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FORT WAYNE, INDIANA

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Countermeasures Laboratory

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A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
3700 EAST PONTIAC STREET, FORT WAYNE, INDIANA

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21 September 1959

Naval Research Laboratories
Washington 25, D. C.

Attention: Code Number 5430

Subject NOnr 2788(00)X

Gentlemen:

We are enclosing herewith two (2) copies of the final report in accordance with the subject contract.

Very truly yours,

ITT Laboratories

T. M. Diederich

T. M. Diederich
Contracts Assistant

Enclosures (2)

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A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
3700 EAST PONTIAC STREET, FORT WAYNE, INDIANA

Serial No. 3000 September, 1959

FINAL REPORT

OMNIDIRECTIONAL MICROWAVE TRANSISTORIZED CRYSTAL-VIDEO RADIO RECEIVING SYSTEM

Contract NOnr 2788(00)X
ITTL Case 032-13600

Prepared by

Electronic Countermeasures Laboratory
ITT Laboratories
Fort Wayne, Indiana

Approved by

L E Gough by [signature]
L. E. Gough, Laboratory Director

1.0 INTRODUCTION

This is a report of the work done by ITT Laboratories, Fort Wayne, Indiana for the Naval Research Laboratories, Washington, D. C. under contract NOnr 2788(00)X for the development of an Omnidirectional Microwave Transistorized Crystal-Video Radio Receiving System. The system is comprised of three basic components: (1) the antennas, (2) the filter-detector units and (3) the amplifier.

The system developed under this contract meets the performance requirements. A straightforward approach was taken to the antenna problem and the result is system yielding optimum pattern performance with extreme simplicity. A unique and new approach to the filter problem yielded a small, lightweight unit with performance equal to or better than more conventional filter techniques. The result was a successful equipment design with a weight of near 20 ounces in comparison to an estimated 60 ounce weight.

The over-all system sensitivity, as influenced primarily by the filter-detector unit, is of great importance. The sensitivity is at least 10×10^{-10} watts/cm^2 as defined in the contract specification.

The antenna system has equal response to any linear polarization being emitted from any direction incident upon the spherical mounting surface of the antennas.

The amplifier is a transistorized unit operating from 12 volts dc with a maximum current drain of 5 ma (power consumption of 60 milliwatt). Separate bias of 20 μa is supplied through a bias network to each of the six detector units.

The various aspects of the development of each of the components is outlined in Sections 2, 3, and 4. Section 5 contains the performance characteristics of the integrated system. Section 6 is a summary of the general characteristics of the system.

2.0 ANTENNA SYSTEM

The antenna system is a combination of six monopole antennas equally spaced around the surface of the sphere. One of the monopole antennas is shown in Figure 1. The r-f signal of each antenna is fed to a separate filter-detector unit. The combination of the six monopoles provides omnidirectional reception of any linear polarization. Experimental patterns show the system has omnidirectional coverage within ±0.5 db for any polarization. Typical patterns showing two polarizations for two orientations of the sphere are shown in Figure 2. The antenna including a Type N to Microdot adapter necessary in the test setup has a vswr of less than 2:1 over the 2.6 to 3.25 kmc frequency band.

3.0 FILTER-DETECTOR UNIT

The filter-detector unit is to provide the maximum system sensitivity in the 2.6 to 3.25 kmc pass band and the maximum attenuation to other frequencies. The insertion loss of the filter is at least 50 db at 2.34 kmc and below and at least 50 db at 3.57 kmc and above. A detailed curve of the bandpass response and a general curve of the frequency response for a typical filter-detector unit is shown in Figure 3.

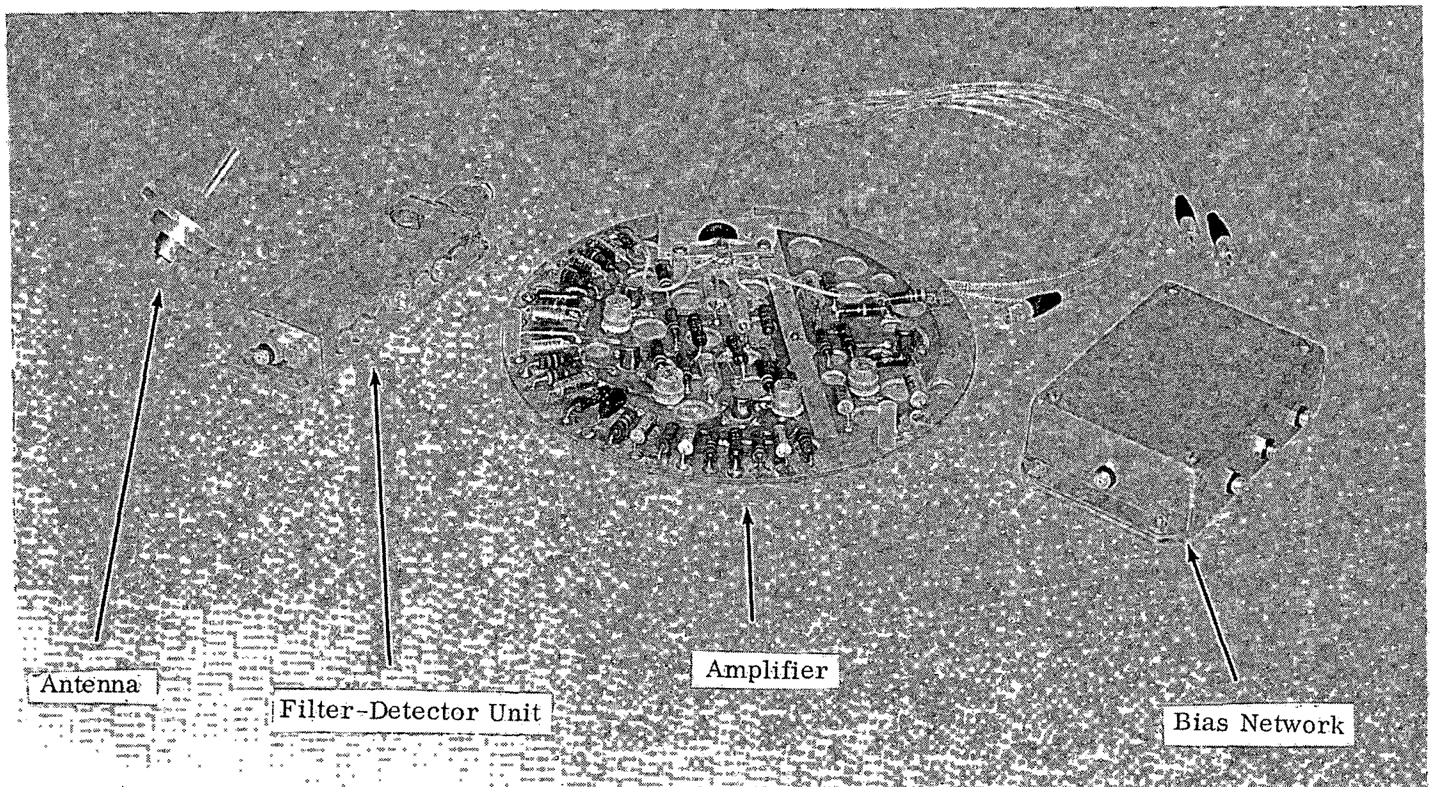

Figure 1 Components of Omnidirectional Microwave Transistorized Crystal-Video Receiving System

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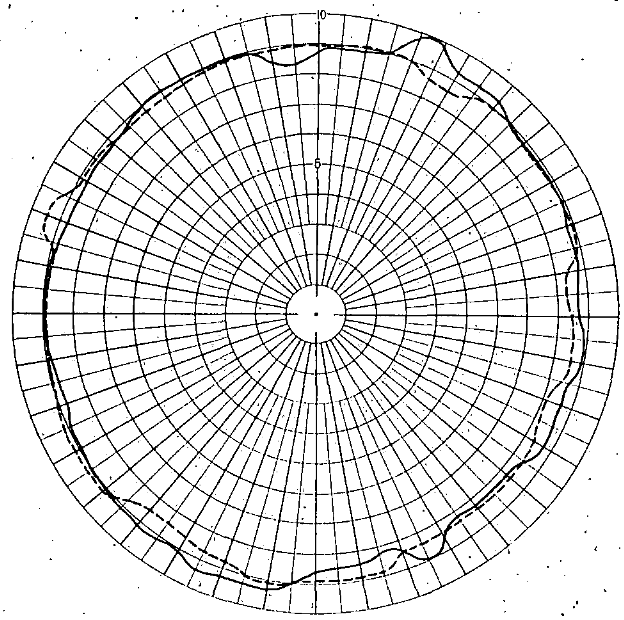
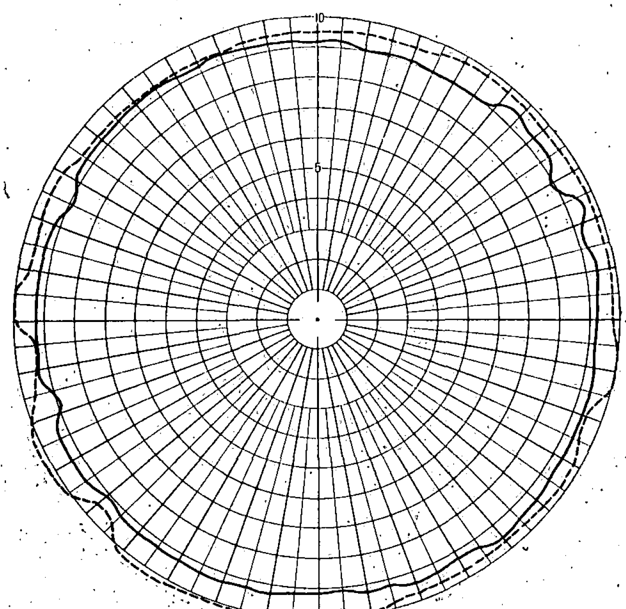
TYPICAL ANTENNA PATTERNS
CALIBRATION-VOLTAGE



FREQUENCY-2.6 KMC



FREQUENCY-3.0 KMC

FIGURE 2

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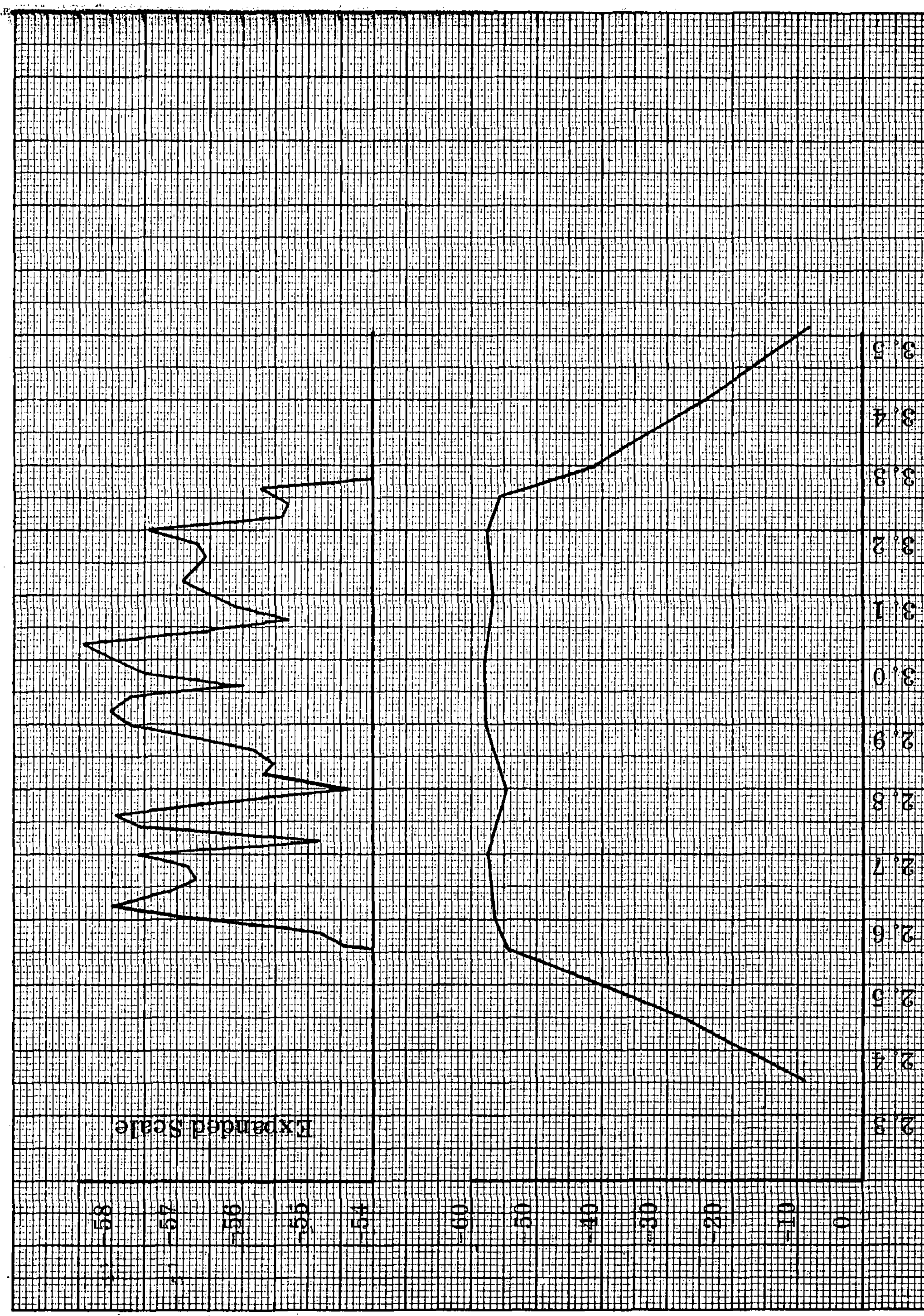

Figure 3 Typical Filter-Detector Characteristics

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The ripple in the pass band includes the variation of the sensitivity due to the Type N to Microdot connector adapter necessary to record sensitivity data on an individual filter. Such ripple is minimized in the complete system as discussed in Section 4.

The filter provides the necessary r-f preselection for the system. To obtain the flat bandpass with the necessary steepness of cutoff, a seven section filter is used. The filter consists of slab-line resonators coupled by the odd and even TEM waves occupying the space between resonators. The filter is of a simple mechanical construction in that it consists of seven posts properly located in a piece of rectangular pipe. In addition to these posts are three mode suppression elements to suppress the spurious response at X-band.

The holder for a MA408B crystal is an integral part of the filter in that the crystal element resonates as part of the seventh filter section. A forward d-c bias current of 20 microamperes must be applied to resonate the crystal detector at the proper frequency.

The crystal mount was designed with low mass spring contacts to allow the crystal cartridge to move slightly due to differences in thermal expansion coefficients. The contact pressure was more than sufficient to prevent the crystal from vibrating with respect to the holder when subjected to severe environmental conditions.

4.0 AMPLIFIER AND BIAS NETWORK

The amplifying system consists of two assemblies, a four cascaded transistor feedback pair amplifier and a crystal bias network. The first pair has a high input impedance and a high output impedance. It is therefore characterized by a voltage input and a current output. The second and third pairs have low impedance inputs and high impedance outputs which makes them current gain pairs. The fourth pair has a low impedance input and a low impedance output which makes it an R_m pair to convert the signal to a voltage output. A schematic of the amplifier is given in Figure 4.

The maximum gain of the four pair amplifier is approximately 2,000. A resistor in the second pair feedback provides a gain adjustment of full gain for a 100-ohm resistor and 23 db below full gain for an open circuit. Any gain between these values is obtained with a suitable resistor of greater than 100 ohms.

The bias network provides a means of paralleling the signal outputs of six detector crystals while providing individual dc bias of approximately 20 μa to the crystals. The voltage across the coupling capacitor is limited to approximately 2 volts so that connecting and disconnecting the crystal with the d-c power on does not have any detrimental effects on either the crystal or the amplifier. The schematic of the bias network is given in Figure 5.

5.0 SYSTEM PERFORMANCE

The major problem of the development program was to attain the maximum system sensitivity. The system was to have a tangential sensitivity of at least 10×10^{-10} watts/cm^2 at any frequency in the pass band and for any polarization without respect for the orientation of the sphere. The system meets the requirement

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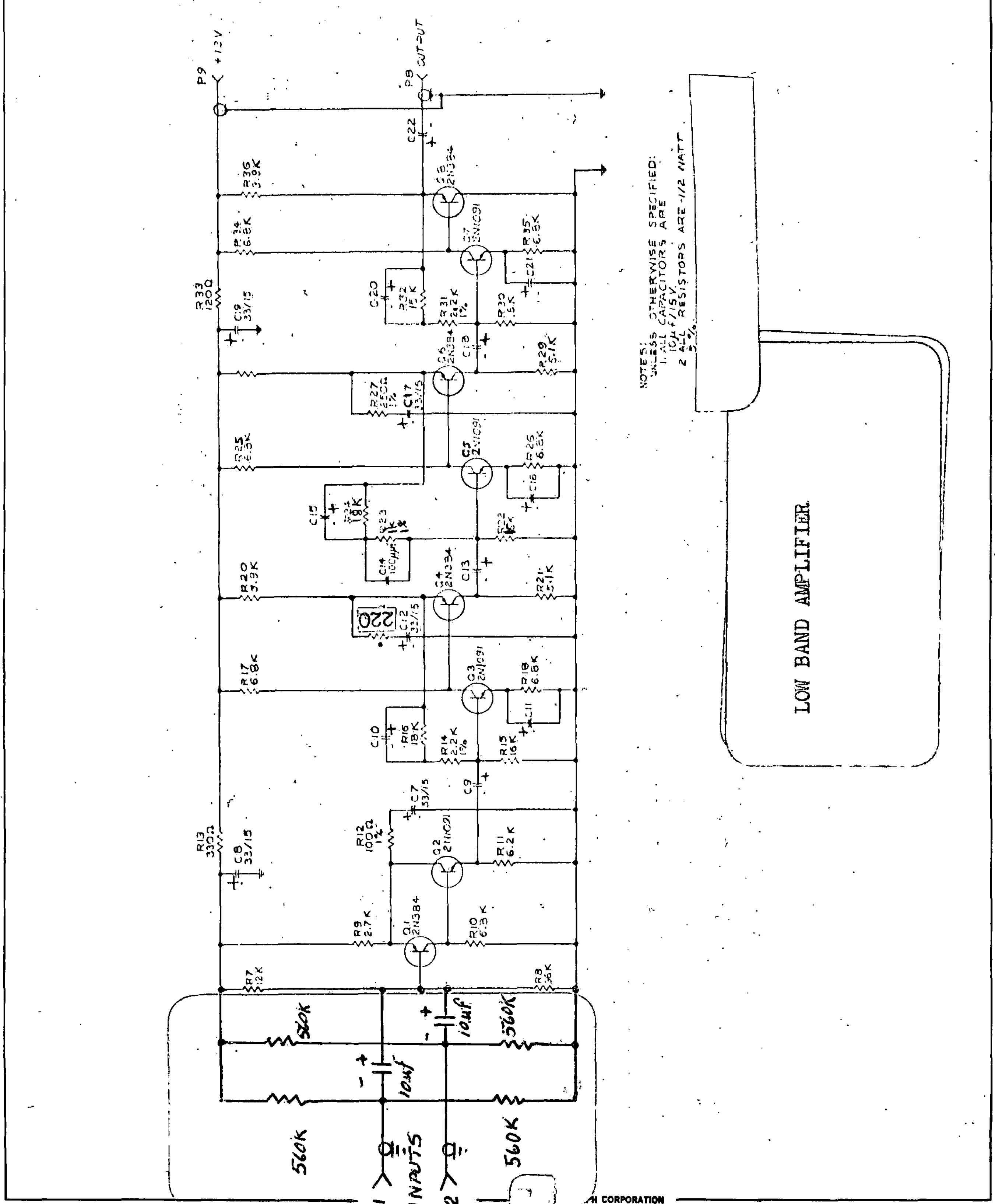

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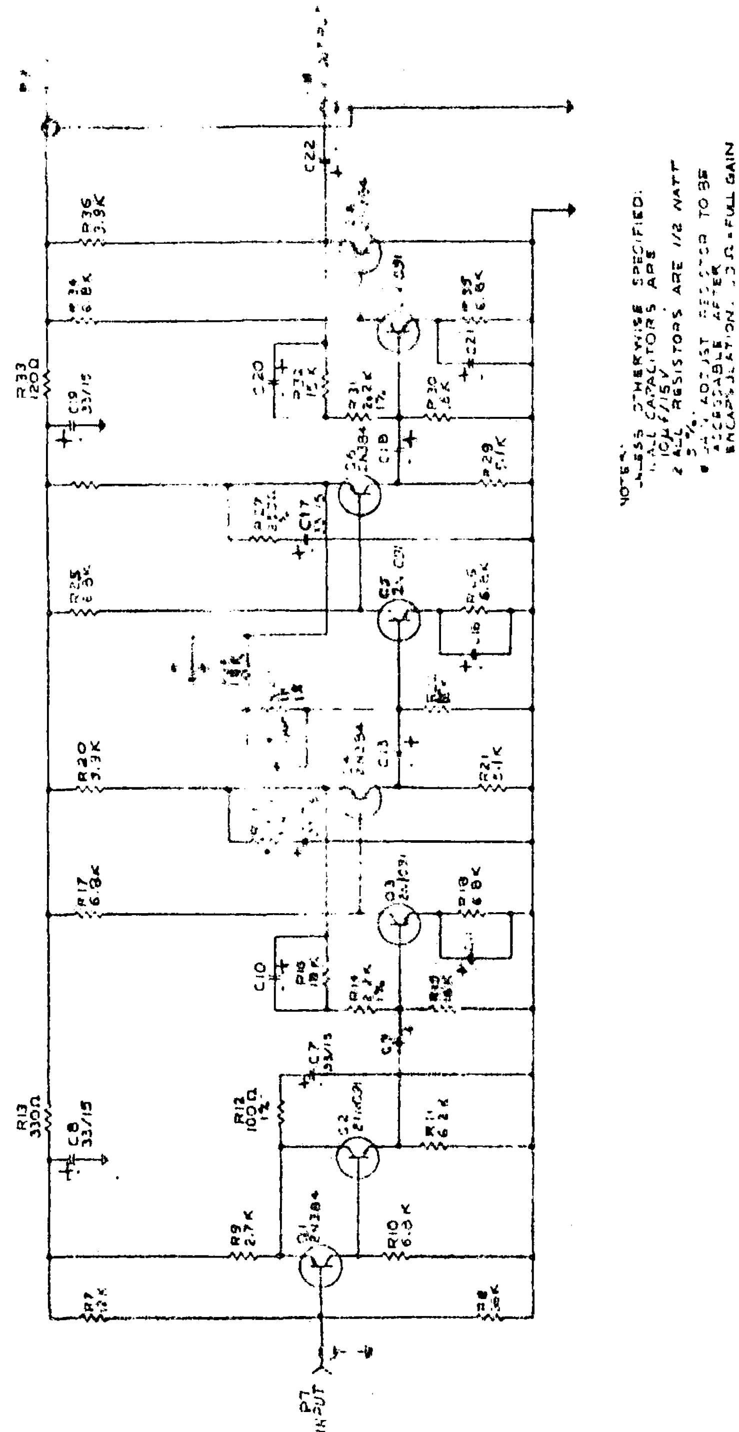
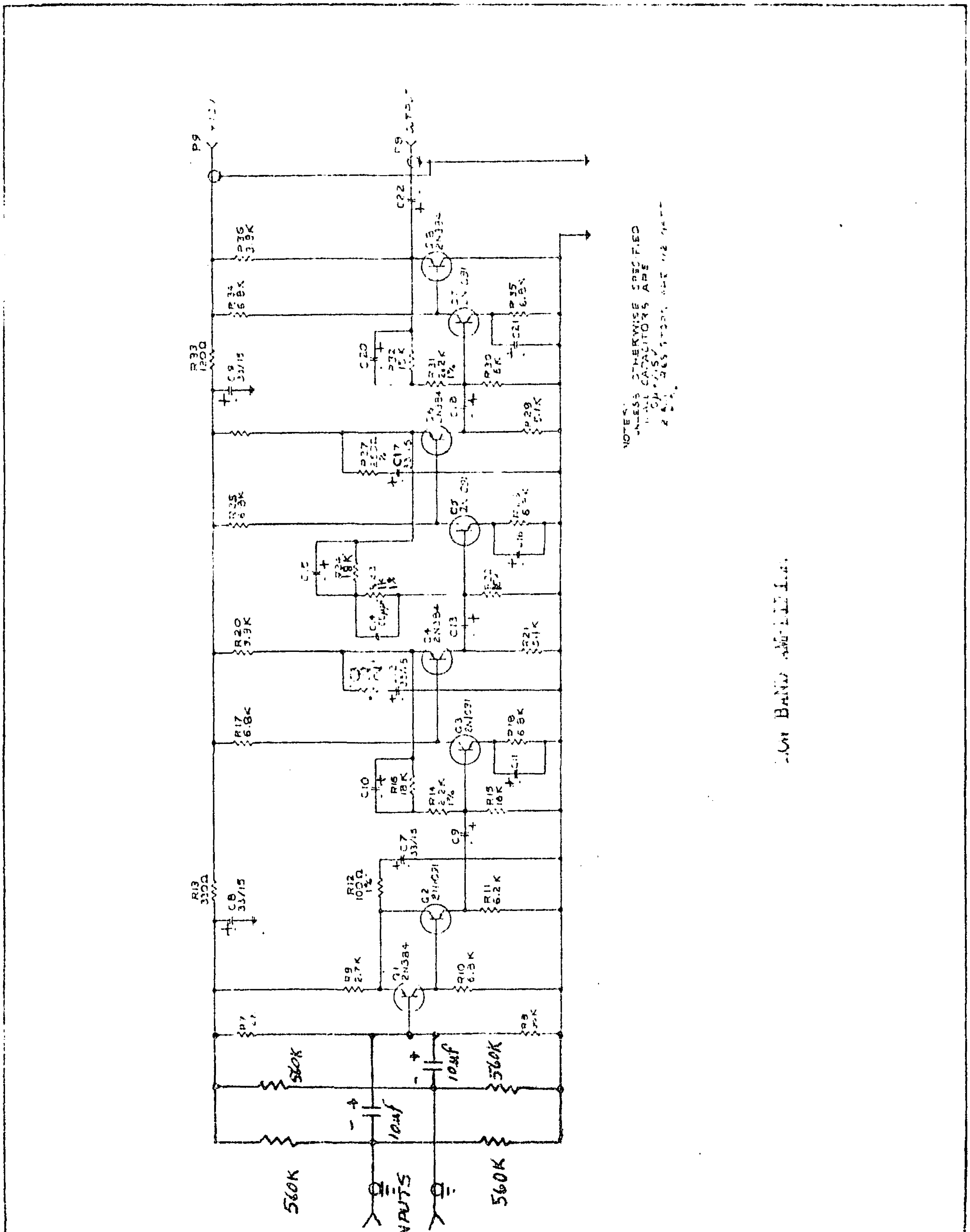


Figure 4 Schematic of Amplifier


INPUTS
1
2
560K
560K
560K
560K
10μf
10μf
R33 120Ω
R13 320Ω
R36 3.9K
R34 6.8K
R20 3.9K
R17 6.8K
R11 6.2K
R10 6.8K
R9 2.7K
R12 100Ω 1%
R14 2.2K 1%
R15 16K
R16 18K
R18 6.8K
R21 5.1K
R29 5.1K
R31 2.2K 1%
R35 6.8K
Q1 2N384
Q2 2N1031
Q3 2N1031
Q4 2N384
C7 33/15
C8 33/15
C9
C10
C13
C20
C22
NOTES:

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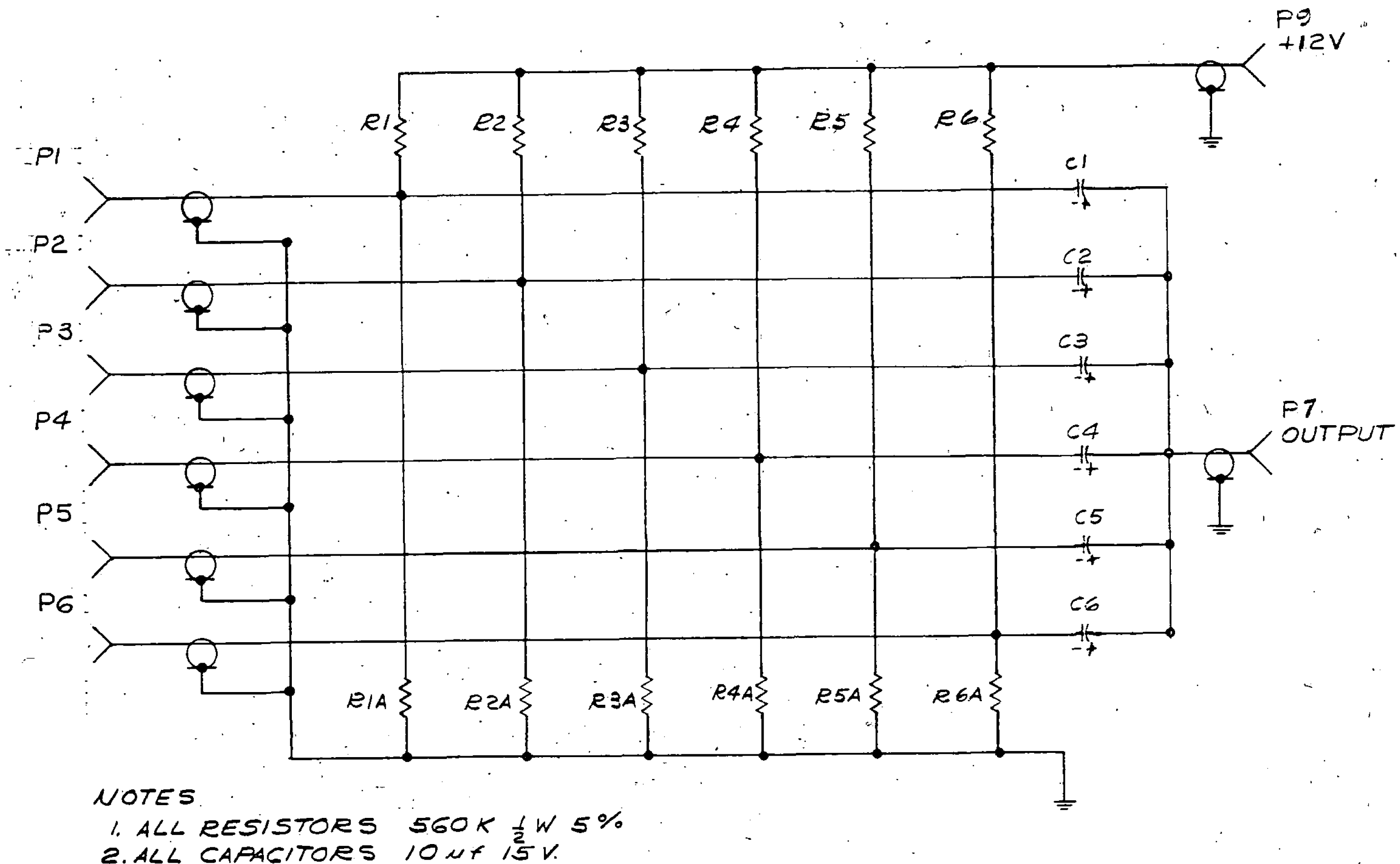

Figure 5 Bias Network

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over the pass band with the exception of a very narrow (20 to 30 mc) frequency band at the extreme upper portion of the pass band. In this region the sensitivity falls 0.5 to 1 db below the 10×10^{-10} watts/cm^2. It is felt that it would be possible to improve the sensitivity over the 20 to 30 mc band where the performance is slightly degraded but it would take a complete redesign of the filter-detector assembly. A typical characteristic of the system sensitivity as a function of frequency is shown in Figure 6.

6.0 GENERAL CHARACTERISTICS

	Filter-Detector Assembly	Antenna each	Amplifier	Bias Network
ITTL Assembly No.	4700931	4700934	4700932	4700933 ?
Size (max.dim.) (main body dim.)	4-1/4" x 1-3/8" x 5/8" 3" x 1" x 5/8"	1-1/2" x 1-1/4" dia. 3/8" x 1-1/4" dia.	5-1/4" dia. x 3/4" 5-1/4" dia. x 5/8"	3-1/2" x 2-3/8" x 1" 3" x 2" x 7/8"
Weight	1-1/2 oz.	1/2 oz.	4 oz.	3 oz.

Weight (complete system)	19 oz.
Frequency range	2.6 - 3.25 kmc
Sensitivity	at least 10×10^{-10} watt/cm^2
Pulse width	0.5 - 12 μsec
PRF	30 - 2500 pps
Required voltage	+12 vdc
Power consumption	60 mw

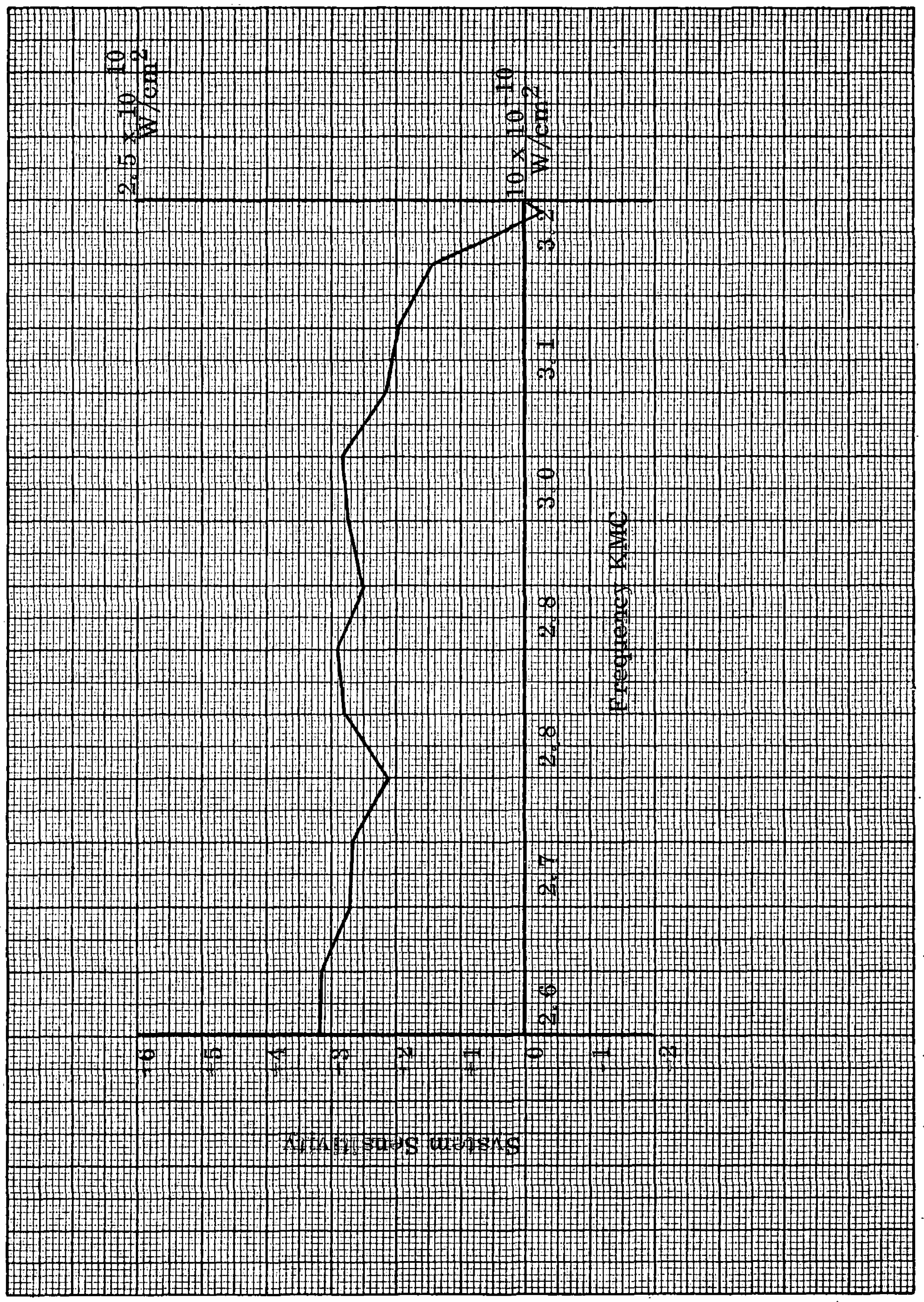

Figure 6 Typical System Sensitivity

Required output termination	270 ohm
Antenna performance	Omnidirectional

The components of the system were subjected to limited environmental tests at ITT Laboratories. The components successfully passed vibration tests of 30 g at frequencies between 25 and 2000 cycles and temperature test from 0 degrees C to 60 degrees C.