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A BROADBAND AMPLIFIER
1 - 161 MHz

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In August 1959 an article by C. L. Ruthroff entitled "Some Broadband Transformers" appeared in the Proceedings of the IRE. Some transformers were described which have a bandwidth of several hundred MHz, in the range from some kHz up to about 1000 MHz. These are transmission line transformers, using ferrite torroids. Since these transformers are the main elements in the broadband amplifier, they shall be described first.

In conventional transformers the distributed capacity resonates with the leak inductance. This resonance results in a loss peak and limits the high frequency response.

In the transmission line transformer, the interwinding capacity is used as a component of the line impedance and thus does not limit the high frequency response.

The broadband transformers consist of a few windings of twisted pair of wire on a small ferrite torroid (Fig. 1). In order to get a good low frequency response, a ferrite material had to be found with extremely high low-frequency permeability. The important characteristic of the ferrite material is shown in Figure 2. With this type of ferrite core, the high permeability at the low end maintains good low-frequency response with a minimum of turns. At high frequencies the good response is maintained by the reactance of the coil.

The right ferrite material, however, was difficult to find. An attempt was made to buy special ferrite torroids since they are used in commercial transistorized IF amplifiers. The manufacturer could not be discovered. With some ferroxcube shielding beads, good results were obtained.

The active elements in the described amplifier are transistors type 2N1742. They are used in common-base configuration for two reasons:

1. High beta cut-off frequency
2. Better stability of gain.

To match the collector impedance to the emitter impedance, a transmission-line transformer was built with the ratio 4:1 (Fig. 3). The windings consist of 40 mm twisted pair wire, Formex 38

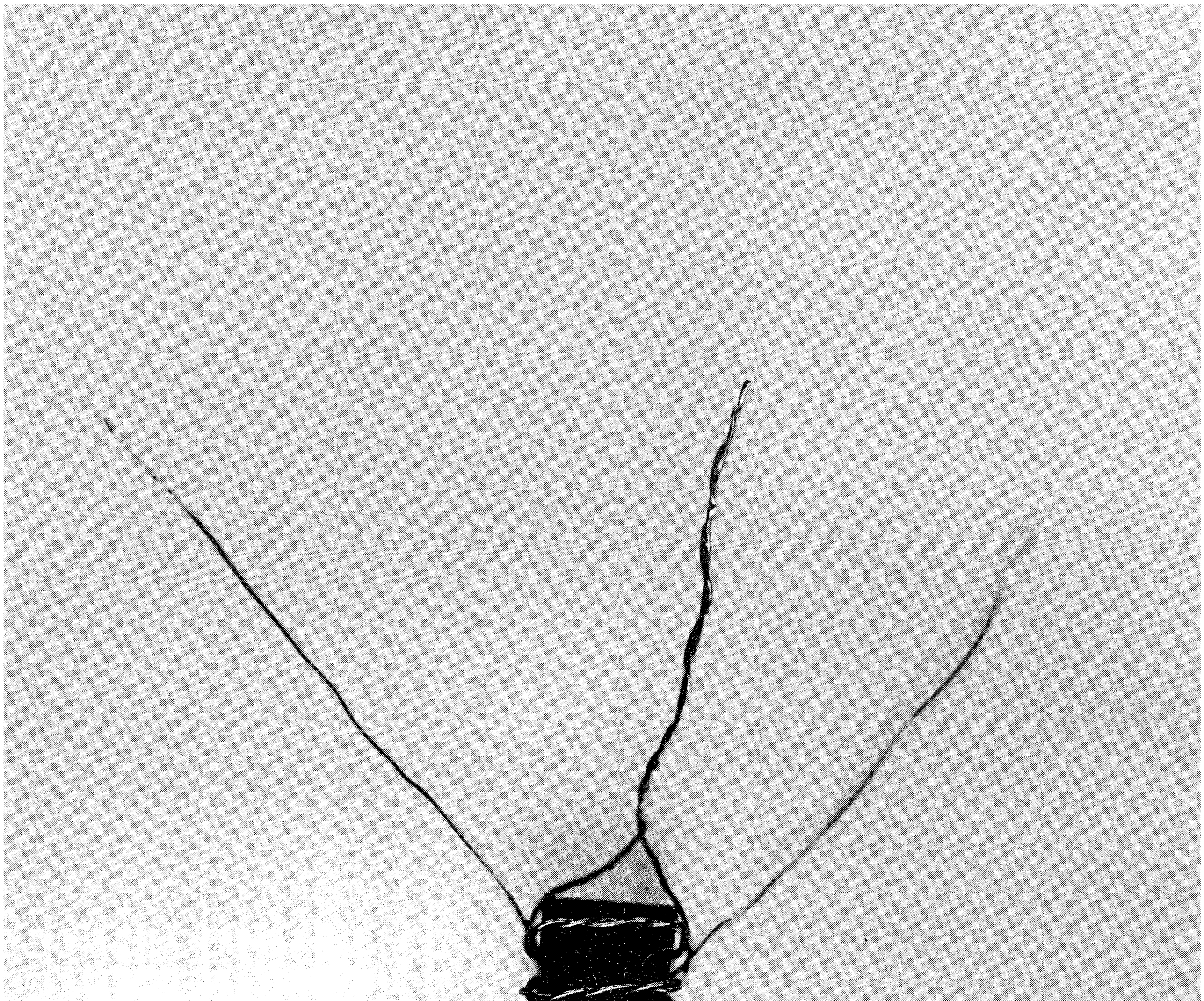


FIG. 1

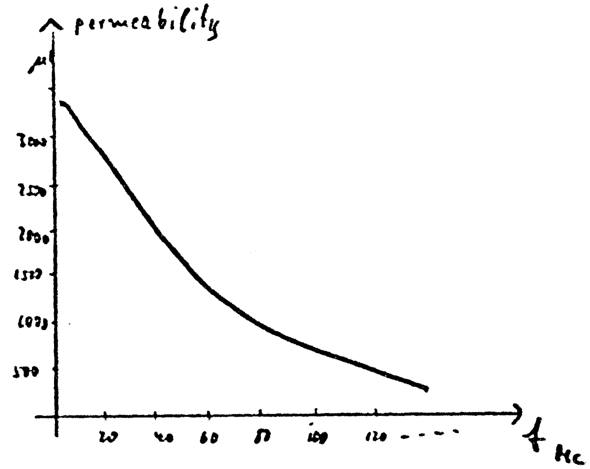


Fig. 2.

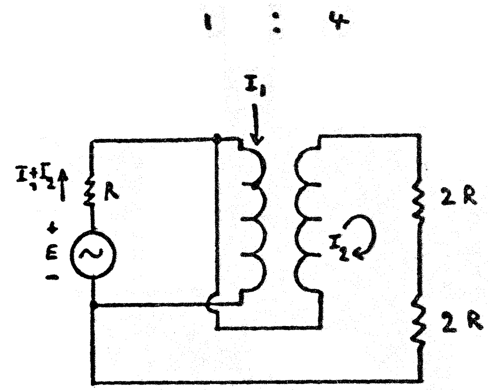


Fig. 3

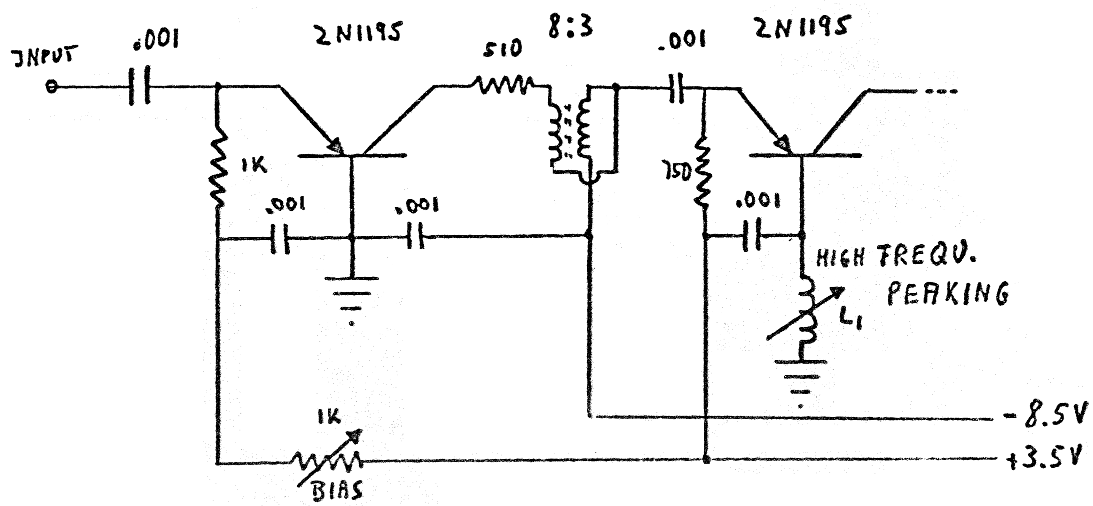


Fig. 5.

All the current gain is obtained from the transformers and since its impedance ratio is 4:1 the maximum gain is 6 db per stage. Certainly the transformer has a loss and another loss is the emitter-resistor that shunts the emitter-base current. Yet a gain of 5.4 db per stage was obtained first. In order to get a better frequency response it was necessary to increase the bias power, and the result is a loss of 1.4 db gain. Thus the prototype had a gain of 46 db with 10 stages.

The emitter-resistor values decrease to the last stages. This prevents the output stages from overloading.

Another difficulty is the input and output circuits. The transformers as well as the transistors are able to manage even higher frequencies, but it is not as easy to get broadband in- and output circuits. The frequency response obtained is shown in Figure 4.

With 2 db ripple the bandwidth is 150 MHz (5-155); 3 db down, the range is 160 MHz (1-161).

The average noise figure over the entire range was measured at 14.5 db (3 db method). At 30 MHz it is 10 db. The reason for this high noise figure may be a coupling problem since it is difficult to design coupling circuits for such a wide frequency range. Until now there has been no attempt made to design a special low noise input circuit.

Ruthroff describes such a circuit, which is shown in Figure 5. It may be possible to bring the noise figure down to about 6-7 db. This, however, will be the next step in further development of the broadband amplifier.

Conclusions

The problem is to obtain the correct type of ferrite torroids. Bell Labs was phoned, and they sent 6 excellent samples but on the condition that we make no further attempts to get more. Bell Labs evidently plan to use the cores for industrial broadband-amplifiers, built on the same principle.

Potentially these transformers have many uses in broadband circuit design.

A temperature stability test of the prototype amplifier is shown in Figure 6.

The mechanical arrangement is quite simple (Figs. 7 and 8). No shields between stages are necessary since the impedance is very low.

Technical Data

Frequency range	:	1-161 MHz (3 db down)
Gain	:	46 db
Average noise figure	:	14.5 db
Noise figure at 30 MHz:		10.0 db
Maximum input voltage:		= 1 mV
Supply voltages	:	+6; 10.5 Ma -12; 10.5 Ma
Dimensions	:	240 mm long 45 mm wide 32 mm high.

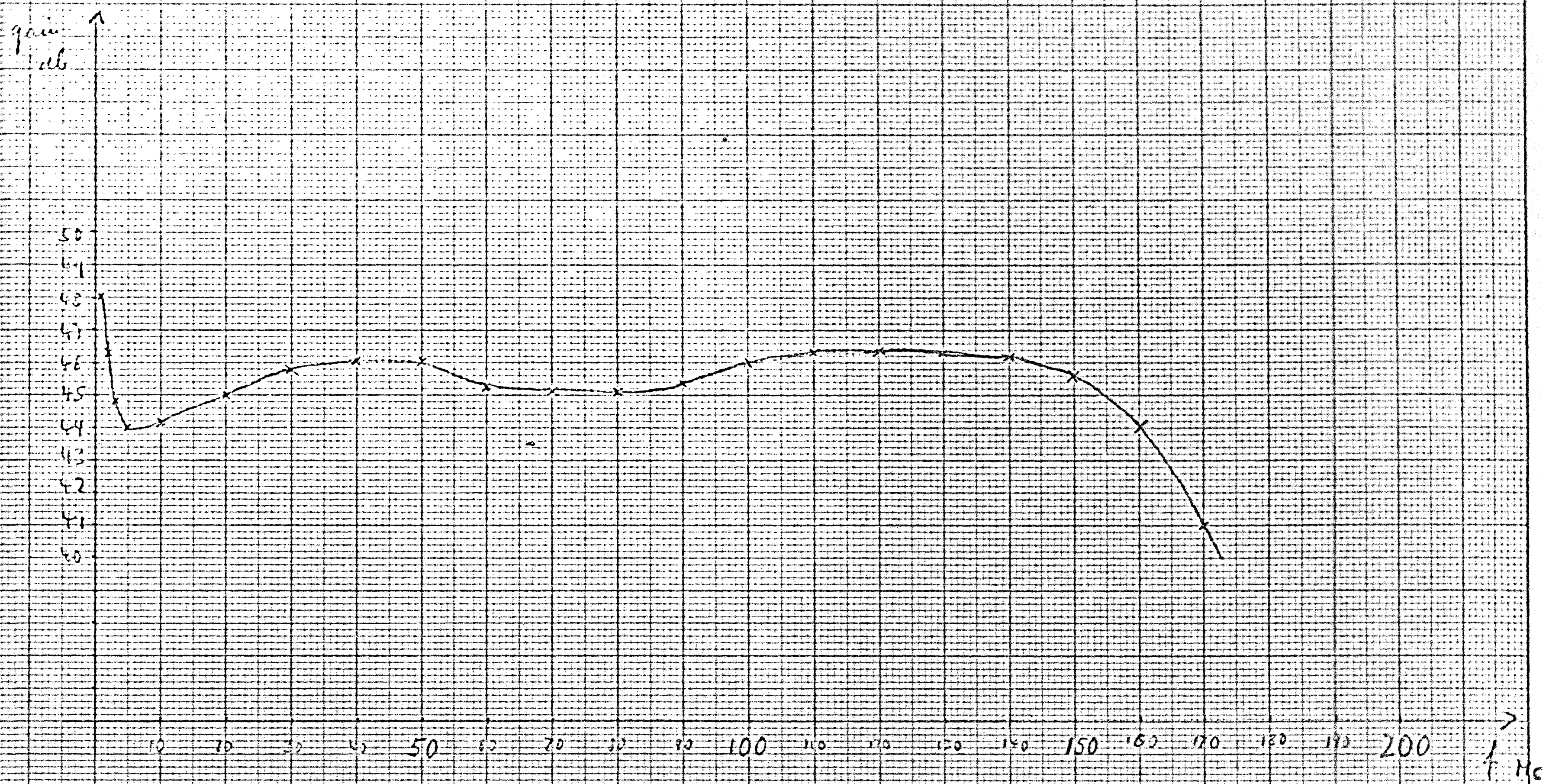
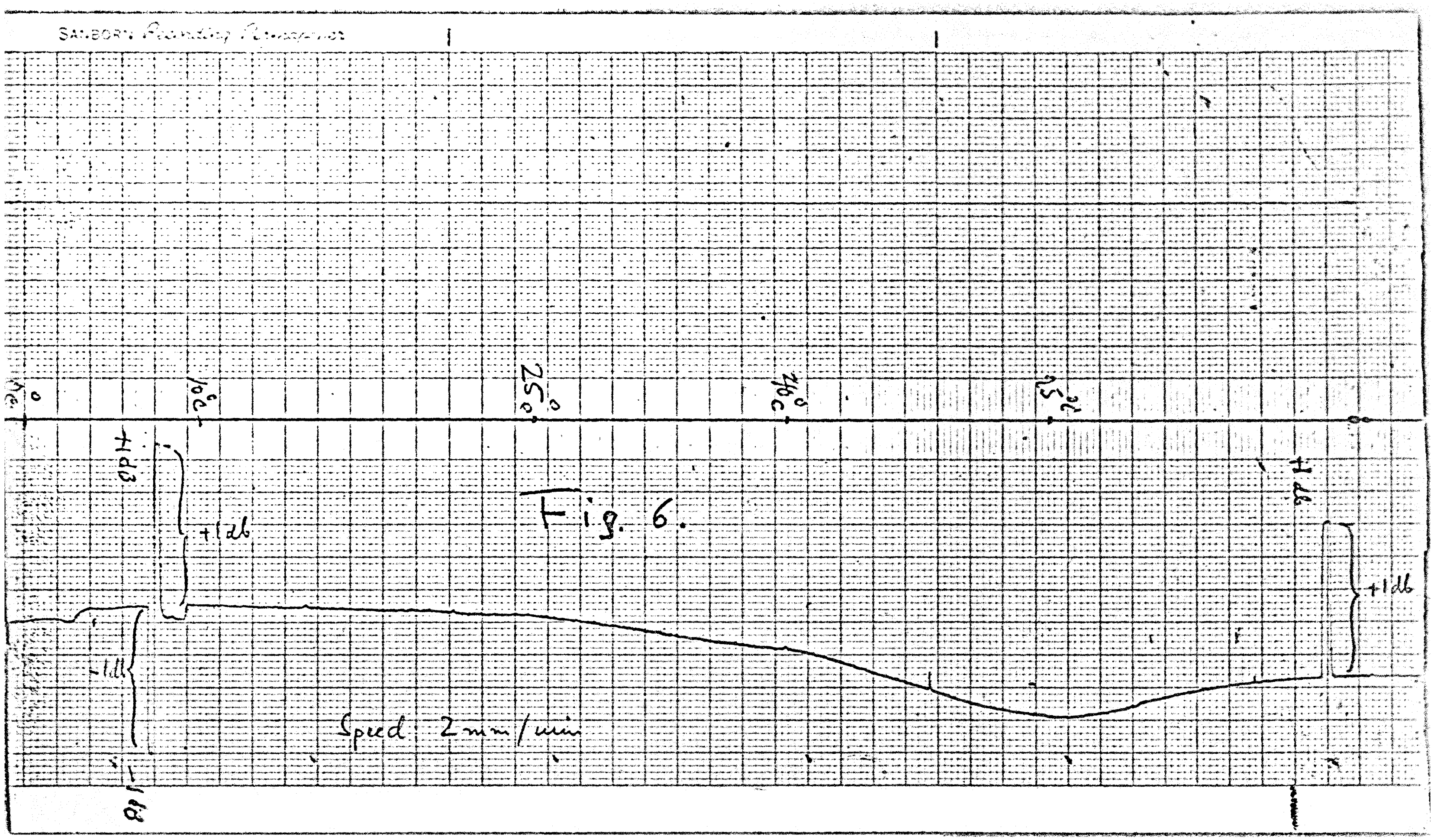


Fig. 4   Frequency response


SANBORN Recording Paper
0°c.
10°c
25°c
40°c
25°c
0°
+1db
+1db
+1db
+1db
-1db
-1db
Fig. 6.
Speed 2mm/min

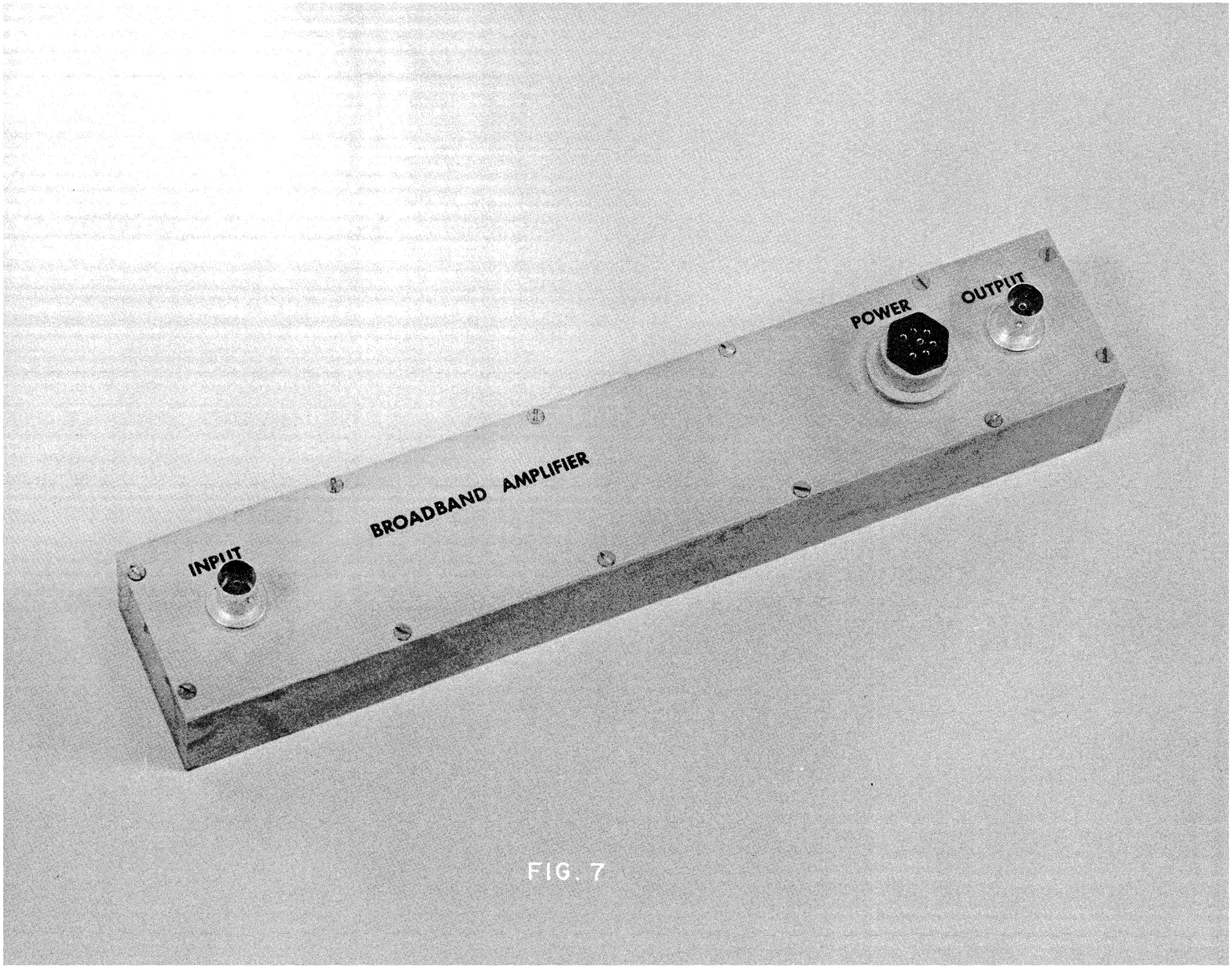


FIG. 7

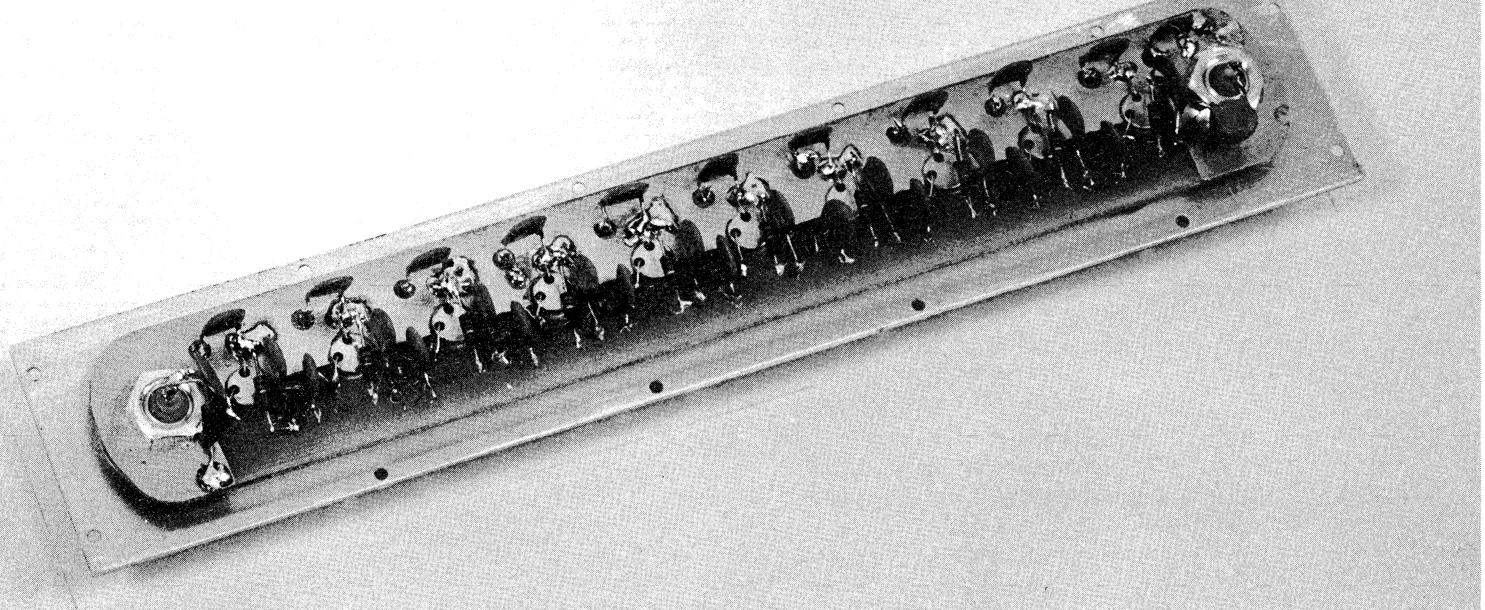
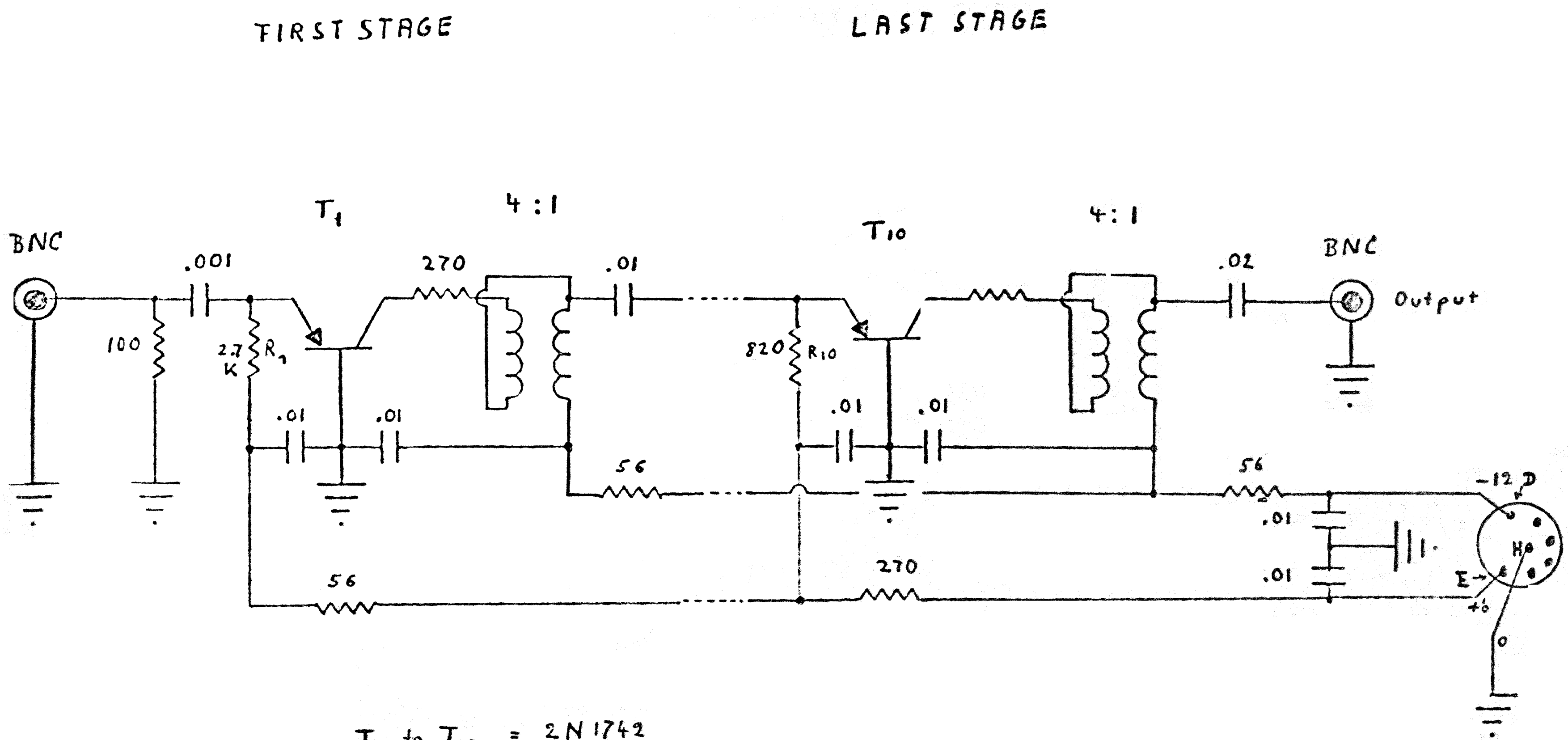


FIG. 8



T_1 to T_{10} = 2N1742

R_1 to R_{10} decreasing from 2.7K to 820Ω

BROADBAND - AMPLIFIER
SCHEMATIC