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NRAO WIDEBAND RF/IF AMPLIFIER: SPECIFICATIONS AND TEST METHODS

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Introduction

A wideband RF/IF amplifier has been developed for general use in receiver front-ends and back-ends. The specifications are as good as or better than the amplifiers commercially available; also, the amplifiers cost less, can be tailored to fit specific requirements, and can be built and tested directly in the lab. The amplifier operates from +15 V DC and has standard OSM (3 mm) connectors.

Noise Figure Measurement

The noise figure of the amplifier was measured using the test setup shown in Figure 1. This method is an accurate and meaningful one and is representative of the actual noise figure over a narrow (5 percent) system bandwidth. Before any measurements were made the system linearity was confirmed and then two methods of measurement were used. One method was to insert 3 dB into the system with the step attenuator and then increase the noise figure meter output until the original power reading is obtained. Padding was used on both sides of the step attenuator to isolate the 3 dB insertion changes on the system by reducing any mismatch error. The second method was to simply increase the noise figure meter output until a 3 dB increase in the power meter reading was obtained. This method requires no changes in the system and relies on the power meter accuracy (1 percent). There was virtually no difference between the two methods used on a random selection of amplifiers. The repeatability from transistor lot to lot was found to be excellent.

VSWR Measurements

The VSWR test measurement setup shown in Figure 2 was used to measure input and output VSWR of the amplifier. This setup is a reflectometer type method where incident power from the sweeper enters port A, splits into two equal parts with one-half being absorbed in an internal load and one-half delivered to the load at port D.

One-half of any reflected power from the load leaves port B to be amplified, detected and displayed on the oscilloscope.

Calibration of the scope display is achieved by substituting standard mismatches at port D and tracing the swept presentation on to the CRT face. This method calibrates out any mismatch errors or nonlinearities in the system components. Standard mismatches of 1.5:1, 2.0:1, and 2.5:1 were used to calibrate the display. Next the amplifier under test was connected to port D and the detector output compared to the calibration traces. The trace on the display is now a relative magnitude of the reflected power vs. frequency. The VSWR at any frequency can be read directly from the display and any anomaly will be readily apparent. The real advantage of this system is that the VSWR over the entire band of interest can be displayed with phase differences, mismatch errors and system gain/loss variations calibrated out with the use of standard mismatches. If standard mismatches are not available, standard attenuators or pads may be used. For an example, an open circuited 3 dB pad closely approximates a VSWR of 3.0:1. Other values of open-circuited pads vs. VSWR are given in Figure 3.

One important property of the power divider used in this type of measurement is the directivity or isolation between port A and B. An isolation of 30 dB or greater over the frequency range of interest was measured on the BNJ-302A. The amplifier connected to port B should be one with a very low VSWR or a pad should be used between the amplifier and port B to help reduce any mismatch error. Since any mismatch error will be calibrated out by using the standard mismatches, precautions such as mentioned above will yield a sound system and one that will have more uniform calibration curves.

The VSWR measurement method was compared to measurements made using the Wiltron 63N VSWR bridge and it was found that there was virtually no difference in the measurements.

System Noise Figure Measurement

A system noise figure of 8.0 dB was measured with the setup shown in Figure 4. Noise figures of between 7.9 to 8.5 dB were measured using different M1 mixers and amplifiers. The Relcom M1 mixer has a noise figure of 8.5 dB max from .2-500 MHz, according to manufacturer's literature.

Power Output Measurements

The 1 dB compression point of output power is defined as the level at which the output power increases only 9 dB for a 10 dB increase in input power.

General Conclusions

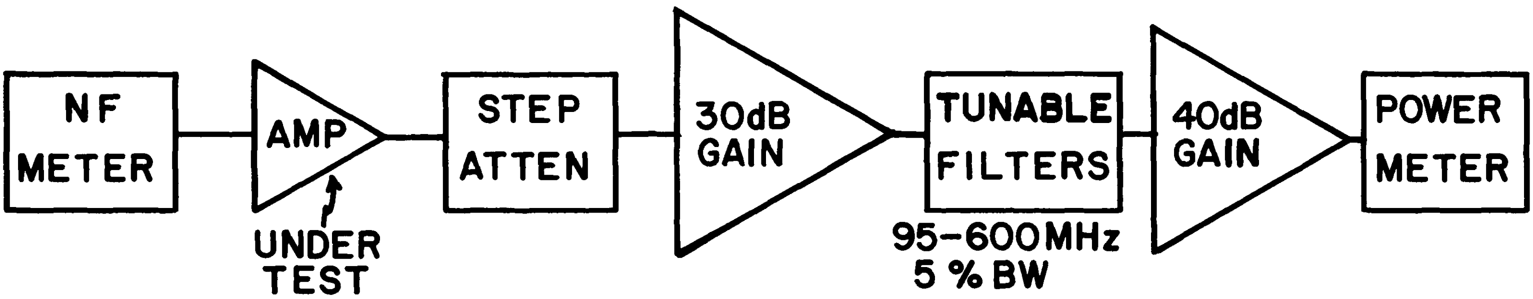
This amplifier can be used in RF/IF applications that require wide bandwidth, low noise figure and low VSWR. The phase vs. frequency change through the amplifier is very smooth with no abrupt or sudden shifts.

The generation of spurious responses, harmonics of single frequencies, as well as intermodulation responses of two or more frequencies is closely related to the linear gain range. This follows from the fact that nonlinearity is a pre-requisite for both mixing and harmonic generation. Tests were made to determine the level at which spurious responses were generated and it was found that this began occurring at the 1 dB compression point, i. e., where nonlinearity begins.

WB-2

Amplifier Specifications

Frequency Range, 3 dB BW	10-500 MHz
Gain	23 dB
Gain Flatness	± 0.5 dB, 20-450 MHz -3 dB, 10 and 500 MHz
Noise Figure	3.0 dB max. See Figure 1.
Power Output, 1 dB Gain Compression Point	+2 dBm min.
Input VSWR	< 2.0:1, 30-500 MHz
Output VSWR	< 2.0:1, 30-500 MHz
Gain vs. Supply Voltage	0.7 dB/volt max.
Power Requirement	+15 V DC at 21 mA
Connectors (Input/Output)	OSM
Size	2.6" long x 1.5" wide x 0.75" high
Weight	3.5 oz.

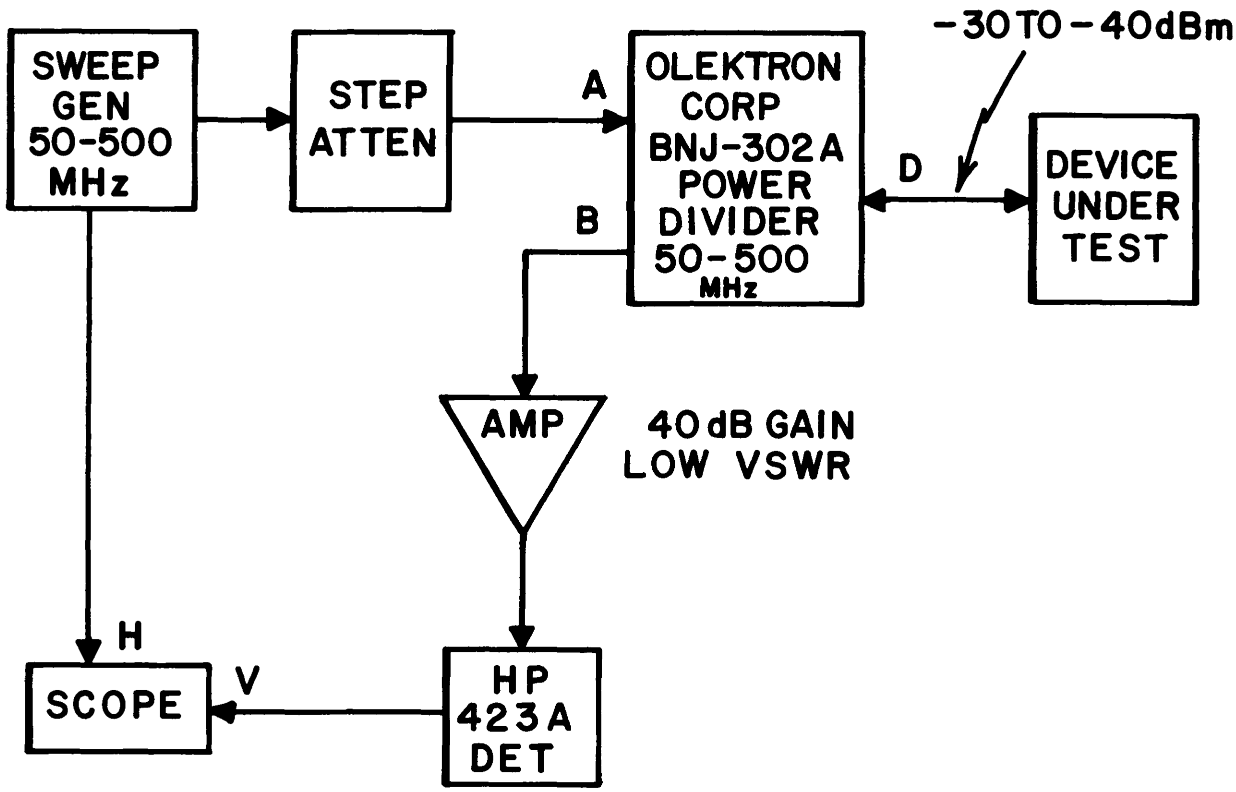


TYPICAL MEASUREMENTS

FREQ.(MHz)	NOISE FIGURE	
	SN 18	SN 19
100	2.3	2.7
150	2.5	2.8
200	2.5	2.8
250	2.5	2.8
300	2.6	2.8
350	2.6	2.8
400	2.6	2.8
450	2.6	2.8
500	2.6	2.8

NOISE FIGURE MEASUREMENT SETUP

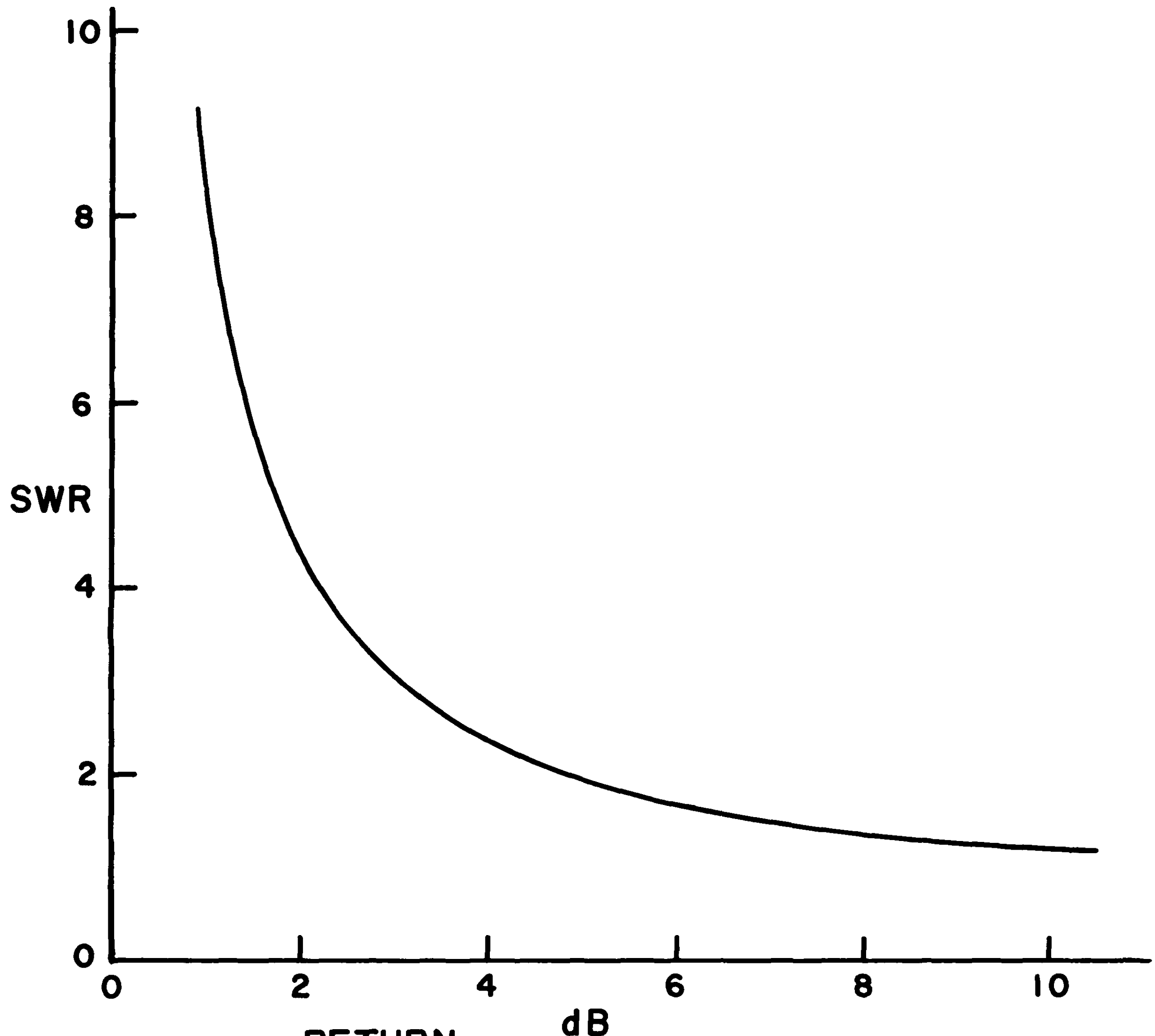
FIG. 1



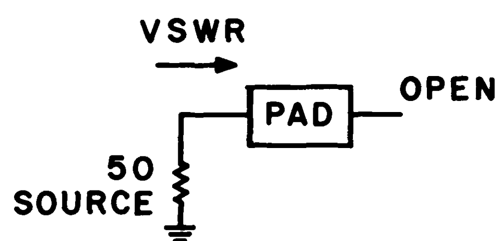
NOTE: BNJ-302A MEASURED ISOLATION—
—(PORT A TO B) ≥ 30 dB

VSWR MEASUREMENT SETUP

FIG. 2



PAD	RETURN LOSS	SWR
0 dB	0	∞
1	2	8.55
2	4	4.4
3	6	3.05
4	8	2.3
5	10	1.92
6	12	1.66
7	14	1.5
8	16	1.38
9	18	1.29
10	20	1.22
20	40	1.02

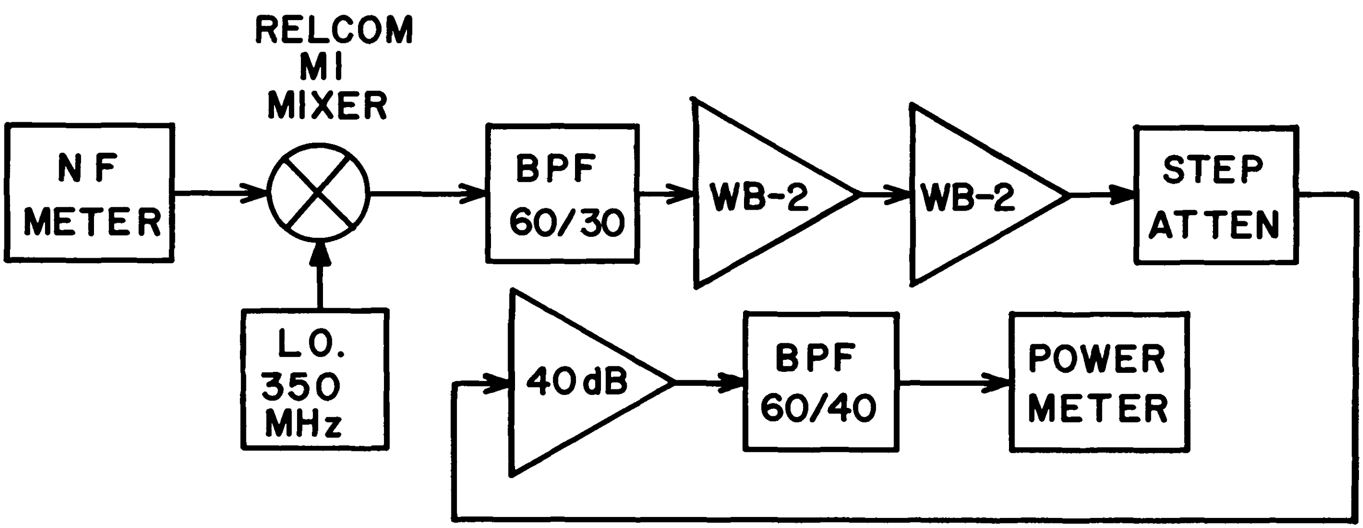


RETURN LOSS (dB) $= 20 \text{ LOG } \frac{1}{\rho}$

ρ = REFLECTION COEFFICIENT

$$\text{SWR} = \frac{1+\rho}{1-\rho}$$

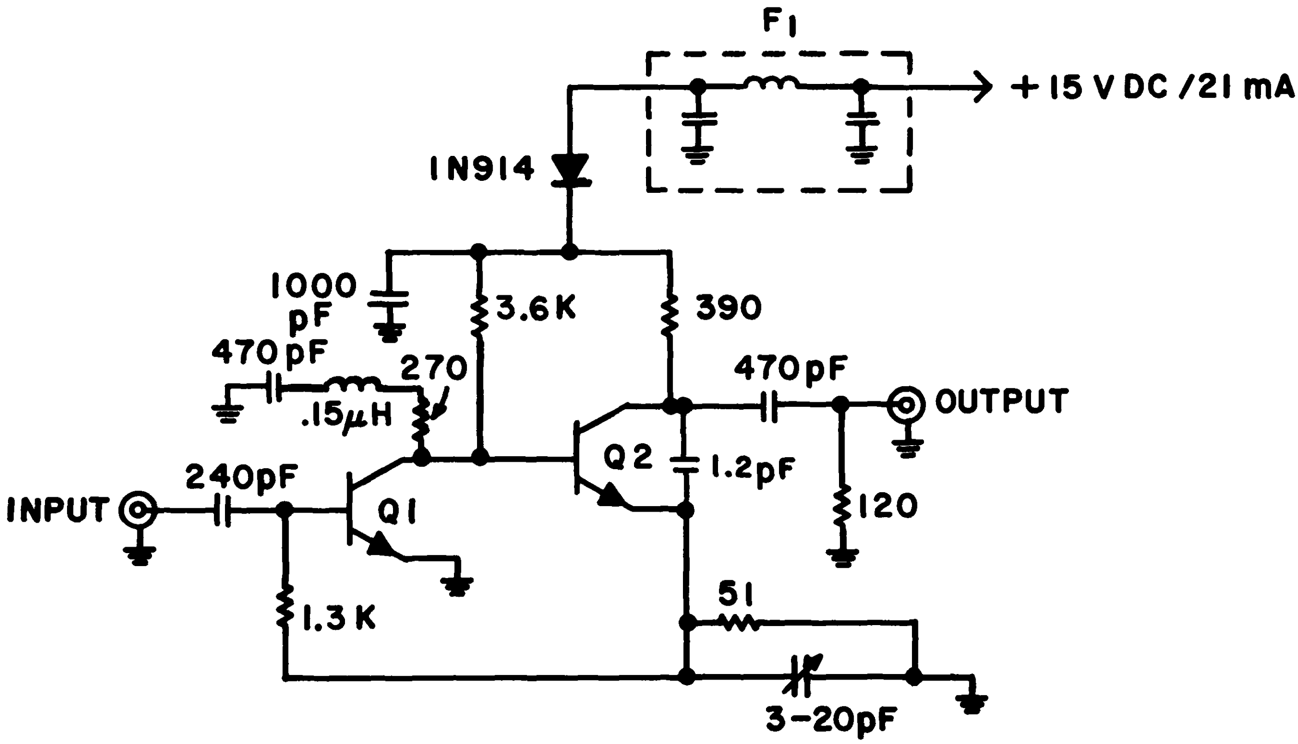
FIG. 3



NOISE FIGURE WITH ABOVE SET UP = 8.0 dB

SYSTEM NOISE FIGURE MEASUREMENT

FIG. 4



Q1, Q2 = KD 5500 KMC SEMICONDUCTOR
VARIABLE CAPACITOR = 3-20pF — JFD MT-320
FIXED CAPACITORS = AMERICAN TECHNICAL CERAMICS CHIPS
RESISTORS = 1/8W, 5% ALLEN-BRADLEY
FILTER = RFI FILTER, ERIE 1270-016
RF CHOKE = .15μH NYTRONICS

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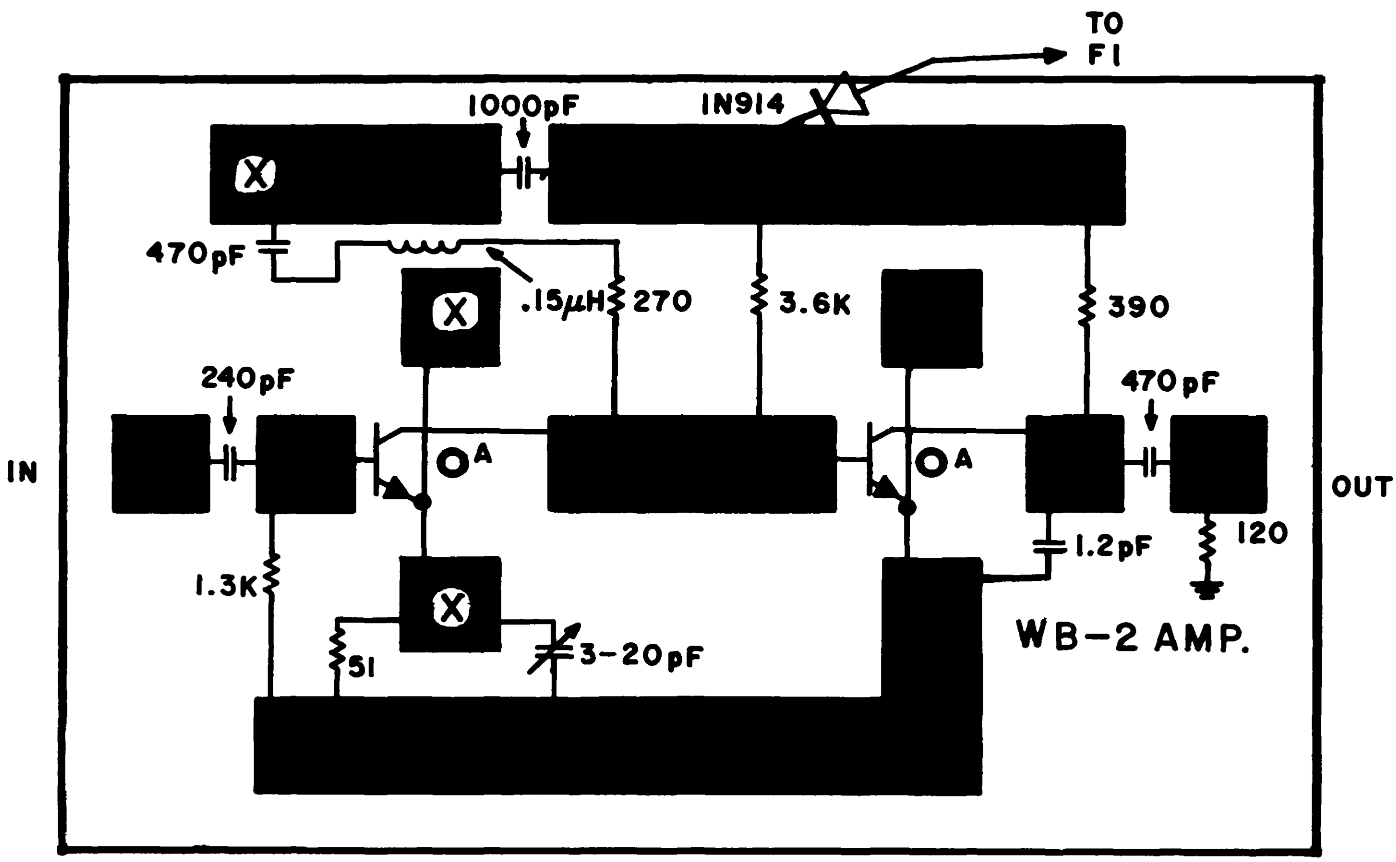
FIG. 5



Notes:

1.- Scale 4:1.

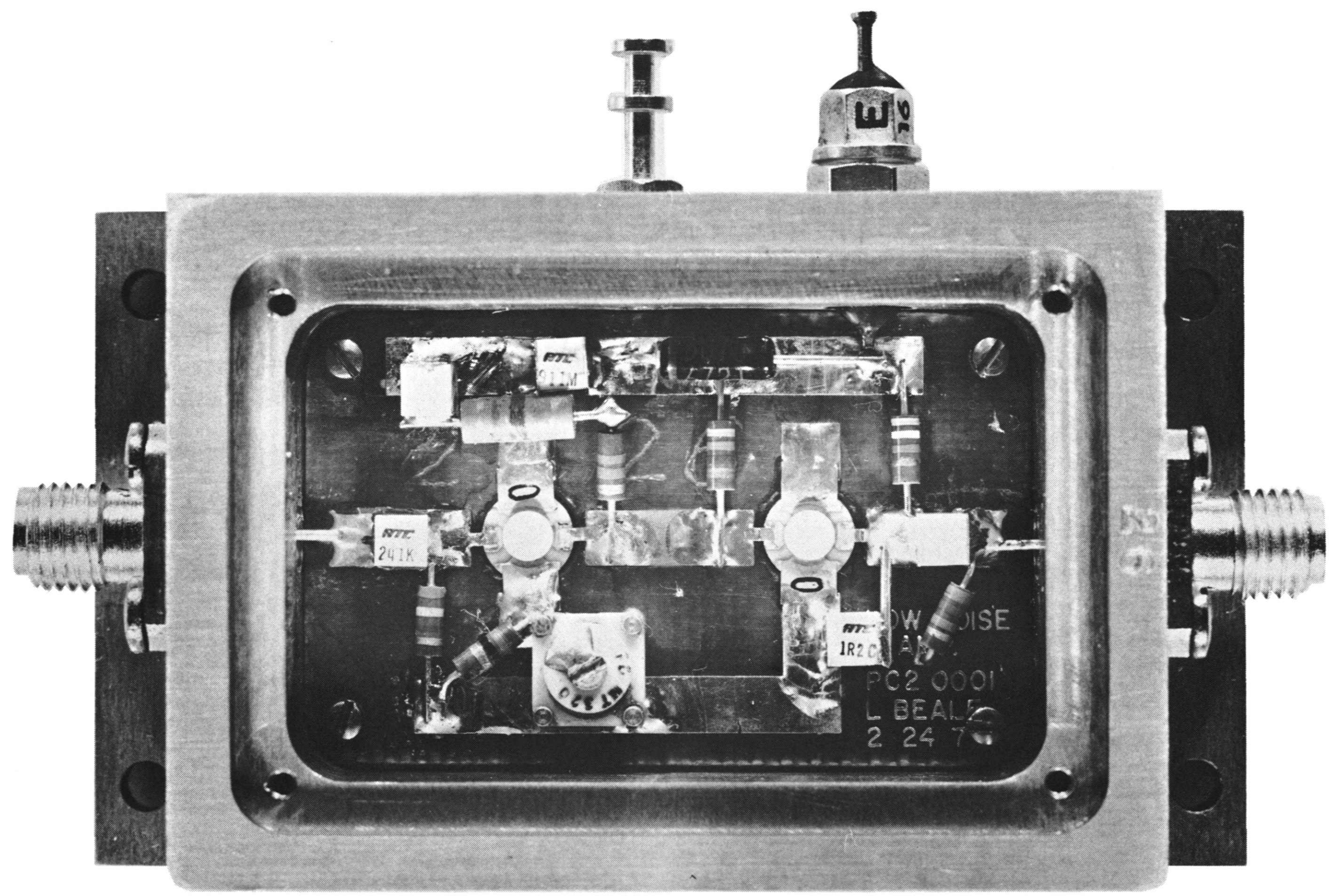
2. Material — 1/16 inch Glass Epoxy, 1 oz. Copper, two sides.

3. "X" denotes stake or wire thru board to ground plane side of board.

4. Drill "A" holes .20 diameter to accept body of "K Disk" transistor KD 5500.

CIRCUIT LAYOUT

FIGURE 6



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