diode CR2 as the primary reference element. Q1 serves as a difference amplifier, amplifying the difference between the reference in the emitter and the voltage across R14, R15. The combination Q2, Q3 and Q6 forms a Darlington amplifier to provide the required current gain. Q3 and Q6 are paralleled to handle the high power dissipation demanded in the series element. The CR1-CR8 diode combination is in series with the input line to prevent damage to the regulator and succeeding circuits in case the input polarity is inadvertently reversed. The parallel combination is required due to the high current involved.

2.1.11.2 Design Considerations

a. Gain: Not applicable.

b. Period: Not applicable.

c. Temperature stability: Temperature compensation is provided by sensistor R14. Maximum variation in output voltage from +5 degrees C to +45 degrees C is 0.84 percent with 22 to 30 volts input and 0 to 200 ma loading.

d. Noise figure: Not applicable.

e. Input regulation: Measured input regulation is tabulated below using -24.5 volts input ± 8.15 percent (22.5 volts to 26.5 volts), and output loading from zero to 400 ma.

0 ma	100 ma	200 ma	300 ma	400 ma
±0.43%	±0.45%	±0.45%	±0.51%	±0.57%

The specified spacecraft power is -24.5 volts ± 2 percent regulated.

f. Load regulation: Measured load regulation is tabulated below at three input voltages and up to 400 ma loading.

Ein	0	100 ma	200 ma	300 ma	400 ma
22.5 V	-	0.115%	0.115%	0.23%	0.4%
24.5 V	-	0.057%	0.057%	0.114%	0.171%
26.5 V	-	0.057%	0.057%	0.057%	0.114%

The above measurements were made using a single series transistor so that at high current levels the dual transistor should improve load regulation.

2.1.12 -18 Volt Telemetry Regulator (4708364)

The purpose of this circuit is to provide voltage regulation for all telemetry circuits, thus enhancing the ultimate accuracy of a measured parameter.

2.1.12.1 Circuit Operation

Operation is much the same as in the primary -18 volt regulator, using a zener diode CR6 as the reference element. A single stage difference amplifier Q4 drives the series regulating element, Q5. Again the input power is fed in through a series diode CR7 to prevent damage by polarity reversal.

2.1.12.2 Design Considerations

a. Gain: Not applicable.

b. Period: Not applicable.

c. Temperature stability: Temperature compensation is provided by sensistor R20. Maximum variation in output voltage is from +5 percent to +45 degrees C is 0.5 percent with 22 to 30 volts input and 0–18 ma loading.

d. Noise figure: Not applicable.

e. Full time telemetry: Full time capability is achieved by operating the regulator directly from the spacecraft regulated buss prior to the command relay.

f. Input regulation: Measured input regulation is tabulated below using -24.5 volts input ±0.15 percent (22.5 volts to 26.5 volts), and output loading from 0 to 20 ma.

0 ma	5 ma	10 ma	15 ma	20 ma
±0.198%	±0.254%	±0.282%	±0.282%	±0.312%

g. Load Regulation: Measured load regulation is tabulated below at three input voltages and up to 20 ma load.

Ein	0 ma	5 ma	10 ma	15 ma	20 ma
22.5 V	-	0.113%	0.228%	0.396%	0.566%
24.5 V	-	0.057%	0.113%	0.226%	0.338%
26.5 V	-	0%	0.057%	0.226%	0.338%

2.1.13 AGC Generator (4708377)

Any time the temperature of the scene being viewed is colder than the chopper temperature, the chopper radiation, which is 180 degrees out of phase with the scene signal, exceeds the scene radiation and causes a positive voltage output at the demodulator. The purpose of this circuit is to detect any positive voltage at the radiometer output and generate a negative d-c voltage which, when injected in the video processing circuit, will shift the output to zero during the cold space scan.

2.1.13.1 Circuit Operation

If the video signal at the radiometer output is negative, diode CR3 is reverse biased, and Q6 is turned on by the current through R17. When Q6 is on, no current will flow through R19, and C9 will remain uncharged. As the video signal passes zero and begins to go positive, the diode CR3 becomes forward biased, allowing a positive base current in Q5, turning off Q6. As Q6 turns off, capacitor C9 is charged through R19 and CR4. The Darlington circuit, Q7, presents such a high input impedance that the discharge time of C9 is determined solely by R20. The diode CR5 in the emitter of Q7 prevents the voltage at C9 from rising beyond the capacitor voltage rating. The voltage change at C9 ($\Delta\ e_c$) is amplified and inverted by Q8 and reinverted by Q9. The correction voltage is taken from the collector of Q9, after filtering by R28 and C10.

2.1.13.2 Design Considerations

a. Gain: The gain of the amplifier stage Q8 will be determined empirically; however, a figure of about 3:1 is estimated to be adequate. This gain is not critical since the circuit functions as a closed-loop system.

b. Period: Not applicable.

c. Temperature Stability: The two important parameters are the turn-on voltage at CR3, and the charge-discharge time constant of the RC circuit. The measured turn-on voltage at three ambient temperatures are listed below:

0^oC	-0.224 V
25^oC	-0.192 V
50^oC	-0.138 V

The RC time constants as measured are:

T	Charge (0.5 V)	Discharge (5V - 1V)
0^oC	16 sec	75 sec
25^oC	16.4 sec	81 sec
50^oC	17.4 sec	87.7 sec

This stability is deemed adequate in this application. Any dc voltage shifts within the amplifier stages are self compensating due to the closed loop nature of the system.

d. Noise Figure: Not applicable.

e. Other: None.

2.1.14 Reference Signal Generator

The reference signal generator provides a 0 degree and 180 degree square wave at the chopping frequency for signal demodulation and modulation.

2.1.14.1 Operation

The circuit diagram for the reference generator is shown on drawing number 4708377. The signal from the chopper magnetic pickup is a low level (10-20 mv) sinusoid or triangular waveform. The amplitude of this signal varies with the distance the pickup is set from the chopper. Due to the fact that the chopper may exhibit a small amount of side to side wobble in addition to being slightly out of round, there is some amplitude modulation on the chopper pickup signal. If the signal is not processed properly, the amplitude modulation causes a frequency modulation on the output waveform while a small variance in setting causes a non-symmetrical square wave.

Q1, a 2N997, amplifies the input signal without clipping. Q2 is a driver for low level clippers CR1 and CR2. The signal into the base of Q3 is nearly a square wave with an amplitude of approximately 1.2 volts peak to peak. Q3 is a squaring amplifier with a square wave output at its collector of about 15 volts peak to peak. Q4 is a dual transistor PNP-NPN symmetrical driver for transformer T1 which provides two opposing phase outputs each about 60 volts peak to peak. The output is a nearly symmetrical square wave for about a 2:1 input variation. R5 sets the gain of Q1 and is set for the expected input voltage.

2.1.14.2 Design Considerations

a. Gain: The only critical gain point in the circuit is Q1. For this reason a 2N997 Darlington transistor with a nominal current gain of about 1000 was used.

b. Period: The waveform is slightly non-symmetrical with first half cycle equal to .92 x the second half cycle. The demodulation efficiency will not suffer from this lack of symmetry.

c. Temperature Stability: The ratio of the time duration of the first half cycle to the second varies with temperature as shown below:

Temperature	Ratio
25°C	0.920
50°C	0.928
0°C	0.906

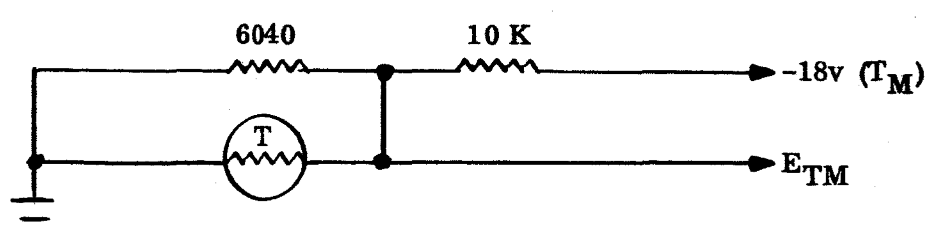
d. Noise Figure: Not applicable.

2.1.15 Telemetry Compendium

2.1.15.1 Reference "A" Temperature (4708364)

Measures the temperature of the portion of the radiometer housing used to provide a black body reference calibration during the back-scan.

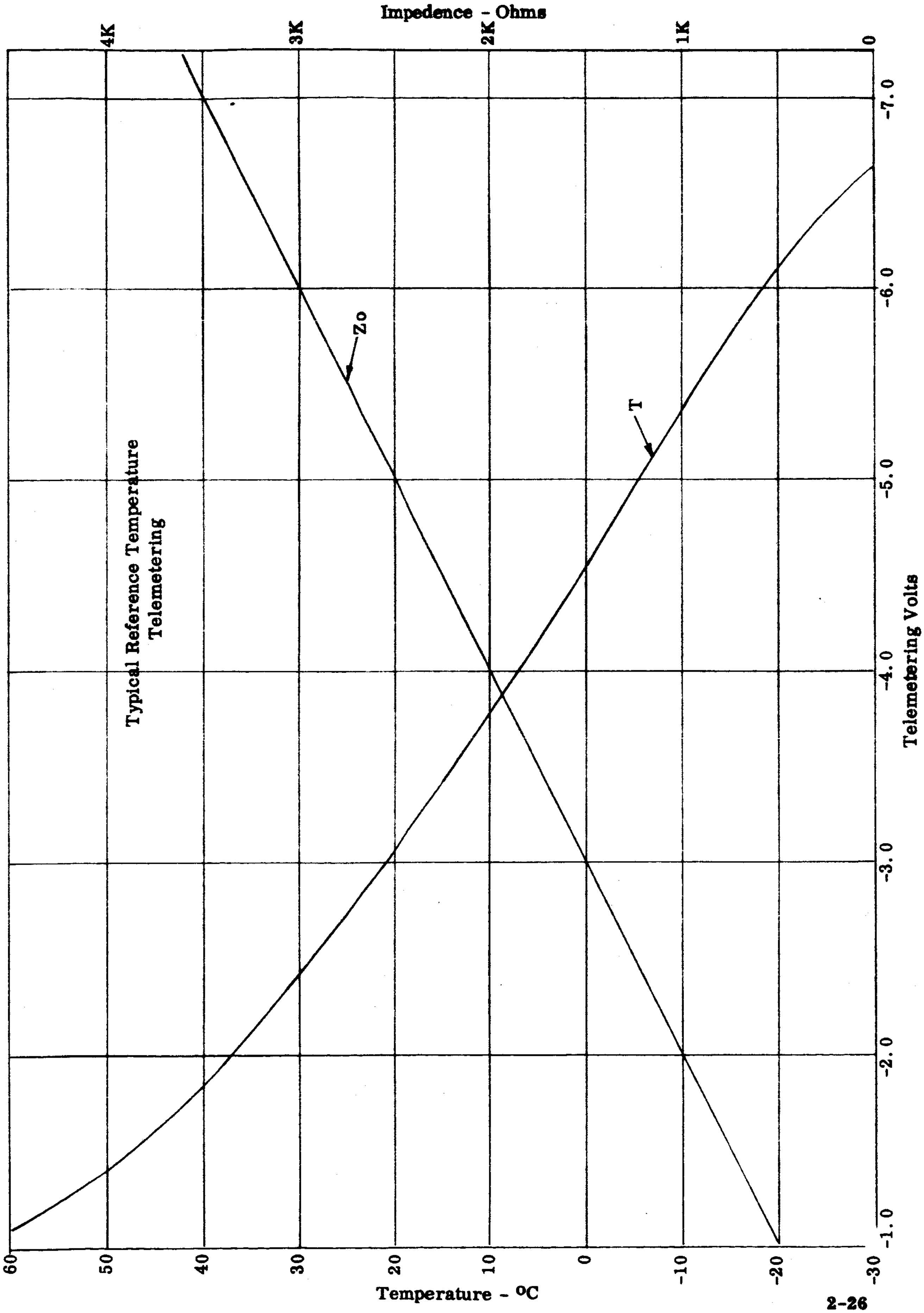
a. Circuit:



b. Voltage: See curve.

c. Impedance: See curve.

d. Resolution: 0.66 degree C (assuming straight line curve).


Typical Reference Temperature
Telemetering
Impedence - Ohms
4K
3K
2K
1K
0
Telemetering Volts
-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
Temperature - °C
60
50
40
30
20
10
0
-10
-20
-30
Zo
T

e. Range: -25 degrees C to +60 degrees C.

f. Failure Modes:

1. Output opens: no effect.

2. Output shorts: continuous 1.8 ma power drain.

3. Thermistor opens: -6.7 volts at TM output.

4. Thermistor shorts: zero TM output, 1.8 ma power drain.

2.1.15.2 Reference "B" Temperature (4708364)

Same as Reference "A". Provides redundancy and temperature gradient information.

2.1.15.3 Reference "C" Temperature (4708364)

Same as Reference "A". Measures the temperature of the preamplifier module directly above the radiation patch cylinder.

2.1.15.4 Reference "E" Temperature (4708364)

Same as Reference "A". Measures the temperature of the electronics module.

2.1.15.5 Detector Cell Temperature (4708379)

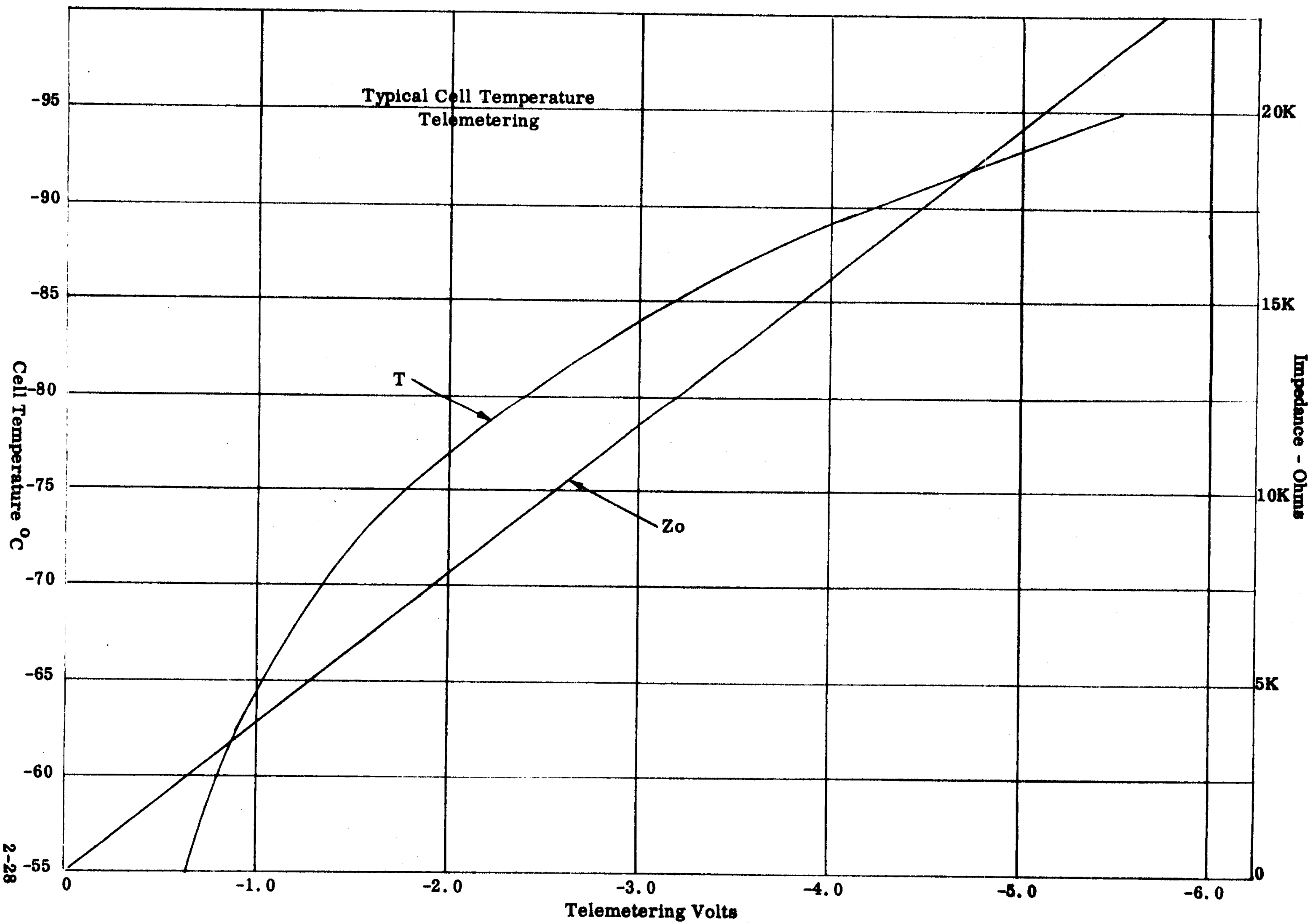
This measures the temperature of the radiation patch which is used for cooling the detector cell. The patch (and cell) temperature is automatically regulated from this point.

a. Circuit: (See 4708379) The measuring circuit consists of the series resistor combination R21, R22, and the patch thermistor. The telemetry voltage is read directly across the thermistor. Transistor Q4 provides isolation between the measuring circuit and the multicoder.

b. Voltage: See curve.

c. Impedance: Approximately 3000 ohms.

d. Resolution: 0.3 degrees C (assuming straight line curve).


Typical Cell Temperature
Telemetering
-95
-90
-85
-80
-75
-70
-65
-60
-55
Cell Temperature °C
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
Telemetering Volts
20K
15K
10K
5K
0
Impedance - Ohms
T
Zo

e. Range: -55 degrees C to -95 degrees C.

f. Failure Modes:

1. Output opens: no effect.

2. Output shorts: continuous 6 ma power drain.

3. Thermistor opens: loss of temperature control, cell becoming warm. -18 volts at TM output.

4. Thermistor shorts: loss of temperature control, cell becoming cold. zero volts at TM output.

2.1.15.6 -18 Volt Regulator (4708364)

Measures the regulated voltage supplied to the radiometer electronics.

a. Circuit: (See 4708364) The telemetry voltage is derived from the voltage divider R1, R2 across the -18 volt line.

b. Voltage: -5.06 volts at -18 volts input.

c. Impedance: 2810 ohms.

d. Resolution: 0.18 volts (0.28 volts/volt).

e. Range: zero to -22.6 volts.

f. Failure Modes:

1. Output opens: no effect.

2. Output shorts: 1.8 ma power drain.

2.1.15.7 -18 Volt Telemetry Regulator (4708364)

Same circuit and characteristics as in 6.0. Measures the regulated voltage supplied to full time telemetry circuits.

2.1.15.8 Correction Voltage (4708377)

Measures the voltage injected into the video processing circuit to correct for chopper radiation.

a. Circuit: (See 4708377) The telemetry voltage is derived from the voltage divider R26, R27 across the correction voltage line.

b. Voltage: Varies according to the amount of potential required to correct for the inverse chopper signal. Normal expected range is zero to -4 volts.

c. Impedance: 5110 ohms.

d. Resolution: 0.10 volts (0.5 volts/volt)

e. Range: zero to 12.6 volts.

f. Failure Modes:

1. Output opens: no effect.

2. Output shorts: zero TM volts. Slightly less loop gain.

2.1.15.9 Marker (4708378)

Seven pulses of 6 msec duration are generated each revolution of the scanning mirror. Presence of this signal indicates mirror rotation and marker generation. Absence indicates either motor or pulse generator failure. Correlation of this signal with the sync pulses received from the recorder, and the motor TM signal will indicate the nature of any failure.

a. Circuit: (See 4708378) The seven marker pulses are fed to a long time constant integrating circuit, R49, R53, and C19, which averages the pulses into a d-c level of about -3 volts. Emitter follower Q15 provides a high impedance discharge path and a low output impedance. Resistor R55 prevents transistor failure in the event of a short at the output line.

b. Voltage: Nominally 3 volts.

c. Impedance: Approximately 2000 ohms.

d. Resolution: Not applicable.

e. Range: Not applicable.

f. Failure Modes:

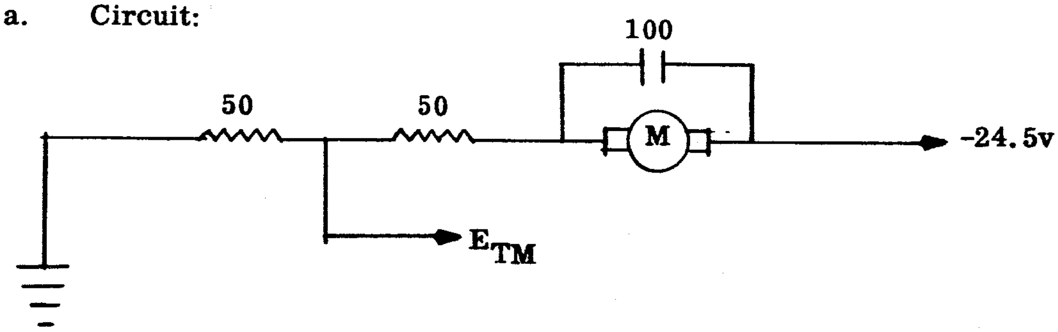
1. Output opens: no effect.

2. Output shorts: 9 ma power drain.

2.1.15.10 Motor Rotation (no drawing)

Measures the current through a resistor in series with the drive motor. The magnitude of the TM voltage (and the motor current) indicates one of three possible conditions: (1) motor synchronous, (2) motor stalled or (3) motor off.

a. Circuit:



b. Voltage: During synchronous operation, the output will be approximately -3 volts. Should the motor stall, the current will increase causing the output to increase to about -4 volts. When the motor is off, the output will read zero volts.

c. Impedance: 50 ohms.

d. Resolution: Not applicable.

e. Range: Not applicable.

f. Failure Modes:

1. Output opens: No effect.

2. Output shorts: Increased motor torque, with higher current drain.

2.1.15.11 Video Signal (4707700)

Provides an indication of the average video output signal.

a. Circuit: (See 4707700) The video signal is fed to a long time-constant network, R19, R20, and C4, where it is averaged, then applied to an emitter follower Q19 to reduce the output impedance. Resistor R17 prevents Q9 from being damaged in the event of a short circuit at the output.

b. Voltage: Since the video signal will vary from 0 to -6 volts during each scan interval, and the level will be determined by the temperature of the scene being viewed, it is impossible to predict the exact conditions at all times. The following limits are anticipated, assuming at least one look at outer space and one look at the radiometer reference surface. The maximum average signal should not exceed -3 volts. The minimum should not be less than -0.5 volt and will vary between these limits depending on the average conditions of the earth in the field-of-view. A time constant of approximately 10 seconds will maintain the TM output voltage to within 10 percent of the average video level.

c. Impedance: Approximately 2000 ohms.

d. Resolution: Not applicable.

c. Range: Not applicable.

f. Failure Modes:

1. Output opens: no effect.

2. Output shorts: 9 ma current drain.

2.1.15.12 Day/Night Relay (4708380)

This is a digital function providing an indication of the position of the D/N relay.

a. Circuit: (See 4708380) The telemetry voltage is derived directly from the D/N relay contacts (K1). In the DAY position, contacts 1 and 7 are closed, giving zero volts, or logic "zero" at the TM output. In the NIGHT position, contacts 1 and 10 are closed, giving -18 volts, or logic "one" at the TM output.

b. Voltage:

1. Logic "zero": zero volts.

2. Logic "one": -18 volts.

c. Impedance:

1. Logic "zero": zero ohms to ground.

2. Logic "one": zero ohms to the logic "one" signal source.

2.1.15.13 Day/Night Override Relay (4708380)

This is a digital function providing an indication of the position of the D/N override relay.

a. Circuit: (See 4708380) The telemetry voltage is derived directly from the day/night override relay contacts (K2). In the "override on" position, contacts 7 and 10 are closed, giving -18 volts, or logic "one" at the TM output. In the "override off" position, contacts 7 and 1 are closed, giving zero volts, or logic "zero" at the TM output.

b. Voltage:

1. Logic "zero": zero volts.

2. Logic "one": -18 volts.

c. Impedance:

1. Logic "zero": zero ohms to ground.

2. Logic "one": zero ohms to the logic "one" signal source.

2.2 Optical Design

The optical design, with the exceptions of the wavelength filter, is essentially the same as the design for the Nimbus A HRIR. Testing and checkout of the optical components and parts will necessarily be more stringent and will follow more rigid procedures than was formerly true. The scanning speed has been slightly increased causing a slight decrease in the detector size. The original design considerations are included herein for the information of these not formerly aware of these facts.

2.2.1 Scan Mirror

The scan mirror is a flat, front surface mirror which reflects radiation or light from the clouds or earth terrain into the main optical focusing element, the telescope. The scan mirror rotates at a constant uniform speed about the optical axis causing the small instantaneous field of view of the radiometer to sweep across the earth in a direction perpendicular to the satellite orbital path. The scanning action is similar to the horizontal line scanning in a television camera. One revolution of the scan mirror corresponds to one horizontal television line, however, the retrace time in electronic TV is much shorter than the corresponding dead time in the infrared radiometric mapper. The natural orbital motion of the satellite gives rise to the corresponding television vertical deflection, i.e., the rotational rate of the scan mirror is adjusted so that the front or leading edge of one scan line overlaps the back or trailing edge of the preceding scan line. In other words, the distance the satellite subpoint moves during the time of one mirror rotation is just equal to the width of a scan line on the earth's surface. It is the rotating scan mirror and the satellite orbital motion which therefore give rise to the infrared maps of the earth below.

2.2.1.1 Design Considerations

The desire for a rigid but light-weight mirror led to the design of an aluminum alloy, flat, elliptical-shaped mirror. The back side was machined to provide a ribbed structure which is typically used to provide rigidity and light weight. Since the aluminum alloy itself is too soft to be optically polished to a precision finish, a special process is followed which hardens the outer surface layer of the mirror blank so that it can then be polished. The process, which is known as "hard coating", is a deeply-penetrating black anodizing process which converts the aluminum outer layer into a aluminum oxide which is extremely hard.

The flat, front surface of the machined mirror blank is first ground flat to remove gross surface irregularities. The mirror blank is then given the hard coating process over its entire surface, the coating thickness being about 0.003 inch thick.

The flat, front surface is then optically polished flat to the required precision which, in optical terminology, is flat to within 15 fringes or less of visible light. The polished surface is then covered with an evaporated layer of high-purity aluminum in a vacuum evaporator so that the mirror will reflect as much of the infrared radiation as possible. A final infrared-transport coating of evaporated silicon monoxide is then put on top of the soft aluminum reflecting layer to protect it from physical damage.

The infrared reflectivity of an aluminized glass mirror is very high, being about 97 ± 1 percent in the 3 to 4 micron region. There is no reason to expect the reflectivity of the finished scan mirror to be significantly different than this. The reflectivity of each scan mirror will be measured as part of the quality assurance program. In the 0.7 to 1.3 micron wavelength region (the daytime spectral response) the reflectivity of evaporated aluminum coatings is lower than in the longer wavelength band. At 0.8 micron the reflectivity reaches a minimum of about 87 percent. Since there is much more energy reflected from the clouds during the daytime than emitted at night (in the corresponding wavelength channels) the lower reflectivity of aluminum in the lower wavelength band should not be a problem.

The flatness of the reflecting surface of the scan mirror should be of such quality that it does not significantly cause a loss in optical resolution. This implies that a light ray be deviated from its correct path by an amount less than about one-tenth of the width of the radiometer field of view which is 7.2 milliradians. The optical manufacturer is accustomed, however, to measuring the flatness of an unknown mirror by comparing it with a known, higher-precision test optical flat. Interference fringes are observed when the unknown and test flats are placed in contact and properly illuminated. The number of fringes or lines observed is a measure of the deviation of the unknown mirror from true flatness. In this terminology, 15 circular fringes across the diameter of the scan mirror would correspond to a maximum angular slope error of about 0.2 milliradian or 0.6 min. of arc. The maximum ray deviation would be twice this or 0.4 milliradian which is well below the permissible deviation of 0.7 milliradian. The deviation of each scan mirror from true flatness is to be measured as part of the quality assurance program.

2.2.2 Telescope

The telescope receives the radiation reflected by the scan mirror and focuses it just behind the rear surface of the primary parabolic mirror, in the plane of the chopper disc. The telescope forms an image of those clouds and earth which are in the direction perpendicular to the optical axis and in the plane of the optical axis and scan mirror normal. The field of view of the radiometer is determined by the telescope focal length, which is 4 inches, the optical magnification of the relay system, and the size of the detector element. The telescope is made as large in diameter as practical (4 inches) so that it will collect a large amount of infrared radiation and thereby produce a large signal. Its focal length is made as short as possible, consistent with optical aberrations, so that it is compact in size and the size of the detector element may be smaller. Smaller area detectors contribute less noise hence the telescope is designed to give the highest possible signal-to-noise ratio (best sensitivity) consistent with other system requirements.

2.2.2.1 Design Considerations

The telescope contains the reflecting mirror elements, the primary mirror, which has a parabolic reflecting surface, and the secondary mirror which has a flat reflecting surface over the area where it receives radiation from the primary mirror. The primary mirror is the focusing element whereas the secondary mirror simply serves to reverse the direction of the rays and form an image in an accessible region. Both mirrors are made of glass which have been optically polished, aluminized for high reflectivity, and overcoated with silicon monoxide for protection. The two mirrors are mounted in a cylindrical housing in which the secondary mirror can be moved along the optical axis to precisely focus distant objects on the chopper teeth. The center portion of the secondary mirror, which is out of the focused beam, has a spherical curvature so that the detector "looks back at itself", i.e., it prevents some extraneous radiation from being directly reflected onto the detector. The telescopes are manufactured by Bausch & Lomb, Inc. Performance specifications are listed below:

2.2.2.2 Performance Specifications

Focal length	4.00 ± 0.10 inch
Clear aperture diameter	4.00 ± 0.06 inch
Primary mirror shape	Parabolic
Secondary mirror shape	Flat (with spherical center inside useful aperture)
On-axis resolution	Diameter of light spot containing 90 percent of energy from point object at infinity shall not exceed 0.007 inch.
Obscuration by secondary	35 ± 1 percent of primary mirror scan
Field of view	Square, 7.2 ± 0.72 milliradians on the edge.

Image plane location (nominal)	0.078 inch behind rear datum surface of telescope
Image plane adjustment	±0.08 inch (min.) from nominal; final adjustment and potting of secondary mirror to be done by ITT Industrial Laboratories
Reflectivity	Reflecting surfaces to be aluminized and silicon monoxide overcoated for highest reflectivity in the 0.7 to 1.5 micron wavelength band.

2.2.3 Reflective Relay Assembly and Optical Filter

After the focused beam of radiation is chopped or modulated by the teeth on the chopper wheel the relay mirrors refocus the radiation onto the infrared detector. One of the relay mirrors (nearest the detector) collimates the radiation so that the rays pass through the optical filter at near normal incidence (the spectral bandpass for an interference-type optical filter shifts if the angle of incidence of the rays strikes the filter at an appreciable angle from the normal). The second relay mirror collects the radiation after passing through the filter and reimages the clouds or scene in the field of view onto the detector. There is only a very small loss in radiation at each mirror, however, there is a larger loss in passing through the filter. The optical filter is used to restrict the wavelength response of the radiometer to the desired bands since the infrared detector responds to all wavelengths from about 0.5 to 5.0 microns. The center of the filter is cut out so that the focused beams of radiation do not pass through it. The cutout also simplified admission of radiation to the detector from the bias light to obtain a zero balance on the Nimbus I HRIR. The relay mirrors and optical filter are mounted in a cylindrical housing to hold them in proper alignment.

2.2.3.1 Design Considerations

The collimating relay mirror works as a telescope in reverse, i.e., rays parallel to the optical axis which enter the telescope are reflected from the collimating mirror so that they are again parallel to the optical axis. The collimating mirror therefore must have the same optical speed as the telescope, which has a geometric f-number equal to 1.0. It is made large enough in diameter so that there are no difficult manufacturing or alignment problems. The reflecting surface has a parabolic shape and is covered with an evaporated layer of high-purity gold to provide high reflectivity in the 0.7 to 4.5 micron wavelength band. Gold is used in place of aluminum because of its lower emissivity; this was done in an attempt to reduce the internal radiation signal.

The optical filter is of the interference type, i.e. the bandpass is obtained by interference of waves in ultra-thin coatings which are vacuum evaporated in an infrared transmitting substrate material. The number of layers for filters of this type varies from 20 to 50, all of which must be closely controlled in thickness. A number of different materials which have different indices of refraction are used in alternate layers to produce the desired spectral bandpass. As explained in the technical proposal (T. P. for HRIR Flight Models 5, 6 and 7, Bid No. 65-415, June 18, 1965 on pages 4 to 9) the filter will be made of two sections which transmit in different spectral regions. The largest section will transmit in the 3.4 to 4.2 micron band to provide nighttime radiometric signals. No useful signals will be obtained due to transmission in the 0.7 to 1.3 micron band at night except possibly from a large well-lighted city in clear weather. The spectral bandpass for the 3.4 to 4.2 micron band will be as near to that used on Nimbus I as manufacturing tolerances permit. As explained in the technical proposal, 15 percent of the total filter area will be used for the daytime section. The nighttime signal will therefore be slightly lower, however, the loss can be tolerated. The smaller filter section will transmit radiation primarily in the 0.7 to 1.3 micron wavelength band to pass reflected sunlight for the daytime signal. The filter will not transmit between 1.3 to 1.8 microns, however, there will be some transmission (much less than in the 0.7 to 1.5 micron band) from 1.8 to about 2.5 microns. This second transmission band does not cause a problem for two reasons, (1) the intensity of the reflected solar radiation will be much lower and (2) the band occurs in an atmospheric transmission window. The two filter sections will be bonded together with Armstrong A-12 which is a flexible epoxy material. The filters will be manufactured by Optical Coating Laboratories, Inc., Santa Rosa, California.

The second, or focusing, relay mirror accepts all the radiation transmitted by the filter which is within the field of view and condenses it onto the detector. The location and optical speed were determined to a large extent by packaging restraints imposed by the chopper wheel and radiant cooler. It also has a parabolic reflecting surface of slightly faster optical speed (shorter focal length) than the other relay mirror so that there is a slight demagnification (0.94) produced by the relay assembly. The precision of the reflecting surfaces of all the mirrors in the radiometer optical system are of such quality that the diameter of the final image of a point light source at infinite is no larger than one-half the width of the detector element. The size of the detector element itself, therefore, primarily determines the size of the resolution element.

2.2.3.2 Performance Specifications

2.2.3.2.1 Relay Mirrors (both unless noted otherwise)

Focal length (collimator)	2.125 ± 0.040 inches
Focal length (condenser)	2.000 ± 0.040 inches
Clear aperture diameter	2.125 ± 0.030 inches
Co-axis resolution	Diameter of light spot containing 90 percent of energy from point object at infinite shall not exceed 0.002 inch.
Reflectivity	Reflecting surfaces to be gold coated and silicon monoxide overcoated for high reflectivity in 0.7 to 4.5 micron wavelength band.
Alignment of optical axis with mirror OD	0.005 inch maximum offset

2.2.3.2.2 Dual Bandpass Filter

See ITT Specification (Dwg.) IL-S-4708251.

2.2.4 Detector

The detector converts infrared radiation falling on its sensitive surface into an electrical signal which can be amplified, measured, etc. It is much more sensitive when cooled to about -80 degrees C than when at ambient temperatures (20 degrees C); this is accomplished by means of a radiant cooler described below. The size and shape of the sensitive area of the detector determines the extent and shape of the instantaneous field of view of the radiometer since it is placed in the final image plane of the optical system. The detector material will be Type E lead selenide made by Eastman Kodak Company; this is the same type detector used in the Nimbus I HRIR.

2.2.4.1 Design Considerations

A detector size of 0.695 mm by 0.695 mm is required to produce the specified field of view of 7.2 milliradians by 7.2 milliradians; there is a 10 percent tolerance on these dimensions. Only detectors with very high detectivity (sensitivity) will be used in the radiometer. Eastman Kodak Company will measure and select only the best detectors out of a large number of elements produced. The detectors will be measured at the same chopping frequency and with radiation in the same spectral band (3.4 to 4.2 micron) as used in the radiometer so that a direct measure of its performance can be made without resorting to mathematical conversions.

In order to operate in the daytime part of the orbit the detector must also respond to radiation in the 0.7 to 1.5 micron wavelength band. In the manufacturing process a special coating is applied over the top of the lead selenide layer which causes the sensitivity to decrease more rapidly than normal at wavelengths shorter than about 1.0 micron when the radiation is incident on that side. Since the substrate material (Irtran 3) is a good infrared transmitting material in both spectral bands, the detector element will be turned upside down from its normally used orientation so that the infrared radiation will pass through the substrate before falling on the lead selenide. The only effect will be an additional reflection loss of about 3 percent; the spectral response will be the same as normal lead selenide detectors without the special coating. The sensing element will be mounted in a specially designed mount fabricated by ITTIL.

2.2.4.2 Specifications

Complete detector specifications and dimensions are given on ITTIL drawing 4708255(B).

2.2.5 Radiant Cooler

The radiant cooler is an assembly consisting of a rectangular reflecting cone, a rectangular flat patch painted black on one side and gold-plated on its opposite side, and the necessary supporting structure to hold the patch in position at the bottom of the cone. The detector is mounted on one end of a rod attached to the patch. The purpose of the radiant cooler is to cool the detector to its proper operating temperature of about -80 degrees C.

2.2.5.1 Design Considerations

The rectangular black patch cools by emitting more radiation (infrared) than it receives by radiation plus thermal conduction through its supporting wires when at near ambient temperatures. As the patch cools, the amount of radiation emitted decreases until at about -80 degrees C the thermal input and output are equal; the patch (and detector) temperature than remain nearly constant, although as found on Nimbus I the temperature does change a small amount as the spacecraft orbits the earth (this was exaggerated on Nimbus I because of the non-circular orbit). The gold-coated cone serves to shield the radiating patch against radiation from the hot solar paddles, spacecraft structure, and the earth. At the same time the cone reflects nearly all the radiation emitted by the black side of the patch out into space. The inner surface of the cone is gold-coated so that it emits the smallest amount of radiation onto the patch. The supporting structures and the back side of the radiating patch are also gold-coated to reduce the amount of radiation falling on the detector and patch.

The basic design of the radiant cooler will be same as that developed on the Prototype-2 Modification program (which incorporated engineering improvements to give better cooling performance than on Nimbus I). The detector temperature will be prevented from becoming too low by means of an electrical sensor and control network.

The cone structure, after fabrication into final form, and the back side of the radiation patch are covered with a thin layer of epoxy material to produce smooth, highly-specular surfaces. These surfaces are then coated with an evaporated gold film to produce the necessary low-emissivity surfaces. The metal parts such as detector envelope, cylindrical housing and end caps are buffed to a high polish and then gold-plated to give them low emissivity surfaces. Since the front side of the patch must have high emissivity it is painted with a special 3 M Company black paint.

The development of a radiant cooler has been the subject of extensive theoretical and experimental effort at ITTIL and has been reported in the Nimbus HRIR project reports. Its ability to cool the detector to its required operating temperature has been repeatedly demonstrated in simulation tests and on the Nimbus I flight. Considering the facts that the cooler requires no power for operation (except for the controller to prevent it from over-cooling) and that its life-time is practically unlimited, this development effort has undoubtedly been worthwhile.

2.3 Mechanical Design

The Nimbus B HRIR mechanical design incorporates a number of modifications of the Nimbus A design as well as some completely new design. The gear ratios have been changed to achieve the increased scan rate, while the gears are pinned or screwed as well as press fit onto the shafts. The secondary casting and radiant cooler suspension rings are of the Prototype 2 modification design. Most of the electronics are now packaged in a 0/3 module and the drive motor torque capability has been increased.

2.3.1 Primary Casting

This casting is the main structure for the radiometer. To it is connected the motor mounting bracket and the relay housing (secondary casting). It also provides the mounting of the drive system which consists of the chopper, scan, and idler gear assemblies. The primary telescope is also mounted into this casting behind the magnetic pickup for the chopper assembly.

2.3.1.1 Design Considerations and Fabrication

The primary casting is the most important structural member of the radiometer. Environmental stresses and weight being very critical, the material used for this casting should have a high strength to weight ratio and also provide as much natural resistance to vibration as possible. The ANC-5 (Strength of Metal Aircraft Elements) manual suggests the use of magnesium. Since this member is so structurally complicated it was decided that the basic configuration be cast from KIA alloys and then machine finished. The problem of maintaining the gear train tolerances was solved by utilizing three stainless steel inserts which were rough machined and press fitted into the casting. The face of the casting which would accept the motor mounting bracket was set up in a vertical bore and the reference dowel pins mounted. The exact position of the duplex bearing surfaces (which were in the stainless steel inserts) were then bored to a tolerance of +0. 0001 inch -0. 0000 inch. The idler gear front bearing surface was also bored with respect to the dowel pins. This method proved to provide a good integration of the motor pinion and the back idler gear assembly bearing into the scan and chopper drive assemblies. The casting was rotated 180 degrees and the back bearing surfaces for the chopper bearings and the telescope mounting hole was bored. The concentricity of the front and back chopper bearing holes was maintained at 0. 0005 TIR. The concentricity of the telescope mounting hole to the center line of the scan mirror bearing surface was maintained at 0.0005 TIR. Since the detector cell is located in the relay housing (secondary casting) dowel pins were installed on the telescope side of the casting. These pins were positioned from the center line of the telescope and scan mirror bearing surface.

The two reference mounting holes between the spacecraft and the primary casting were maintained at +0.0002 inch -0.0000 inch and parallel and perpendicular to the front and side surfaces of the primary casting to 0.0002 inch. Because the chopper magnetic pickup allows for a considerable amount of mechanical adjustment, the mounting holes for the pickup bracket are not considered critical and were positioned to standard tolerances. After fabrication the casting was Dow No. 10 treated.

a.	Environmental stress:	Designed for a 20 g input and tested
b.	Weight:	Considered critical thus magnesium was chosen
c.	Expansion coefficients:	a and b above determined the material thus this item will become a consideration in designing the chopper shaft assembly due to the shift in the chopper plane at extreme temperatures
d.	Balance:	N/A
e.	Dimensional tolerances:	Critical with respect to gear driver and motor mounting plate. Considerable effort exerted at this level.
f.	Torque requirements:	N/A
g.	Lubrications:	See section on Lubrication
h.	Other special properties:	N/A

2.3.2 Secondary Casting (Relay Housing)

The relay housing is mounted to the main casting and houses the relay optics, cylinder assembly, cooling cone, and provides a mounting surface for the preamplifier electronics.

2.3.2.1 Design Considerations and Fabrication

The original unit was cast from KIA magnesium and machine finished. Throughout the program some difficulty in cooling the cell reduced the reliability of the instrument. An analysis of this problem showed that the greatest percentage of heat generated in the instrument was dissipated into the main casting and transferred to the secondary casting by conduction. The use of a plastic secondary casting was studied which resulted in the selection of G-10 synthane. This material has a K factor 300 times less than KIA magnesium. It also exhibited a tensile strength of 35, 000 PSI with a specific gravity of 1.82. The strength of G-10 is greater than KIA but it has a higher specific gravity. The G-10 housing was designed in three pieces to take advantage of the natural positioning of the glass filaments and assembled under high pressure and heat with epoxy. The three sections were further strengthened with mechanical fasteners.

The mounting surface for the relay optics and cylinder assembly were bored into the G-10 housing. From the center of this hole the dowel pin mating holes were positioned and drilled. These holes then mated with the dowel pins located on the telescope side of the KIA casting. The G-10 housing is mated directly to the KIA casting and secured by eight screws.

a.	Environmental stress:	Housing mounts on primary casting secured at one end only therefore it is subject to g amplification from the inputs to the main casting. System was vibrated at twice prototype levels.
b.	Weight:	Some weight was sacrificed to reduce the thermal conductivity and increase the strength.
c.	Expansion coefficients:	Expansion coefficient of G-10 is 1×10^{-6} in/in degree F - coefficient for KIA is 26×10^{-6} in/in degree F. G-10 is much more stable which will result in less shifting between the relay optics and the cell.
d.	Balance:	N/A
e.	Dimensional tolerances:	Consideration given position of relay and cylinder mounting surfaces and mating of dowel pins to main casting
f.	Torque requirements:	N/A
g.	Lubrication:	N/A
h.	Other:	Outgassing of materials in space and effects of radiation on strength of G-10

2.3.3 Drive System

The drive system includes the motor, scan gear assembly, idler gear assembly, and chopper gear assembly. One motor will drive both the chopper and mirror.

2.3.3.1 Design Considerations and Fabrication

Torque requirements are of prime importance in selecting the drive motor. Due to the fact that the oil seals require a tight fit and consequently will add friction to the system, an exact analysis of the minimum torque requirements is not practical. Moreover, there is no requirement for fast acceleration of the system to the stable scanning rate. For the previous units a motor was used that had a 0.08 in/oz starting torque. At low temperatures the capability of this motor was marginal. Since the rate of scanning of the new systems will be increased from 44.7 to 48 RPM, it is proposed that a motor with at least 0.2 in/oz of starting torque be used.

The gear system is designed to allow an aluminum gear to be driven by a stainless pinion which permits the desirable mating of gear teeth of dissimilar metals.

After the system is fabricated and assembled, a torque watch is used to determine the amount of torque needed to accelerate the drive system. This reading is taken at the chopper shaft and compared to the stall torque of the motor before it is assembled into the system. This torque is also compared to the stall torque of the assembled system taken at the output of the chopper shaft. Vibration being detrimental to the system, each gear on each assembly is staked and pinned to its respective shaft prior to the grinding of the gear teeth. The runout of each gear assembly is taken with respect to the bearing surfaces located on the shaft.

After the gear assemblies are fabricated they are dynamically balanced to within 50 microinches.

a.	Environmental stress:	Prime importance
b.	Weight:	N/A
c.	Expansion coefficients:	Considered to maintain the proper positioning of the centerlines of the shaft rotation
d.	Balance:	All rotating parts to 50 microinches
e.	Dimensional tolerance:	Prime importance

f.	Torque requirements:	Prime importance
g.	Lubrication:	See Lubrication Section
h.	Other:	N/A

2.3.4 Idler Gear

This assembly serves as a speed reduction device for the scan mirror drive system.

2.3.4.1 Design Considerations and Fabrication

The same basic considerations and methods of fabrication applicable for the chopper shaft assembly, also apply to this assembly.

a.	Environmental stress:	Use of duplex bearings
b.	Weight:	N/A
c.	Expansion coefficients:	N/A
d.	Balance:	All systems shall be dynamically balanced to 50 microinches
e.	Dimensional tolerances:	Extreme care must be exercised in providing a close tolerance on the surfaces where the bearing will be mounted. The shafts were ground at these sections to $^{+.0000}_{-.0001}$ inch.
f.	Torque requirements:	See Motor Drive section
g.	Lubrication:	See Lubrication section
h.	Other:	Use of sulphur free stainless. Extensive tests resulted in the spur gear being vibrated loose from the shaft. To prevent this, the gear is pinned to the shaft and staked prior to the final grinding of the gear teeth.

2.3.5 Scan Shaft

The scan shaft assembly is part of the gear drive system and also serves as a mount for the mirror carriage and scan mirror.

2.3.5.1 Design Considerations and Fabrication

The same basic considerations and methods of fabrication are applicable to the scan shaft assembly that were used in the chopper shaft assembly. Only one set of duplexed bearings preloaded at 4 pounds is used. Since a bearing is required at each end of the shaft, two precision ground spacers are used to separate the duplexed pair. An oil reservoir similar to those used on the chopper shaft assembly is used. The shaft of the scan assembly is countersunk to provide a seat for the set screw used to secure the scan mirror carriage.

a.	Environmental stress:	Use of duplex bearings
b.	Weight:	N/A
c.	Expansion coefficients:	N/A
d.	Balance:	All systems shall be dynamically balanced to 50 microinches.
e.	Dimensional tolerances:	Extreme care must be exercised in providing a close tolerance on the surfaces where the bearings will be mounted. The shafts were ground at these sections to $^{+.0000}_{-.0001}$ inch.
f.	Torque requirements:	See Motor Drive section
g.	Lubrication:	See Lubrication section
h.	Other:	Use of sulphur free stainless. Extensive tests resulted in the spur gear being vibrated loose from the shaft. To prevent this, the gear is pinned to the shaft and staked prior to the final grinding of the gear teeth.

2.3.6 Motor Mounting Bracket

This bracket is used to mount the drive motor and scan mirror magnetic pick-up. It is also used to retain one bearing for the idler gear assembly. The bracket is attached to the main radiometer casting with screws.

2.3.6.1 Design Considerations and Fabrication

Since this bracket mates the drive motor pinion to the chopper, idler, and scan gear assembly, the dimensional tolerances will be critical and must be transferred to the main radiometer casting. It was originally intended that smaller individual brackets be utilized to mount the motor and idler bearing. Vibration testing of this proposed design resulted in g forces in excess of 100 being transferred to the motor. The possibility of motor failure dictates the present mounting configuration. With this configuration it was possible to introduce a buna-N gasket between the motor mounting bracket and the main casting and another gasket between the securing washers and the bracket which greatly reduced the g forces transferred to the motor. This method also allowed for a small preload on the idler gear assembly which results when the gaskets are compressed. It was determined that a torque of 4 in/lbs must be used to secure the retaining screws on the bracket to provide the proper preload and to allow sufficient compression of the gaskets to inhibit vibrational buildup. To maintain the proper tolerances between the bracket and casting, two precision dowel pins are installed into the casting and indexed into the bracket. These dowel pins were set on 1.750 inch centers from the centerline of rotation of the gear train and precision based to +.0002 and -.0000 inch. The reference point on the bracket was taken at the center line of the mounted motor pinion. The idler gear back bearing was then positioned from the dowel pin at the same tolerance level. All critical dimensions are taken from the dowel pins which are transferrable to the main casting.

Weight is of importance and AZ-31-B magnesium is used to fabricate the bracket. After fabrication it is treated with Dow No. 7 for corrosion protection.

a.	Environmental stress:	Designed to reduce maximum g on motor to less than 100 during random and sinusoidal vibration. Tests were run to verify this.
b.	Weight:	Critical and considered along with (a) above.
c.	Expansion coefficients:	N/A

d. Dimensional tolerances: Consideration was given to provide proper mating of the motor pinion into the gear train.

e. Torque requirements: N/A

f. Lubrication: N/A

g. Other: Surface treatment with Dow No. 7 for corrosion resistance.

2.3.7 Chopper Shaft

The chopper shaft assembly is part of the gear drive system and also serves as a mount for the chopper assembly.

2.3.7.1 Design Considerations and Fabrication

The vibration level to which this assembly is exposed and its expected operational lifetime were of prime consideration. The chopper assembly attached to one end of the shaft generated a considerable force on the shaft and thus to the gears during vibration. It is also very important that the slipping of the shaft be minimized to provide good dimensional positioning of the chopper. To stabilize the shaft, two sets of preloaded duplex bearings were used, one set at either end of the shaft. These bearings were secured by fixed nonflexible retainers held against the outside case of the duplexed pair. The bearings have a preload of 4 pounds. The fact that a seal must be used between the back duplex pair and the chopper assembly required that some method be devised to provide additional lubrication as the oil is evaporated through the back seal. A sleeve made from porous material is impregnated with oil and slipped around the shaft. Two such sleeves were used at either end of the shaft. A key way is milled into the shaft to accept a securing device to retain the chopper assembly. An additional true-arc groove is also provided to hold the chopper assembly against the step shoulder in the shaft.

a. Environmental stress: Use of duplex bearings

b. Weight: N/A

c. Expansion coefficients: The position of the chopper is critical. The analysis of the chopper shift due to temperature changes showed that a material with a coefficient of 10.6×10^{-6} in/in degree F would perfectly balance the system. The closest to this was stainless steel at 9.2×10^{-6} in/in degree F.

d.	Balance:	All systems shall be dynamically balanced to 50 microinches.
e.	Dimensional tolerances:	Extreme care must be exercised in providing a close tolerance on the surfaces where the bearing will be mounted. The shafts were ground at these sections to $^{+.0000}_{-.0001}$ inch.
f.	Torque requirements:	See Motor Drive section
g.	Lubrication:	See Lubrication section
h.	Other:	Use of sulphur free stainless. Extensive tests resulted in the spur gear being vibrated loose from the shaft. To prevent this, the gear is pinned to the shaft and staked prior to the final grinding of the gear teeth.

2.3.8 Chopper Assembly

The function of the chopper assembly is to provide a means of chopping the radiation falling upon the detector cell. This assembly is attached to the chopper shaft assembly and is rotated by a direct coupling of the motor pinion to the chopper shaft spur gear.

2.3.8.1 Design Considerations and Fabrication

The basic requirement and thus the basic design consideration was to chop the input signal to the detector at the focal point of the primary telescope. The chopper should not move out of the focal plane of the telescope after vibration nor should the run out of the chopper assembly be greater than the thickness of the chopper itself. Another consideration is that through the operating temperature range the chopper would remain at the focal point of the telescope. The change in position due to temperature changes was considered when the chopper shaft assembly was designed.

To reduce the stresses during vibration it is desirable to make the chopper carriage as light as possible. This was accomplished by the use of aluminum which is relieved and reduced in weight by drilling large holes through the carriage. Flatness is also critical, - to minimize this the carriage was aged after each machining operation with a final machine cut made to effect the mounting surface for the chopper.

The chopper is constructed of stainless steel which is then diffused and passivated. The chopper is then mounted onto the carriage and secured by a Truarc retaining ring.

a.	Environmental stress:	Critical with respect to permanent deformation of the system during vibration
b.	Weight:	Critical as in (a) above
c.	Expansion coefficients:	See Chopper Shaft Assembly
d.	Balance:	See Balance section
e.	Dimensional tolerances:	The chopper must operate at the focal point of the primary telescope
f.	Torque requirements:	See Motor Drive Section
g.	Lubrication:	N/A
h.	Other:	Extreme care must be exercised in the preparation and diffusion of the chopper

2.3.9 Magnetic Pickup Bracket

This bracket is secured to the main casting and positioned over the chopper blade. It holds the pickup which produces the reference chopping signal. The pickup is adjustable vertically and horizontally with respect to the chopper teeth.

2.3.9.1 Design Consideration and Fabrication

The physical configuration of this bracket was dictated by the design of the radiometer castings and the position of the chopper. Little difficulty in providing the adjustments required was encountered. After the original prototype was fabricated and tested, it was apparent that the physical configuration of the pickup must be changed to prevent it from rubbing against the relay optics during vibration. The edges on the bracket are also rounded to protect the relay optics. After further tests of this assembly, it was observed that the pickup would drift. This was found to be caused by a horizontal shift in the sensor during vibration. An additional set screw was placed in the pickup to eliminate this condition.

a.	Environmental stress:	Pickup must return to its original position after vibration.
b.	Weight:	Secondary
c.	Expansion coefficients:	The bracket and the chopper carrier are both aluminum.
d.	Balance:	N/A
e.	Dimensional tolerances:	Pickup is adjustable
f.	Torque requirements:	N/A
g.	Lubrication:	N/A
h.	Other special properties:	N/A

2.3.10 Radiant Cooler Assembly

The radiant cooler assembly consists of the cell assembly, radiation patch, support rings for radiant patch, cylinder assembly and radiation cone. The purpose of the radiant cooler assembly is to cool the detector cell.

2.3.10.1 Design Considerations and Fabrication

The cell is cooled by the extraction of heat from the radiation patch to which the cell assembly is attached. Heat is extracted by radiating energy to space. The radiation cone protects the patch from seeing any of the earth or spacecraft components. Two heat transfer conditions must be considered in designing the cooler assembly; they are radiation coupling between the patch and cylinder and the cylinder and relay housing, and direct conduction from the ends of the patch to the cylinder and relay housing. Surface treatment and configurations directly affect the radiative coupling while the thermal conductivity and effective thermal path affect the conductive heat transfer. All reflective surfaces are made as free from dark spots or corners as practical while maintaining a configuration suitable for the vibration environment. The underside of the patch and the outside of the cell assembly are also gold plated and polished. The front side, or radiation side, of the patch is vapor blasted and painted with 3M flat black. This type of paint was found to have the best vacuum characteristics. The problem now is to mount the cell assembly onto the radiation patch and suspend them in the cylinder. Several different types of suspension systems were considered and tested. The suspension system most desirable was one which utilized titanium (3 wires) wires molded into two epoxy support rings. Titanium was used because it has the highest strength-to-thermal conductivity factor. Experimentation resulted in the use of 0.012 inch wires. After the support rings were molded they were vapor deposited with gold to enhance their reflective qualities.

The radiant cone, which is also highly reflective, is fitted over the radiant patch and is designed so the patch will look only at space. This cone must also be rugged enough to withstand the extreme vibrations. After several experimental systems were tested it was found that an aluminum cone coated with epoxy and heat cured was best from both reflective and structual standpoints. The cone is then vapor deposited with gold.

Since weight on the support rings is critical and since most of this weight was due to the cell assembly, a redesign of this assembly to reduce its weight was undertaken. It was found that by using magnesium rather than aluminum for the cell assembly parts and radiation patch the stresses on the support wires were greatly reduced. Some difficulty was encountered in plating of the magnesium but the location of a reliable subcontractor has resolved this problem.

a.	Environmental stress:	Especially critical with respect to the support system. All systems are checked at prototype levels prior to use on any flight models.
b.	Weight:	Especially critical with respect to support system.
c.	Expansion coefficients:	Secondary
d.	Balance:	N/A
e.	Dimensional tolerances:	The support system must center the cell with respect to the relay optics. This resulted in testing of each support system after assembly. Special molding fixtures are used.
f.	Torque requirements:	N/A
g.	Lubrication:	N/A
h.	Other special properties:	Special consideration given to drawing the high strength titanium wire for the support system.

2.3.11 Electronics Box

The electronics box consists of a 3/0 module which is mounted into the spacecraft and a preamplifier module which is mounted onto the relay housing.

2.3.11.1 Design Consideration and Fabrication

The basic mechanical consideration for electronic packages is that the modules protect the electronics from the test and operational environments and provide a relatively easy physical assembly that will lend itself to maintenance, testing, and repairs.

Strength to withstand vibration and light weight construction dictate the use of magnesium for the basic 3/0 module. The magnesium will also provide good heat transfer in maintaining the 3/0 module at the required temperature. The preamplifier is smaller than the 3/0 system and much more prone to R-F interference. Because of this conetic AA was chosen for the outside envelope.

Corrosion is always a consideration especially when dissimilar metals or moisture is present. Therefore all stainless fasteners will be passivated, all magnesium components treated with Dow No. 7 and all conetic AA items chrome plated.

a.	Environmental stress:	The 3/0 module is designed for the same level of stress as the radiometer. The preamplifier module is tested as a part of the radiometer.
b.	Weight:	Considered for the 3/0 module which is designed to weigh less than 9 pounds complete.
c.	Expansion coefficients:	Secondary
d.	Balance:	N/A
e.	Dimensional tolerances:	The dimensions on the 3/0 module are critical in that they must agree with the basic design of the spacecraft sensory ring.
f.	Torque requirements:	N/A
g.	Lubrication:	N/A
h.	Other:	The spacecraft bay mounting must be duplicated in testing of the 3/0 module during vibration.

2.3.12 Lubrication, Seals, and Balancing

While these items are not assemblies, nevertheless, their importance to the operation of the HRIR requires some discussion here. The lubricant allows low friction operation by preventing the mating of unlubricated rotating parts. The oil seals limit the evaporation of the lubricant over the intended system lifetime. Balancing of rotating parts is called out in the specifications and will assure that the drive system has a nearly constant operational load. This gives the added benefit of increased bearing life.

2.3.12.1 Design Considerations

The lubrication used is Anderson Oil L-245X per MIL-L-6085A. This oil was chosen for its vacuum qualities and is also used in the ball bearings purchased from New Hampshire Ball Bearings, Inc. Before lubrication, the parts are cleaned and degreased and the lubricant is then applied prior to assembly under a positive pressure hood with a non-contaminating applicator.

Seals are used on the chopper shaft and on the scan mirror shift to inhibit evaporation of the oil in the shaft reservoirs. The maximum annulus between the shaft and seals as defined by the diametric tolerances is 0.001 inch. With this annulus, the evaporation of the lubricant will not limit the life of the system. After the system is assembled, it is periodically run and disassembled for cleaning. A Buna-N gasket forms a static seal around the drive system between the motor mounting plate and the primary casting.

To simplify the balancing of rotating parts, an effort was made to utilize symmetrical construction. Only in the case of the rotating mirror assembly was this not possible. The mirror, however, was designed with counter weights which can be shaved as necessary to achieve a proper balance. The balancing will be subcontracted and will require special tooling and test equipment.

a.	Environmental stress:	N/A for lubricants, seals are held in by retainers and bearing stresses should be reduced by balancing.
b.	Weight:	N/A
c.	Expansion coefficients:	N/A for lubricants and balancing, housings of seals fabricated from some material as shafts.
d.	Balance:	50 microinches for rotating parts

e.	Dimensional tolerances:	N/A for lubricant. The seals are obtained undersized and reamed out to the proper tolerances. The run in procedure then effects an optimum fit.
f.	Torque requirements:	Torque gauging is used to verify proper seal run-ins. Balancing of rotating parts will remove excessive starting torque at some particular spot.
g.	Lubrication:	As stated
h.	Other special properties:	The oil seals require rigidity but a low coefficient of friction. A ceramic filled teflon is used.

2.4 Electronics Packaging

The packaging is designed to provide a relatively compact and lightweight, yet serviceable housing for the electronics circuits of the radiometer. The electronics circuitry is broken down into seven printed boards according to the schematics listed below:

Board 1	Power - TM (4708364)
Board 2	Video Processing (4708385)
Board 3	Reference - AGC (4708377)
Board 4	Calibration - Marker (4708378)
Board 5	Video Output No. 1 (4707700)
Board 6	Video Output No. 2 (4707700)
Board 7	Video Output No. 3 (4707700)

Each board is approximately 5.7 inches by 4.5 inches and is individually potted. These boards slide into slots in the package and mate with connectors mounted in the top section. The boards are held in place with a pressure plate on the bottom. All wiring and the command relay and connectors are in the top section which is potted as a unit.

2.4.1 Design Considerations

a. Printed circuitry: All printed circuit boards will be fabricated from Formica FR-45 material which exhibits a very high surface resistivity. Circuitry will be on both sides using plated through holes, however the plated through holes will not be used for side-to-side continuity. Jumper wires will be used in all cases where it is necessary to go to the opposite surface. All circuitry will be solder coated by either dip or plated solder. The primary design criteria is NPC-200-4 wherever practicable.

b. Potting: At this time we plan to individually pot each board with clear Sylgard approximately 3/16 inch thick. Heavier components will be secured prior to potting with a bead of epoxy. The top section of the housing will probably be potted with foam to conserve weight.

c. Maintainability: Relatively easy maintenance and repair is possible due to the removable boards and clear potting. A single board may easily be removed and repaired by simply cutting away the potting at the correct point, replacing a component, and filling the hole with Sylgard. The top section of the module will be an expendable unit, replaceable if it should fail.

d. R-F Filters: All wiring entering the module from the spacecraft is brought into a sealed compartment through standard DA series connectors. The conductors leave this compartment through bulkhead mounted, multi-channel R-F filter made by Erie. Minimum attenuation of these filters is 50 db from 100 mc to 2000 mc. All wires leaving the module to the scanner housing pass through a Cannon type DD-35PJ3-C33 filter pin connector. These filter pins have approximately the same attenuation characteristics as the multichannel units.

e. Access: Access to the printed boards is gained through a door in the bottom of the module. Wiring access for the top section is available on all four sides and a door in the top when disassembled. When assembled and potted, access is not required since the entire head is replaced in the event of failure.

2.5 Design Review Summation

The Design Review at NASA moved along very well and was finished in 2 days. Many questions were asked and suggestions were made but the basic design was allowed to remain intact. The electronics discussion occupied the greatest amount of time and therefore many ideas were reviewed. Among the questions raised were:

a. It was pointed out that many components as shown were stressed to near maximum ratings and it was thought that these should be derated. ITT agreed to do this.

b. A diode to protect C4 on 4707700 from reverse polarization was suggested. This was agreed to by ITT.

c. Since the AGC operation is so critical it was suggested that the AGC trigger input have the capability of being switched from one output to the other. ITT pointed out that there was no room for a relay and there were no spare pins on the RFI filters with the present design. It was agreed, however, that ITT would look into a way of doing this.

d. Additional telemetry points were suggested for monitoring the operations of the different circuits. It was pointed out that while some printed-circuit board space was available, that there were no spare pins on the RFI filters.

e. The use of a 2N930 transistor in the second stage of the preamplifier was questioned. It seems this device is extremely susceptible to radiation. ITT agreed to look into this for a possible replacement device.

f. A question was asked concerning the increased torque capability of the new motor and how this was accomplished. ITT at that time did not know the answer to this. Since that time, however, further information from H.C. Roters indicated that the increased torque was accomplished by a change in the windings and a higher driving voltage. There were no mechanical changes made, such as using smaller bearings, etc.

These are but a few of many questions and points discussed. We feel that these are the most important from a review standpoint.

3.0 TEST EQUIPMENT

Modification of the test equipment is nearly complete at this time. The checkout console is completed including changes necessitated by the addition of the three telemetry points and one command. The chamber modifications are nearly complete, requiring only internal wiring and plumbing. The albedo simulator has been designed and components parts are either on order or being fabricated.

3.1 Space Chamber Modifications

The chamber bell jar was rotated 22 degrees to accommodate the albedo simulator. This places the window directly in line with the radiometer scan so that the opal glass diffuser can be placed exactly perpendicular to the scan.

The chamber base plate was removed and a larger penetration hole drilled. A demountable penetration plate, O-ring sealed, is bolted over this hole so that future changes can be more readily accomplished. A 54 pin header is used in this application to bring power and signals in and out of the chamber. Chamber wiring is such that the 0/3 module can be operated either in or out of the chamber simply by changing cables.

A new mounting plate was made to allow for horizontal mounting of the blackbody target. The new plate also includes mounts for the electronics module and opal glass diffuser target.

3.2 Bench Checkout Console

The bench checkout console is now capable of manually or automatically reading all test points and telemetry signals available at the radiometer output connectors. Video signals are monitored by oscilloscope or visicorder, and may also be sampled by the digital voltmeter. An input scanner sequentially scans the 18 telemetry points, -24.5 volts power, chopper signal, and the three video outputs, and feeds these signals to a Non-Linear Systems Model 2917A digital voltmeter. The NLS digital voltmeter measures the voltage or frequency and feeds the digitized information to a NLS Model 155 digital printer where it is printed out in eleven columns. The digital voltmeter and printer operation is programmed by the input scanner for each positional reading. An automatic delay and sample circuit allows the video signal to be read during the target portion of the scan. Since the 2917A is an integrating voltmeter, it will integrate the noise and read the actual average dc level.

A functional patch panel provides for monitoring of outputs and test points by either oscilloscope or visicorder. Six channels of high-frequency information may be recorded simultaneously. In addition, this panel provides command switching circuits and meters for voltage and current monitoring.

3.3 Albedo Simulator

A power supply, tungsten iodide lamp, blower, Schott filters, and a series of neutral density filters have been ordered. The housing, mirror, and water filter are being fabricated in-house. When all of these parts are available, the unit will be put together for a series of bench tests. These tests will determine the effects of heat on the filters and on the chamber window. It may prove necessary to modify the existing design if such problems do occur.

4.0 TESTS AND PROCEDURES

Inspection and test procedures are being written for incoming inspection of electrical, mechanical, and optical components, module tests, and alignment and assembly operations. In addition, screening documents are being generated to allow the ordering of prototype and flight model parts. Such documents completed at the end of this reporting period are for:

a. Tunnel diodes (germanium)

b. Fixed ceramic capacitors

c. Transformers and inductors

d. RFI filters

e. Relays

f. Connectors

g. Relay diode assemblies

4.1 Incoming Inspection Test Procedure, Optics

4.1.1 Telescope

a. Item - Optical telescope, 4 inch diameter clear aperture, 4 inch focal length.

b. Manufacturer - Bausch and Lomb Inc., Rochester, New York.

c. Test to be Performed:

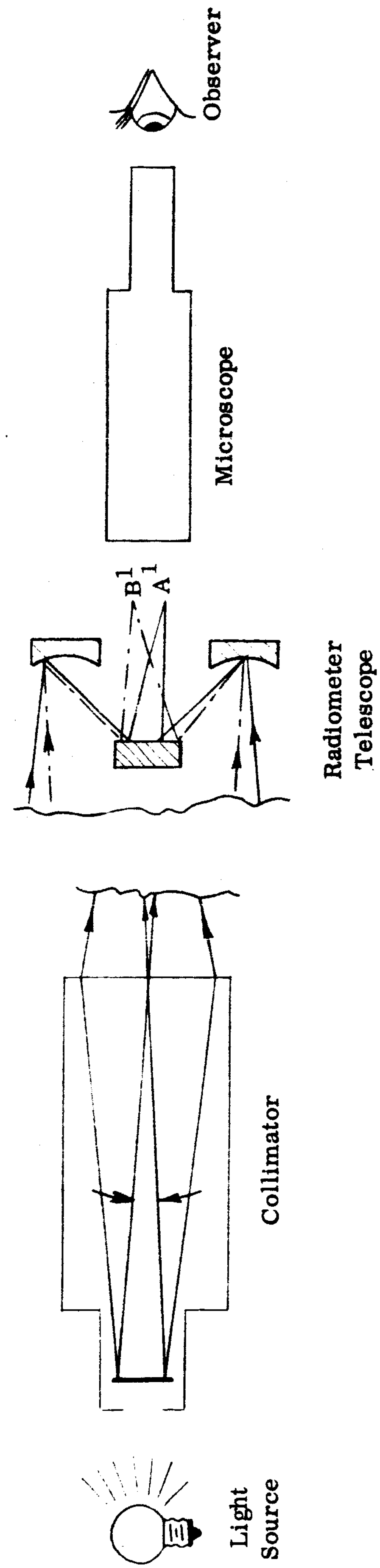
1. Inspection for quality of workmanship

2. Focal length

3. Resolution

4. Clear aperture diameter

ITTIL Drawing No. D-4708370


Observer
Microscope
B1
A1
Radiometer Telescope
Collimator
Light Source

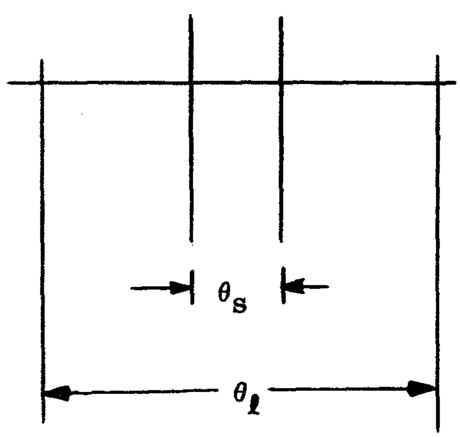
4.1.1.1 Workmanship

Visually inspect reflective surfaces to determine whether reflective coating on the glass has deteriorated. Any dust particles should be removed by light brushing with a soft-bristled camel hair brush. The telescope mounting should be inspected for quality of workmanship, possible flaking on the surface, etc. It is assumed that the mechanical dimensions have previously been checked.

4.1.1.2 Focal Length

The telescope focal length, the magnification of the relay optical system and the detector dimensions determine the field of view of the radiometer. The telescope focal length will be measured using the focal collimator method (see "Optics and Optical Instruments" by B. K. Johnson, pg. 33, Dover Publications Inc., 1960). The method is illustrated in the sketch on the following page.

The optical collimator consists of a highly-corrected lens and a reticle with two parallel lines designated as A and B in the sketch. The reticle is placed in the focal plane of the lens so that the light from either line is "collimated" (the rays leaving the lens are parallel to each other). In order to accomplish this an optical telescope or surveyor's transit (Polara) is first focused on a distant object which is at least 1/2 mile away. By sighting the telescope, which is now focused at infinity, directly into the collimator lens the reticle is positioned until the image of the lines on the reticle are in sharp focus. The collimator is properly adjusted and the reticle is locked into position. The angle, θ, is then measured using the surveyor's transit by lining up the image of line A with the transit cross hair, recording the reading, retating the transit until the image of line B coincides with the transit cross hair and again recording the reading. The difference between these transit readings gives the angle θ. A reticle with four lines has been used and the angles measured are given below.



$\theta_s = 29.3' \pm 0.5'$ $\qquad \frac{1}{\theta 1} = 117 \pm 2$

$\theta_1 = 2^o\ 18' \pm 2' = 136' \pm 2'$ $\qquad \frac{1}{\theta_1} = 24.9 \pm 0.4$

The collimator, radiometer telescope, and observing microscope are now mounted on an optical bench as illustrated. An image of the reticle lines is formed at A' and B' by the radiometer telescope and the separation between them must be measured in order to determine the focal length, F, from the equation

$$F = \frac{}{A'B'} \times \frac{1}{\theta}$$

The observing microscope must contain a calibrated reticle (Bausch and Lomb Inc.) or must have cross hairs and calibrated horizontal travel (A.O. Meyer) to measure the distance $\overline{A'B'}$ accurately (to within ± 0.005 inch). Because of the obscuration of the center portion of the beam the microscope must have an objective with high numerical aperture (0.5 or larger) or else a frosted-glass plate must be inserted at A'B' to scatter the light into the microscope with a smaller numerical aperture objective (the latter approach is preferable because a wider field of view can be observed).

The radiometer telescope focal length must be 4.00 inch ± 0.10 inch to be acceptable.

4.1.1.3 Resolution

This test is a measure of the imaging quality of the radiometer telescope. If the telescope focusing element (primary mirror) were a perfect parabola of revolution then the image of a distant "point" light source (e.g. a star) on the optical axis would have a size determined by diffraction effects (for visible light this would be a light spot with diameter = 0.00005 inch). The actual size of the light spot is a measure of the quality of the optical polishing of the reflecting surfaces.

A distant "point" light source can best be simulated by using a long focal length collimator and a small area light source. A Newtonian astronomical telescope having a primary mirror diameter of 9.5 inches and a speed of f/8 (focal length of 76 inches) makes an ideal collimator for this purpose. A zirconium arc lamp (Sylvania Type C-2) is used as the light source and has a source diameter of 0.005 inch. The light beam spread out of the collimator is therefore 0.066 milliradian which is smaller than actually required for the intended measurements (a source diameter of 0.015 inch subtends an angle of 0.2 milliradian which could also be used).

The nearly parallel light beam from the collimator is directed into the radiometer telescope under test. An image of the "point" light source is formed at the telescope focal plane - the telescope is adjusted so that this light spot lies on the telescope optical axis. An observing microscope is then used to measure the diameter or largest extent of the light spot. If the diameter of this light spot does not exceed 0.007 inch the resolution of the telescope is acceptable (in angular measure this light spot represents 1.2 milliradians).

4.1.1.4 Clear Aperture Diameter

The clear aperture diameter is the inner diameter of the cylindrical housing. It may be measured with a high-grade straight steel ruler or a micrometer caliper. The diameter should be 4 ±1/16 inch.

4.1.2 Relay Mirrors

a. Item - Part 1: Parabolic, front-surface mirror, 2-1/8 inch diameter clear aperture, 2-1/8 inch focal length.

Part 2: Parabolic, front-surface mirror, 2-1/8 inch clear aperture, 2 inch focal length.

b. Drawing No. 4708332

c. Manufacturer - Unertl Optical Company, Pittsburgh, Pa.

d. Tests to be Performed:

1. Visual inspection for quality of workmanship

2. Focal length

3. Resolution

4. Clear aperture diameter

These tests are all performed in the same manner as those for the radiometer telescope (see Incoming Inspection Test Procedure for Telescope). A flat secondary mirror must be used so that the relay mirror - secondary mirror configuration resembles the radiometer telescope (ie. the flat mirror must be used to make the image plane accessible). The acceptable values are listed below.

Part No. 1: Focal length = 2.125 ± 0.040 inch
Dia. of point source image = 0.002 inch max.
Clear aperture diameter = 2-1/8 inches ±1/32 inch

Part No. 2: Focal length = 2.000 inches ● 0.040 inch
Dia. of point source image = 0.002 inch max.
Clear aperture diameter = 2-1/8 inches ±1/32 inch

4.1.3 Dual-Bandpass Optical Filter

a. Item - Infrared Dual-Bandpass Optical Filter

b. Manufacturer - Optical Coating Lab., Inc., Santa Rosa, California

c. Tests to be performed:

1. Physical dimensions

2. Visual inspection of coatings and bond

3. Spectral transmission

4.1.3.1 Physical Dimensions

Measure the physical dimensions noted on Drawing ITTIL-4708251.

4.1.3.2 Visual Inspection

Visually inspect the antireflection coatings and the bond between the two annular sections. Any pealing of the coatings inside the clear aperture diameter (2.125 inch) shall be cause for rejection. Complete failure of the bond shall also be cause for rejection of the filter.

4.1.3.3 Spectral Transmission

The transmission of both the short wavelength (0.7 to 1.3 microns) and the long wavelength (3.4 to 4.2 microns) sections shall be measured separately using the Perkin-Elmer Model 112 Spectrometer. The acceptable limits are given in the purchase specifications (see ITTIL drawing A-4708371).

4.1.4 Scan Mirror

a. Item - Scan Mirror (Drawing C-4708309)

b. Tests to be Performed:

1. Workmanship

2. Flatness

3. Infrared Reflectivity

4.1.4.1 Workmanship

Visually inspect the flat reflecting surface to determine that there are no large digs or scratches. The surface should have the general appearance of a good reflecting mirror free of surface contamination, large dirt spots, etc. A slight graying appearance is tolerable since it is its infrared reflecting properties that are important rather than visual properties. Any dust particles should be removed by light brushing with a soft-bristled camel hair brush.

4.1.4.2 Flatness

The flatness of the scan mirror can be ascertained by measuring the resolution of one of the radiometer telescopes after the optical beam has been reflected at right angles by the scan mirror. One of the radiometer telescopes that have previously had their resolution measured should be used for this measurement (see Incoming Inspection Test Procedure for Telescope). The same optical collimator, measuring microscope, etc. should be used as for the telescope resolution measurement.

The scan mirror, radiometer telescope, and observing microscope are suitably mounted on an optical bench which is at right angles to the collimator beam. If the scan mirror were perfectly flat the image of the "point" light source would appear exactly the same as that observed during the radiometer telescope resolution test. Actually it will be observed that the shape and size of the light spot is different from that previously seen without the scan mirror. If the largest extent of the observed light spot does not exceed 0.011 inch on the optical axis the flatness of the scan mirror is acceptable.

4.1.4.3 Infrared Reflectivity

The specular reflectivity is measured on a standard infrared spectrometer, Perkin-Elmer Model 112. The spectral reflectivity is measured by substituting the scan mirror for the plane source diagonal mirror normally used. The signal obtained using the normal mirror is recorded and then later compared with the corresponding signal obtained with the radiometer scan mirror. The infrared reflectivity of the aluminized glass mirror (the normal mirror) is very high, about 97 $\pm$1 percent. This measurement is then a comparison test with the normal mirror serving as a reference standard. If the reading obtained with the scan mirror is 0.93 times the reading with normal mirror or higher the reflectivity of the scan mirror is acceptable. Absolute reflectivity results could be obtained if the absolute reflectivity of the normal or reference mirror was known.

5.0 STATUS AND FORECAST

The HRIR is now being built according to the design established by the review of November 15, 1965. Several changes to this design were discussed at NASA on December 20, 1965. These changes would include a new command and several additional telemetry points. ITT is also making several changes which will reduce power consumption and improve radiation resistance.

During the next quarter, a breadboard unit will be put together and tested. The result of these tests will be reflected in changes to the Prototype HRIR. This unit will then be turned over to reliability for further tests.

APPENDIX

DRAWINGS

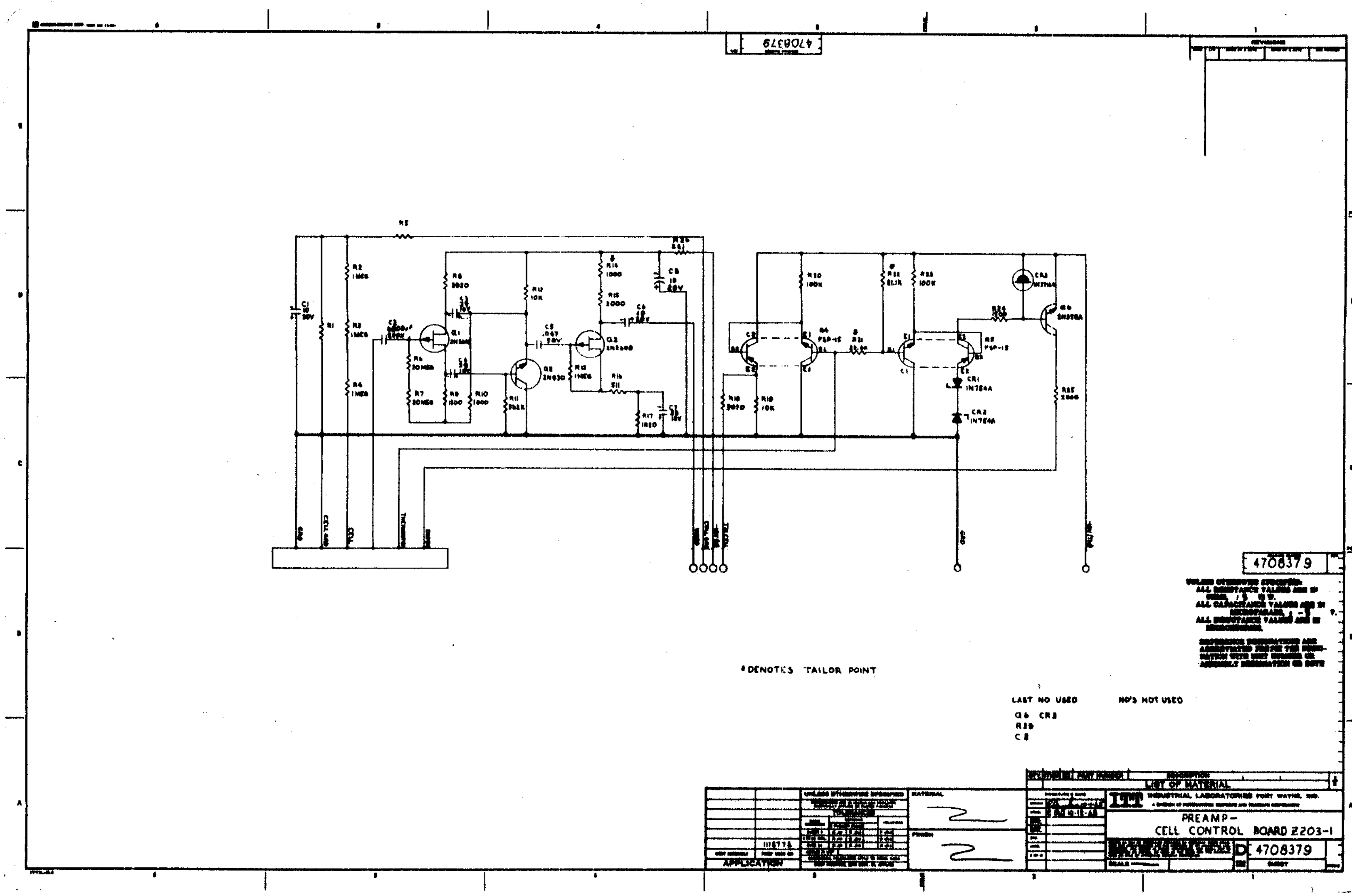
The following schematics and drawings were presented at the design review of November 15, 1965.

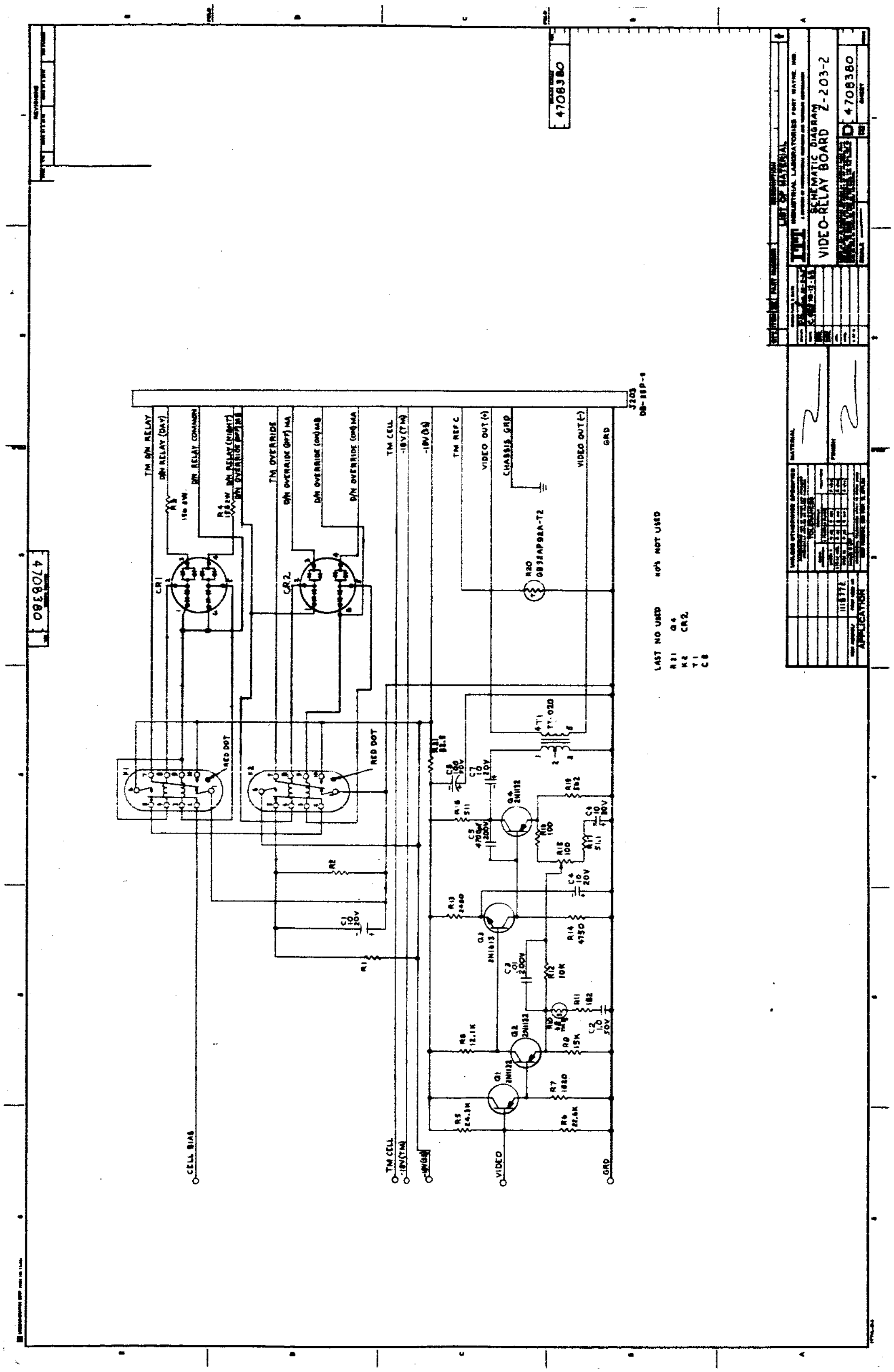
1. Preamp - Cell Control Board Z203-1, 4708379
2. Video - Relay Board Z203-2, 4708380
3. Video Processing Board Z106, 4708385
4. Video Output Board Z109-Z111, 4707700
5. Reference - AGC Board Z107, 4708377
6. Calibrator - Marker Board Z108, 4708378
7. Power - TM Board Z105, 4708364
8. Wiring Diagram, HRIR Scanner Housing, 4708393
9. Wiring Diagram, HRIR Electronics Module, 4708410
10. Function Block Diagram, Nimbus B Day-Night HRIR, 4708392
11. Optical System of the HRIR
12. Reflectivity of Three Aluminized Mirrors and of Two Gold Coated Mirrors, Solar Intensity, and Emission of 300 degrees K Source vs. Wavelength
13. Detectivity vs. Wavelength of Kodak Ektron Detector at -70 degrees C.
14. Infrared Dual Bandpass Filter, 4708251
15. Detector Cell Assembly, 4708256
16. Rotating Mirror Assembly, 4708316
17. Cylinder Assembly, 4708277

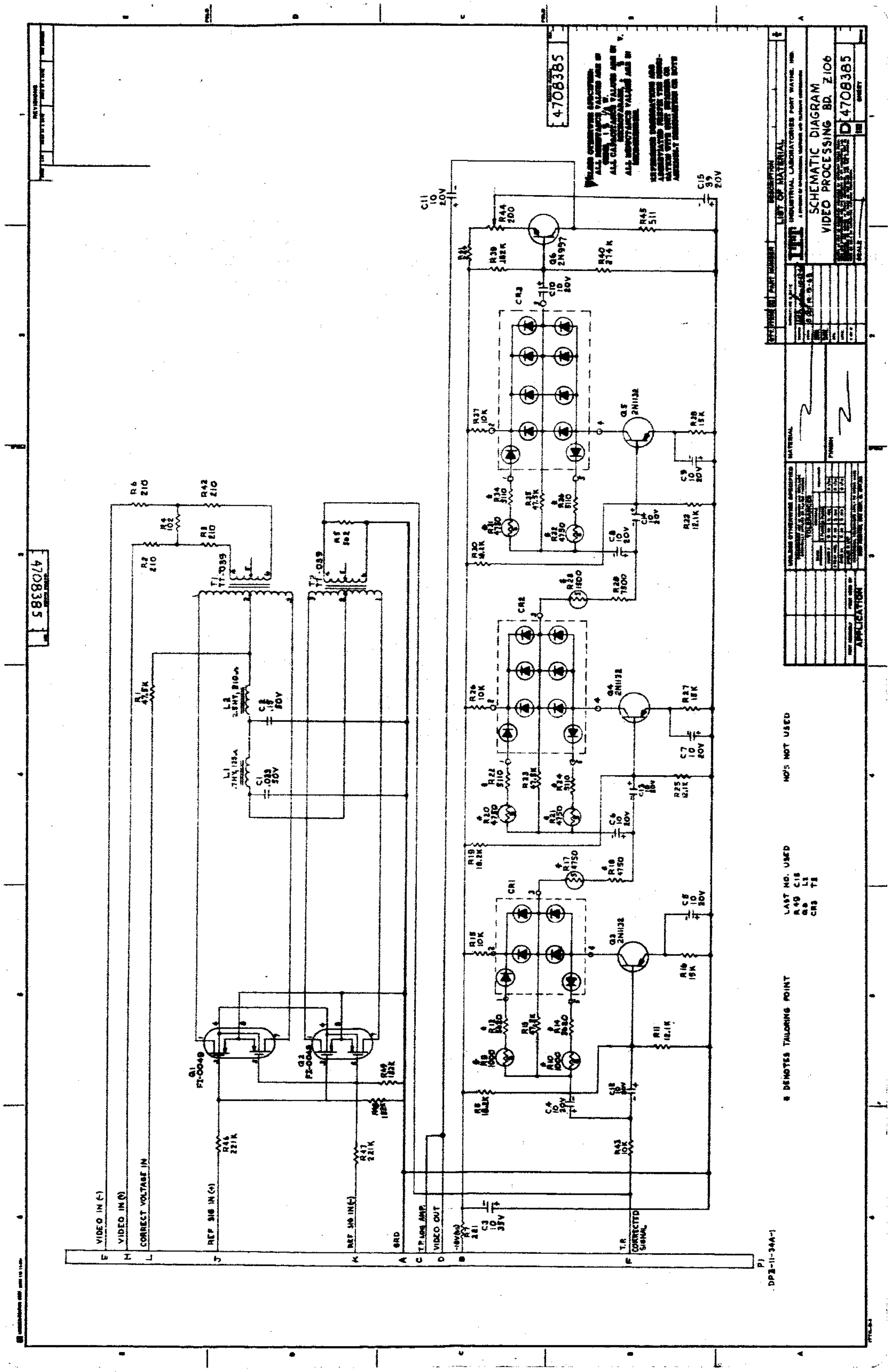
APPENDIX

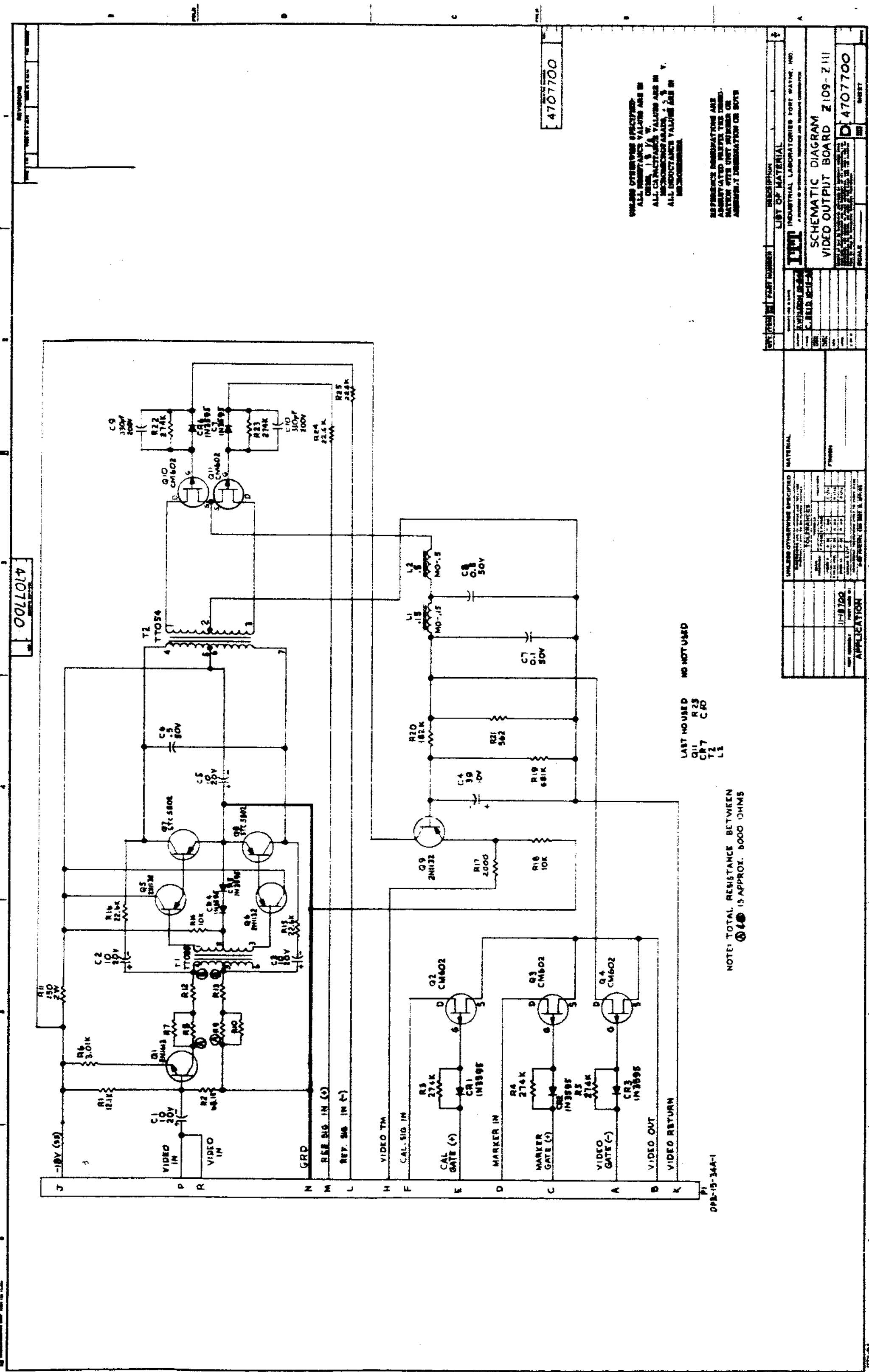
DRAWINGS (Cont.)

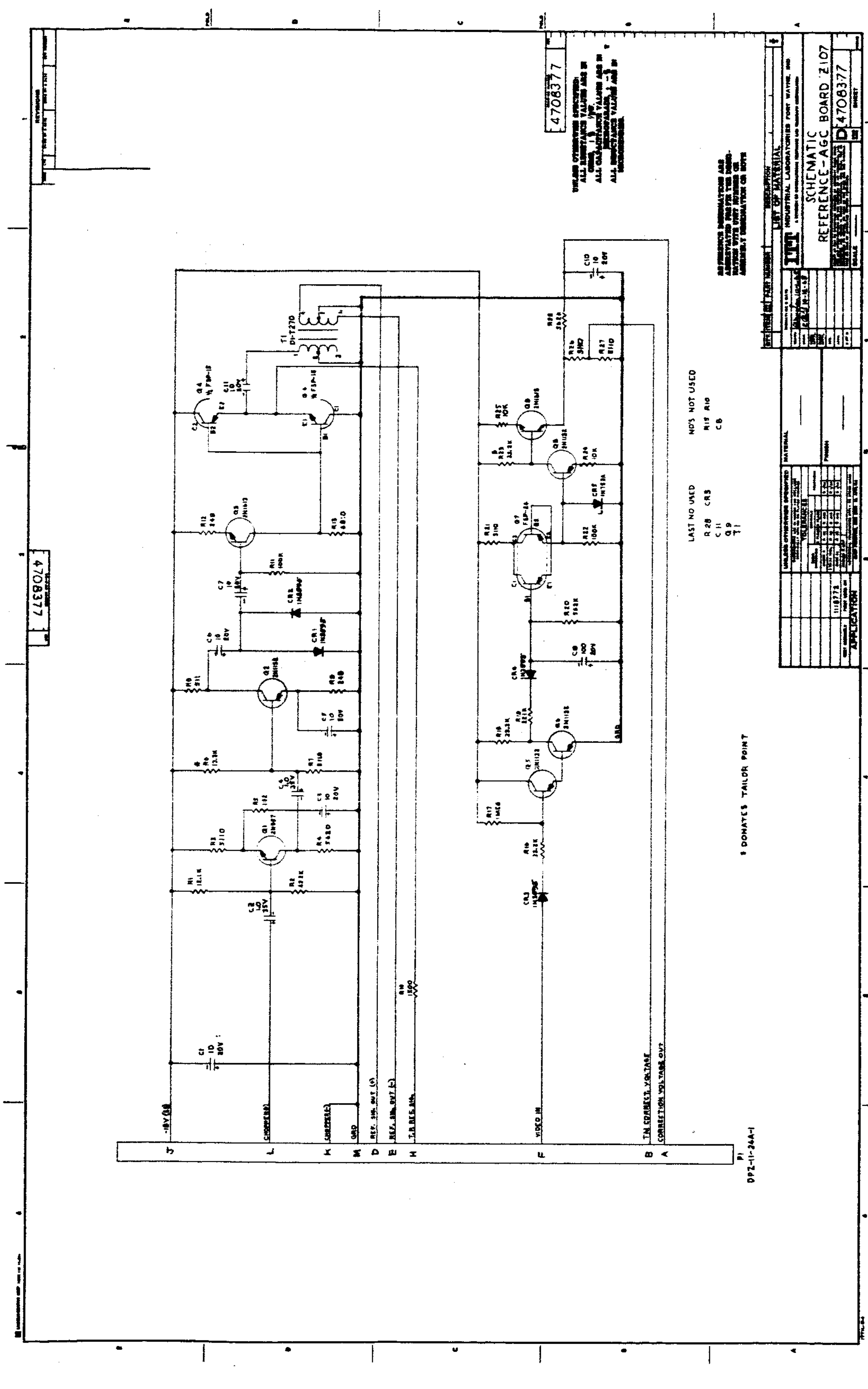
18. Patch Assembly - Radiant Cooler, 4708264
19. Support Ring Assembly, 4708270
20. Wire, 4708268
21. Housing - Relay, 4708411
22. Bracket, Electronics Module, 4708375
23. Case, Electronics Module, 4708376

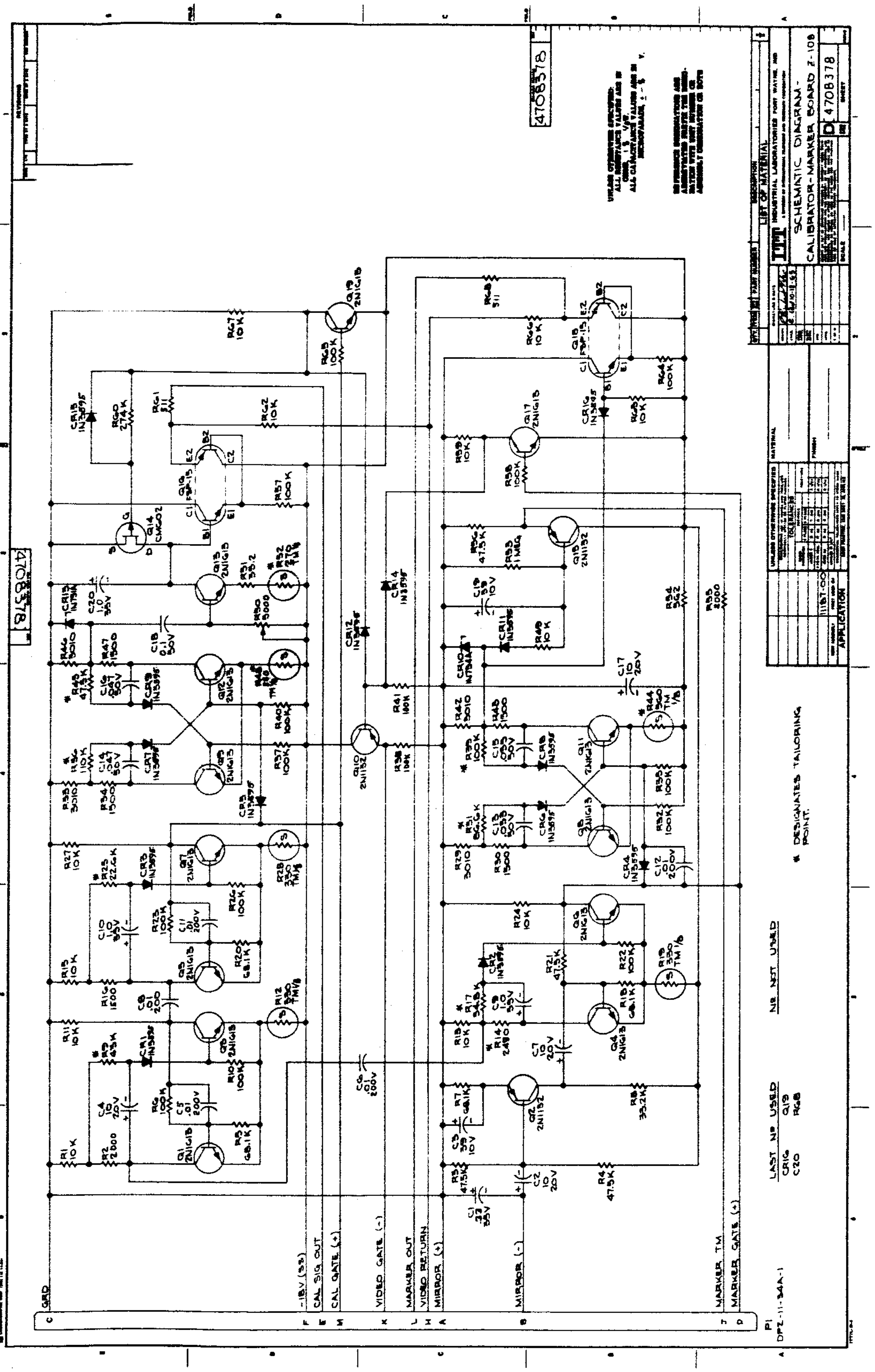

4708379
# DENOTES TAILOR POINT
LAST NO USED
NO'S NOT USED
Q6 CR3
R26
C8
LIST OF MATERIAL
INDUSTRIAL LABORATORIES FORT WAYNE, IND.
PREAMP-
CELL CONTROL BOARD 2203-1
4708379
MATERIAL
FINISH
APPLICATION

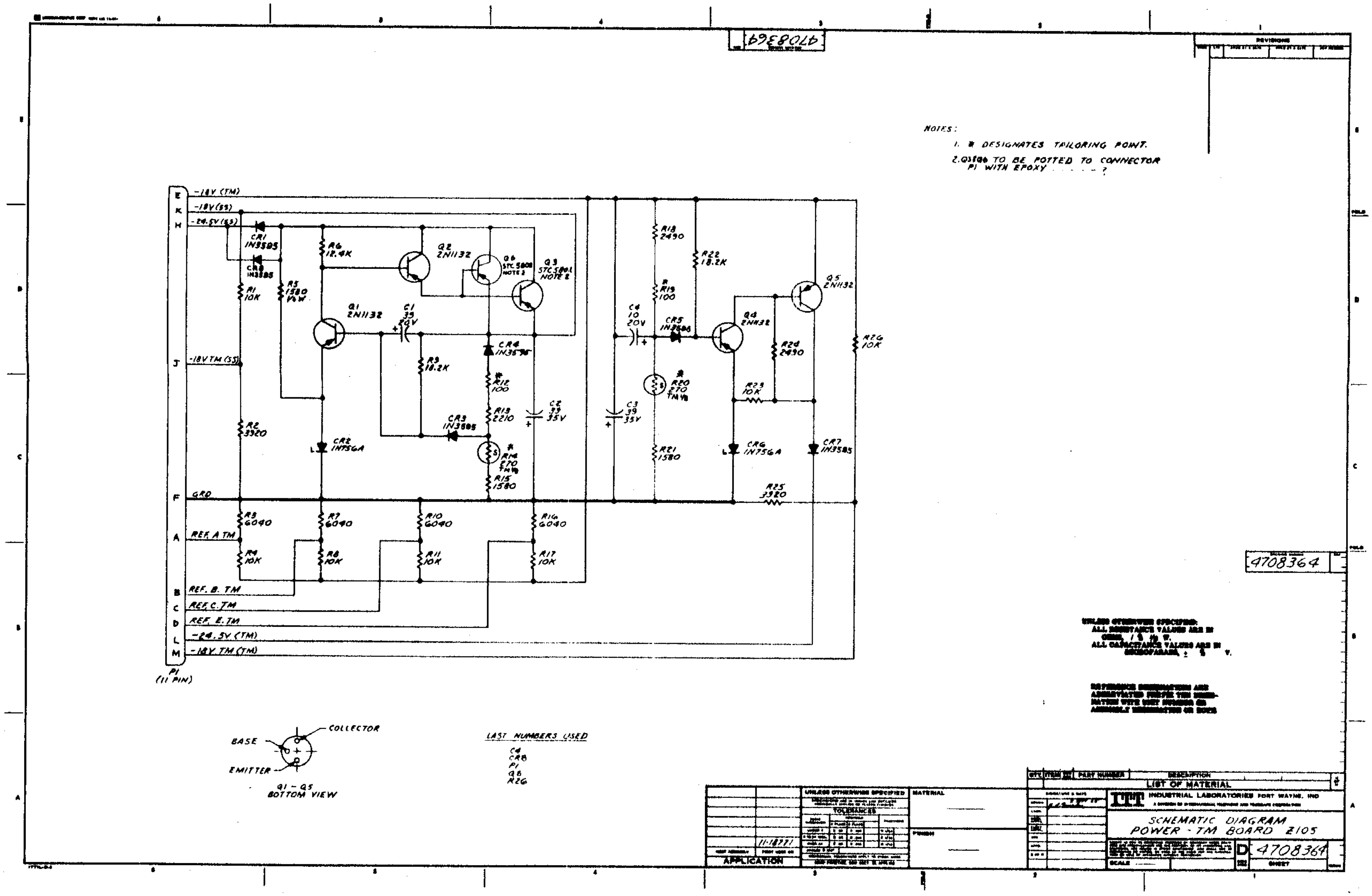

SCHEMATIC DIAGRAM
VIDEO-RELAY BOARD
Z-203-2
4708380
LIST OF MATERIAL
APPLICATION
TM D/N RELAY
D/N RELAY (DAY)
D/N RELAY COMMON
D/N RELAY (NIGHT)
TM OVERRIDE
TM CELL
-18V(TM)
TM REF C
VIDEO OUT (+)
CHASSIS GRD
VIDEO OUT (-)
GRD
J203
CR1
CR2
RED DOT
CELL BIAS
VIDEO
LAST NO USED
R21
K2
T1
C8
Q4
CR2


SCHEMATIC DIAGRAM
VIDEO PROCESSING BD. Z106
4708385

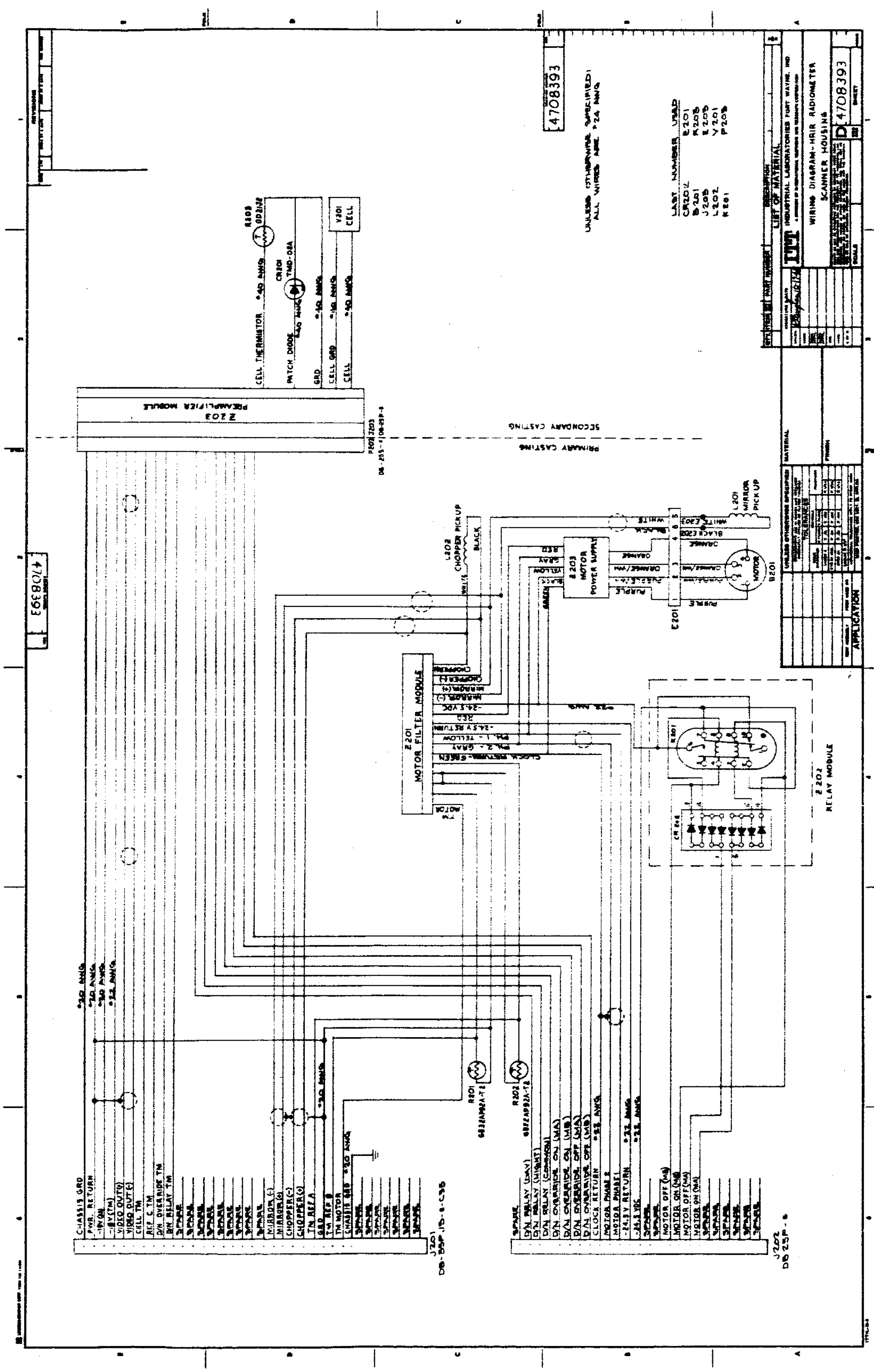

SCHEMATIC DIAGRAM
VIDEO OUTPUT BOARD Z109-Z111
4707700
LIST OF MATERIAL
APPLICATION
NOTE: TOTAL RESISTANCE BETWEEN
IS APPROX. 8000 OHMS
LAST HOUSED
NO NOT USED
VIDEO IN
GRD
REF SIG IN (+)
REF SIG IN (-)
VIDEO TM
CAL SIG IN
CAL GATE (+)
MARKER IN
MARKER GATE (+)
VIDEO GATE (-)
VIDEO OUT
VIDEO RETURN

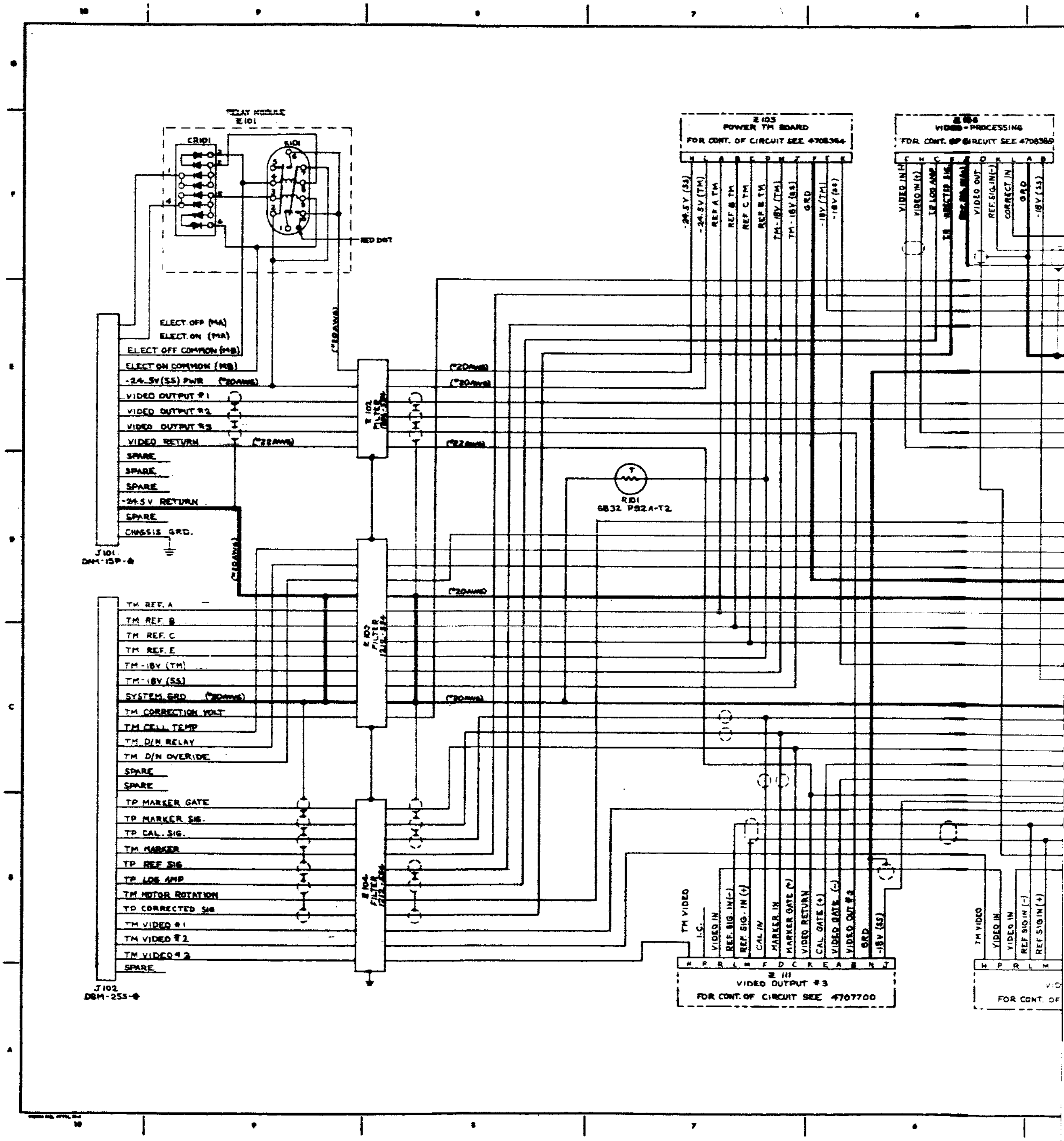

SCHEMATIC
REFERENCE-AGC BOARD Z107
4708377
LIST OF MATERIAL
INDUSTRIAL LABORATORIES FORT WAYNE, IND.
APPLICATION
LAST NO USED
R 28 CR3
C 11
Q 9
T 1
NO'S NOT USED
R15 R16
C8
* DONATES TAILOR POINT
P1
DPZ-11-24A-1


SCHEMATIC DIAGRAM-
CALIBRATOR-MARKER BOARD Z-108
4708378
* DESIGNATES TAILORING POINT.
LAST No USED
No NOT USED
GRD
-18V (SS)
CAL SIG OUT
CAL GATE (+)
VIDEO GATE (-)
MARKER OUT
VIDEO RETURN
MIRROR (+)
MIRROR (-)
MARKER TM
MARKER GATE (+)
P1
DPZ-11-34A-1

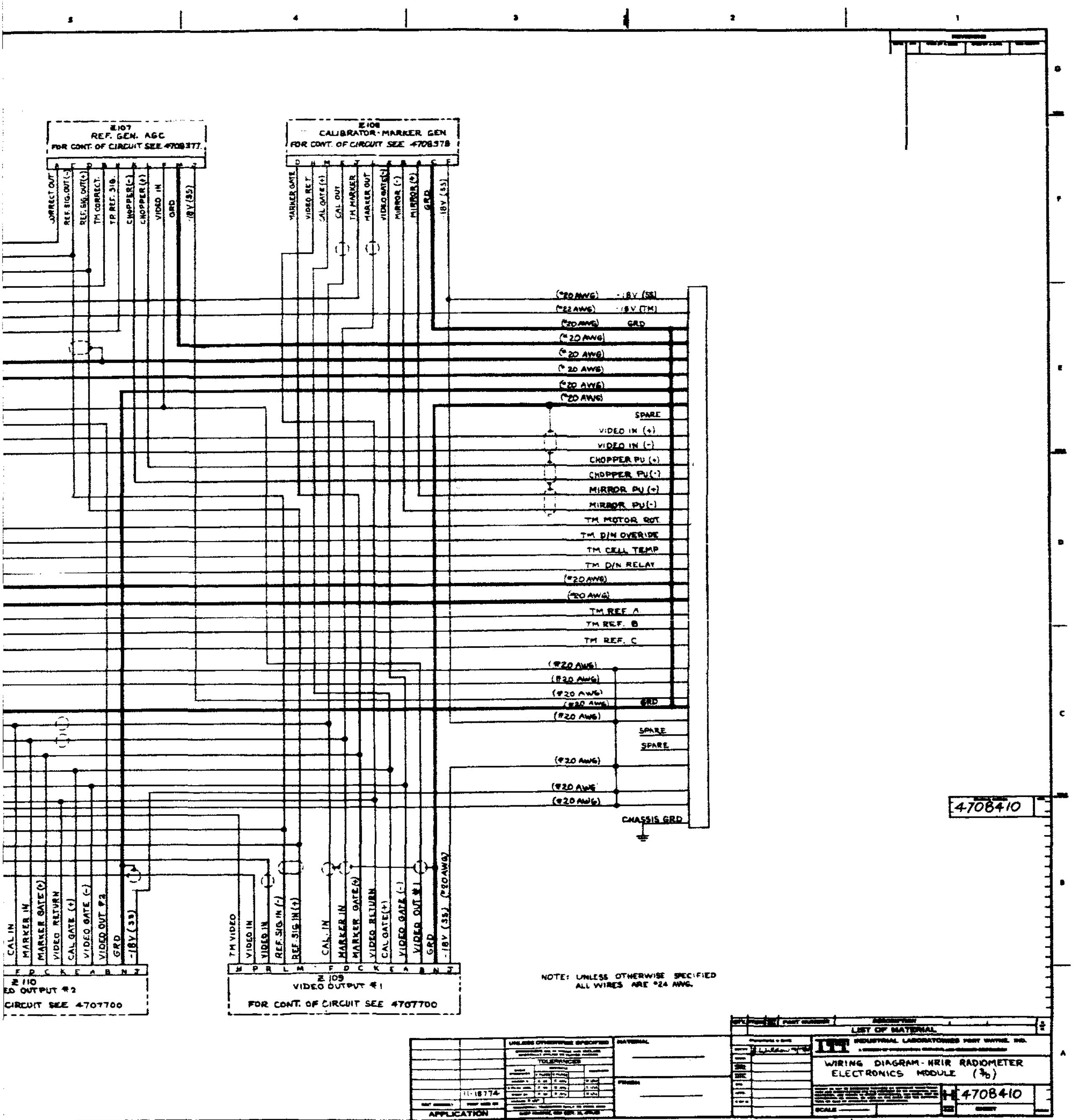


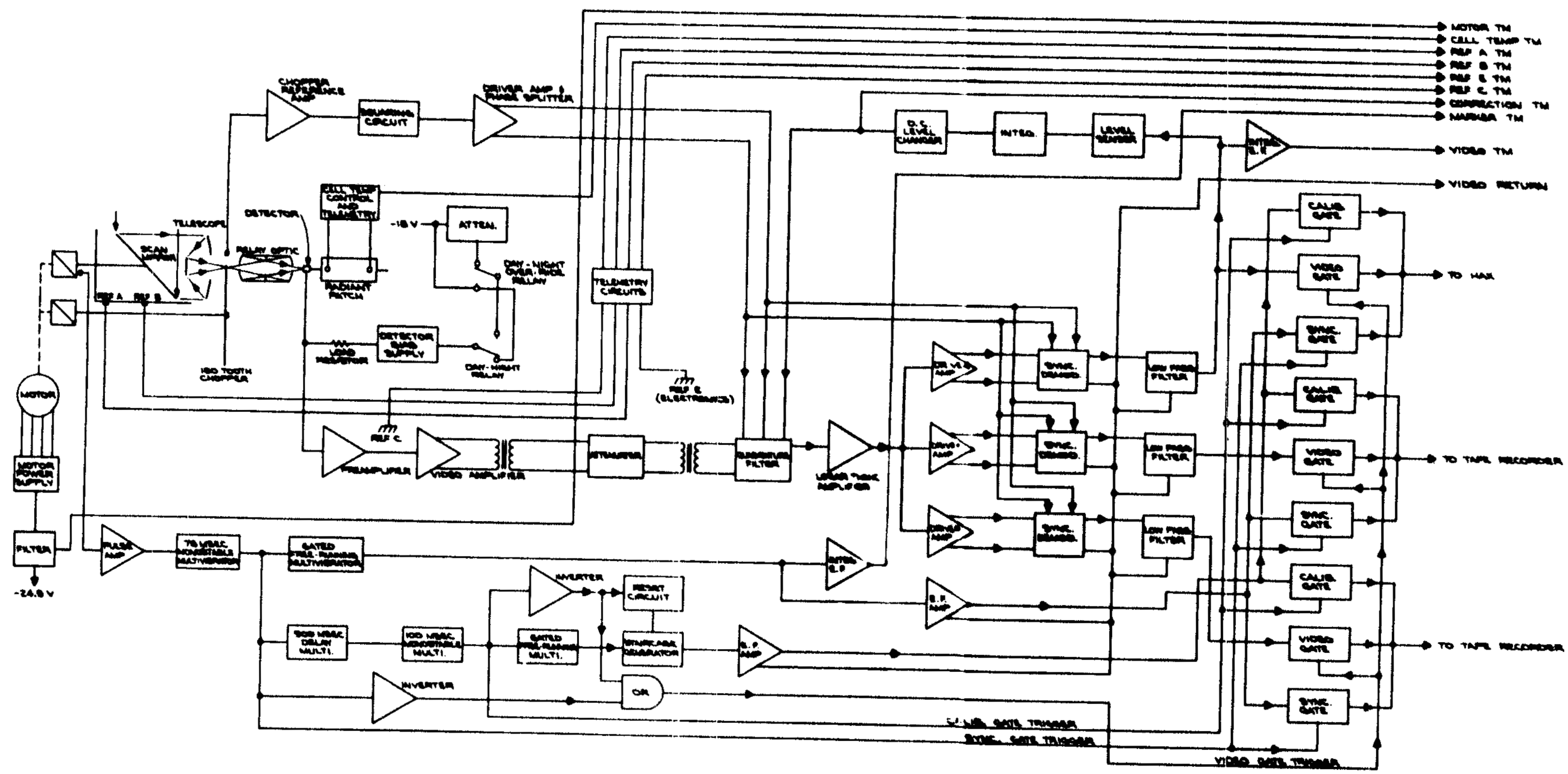
NOTES:
1. # DESIGNATES TAILORING POINT.
2. Q3 & Q6 TO BE POTTED TO CONNECTOR P1 WITH EPOXY
LAST NUMBERS USED
C4
CR8
P1
Q6
R26
BASE
COLLECTOR
EMITTER
Q1 - Q5 BOTTOM VIEW
P1 (11 PIN)
-18V (TM)
-18V (SS)
-24.5V (SS)
-18V TM (SS)
GRD
REF. A TM
REF. B. TM
REF. C. TM
REF. E. TM
-24.5V (TM)
-18V TM (TM)
LIST OF MATERIAL
ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND
SCHEMATIC DIAGRAM
POWER - TM BOARD Z105
4708364
APPLICATION
11-18771


4708393
WIRING DIAGRAM-HRIR RADIOMETER SCANNER HOUSING
LIST OF MATERIAL
INDUSTRIAL LABORATORIES FORT WAYNE, IND
UNLESS OTHERWISE SPECIFIED ALL WIRES ARE #24 AWG
Z203 PREAMPLIFIER MODULE
Z201 MOTOR FILTER MODULE
Z202 RELAY MODULE
SECONDARY CASTING
PRIMARY CASTING
APPLICATION

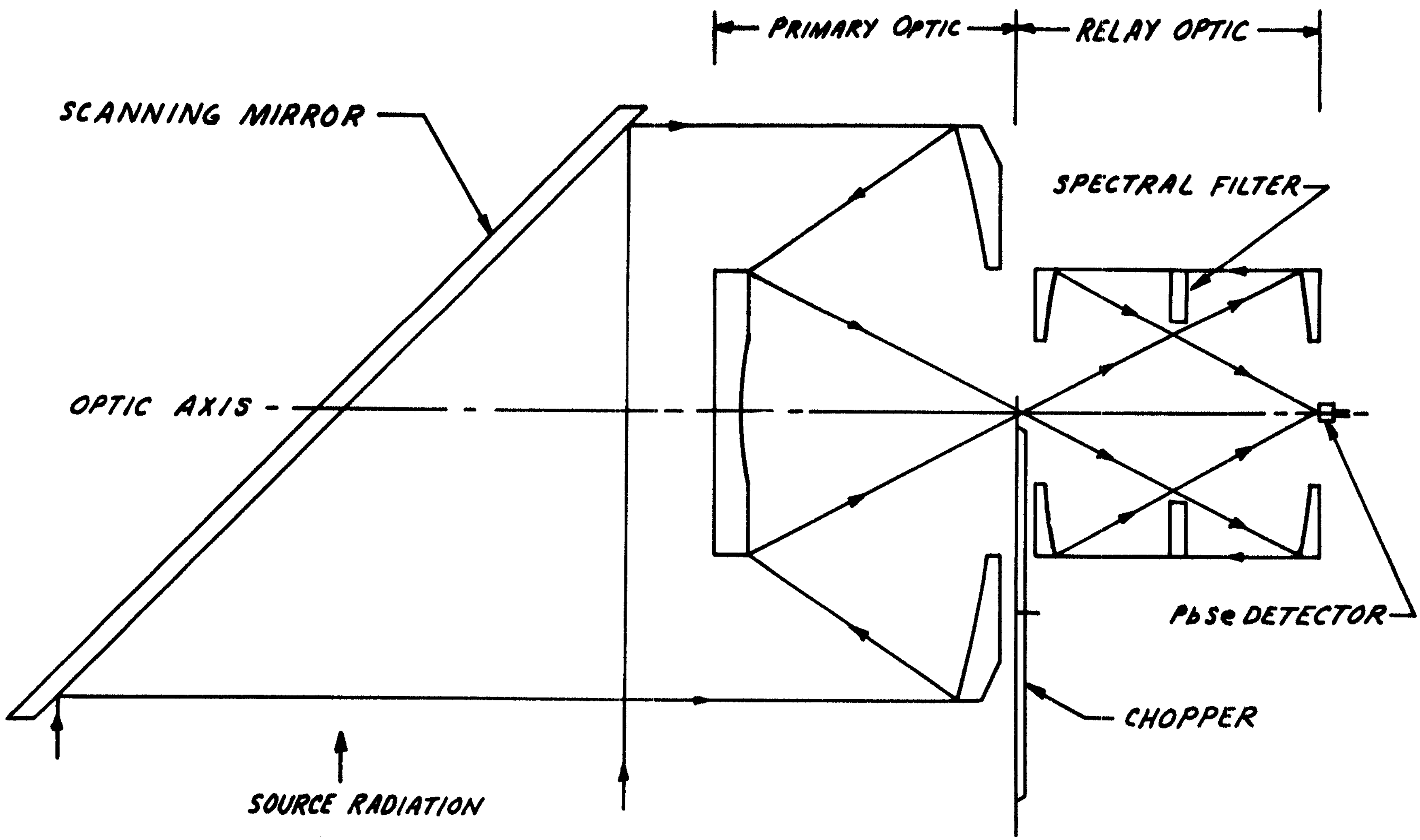

RELAY MODULE E101
CR101
K101
RED DOT
ELECT OFF (MA)
ELECT ON (MA)
ELECT OFF COMMON (MB)
ELECT ON COMMON (MB)
-24.5V (SS) PWR
VIDEO OUTPUT #1
VIDEO OUTPUT #2
VIDEO OUTPUT #3
VIDEO RETURN
SPARE
-24.5 V RETURN
CHASSIS GRD.
J101
DAM-15P-0
TM REF. A
TM REF. B
TM REF. C
TM REF. E
TM -18V (TM)
TM -18V (SS)
SYSTEM GRD
TM CORRECTION VOLT
TM CELL TEMP
TM D/N RELAY
TM D/N OVERIDE
TP MARKER GATE
TP MARKER SIG.
TP CAL. SIG.
TM MARKER
TP REF SIG
TP LOG AMP
TM MOTOR ROTATION
TP CORRECTED SIG
TM VIDEO #1
TM VIDEO #2
TM VIDEO #3
J102
DBM-25S-0
R101
6832 PB2A-T2
E 103
POWER TM BOARD
FOR CONT. OF CIRCUIT SEE 4708364
VIDEO-PROCESSING
FOR CONT. OF CIRCUIT SEE 4708369
E 111
VIDEO OUTPUT #3
FOR CONT. OF CIRCUIT SEE 4707700
TM VIDEO
I.C.
VIDEO IN
REF. SIG. IN (-)
REF. SIG. IN (+)
CAL IN
MARKER IN
MARKER GATE (+)
VIDEO RETURN
CAL GATE (+)
VIDEO GATE (-)
VIDEO OUT #3
GRD
-18V (SS)

A-11-1

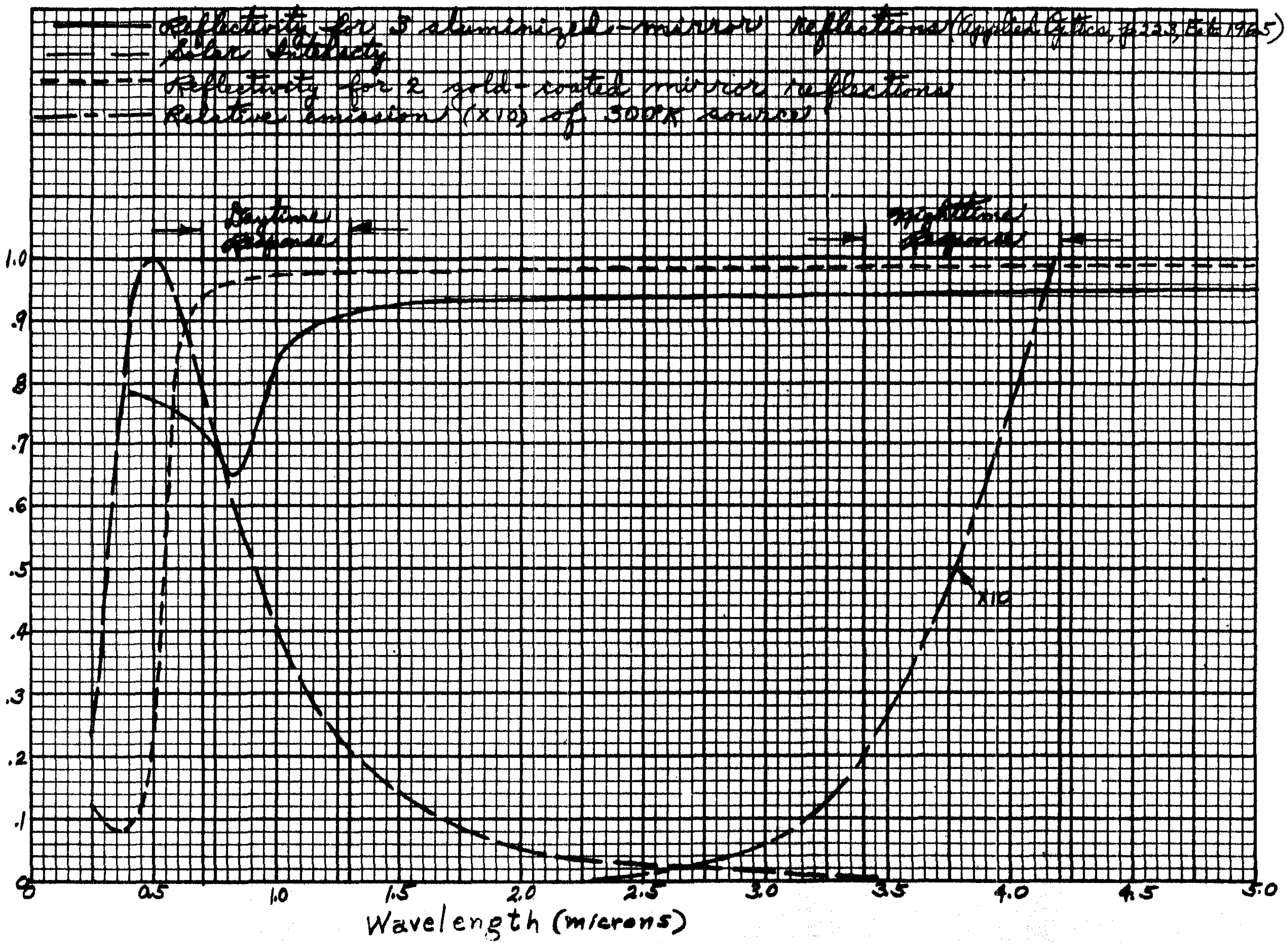

Z107
REF. GEN. AGC
FOR CONT. OF CIRCUIT SEE 4708377
Z108
CALIBRATOR-MARKER GEN
FOR CONT. OF CIRCUIT SEE 4708378
-18V (SS)
-18V (TM)
GRD
SPARE
VIDEO IN (+)
VIDEO IN (-)
CHOPPER PU (+)
CHOPPER PU (-)
MIRROR PU (+)
MIRROR PU (-)
TM MOTOR ROT
TM D/N OVERIDE
TM CELL TEMP
TM D/N RELAY
TM REF. A
TM REF. B
TM REF. C
CHASSIS GRD
Z110
VIDEO OUTPUT #2
CIRCUIT SEE 4707700
Z109
VIDEO OUTPUT #1
FOR CONT. OF CIRCUIT SEE 4707700
NOTE: UNLESS OTHERWISE SPECIFIED ALL WIRES ARE #24 AWG.
LIST OF MATERIAL
ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.
WIRING DIAGRAM - HRIR RADIOMETER ELECTRONICS MODULE
4708410
APPLICATION
TOLERANCES
MATERIAL
FINISH
SCALE

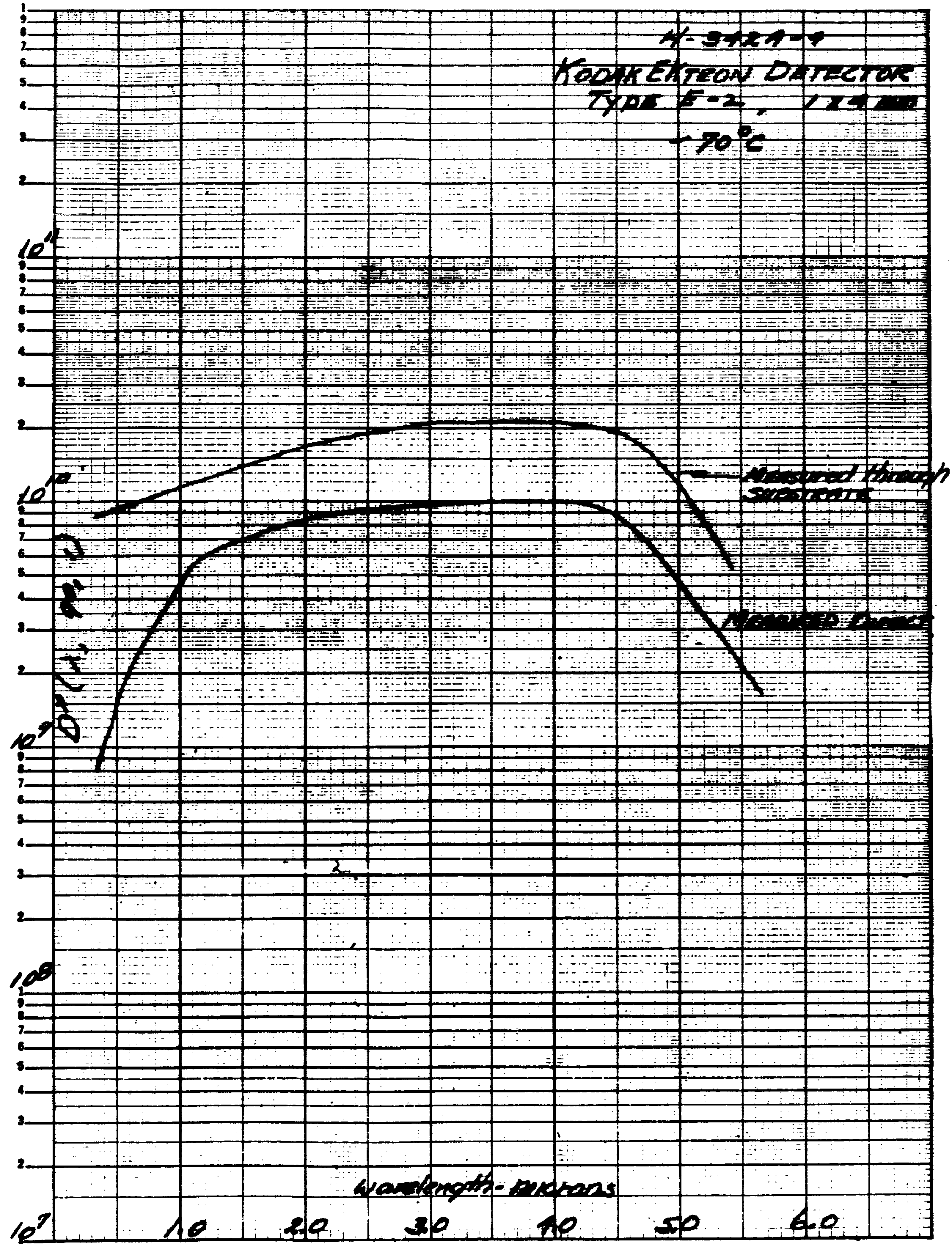


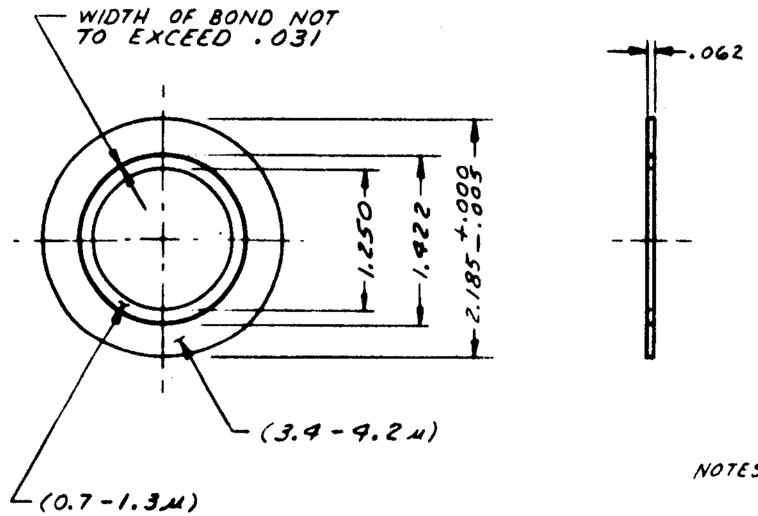
Functional Block Diagram Nimbus B Day-Night HRIR 4708392



Optical System of the High Resolution Infrared Radiometer


Reflectivity for 3 aluminized-mirror reflections (Applied Optics, p.223, Feb 1965)
Solar Intensity
Reflectivity for 2 gold-coated mirror reflections
Relative emission (x10) of 300°K source
Daytime response
Nighttime response
x10
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Wavelength (microns)


H-3421-4
KODAK EKTEON DETECTOR
TYPE E-2, 1x4 mm
-70°C
Measured through SUBSTRATE
MEASURED DIRECT
Wavelength - Microns
1.0
2.0
3.0
4.0
5.0
6.0
10^7
10^8
10^9
10^10
10^11



NOTES:

1. CONCENTRICITY OF SECTIONS TO BE LESS THAN ±.005 T.I.R.

QTY.	ITEM	PART NUMBER	DESCRIPTION
			LIST OF MATERIAL

ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.
A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

INFRARED DUAL-BANDPASS FILTER

B 4708251

SCALE 1/1 — SHEET

DRAWING NUMBER: 4708251

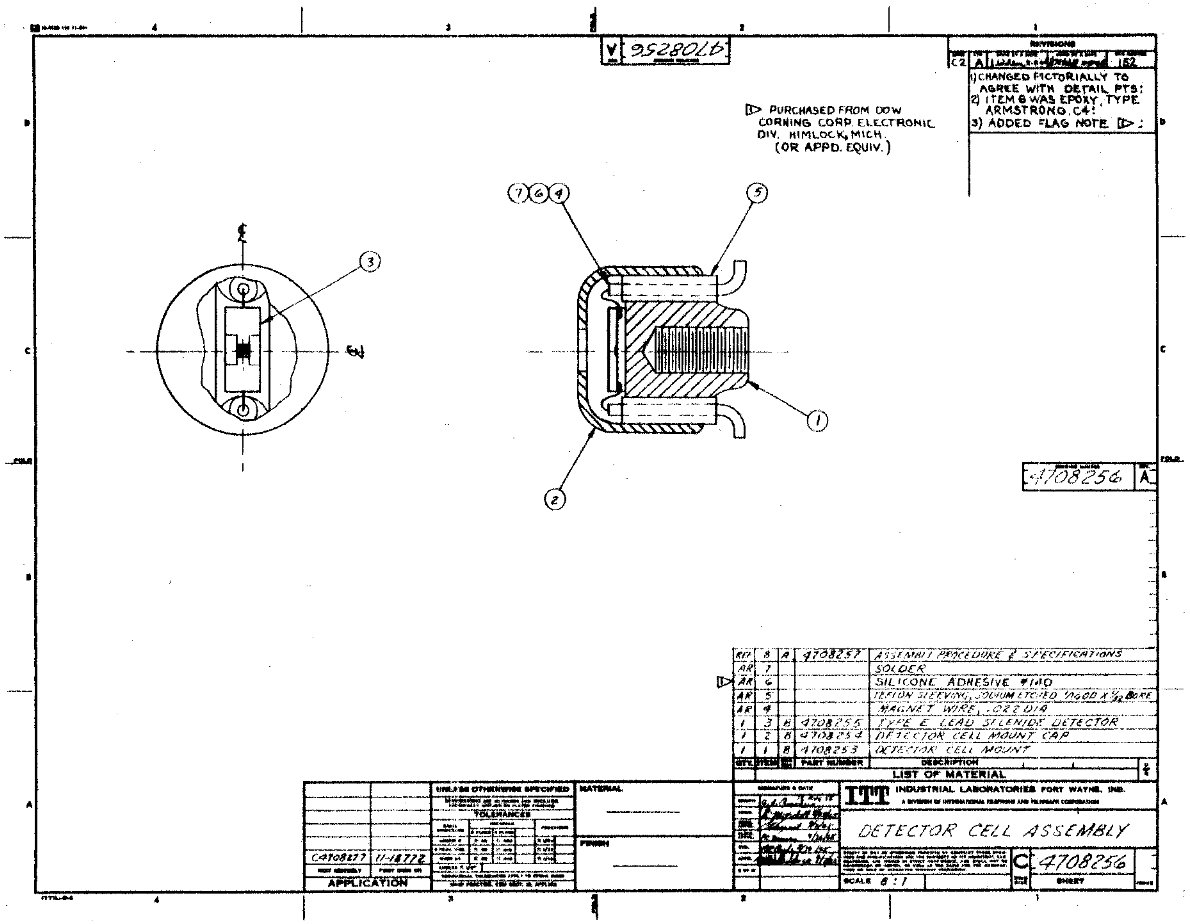
MATERIAL: SEE SPEC # IL-S-4708251

FINISH: —

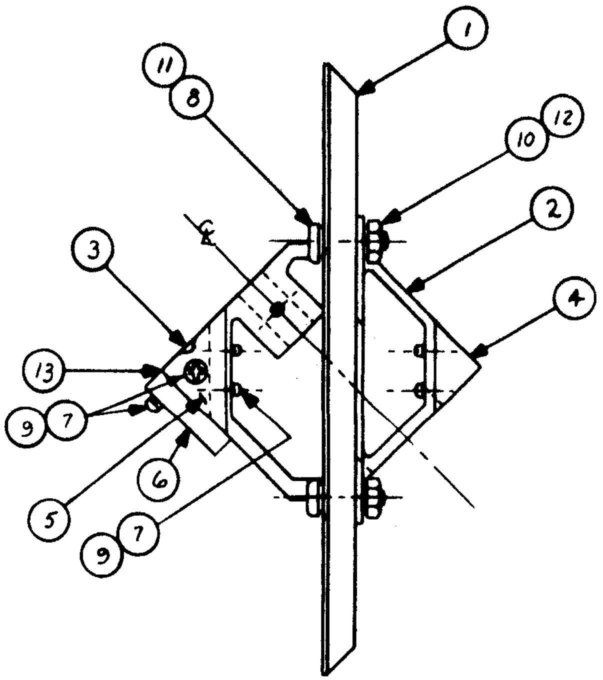
UNLESS OTHERWISE SPECIFIED — TOLERANCES

NEXT ASSEMBLY	FIRST USED ON
	11-18773

APPLICATION


REVISIONS
C2 A 152
1) CHANGED PICTORIALLY TO AGREE WITH DETAIL PTS.
2) ITEM 6 WAS EPOXY, TYPE ARMSTRONG C4.
3) ADDED FLAG NOTE
PURCHASED FROM DOW CORNING CORP. ELECTRONIC DIV. HIMLOCK, MICH. (OR APPD. EQUIV.)
4708256 A
REF 8 A 4708257 ASSEMBLY PROCEDURE & SPECIFICATIONS
AR 7 SOLDER
AR 6 SILICONE ADHESIVE #140
AR 5 TEFLON SLEEVING, SODIUM ETCHED
AR 4 MAGNET WIRE, .022 DIA
1 3 B 4708255 TYPE E LEAD SELENIDE DETECTOR
1 2 B 4708254 DETECTOR CELL MOUNT CAP
1 1 B 4708253 DETECTOR CELL MOUNT
QTY ITEM PART NUMBER DESCRIPTION
LIST OF MATERIAL
ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.
DETECTOR CELL ASSEMBLY
C 4708256
SCALE 8:1
UNLESS OTHERWISE SPECIFIED
TOLERANCES
MATERIAL
FINISH
C4708277 11-18772
APPLICATION

4708316



NOTES:

1. ASSEMBLY TO BE DYNAMICALLY BALANCED TO WITHIN 50 MICRO-INCHES.

REVISIONS

QTY.	ITEM	DWG SIZE	PART NUMBER	DESCRIPTION
REF	14	A	4708315	ASSEMBLY PROCEDURE & SPECIFICATIONS
AR	13			LOCKTITE "C"
4	12		MS25082-1	NUT, PLAIN, HEX, STL, CAD PL #6-32NC-2B, 5/16 AF
4	11		MS27183-6	WASHER, FLAT, STL, CAD PL .375 O.D. X .065 THK
4	10		MS35338-22	WASHER, LOCK, SPLIT, CARB STL, ZN & CH, MED #6
7	9		MS35338-20	WASHER, LOCK, SPLIT, CARB STL, ZN & CH, MED #2
4	8		MS35206-231	SCR, MACH, PAN HD, CARB STL, CAD PL #6-32UNC-2A X 5/8
7	7		MS35206-204	SCR, MACH, PAN HD, CARB STL, CAD PL #2-56UNC-2A X 5/16
1	6	B	4708314	COUNTERWEIGHT END
2	5	B	4708313	COUNTERWEIGHT SIDE
1	4	B	4708312	COUNTERWEIGHT
1	3	B	4708311	COUNTERWEIGHT
1	2	D	4708310	SUPPORT FRAME, MIRROR
1	1	C	4708309	MIRROR, ROTATING

LIST OF MATERIAL

NEXT ASSEMBLY	FIRST USED ON
	11-18772

APPLICATION

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES

TOLERANCES

BASIC DIMENSION	DECIMALS 2 PLACE	DECIMALS 3 PLACE	FRACTIONS
UNDER 6	± .02	± .005	± 1/64
6 TO 24 INCL.	± .03	± .010	± 1/32
OVER 24	± .05	± .010	± 1/16

ANGLES ± 1/2°

COMMERCIAL TOLERANCES APPLY TO STOCK SIZES

SHOP PRACTICE, EDM SECT. 20, APPLIES

MATERIAL

FINISH

SIGNATURE & DATE

DRAWN: J. Walden Snider

CHKD.: [signature]

DSGN. ENGR.: [signature] 9/9/65

STD.: [signature] 9/13/65

APPD.: [signature] 9/1/65

ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.

A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

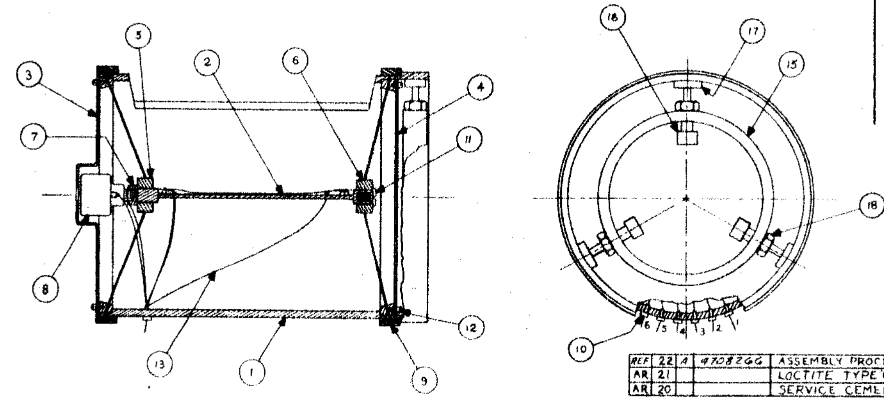
ROTATING MIRROR ASSY

B 4708316

SCALE 1/1

SHEET

ITTIL-D-1



QTY.	ITEM	SIZE	PART NUMBER	DESCRIPTION
REF	22	A	4708266	ASSEMBLY PROCEDURE & SPECIFICATION
AR	21			LOCTITE TYPE "C"
AR	20			SERVICE CEMENT
AR	19			WIRING SCHEMATIC HRIR RADIOMETER
3	18		MS 35649-42	NUT, PLAIN HEX, STL, CAD PL, 3/32 THK, #4-40NC-2B, 1/4 AF
3	17	B	4708274	INSERT NYLON
3	16	B	4708275	PIN SECURING
1	15	B	4708276	RING SECURING
REF	14			WIRING SCHEMATIC RADIOMETER
AR	13			WIRE, CHROMEL A .003 DIA.
6	12			SCREW MACH, FIL HD #00-90×
1	11		MS 35206-201	SCR, MACH, PAN HD, CARB STL, CAD PL #2-56 UNC-2A × 1/8
6	10	B	4708263-1	INSERT-TEFLON
2	9	B	4708273	BEARING CYLINDER
1	8	C	4708256	DETECTOR CELL ASSY
1	7	B	4708272	COLLAR, THREADED
1	6	B	4708270-2	SUPPORT RING ASSY
1	5	B	4708270-1	SUPPORT RING ASSY
1	4	B	4708271	COVER-CYLINDER END
1	3	B	4708258	COVER-CELL (CYLINDER)
1	2	C	4708269	PATCH ASSY - RADIANT COOLER
1	1	D	4708267	CYLINDER - PATCH

LIST OF MATERIAL

ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.

CYLINDER ASSY

C 4708277

SCALE 2/1

11-18772

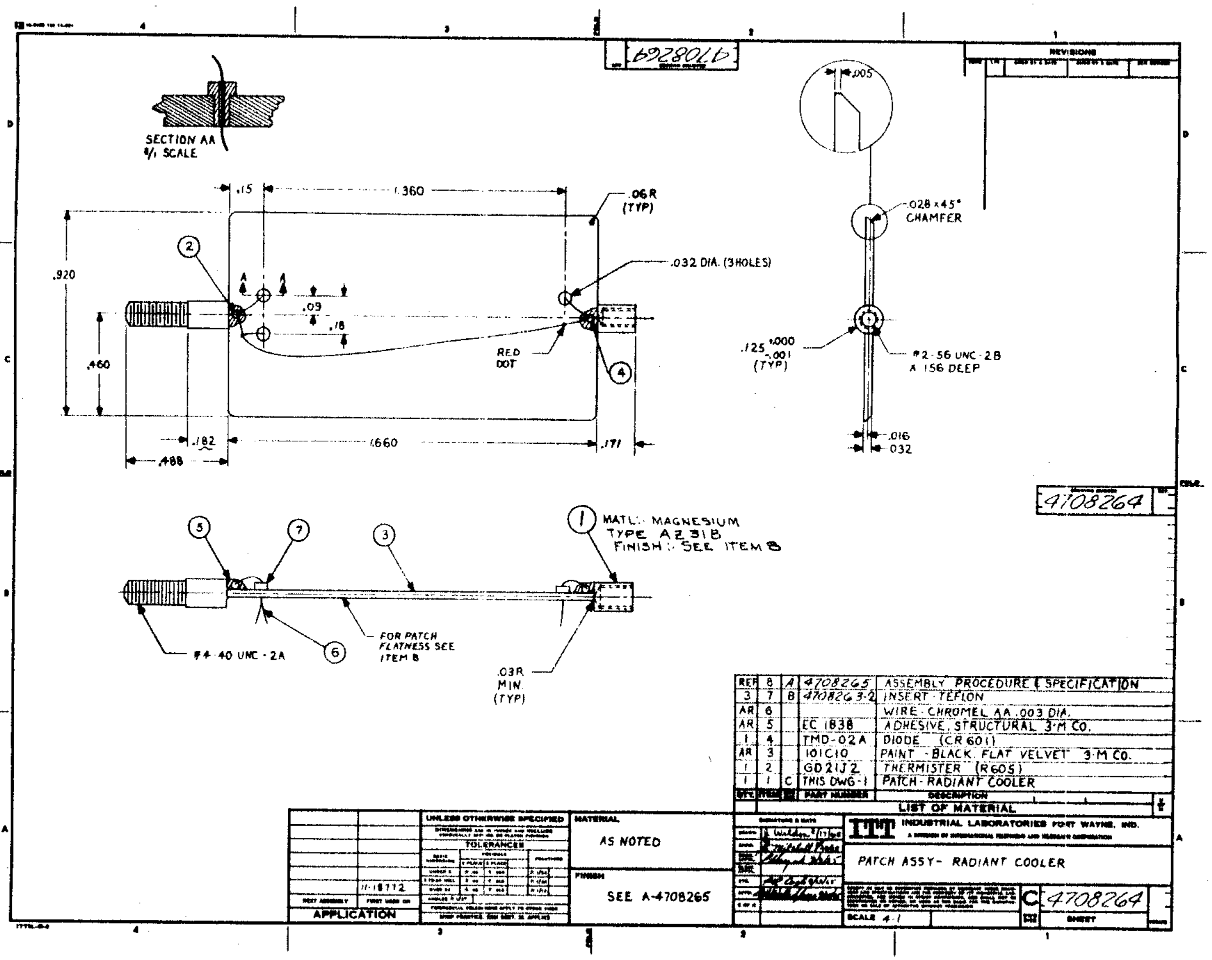
APPLICATION

UNLESS OTHERWISE SPECIFIED

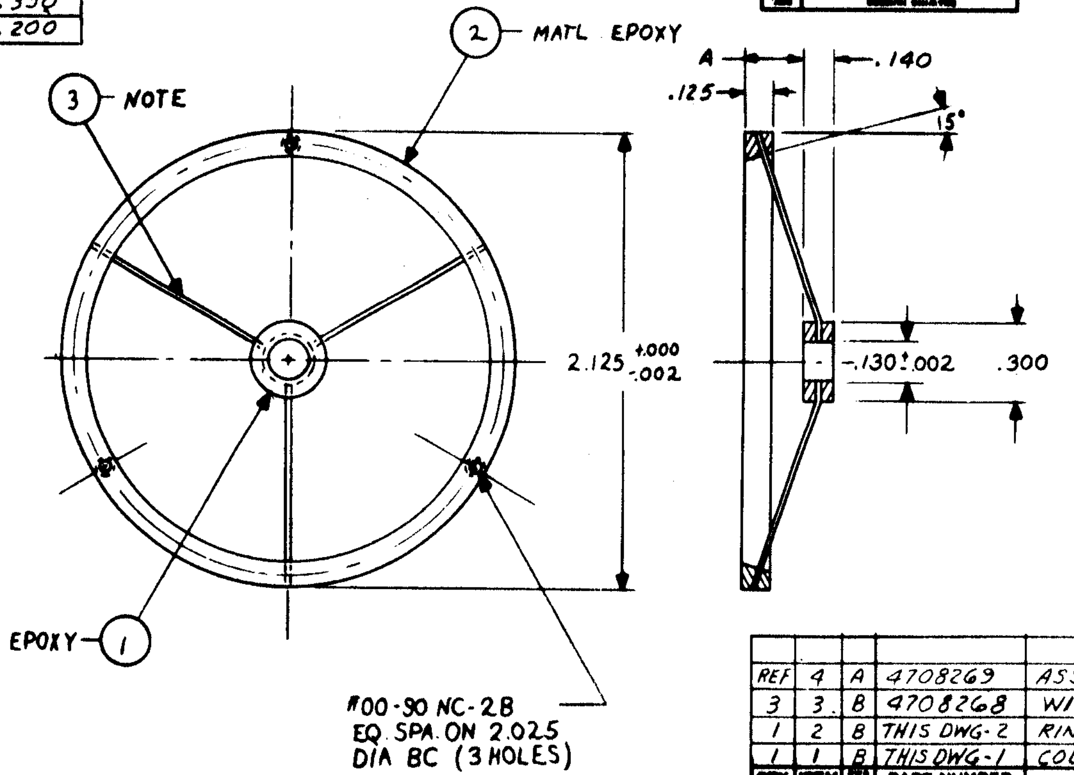
TOLERANCES

MATERIAL

FINISH


SECTION AA
4/1 SCALE
.15
1.360
.06 R (TYP)
.920
.032 DIA. (3 HOLES)
.09
.18
.460
RED DOT
.182
1.660
.171
.488
.028 x 45° CHAMFER
.005
.125 +.000 -.001 (TYP)
#2-56 UNC-2B x .156 DEEP
.016
.032
4708264
MATL: MAGNESIUM TYPE AZ31B
FINISH: SEE ITEM 8
#4-40 UNC-2A
FOR PATCH FLATNESS SEE ITEM 8
.03R MIN (TYP)
REF 8 A 4708265 ASSEMBLY PROCEDURE & SPECIFICATION
3 7 B 4708263-2 INSERT - TEFLON
AR 6 WIRE - CHROMEL AA .003 DIA.
AR 5 EC 1838 ADHESIVE, STRUCTURAL 3M CO.
1 4 TMD-02A DIODE (CR 601)
AR 3 101C10 PAINT - BLACK FLAT VELVET 3M CO.
1 2 GD21J2 THERMISTER (R605)
1 1 C THIS DWG-1 PATCH - RADIANT COOLER
PART NUMBER
DESCRIPTION
LIST OF MATERIAL
REVISIONS
UNLESS OTHERWISE SPECIFIED
TOLERANCES
MATERIAL
AS NOTED
FINISH
SEE A-4708265
11-18772
APPLICATION
ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.
PATCH ASSY - RADIANT COOLER
C 4708264
SCALE 4/1
SHEET

PT. NO.	'A' DIA
G1	.350
G2	.200



4708270

REVISIONS

QTY.	ITEM	DWG SIZE	PART NUMBER	DESCRIPTION
REF	4	A	4708269	ASSEMBLY PROCEDURE & SPEC DWG
3	3	B	4708268	WIRE
1	2	B	THIS DWG-2	RING, PATCH MTG
1	1	B	THIS DWG-1	COLLAR, PATCH

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED

TOLERANCES

MATERIAL: AS NOTED

FINISH: ———

11-18772

NEXT ASSEMBLY | FIRST USED ON

APPLICATION

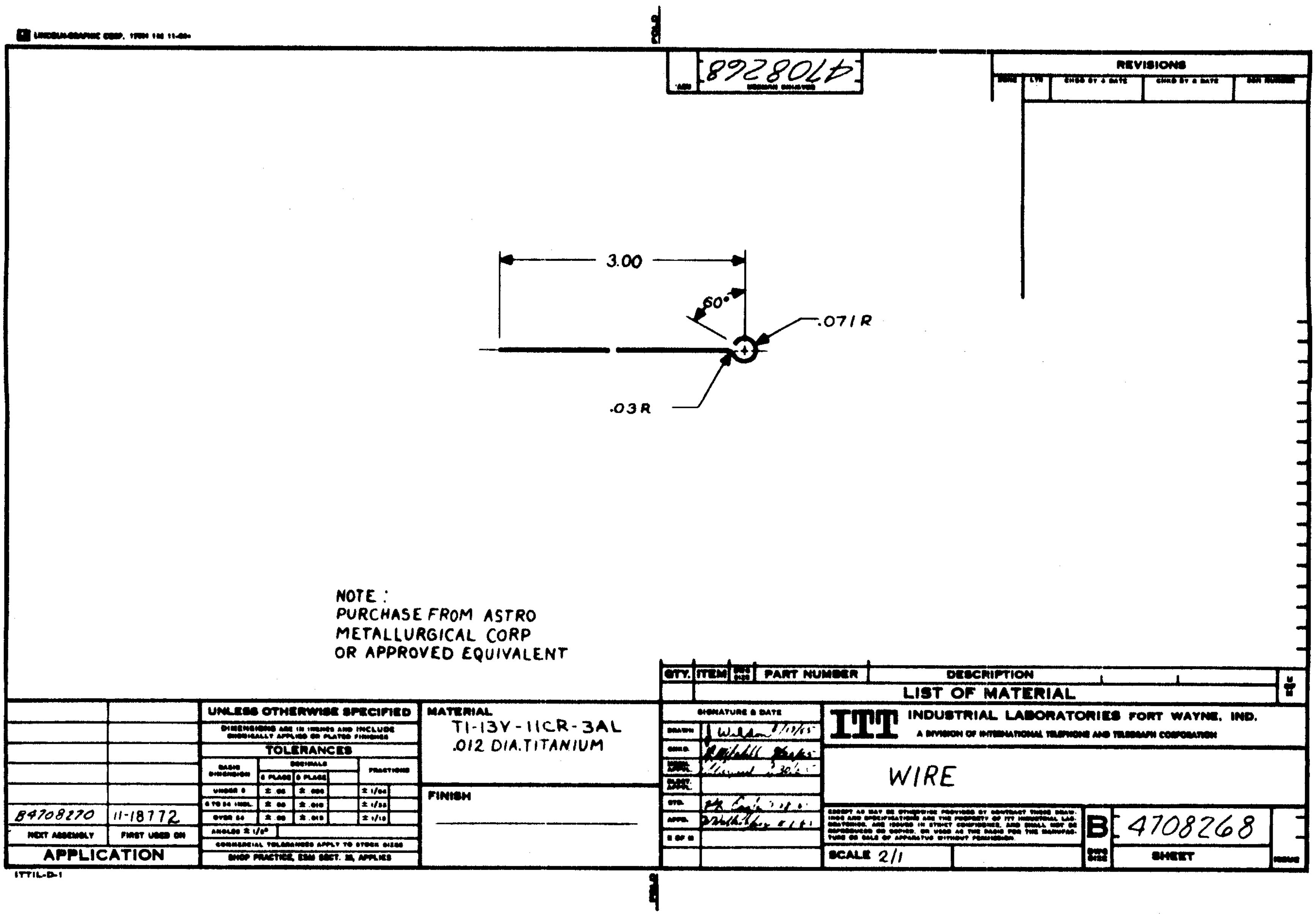
ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.
A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

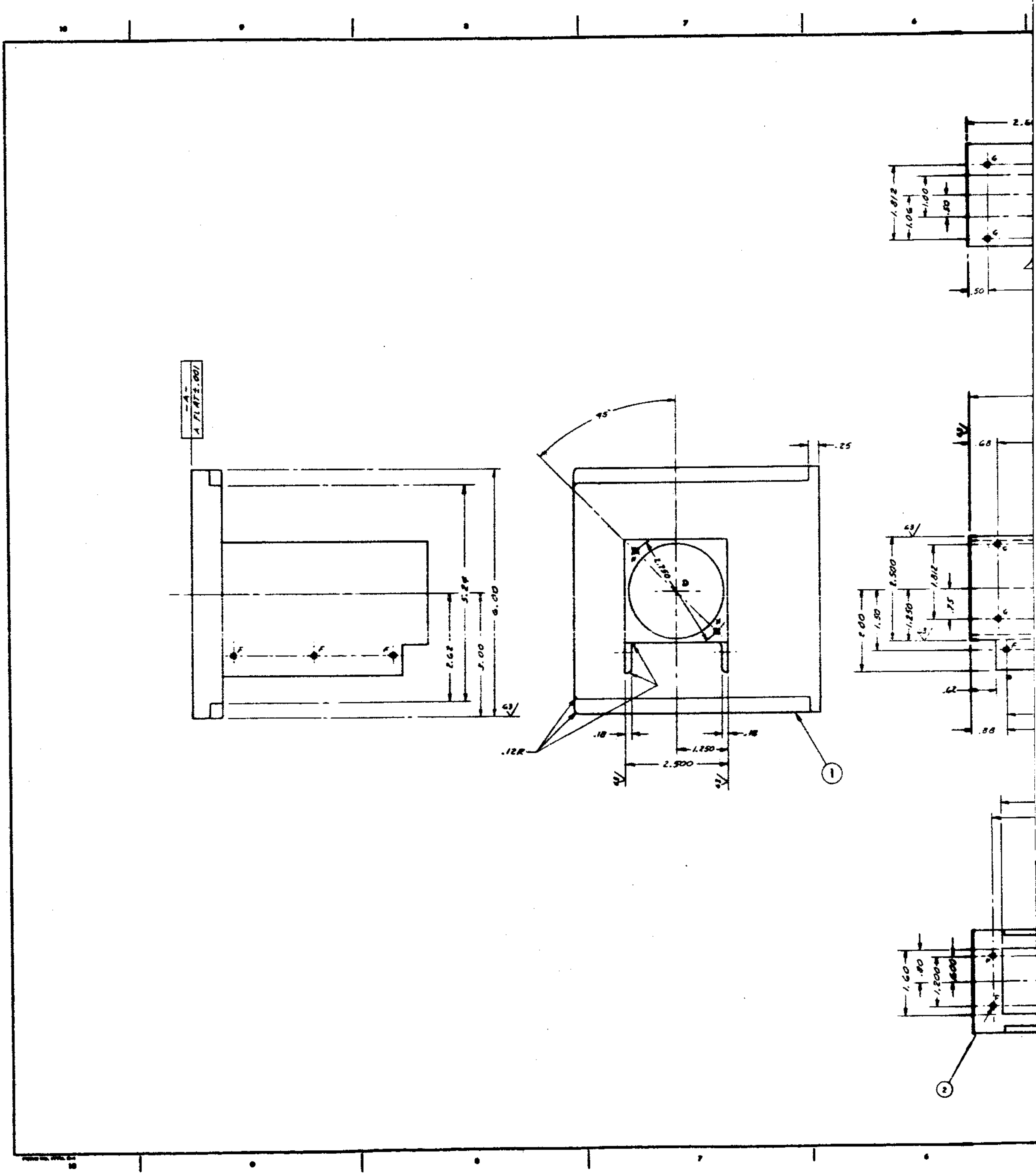
SUPPORT RING ASSY

DRAWN: [signature] 5/17/65

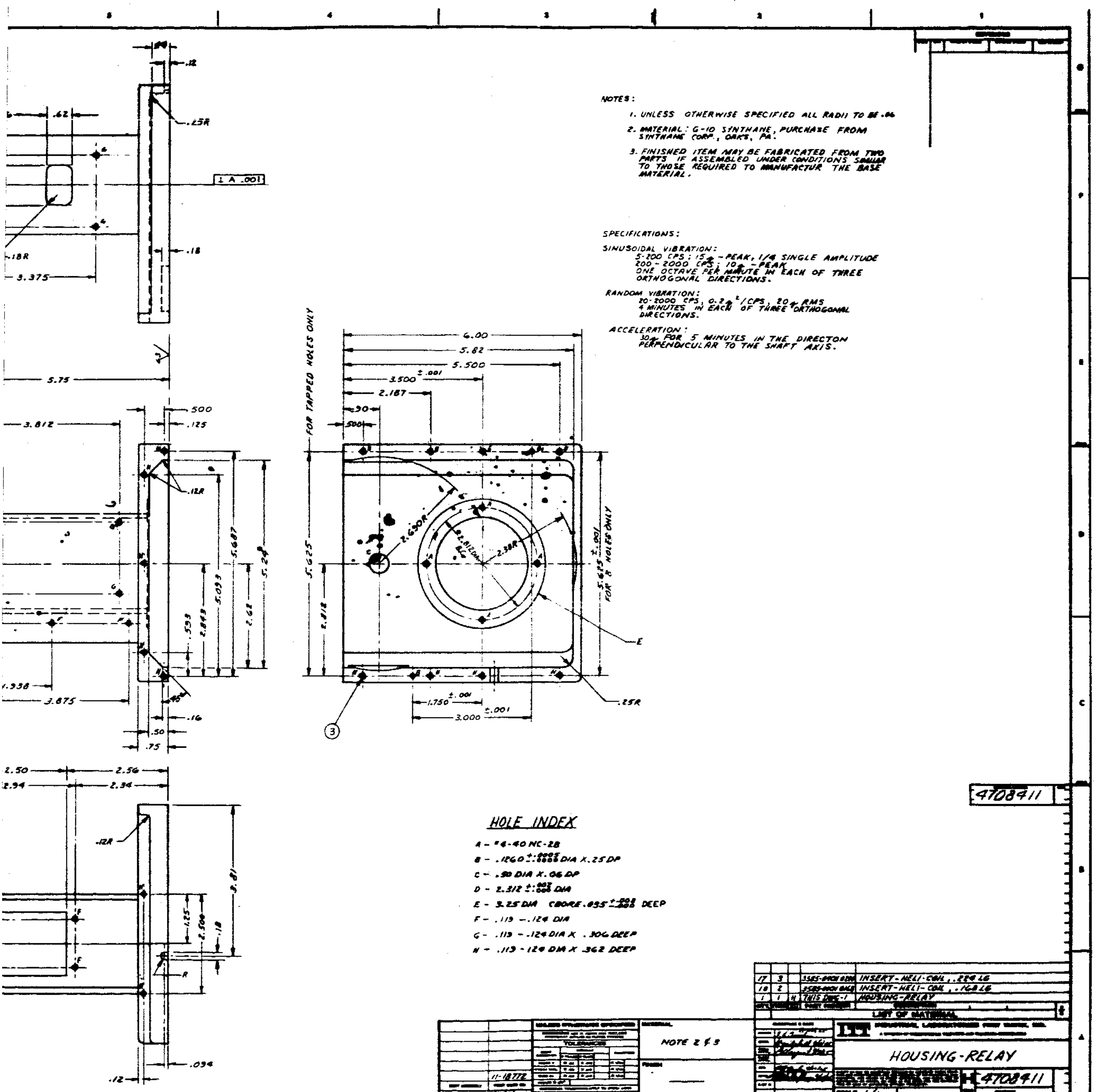
SCALE NONE

DWG SIZE B | 4708270 | SHEET


3.00
60°
.071 R
.03 R
NOTE :
PURCHASE FROM ASTRO
METALLURGICAL CORP
OR APPROVED EQUIVALENT
4708268
REVISIONS
QTY. ITEM PART NUMBER DESCRIPTION
LIST OF MATERIAL
ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.
A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
WIRE
B 4708268
SCALE 2/1
SHEET
SIGNATURE & DATE
DRAWN
CHKD.
FINISH
MATERIAL
TI-13V-11CR-3AL
.012 DIA.TITANIUM
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES
TOLERANCES
SHOP PRACTICE, ESM SECT. 35, APPLIES
B4708270
11-18772
NEXT ASSEMBLY
FIRST USED ON
APPLICATION
ITTIL-D-1



A-23-1



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RADII TO BE .06
2. MATERIAL: G-10 SYNTHANE, PURCHASE FROM SYNTHANE CORP., OAKS, PA.
3. FINISHED ITEM MAY BE FABRICATED FROM TWO PARTS IF ASSEMBLED UNDER CONDITIONS SIMILAR TO THOSE REQUIRED TO MANUFACTUR THE BASE MATERIAL.

SPECIFICATIONS:

SINUSOIDAL VIBRATION:
5-200 CPS; 15 g - PEAK, 1/4 SINGLE AMPLITUDE
200-2000 CPS; 10 g - PEAK
ONE OCTAVE PER MINUTE IN EACH OF THREE ORTHOGONAL DIRECTIONS.

RANDOM VIBRATION:
20-2000 CPS, $0.2\,g^2$/CPS, 20 g RMS
4 MINUTES IN EACH OF THREE ORTHOGONAL DIRECTIONS.

ACCELERATION:
30 g FOR 5 MINUTES IN THE DIRECTON PERPENDICULAR TO THE SHAFT AXIS.

HOLE INDEX

A - #4-40 NC-2B
B - .1260 $^{+.0005}_{-.0000}$ DIA X .25 DP
C - .90 DIA X .06 DP
D - 2.312 $^{+.002}_{-.000}$ DIA
E - 3.25 DIA CBORE .035 $^{+.002}_{-.000}$ DEEP
F - .119 - .124 DIA
G - .119 - .124 DIA X .306 DEEP
H - .119 - .124 DIA X .362 DEEP

17	3	3585-0404 0224	INSERT-HELI-COIL, .224 LG	
18	2	3585-0401 0168	INSERT-HELI-COIL, .168 LG	
1	1	THIS DWG-1	HOUSING-RELAY	

LIST OF MATERIAL

MATERIAL: NOTE 2 & 3

11-18772

APPLICATION

ITT

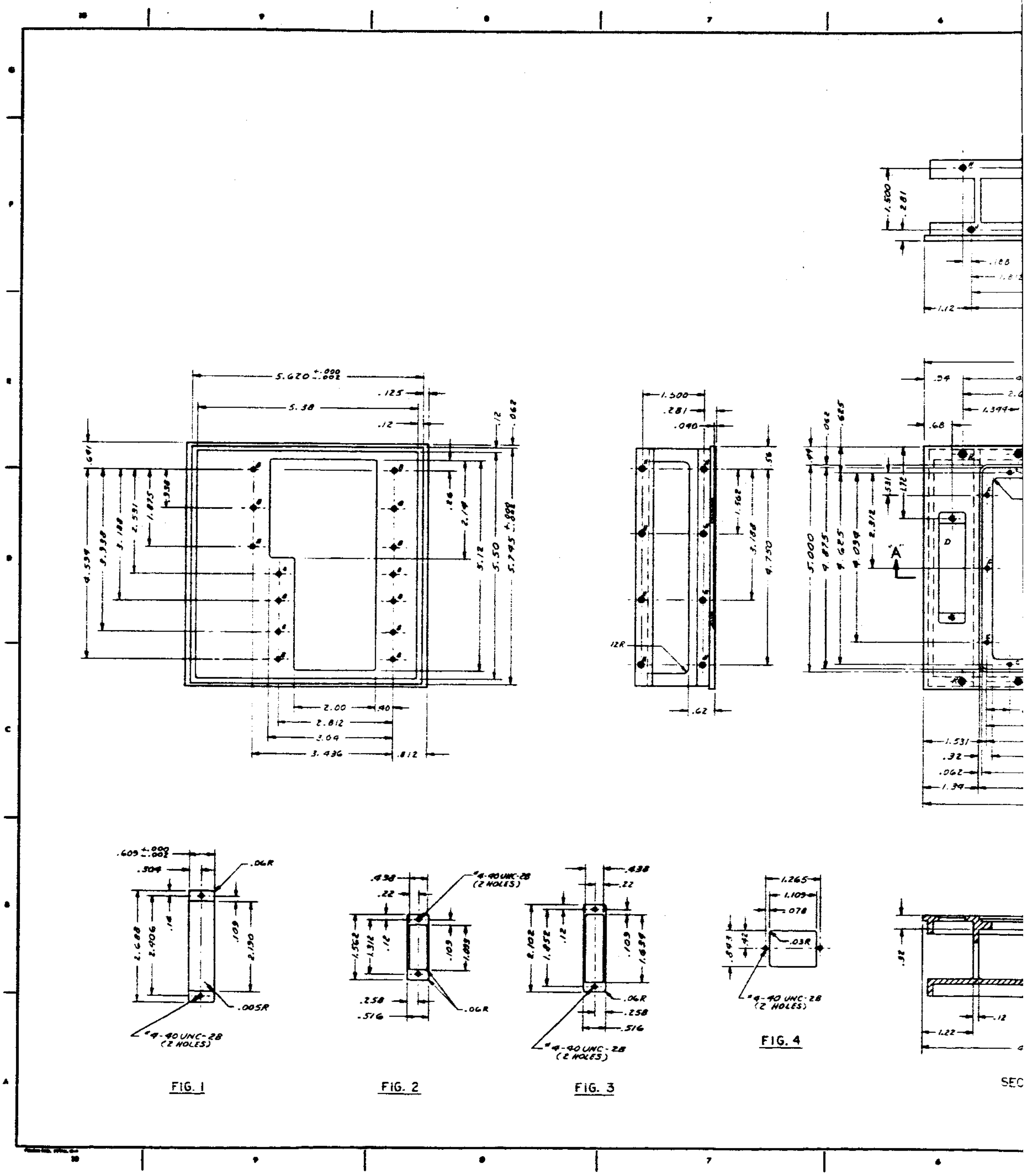
HOUSING-RELAY

H 4708411

SCALE 1/1

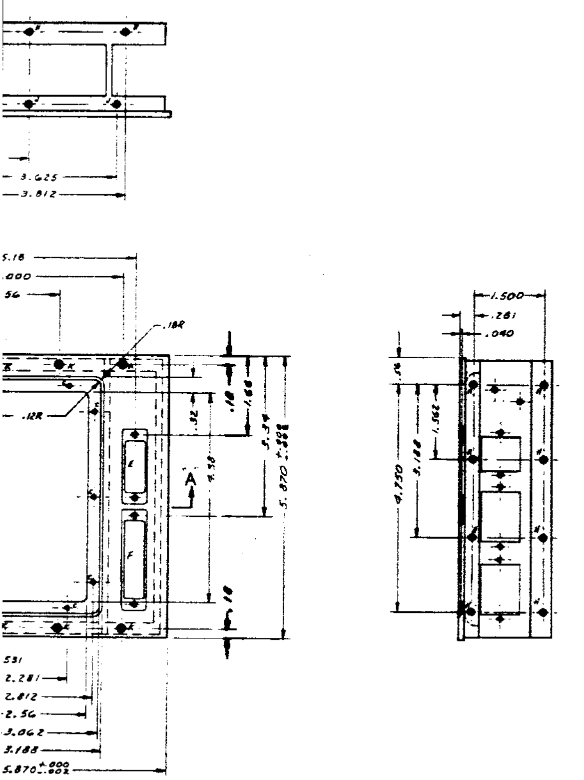
4708411

2



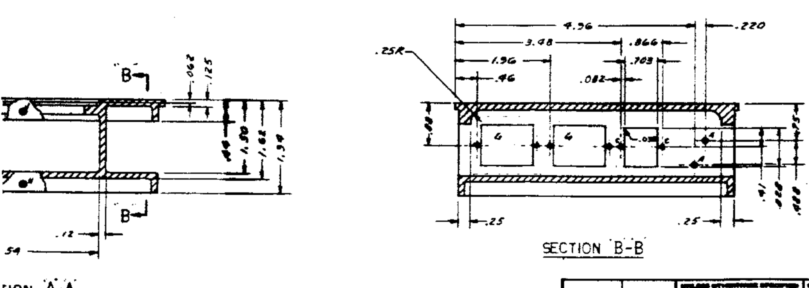
A-24-1

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RADII TO BE .06R.



SYM	DESCRIPTION	REQD
A	.125 DIA	2
B	.144 DIA	14
C	#4-40 UNC-2B	12
D	SEE FIG 1	1GR
E	SEE FIG 2	1GR
F	SEE FIG 3	1GR
G	SEE FIG 4	2GR
H	#21208-C0410 HELI-COIL INSERTS, INSTALL PER MS33646 FOR CLASS 2B THD WITH CSK HOLE, REMOVE TANG	22
J	#21203-C0420 HELI-COIL INSERTS, INSTALL PER MS33646 FOR CLASS 2B THD WITH CSK HOLE, REMOVE TANG	6
K	#21203-C0615 HELI-COIL INSERTS, INSTALL PER MS33646 FOR CLASS 2B THD WITH CSK HOLE, REMOVE TANG	8

4708375



SECTION B-B

LIST OF MATERIAL

MATERIAL: MAGNESIUM AZ31B PER QQ-M-31

APPLICATION: 11-18272

ITT INDUSTRIAL LABORATORIES FORT WAYNE, IND.

BRACKET, ELECTRONICS MODULE

4708375

SCALE 1/1