AN UNUSUAL MICROWAVE MIXER

G. Tomassetti

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Dr. G. Tomassetti,
Istituto di Radioastronomia del C.N.R.
Via Irnerio, 46 - BOLOGNA, Italy.

ABSTRACT

Some preliminary tests on an unusual GaAs FET mixer configuration are reported.

Conversion gains and 360 K DSB receiver noise temperatures were measured at X band. Cooled to 78 K, about 200 K receiver noise temperature are attainable across a 6% bandwidth.

The operating noise temperature of the I.F. was 120 K.

Acceptable performances of packaged devices were also measured at K band.

DESCRIPTION

An unusual microwave mixer configuration was recently tested in our laboratory by making only minor modifications to a single stage coaxial amplifier of well known design [1], [2], [3].

The experimental results reported here refer to two units working at X and K bands. Both utilise packaged GaAs FETs in circuits optimised as low noise amplifiers. Standard Smith chart computation was performed following S parameters as published by NEC for the input and output matching.

The basic idea is to realise a 3 port mixer by applying the R.F. input signal to the gate and the L.O. signal to the drain. The I.F. voltage is available across a load resistor connected after the low-pass filter biasing network of the drain.

Refer to Fig. 1 for electrical details.

In order to choose a suitable working point the static direct and reverse d.c. drain characteristics were measured and plotted as in Fig. 2 with the gate voltage as a parameter. Best fitting the measured data it was found that curves relative to -.6 V and -.7 V approximate almost perfectly a parabola equation both for positive and negative drain voltages so those were chosen as locus for best mixing.

In practice in this mixer configuration d.c. drain biasing need not be applied; however negative biasing of the gate is necessary and needs to be critically adjusted for best performance. As shown in Fig. 3, changing the gate bias has effect on noise temperature but the tuning and the bandwidth of the mixer are effected as well. The graph of Fig. 3 was obtained with an automatic noise measurement set up: an "Apple" computer driven by an "ADIOS" interface according to National Radio Astronomy Observatory (N.R.A.O.) specs and programs.

The I.F. port was noise matched. Nevertheless a return loss of about 10 dB and a maximum conversion gain of about 2 dB were measured at 30 MHz.

Receiver noise temperature and conversion loss vs. L.O. power are plotted in Fig. 4 while Fig. 5 shows conversion loss vs. gate biasing at a fixed L.O. level of + 6 dBm.

The saturation behaviour at + 6 dBm L.O. power is shown in Fig. 6. A straight line response is obtained up to - 8 dBm input signal (A). The second armonic level of the I.F. is shown in the same Figure by curve B (single tone intermodulation product).

The unit under test was then cooled to 78 K physical temperature.

Its noise temperature is strongly dependent on this parameter and showed a 1 to 1 dependence down to cryogenic values where an asymptotic value of about 200 K DSB was reached.

A 10% increase of negative biasing of the gate was necessary for minimum noise. It was also verified that conversion loss is independent of I.F. frequency in the range 10 to 2000 MHz and invariant with respect to physical temperature.

An interesting specification of mixers is the isolation between any two ports. In this case it was measured:

i) L.O. to input = 13 dB
ii) L.O. to I.F. = 30 dB
iii) input to I.F. = 38 dB
iv) input to L.O. = 7 dB (I.F. = 30 MHz); 14 dB (I.F. = 1 GHz).

A similar unit using an NE673 GaAs FET operating at 22.5 GHz was also tested. A summary of preliminary meaured data at an I.F. frequency of 1.3 GHz is given below:

conversion loss $\cong$ 3 dB
receiver noise temperature at 290 K $\cong$ 900 K
receiver noise temperature at 78 K $\cong$ 400 K

These were best values but "usable" noise temperature were measured

from 19 to 25 GHz. As before, matching of input ports was performed assuming the device to be a low noise amplifier.

CONCLUSIONS

A really low noise, low conversion loss, coolable mixer could simplify front end designs in radioastronomical and telecommunication receivers. The possible reduction of front end gain before mixing reduces complexity but it might be useful in cutting saturation problems and costs.

ACKNOWLEDGEMENT

Dr. S. Weinreb of N.R.A.O., Charlottesville and Prof. G. Sinigaglia of the Bologna University are aknowledged for valuable discussion and suggestions.

REFERENCES

(1) TOMASSETTI, G., WEINREB, S.and WELLINGTON, W.: "Low noise, 10.7 GHz, cooled GASFET Amplifier", Electronic Letters, 1981, 17, no 25/26.

(2) SIERRA, M.: "15 GHz cooled GaAs FET Amplifier. Design background information", N.R.A.O. E.D.I.R., June 1982, no 229.

(3) POSPIESZALKI, M.: "Low noise, 8.0 - 8.8 GHz, cooled GASFET Amplifier", N.R.A.O. E.D.I.R., Dec 1984, no 254.

FIGURE CAPTIONS

Fig. 1 : Wiring diagram of the mixer

Fig. 2 : Static direct and reverse d.c. drain characteristics. The parameter is gate bias.

Fig. 3 : DSB receiver noise temperature (K) vs. frequency (GHz). Curves A to E refer to negative gate voltages of −.2, −.4, −.6, −.8 and 1.0 V respectively.

Fig. 4 : SSB conversion loss vs. L.O. power (A) and DSB receiver noise temperature vs. L.O. power (B).

Fig. 5 : SSB conversion loss vs. gate voltage at +6 dBm L.O. power.

Fig. 6 : Saturation characteristic (A) and second harmonic level of I.F. (I

The photo shows the mixers for X and K bands.

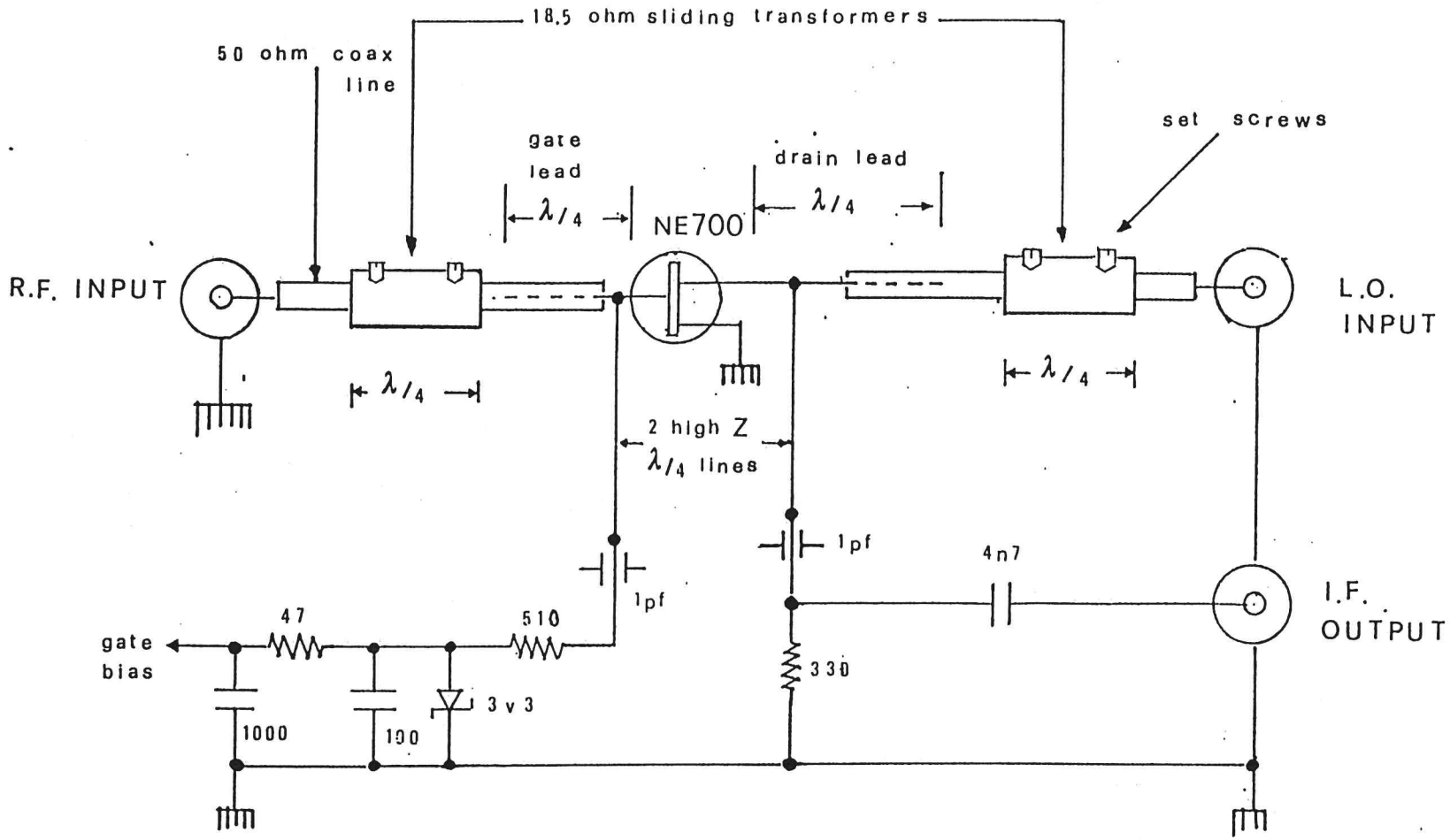

18.5 ohm sliding transformers
50 ohm coax line
gate lead
drain lead
set screws
NE700
R.F. INPUT
L.O. INPUT
λ/4
2 high Z λ/4 lines
1pf
4n7
I.F. OUTPUT
gate bias
47
510
330
1000
100
3v3

FIG. 1

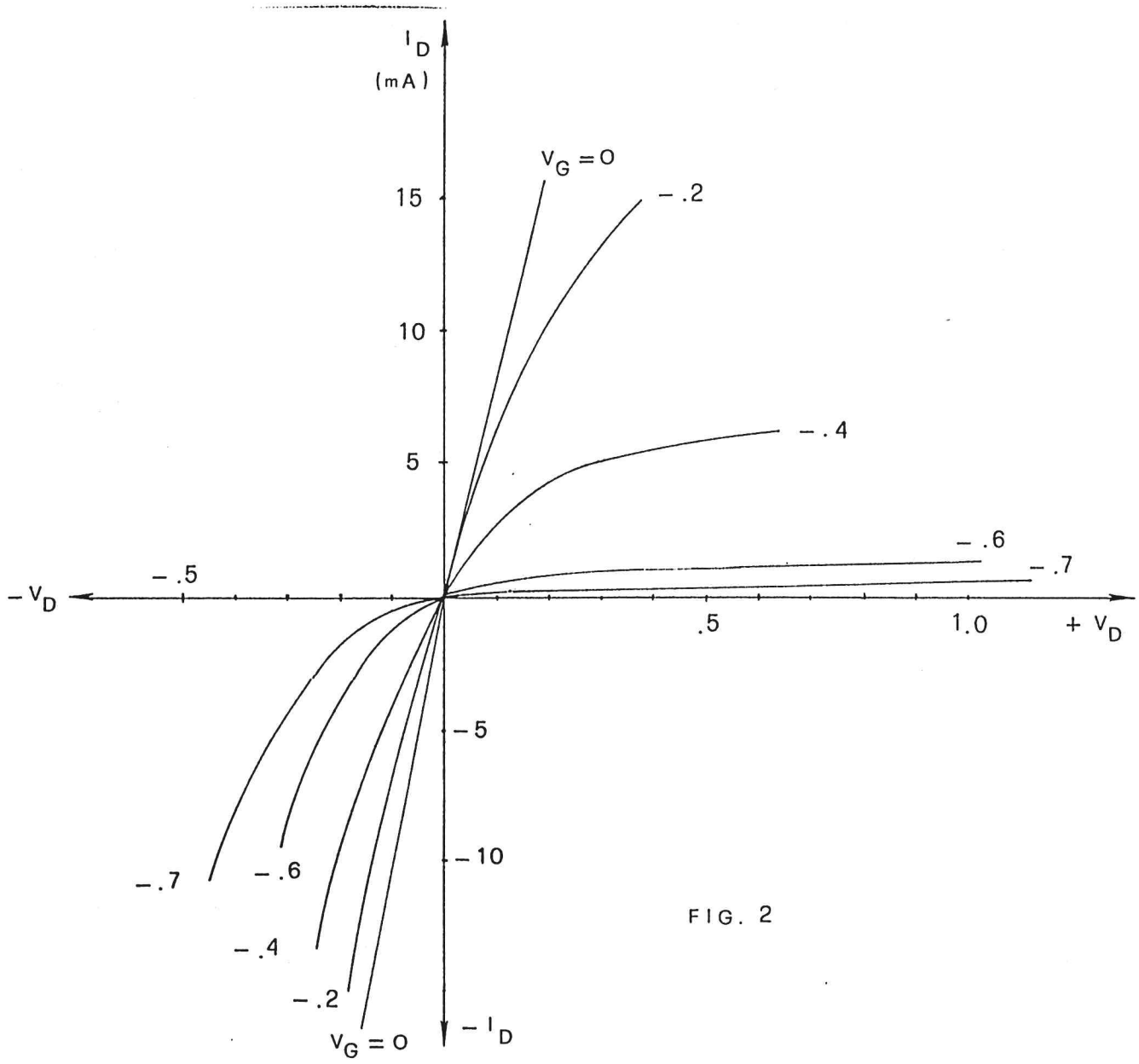


FIG. 2

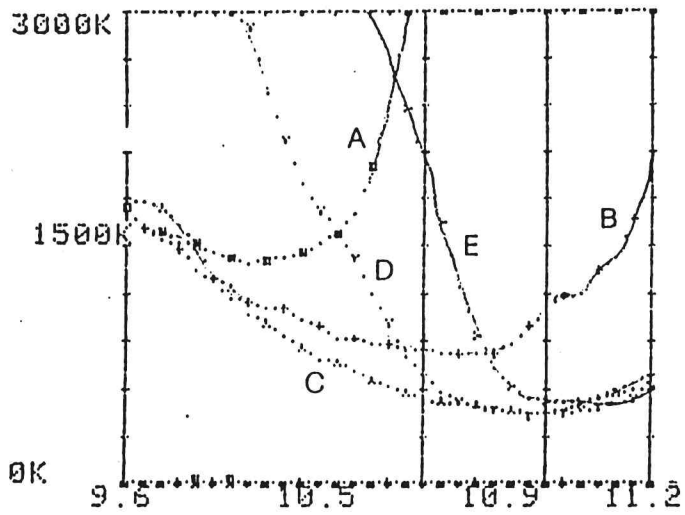


FIG. 3

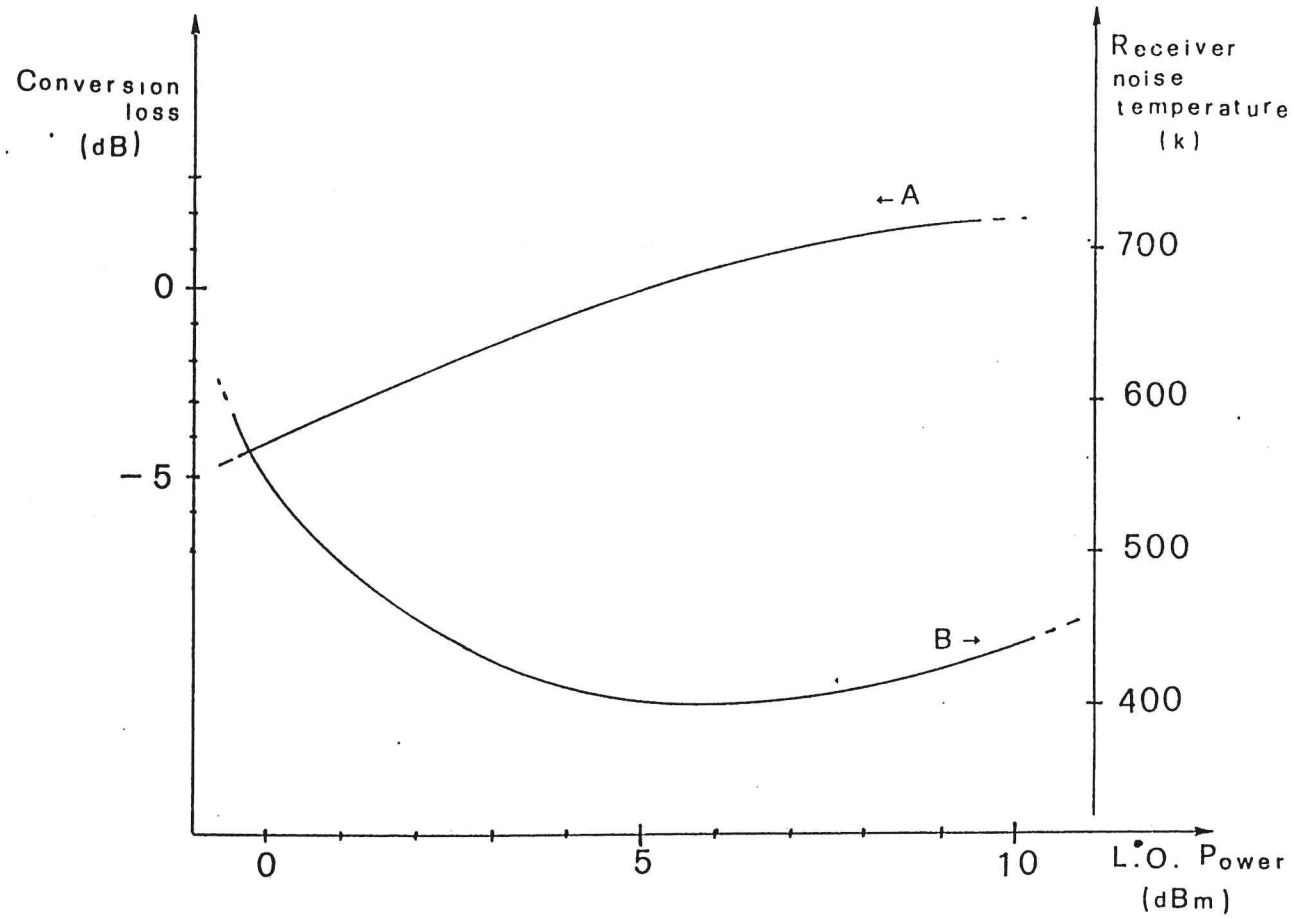

Conversion loss (dB)
0
−5
←A
B→
Receiver noise temperature (k)
700
600
500
400
0
5
10
L.O. Power (dBm)

FIG. 4

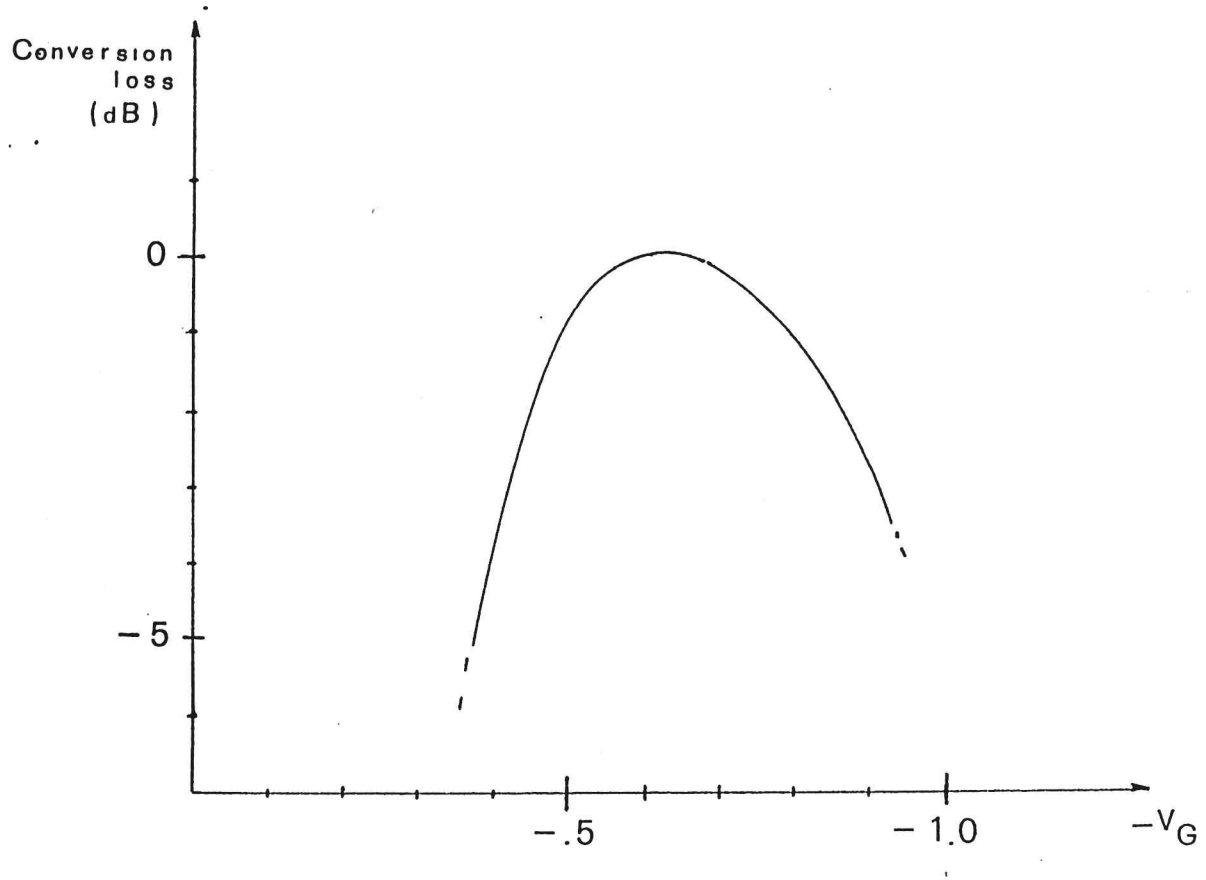


FIG. 5

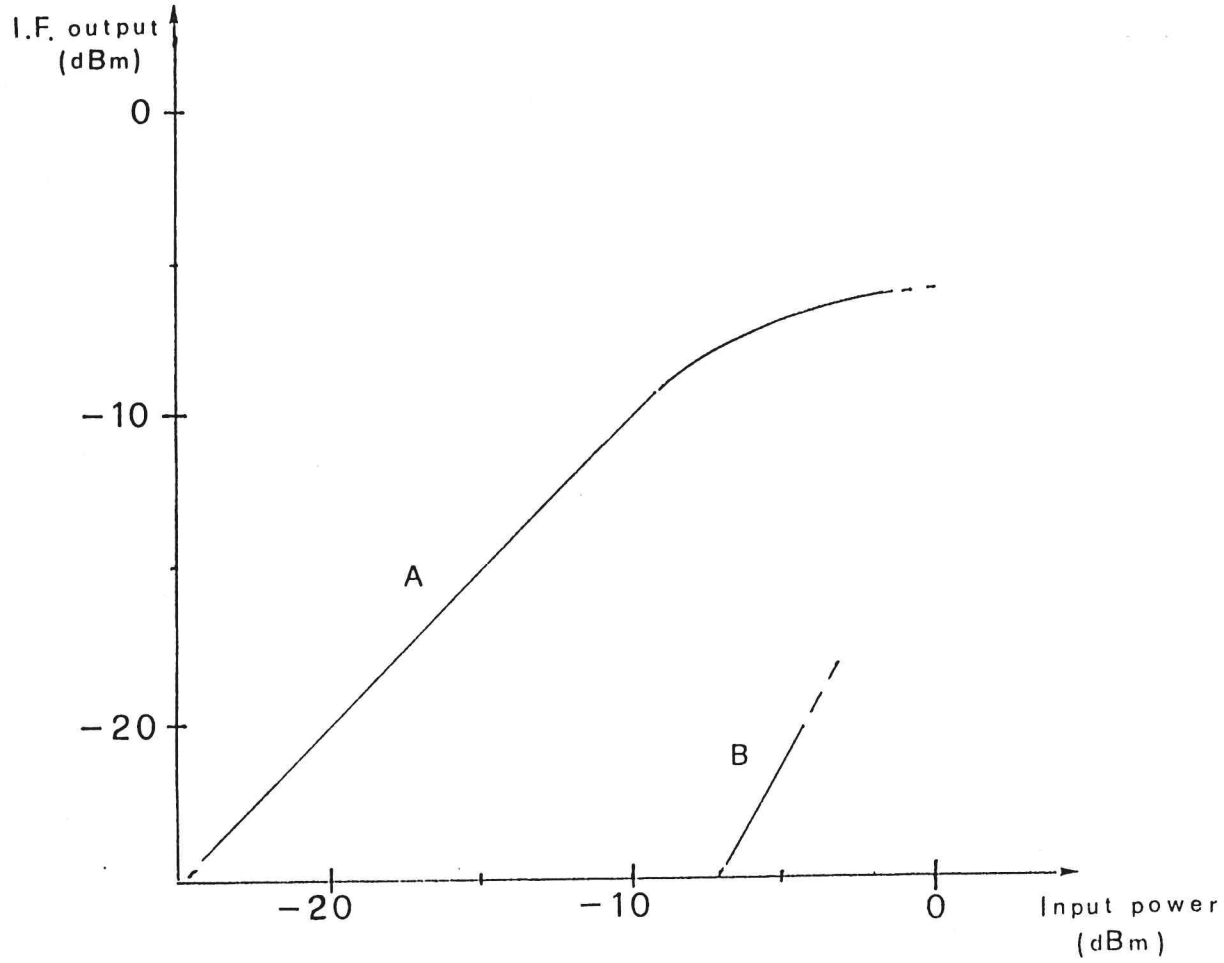
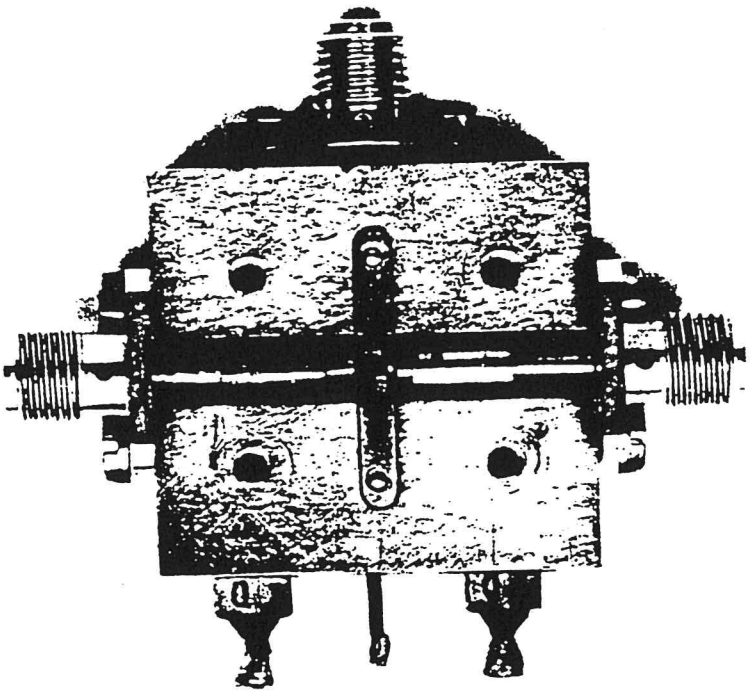
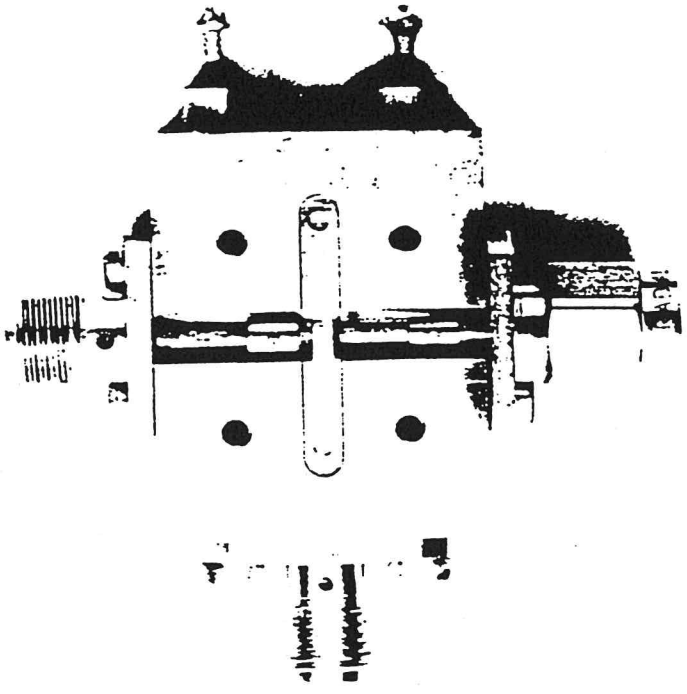


FIG. 6

A





B

A PHOTO OF THE MIXERS