

Communicate On 10.25 GHz

-- with a simple transceiver

Many hams feel that the world of amateur radio ends at two meters, or even twenty in some cases! As the frequency increases, the amount of commercially available gear diminishes. Above 450 MHz, the operator must build his equipment — little prebuilt equipment is around. Thus, the bands

above 450 are underpopulated, and misunderstood by the majority of hams. Possibly you have eyed those "microwave" frequencies starting at 1220 MHz... and wondered how to operate or experiment there. Well, let's see... 1296 might not be too bad — you can triple an old Motorola transmitter

strip, and come up with a converter for your 2m rig. Definitely a project for two hams, as it is nice to have someone to talk with after the construction is done! However, if you desire to experiment with waveguide, horns, and point-to-point communications, the 10.5 GHz band is the place to go.

Why 10.5 GHz? The possibilities for experimentation are endless. If you need a true point-to-point link for your repeater, microwaves are the answer. A low power link can provide reliable control for remote bases, with a lower long-term cost than phone lines! Everyone is familiar with police radar, which is, incidentally, located just above the ham band. Experiments with Doppler radar are possible on 10 GHz.

The road to 10 GHz has not been easy. Little military gear is available, and a machine shop is often required to build microwave gear. The problem of equipment has stifled most amateur ventures into the world of microwaves. However, this problem no longer exists!

Enter the Gunnplexer

A progressive company in Massachusetts has introduced a line of microwave gear specifically designed for

amateurs operating on 10.5 GHz. Microwave Associates, Inc., provides a microwave transmitter and receiver front end in a single package. Dubbed the Gunnplexer, this device produces 20 mW of microwave energy. A portion of that energy is coupled to a receiving diode, which, in the presence of another microwave signal, produces a low frequency i-f signal. The Gunnplexer is easily incorporated into a complete communications system. All that is needed is a Gunnplexer, i-f receiver, and power supply. This article describes just such a system. This transceiver can be used for two-way communications on 10.5 GHz, as a control link, or for Doppler effect radar. Before starting, let's look at the Gunnplexer and discuss its operation.

A Gunn Diode Is the Key

The Gunnplexer consists of five main parts. The heart of the rf head is a Gunn diode. This diode produces a microwave energy directly from dc when it is properly mounted in a resonant cavity. Similar to the familiar tunnel diode, the Gunn diode exhibits a negative resistance region under certain bias conditions. Microwave oscillations occur in this region. The diode employed in the Gunnplexer produces about 20 mW at 10 volts. Current drain is about 225 mA. Referring to Fig. 1, the Gunn diode is contained in the left barrel on the rear of the rf head.

The second component of the device is a varactor diode, housed in the right barrel, next to the Gunn diode. The varactor is used to control the frequency of the microwave radiation. If af modulation is applied to the varactor, FM will occur. The varactor can shift the frequency of the Gunnplexer 60 MHz. A crystal or other high output microphone may be coupled directly to the diode — no preamp is required on a simple system.

The receive components

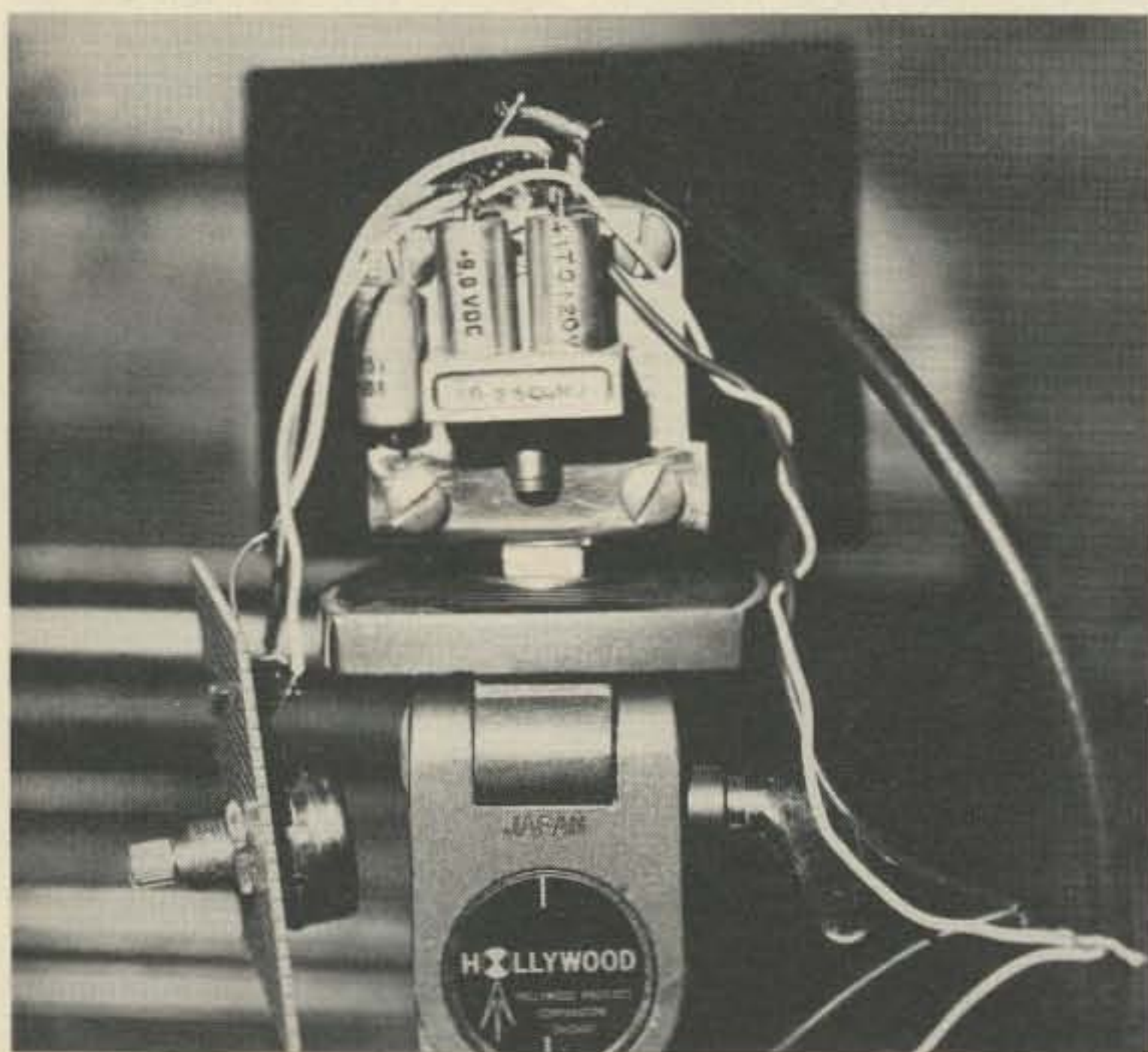


Fig. 1. A rear view of the Microwave Associates MA-87108 Gunnplexer. The Gunn diode is in the cavity under the left barrel. The tuning varactor diode is under the right barrel. Electrical tuning control is mounted on the perfboard, and the i-f connection is visible at the top of the rf head. The homemade bracket for tripod mounting is attached to the lower two bolts. A 1/4 inch nut is sweat soldered to the bottom of the copper flashing. Refer to the text for details.

comprise the third and fourth areas of the Gunnplexer. A tiny portion (about .5 mW) of the transmitted energy from the Gunn diode is coupled to a microwave mixer diode. An i-f signal is produced when a received signal is heterodyned in the mixer. Mixer injection is accomplished by a ferrite "circulator," located next to the mixer diode (Fig. 3). Injection is also controlled by a screw protruding into the body of the Gunnplexer. The standard i-f frequency used by amateurs is 30 MHz. However, different i-fs can be produced by mechanical and electrical tuning of the Gunnplexer. Remember, the transmitted signal also provides mixer injection! A standard FM broadcast receiver can be used as the i-f receiver in a simple transceiver. More on this later!

The normal Gunnplexer frequencies are 10.250 and 10.280 GHz. Thus, it can be

seen that the difference frequency is 30 MHz, even though the local oscillator injection is different at each end of the communications link.

The last major part of the Gunnplexer is, as expected, an antenna. The body of the Gunnplexer is actually a section of UG-39/U waveguide. This guide can be bolted to transmission waveguide, or a gain horn antenna may be attached. Microwave Associates provides a 17 dB gain horn for the Gunnplexer (Fig. 4).

Using the Gunnplexer as a Transceiver

A microphone, i-f receiver, and power supply is required to turn a Gunnplexer into a complete transceiver for 10.25 GHz. A well-regulated 10 volt supply is required for the Gunn diode. About 4.5 volts of bias is needed for the varactor to maintain frequency. The Gunn diode

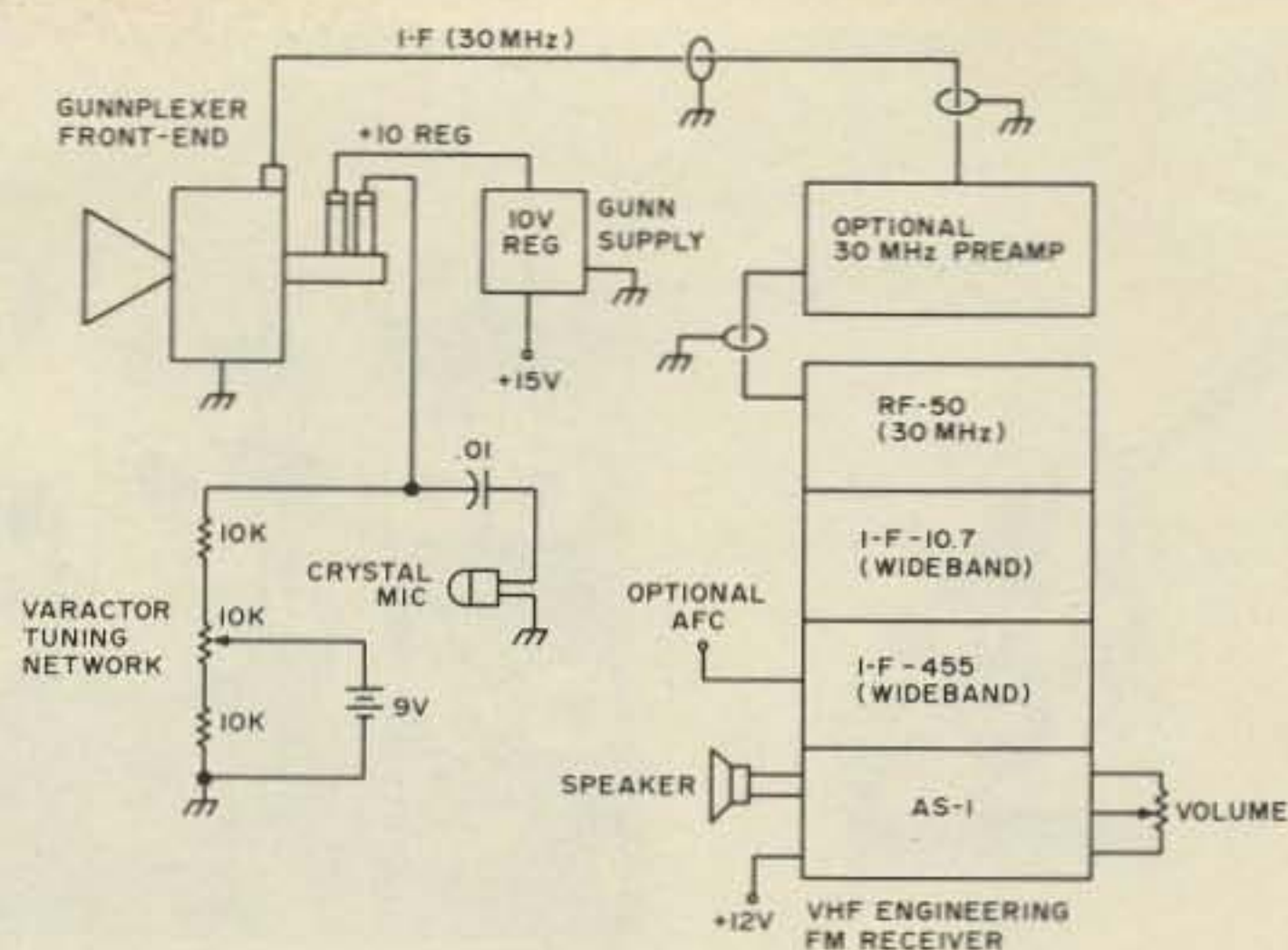


Fig. 2. Block diagram of the simple Gunnplexer transceiver. Details of the bias supply are shown, as well as all interconnections. This circuit uses VHF Engineering receiver strips for the receiver i-f and FM detector. A National Semiconductor LM-317 regulator chip is employed to provide the 10 volts required by the Gunn oscillator.

output drifts as temperature changes, at a rate of -350 kHz per degree Centigrade. Quite a drift factor!

Thus, a change in temperature of only a degree will move the Gunnplexer frequency 350 kHz — right out of your i-f passband! In some cases, afc is required to maintain communications, especially when a narrow i-f passband is employed. A simple transceiver can use a voltage divider with the varactor supply to "tune" the Gunn transceiver. This scheme is adequate, especially in a system with wideband i-f

capability. Refer to Fig. 2 for details of the bias voltage divider.

The most important element (next to the Gunnplexer) in the transceiver is the i-f receiver. A low noise figure is required. The i-f channel must also match the 200 Ohm impedance of the mixer diode for optimum results. Of course, the receiver must have an FM detector! An additional consideration is the i-f bandpass characteristic. If a narrow (10 kHz) i-f is used, Gunnplexer range increases — up to 100 miles under good conditions!

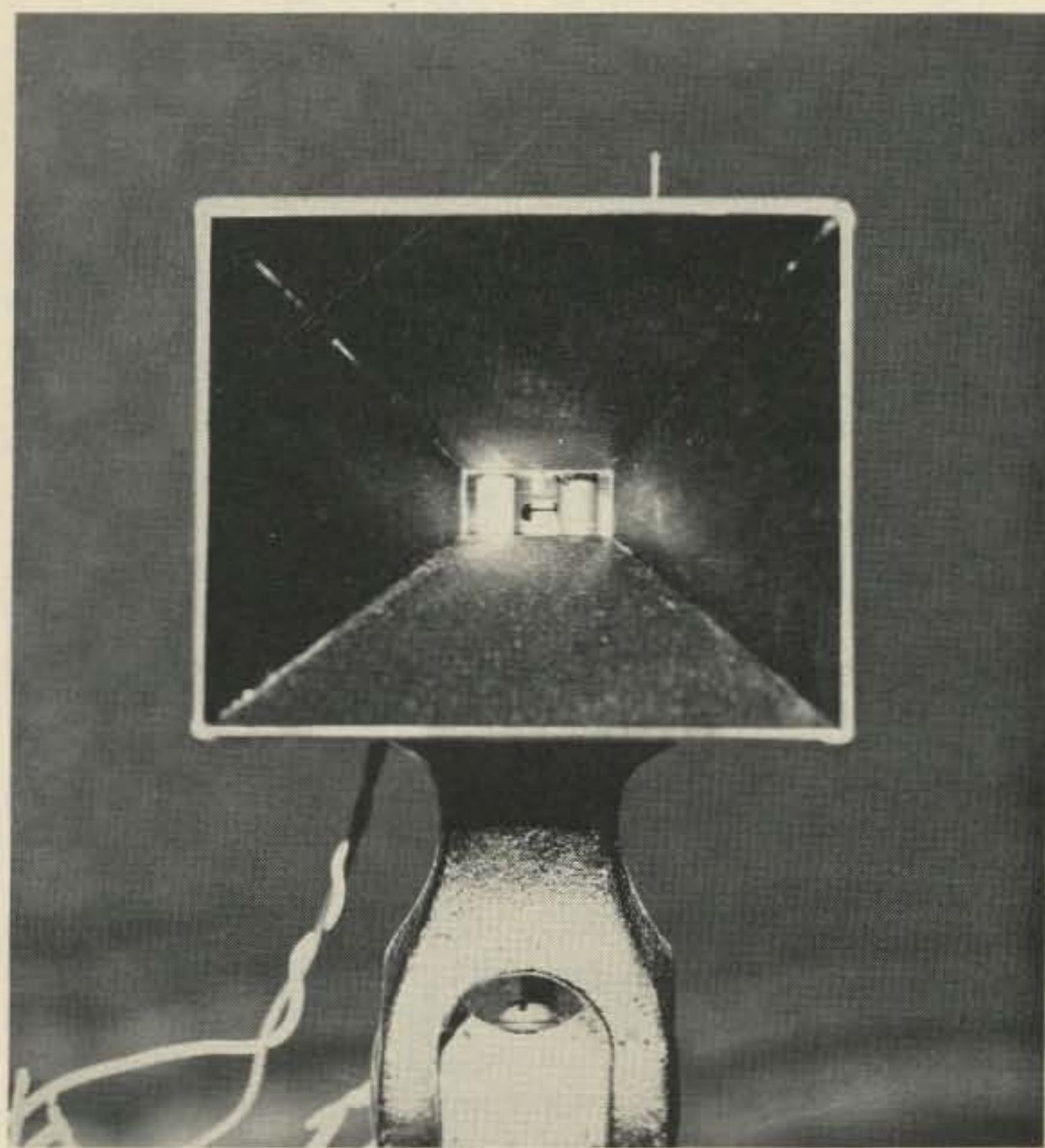


Fig. 3. Big Brother is watching you! This shot shows the mixer diode (left) and the ferrite mixer circulator in the waveguide. The tuning screw can be seen between the diode and circulator. Microwave energy is generated in the cavity behind the oval "iris," which is visible directly behind the tuning screw. The wire extending from the top of the horn is not a scratch in the photo, but rather a ground bus mounted on the rf head.

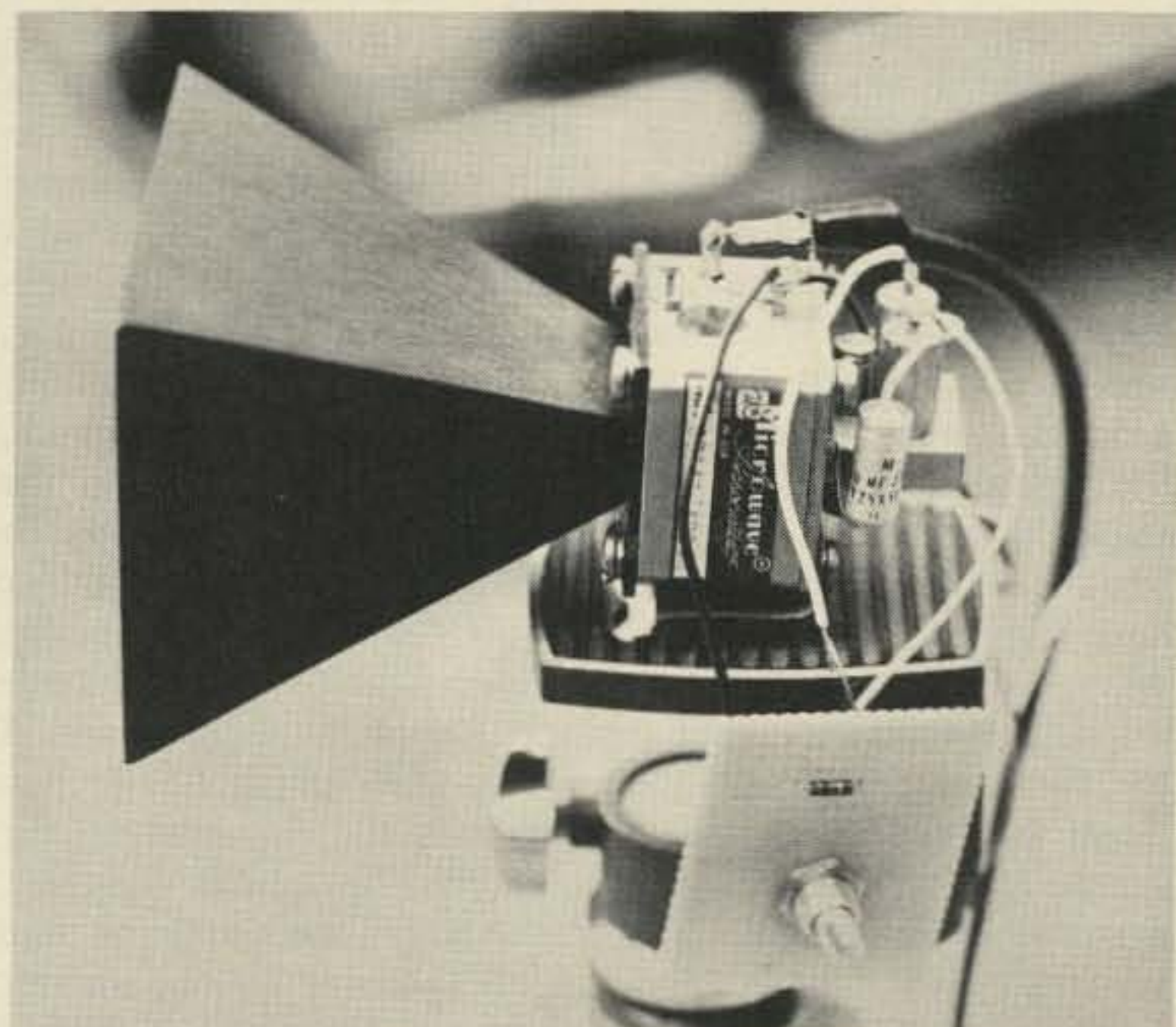


Fig. 4. Side view of the Gunnplexer. The 17 dB horn is clearly visible, as well as the tuning control, cavity, and mounting bracket.

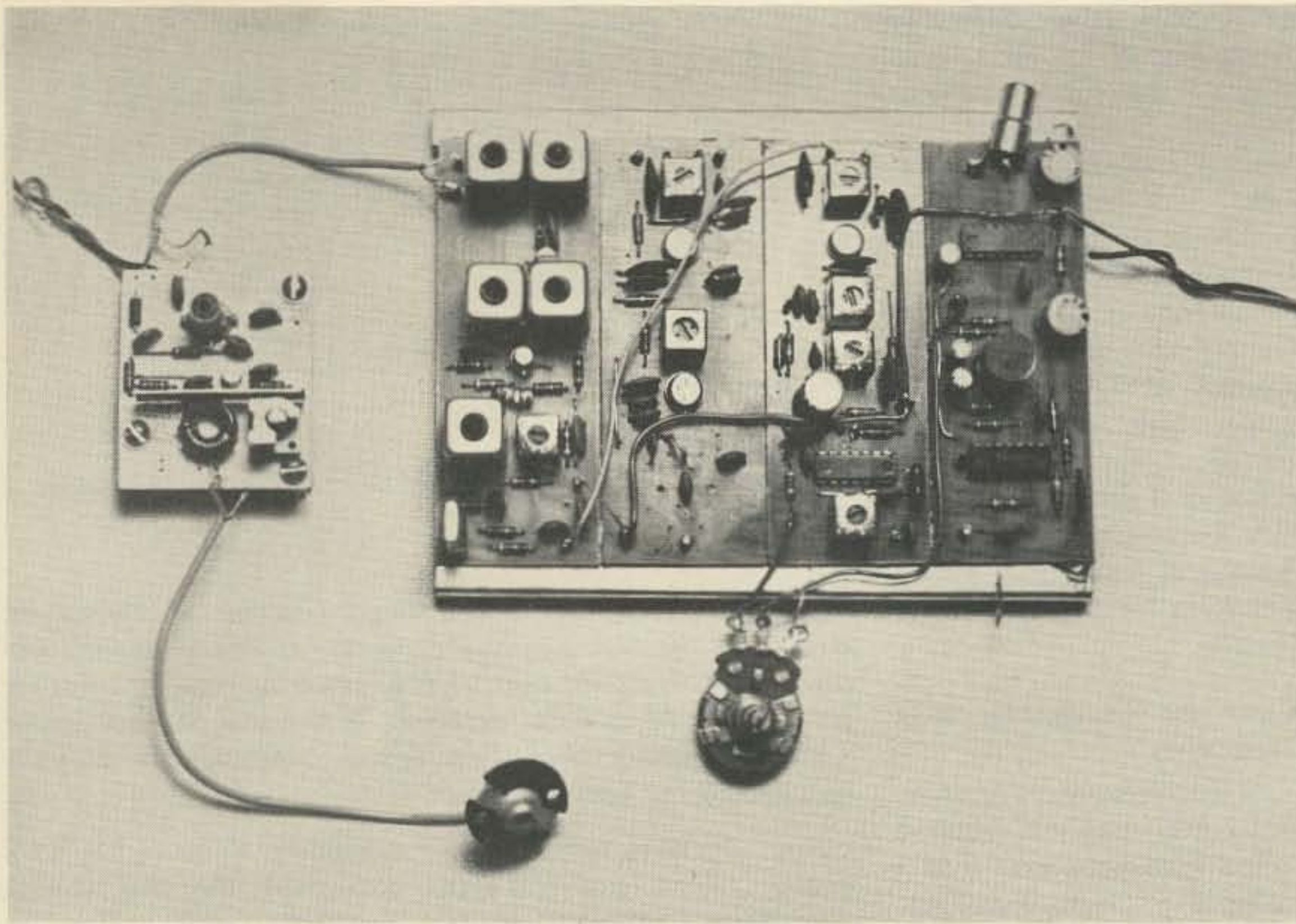


Fig. 5. The i-f receiver and preamplifier. The wideband VHF Engineering receiver consists of the rf module (second from left), two 100 kHz 10.7 MHz i-f amplifiers, and an audio amplifier. The pot is the volume control. No squelch is used on my system. A converted OSCAR 30 MHz preamp is also illustrated. The rewound toroid matches the 200 Ohm Gunnplexer mixer diode.

However, as mentioned earlier, afc is required on a narrowband system. Afc can be produced by comparing the i-f to a standard, and using the error voltage to tune the varactor. Additional details are provided in the Microwave Associates bulletin, number 7624A.

A wide i-f passband decreases effective range. However, the drift problem is eliminated. Range with an i-f passband of 100 kHz is about 50 miles. As indicated earlier, a commercial FM broadcast receiver can be used in experimental systems. The bandwidth of commercial FM broadcasting is 150 kHz; thus the commercial receiver is a viable i-f system. If used, the broadcast receiver should have a good front end. Provision should be made to match the receiver's input to the Gunnplexer mixer diode.

My goal was to construct a simple i-f receiver that would perform in an experimental system. I also wanted to use available parts around the shack. Let's see ... an FM receiver, battery operated, simple? My first thought was

an unused VHF Engineering receiver once used for 2m experiments. The only real problems were that the i-f was 10.7 MHz, and narrowband at that! I needed a 30 MHz i-f with a bandpass of 100 kHz. The first problem was solved by building a converter from International Crystal modules. This scheme used an International OF-1 oscillator with an inexpensive OX crystal oscillator, and an MXX-1 mixer module. The EX crystal provides injection at 19.3 MHz, thus matching a 10.7 i-f when 30 MHz is present. The only item purchased was the EX crystal.

If you try this technique, increase the link coil on the MXX-1 several turns to match the Gunnplexer. The mixer must be mounted as close as possible to the mixer diode on top of the Gunnplexer. A short run of RG-174 coax couples the converter to the VHF Engineering receiver. The mixer and oscillator were powered by a 9 volt transistor battery. This system worked fairly well. However, the mixer is noisy, and is not sensitive enough to comple-

ment the Gunnplexer.

I decided to use a better converter in my system. VHF Engineering makes a 30 MHz receiver strip, called the RF-50. This receiver has an FET preamp, and can be tuned over a range of 30-50 MHz. Remember to wind the coils for the 30 MHz option! This rf module is then used with the VHF receiver, consisting of the IF-10.7, IF-455, and AS-1 audio module. If you order these strips from VHF Engineering, specify the "wideband" option. The wideband kit consists of 10.7 MHz transformers that replace the 455 kHz units normally used. The wideband option converts the double-conversion receiver to a wideband (100 kHz) single-conversion job, suitable for Gunnplexer use.

It is best to wideband your modules immediately. I had to convert mine, which was a messy, time-consuming job. All the old 455 i-f transformers had to be removed from the PC board — ugh! Fig. 5 details the completed i-f receiver, mounted on standard VHF Engineering

rails.

Preamplifier Option

An additional problem exists when using the VHF receiver. The input impedance of the RF-50 is 50 Ohms, and the Gunnplexer diode impedance is 200 Ohms. A simple balun could be used to effect a match, or the input coil on the receiver could be rewound. In the interest of performance, I chose another tack. I just happened to have a small, low noise OSCAR 10 meter preamp available. This preamp has a broadband toroid as an input circuit. It was a simple matter to rewind the toroid to produce a 200 Ohm input impedance. This preamp is visible in Fig. 5. A preamp is *not* necessary. I used one because it was available. I think the best method of matching the mixer in a simple system is to modify the input coil on the RF-50. The system will work if a 200-50 Ohm mismatch is present — you won't even notice it in close range tests!

Putting It All Together

Since my system is experimental at this point, I did not mount all the components in a single enclosure. I coupled the mixer to the OSCAR preamp (Mode X?), and ran a piece of RG-58 from the preamp to the RF-50. A nine volt battery powers the preamp, while a 12 volt nicad is used for the VHF receiver. The Gunn oscillator requires regulated power at 10 volts. I derived this voltage by using a National LM317 three terminal regulator (Fig. 6). This regulator requires an input voltage at least 2 volts higher than the regulated output. I built a battery producing about 16 volts from old AA nicad cells. Remember that the Gunn diode draws considerable current, and carbon cells probably won't last during experiments. Fig. 2 is a block diagram of the system. The voltage divider is constructed from a 10k pot and two 10k

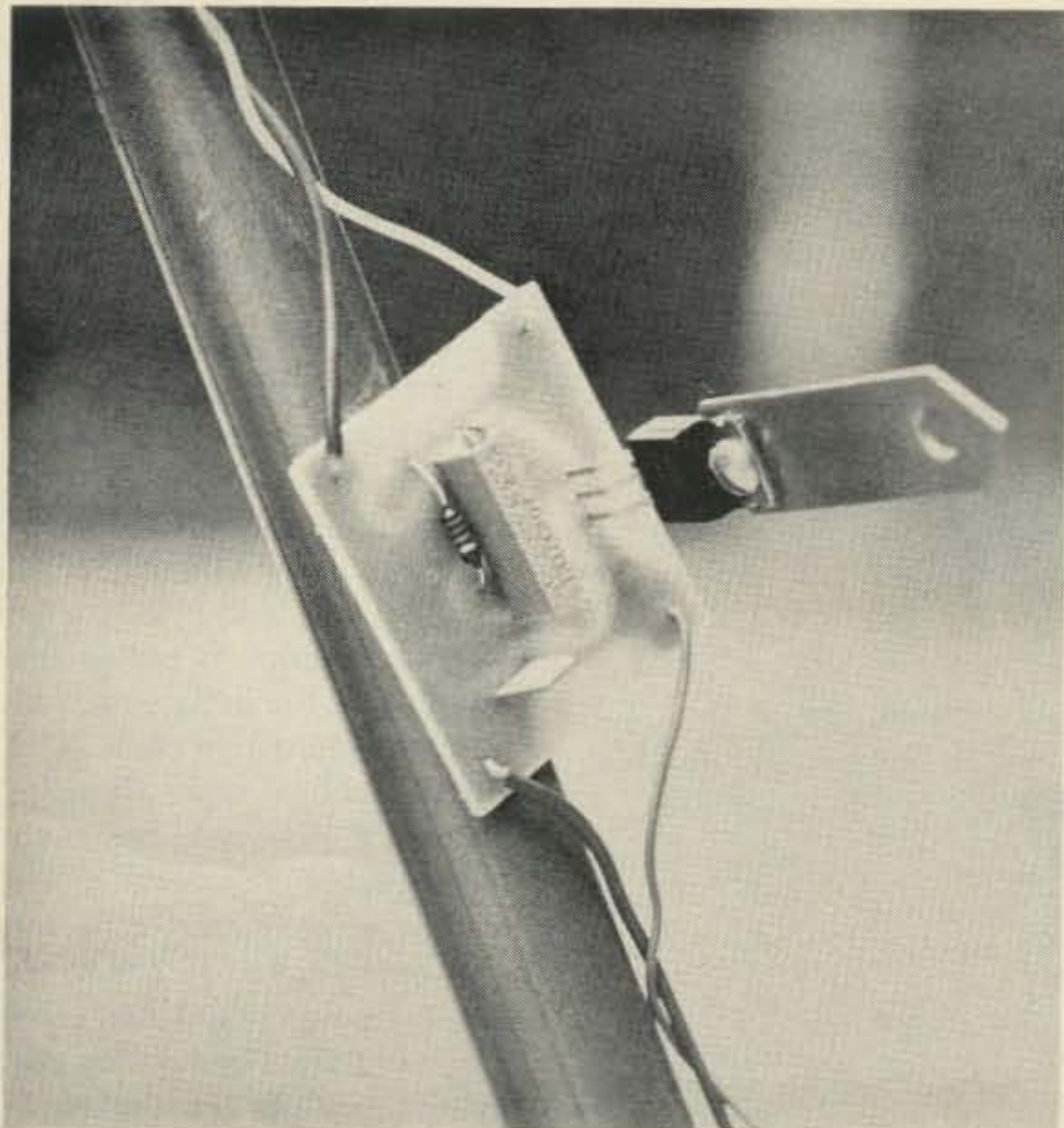


Fig. 6. The Gunn oscillator voltage regulator. A National LM-317 variable regulator, set for 10 volts, is used. The PC board and resistor are part of an evaluation device from National Semiconductor. The regulator is mounted on a leg of the tripod in my experimental system.

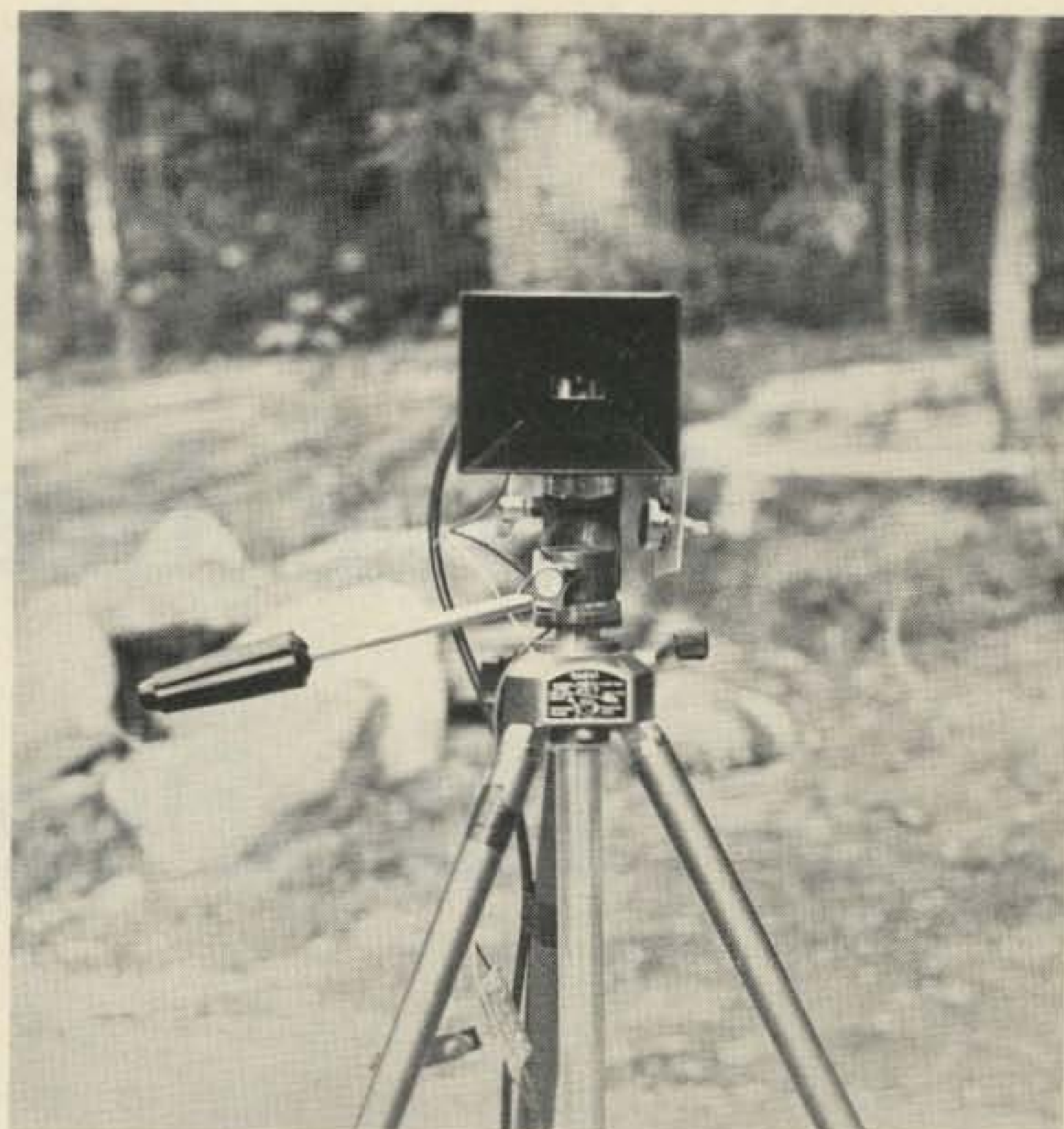


Fig. 7. Not a Martian, but a Gunnplexer transceiver rf head. The i-f amplifier and power supply is at the base of the tripod. Two transceivers should be separated by 25-50 feet for initial test. Ultimate range is 50 miles with this system.

resistors in series with a 9 volt battery. The varactor bias is developed at the slider. The negative side of both the Gunn supply and bias supply should be connected to the body of the Gunnplexer. I mounted the Gunnplexers to standard photo tripods by making a simple mount out of copper flashing. Drill two 1/4" holes in a 2" piece of flashing to line up with the bottom screws holding the Gunn baseplate to the Gunnplexer body. Bend the flashing around the bottom of the Gunnplexer, and sweat-solder a 1/4" nut to the flashing. The nut will mate with the bolt built into most tripods.

Tuning Up

My system consists of two Gunn transceivers. When initially checking your system, position the two transceivers about 50 feet apart, facing each other. Adjust the bias supply so that about 4.5 volts is present at the varactor diode on each transceiver. Apply Gunn voltage. If a 0-500 mA meter is available, check current

draw. The Gunn diodes should draw about 225 mA at 10 volts. This is not standard; different diodes draw slightly different currents. Adjust the varactor voltage divider on one transceiver. Tune very carefully until the receiver quiets — there, you're on 10.25 GHz! This system is full duplex — you will hear yourself in your receiver when talking. Occasional tweaking of the bias will be required to keep the transceivers locked ... however, once they are temperature stabilized, remarkable stability will be noted with a 100 kHz i-f.

At this point, you will probably begin experimenting with the transceivers. Try reflecting the signal around a 90 degree corner with aluminum foil. I won't even attempt to suggest experiments and applications — if you've followed me this far and built a system, you don't need my prodding! However, I will be continuing this series with practical experiments and applications involving radar. Don't keep us in the

dark, however. I would appreciate hearing from anyone experimenting with Gunnplexers and will welcome articles featuring the device. Write me, in care of 73.

A Word of Caution

If you have been following my editorial in 73, what follows will be repetitive. Microwaves are potentially dangerous. Do not needlessly expose yourself to the microwaves generated by the Gunnplexers. Although the level is very low, why take a chance? Opinion concerning microwaves varies, but one fact is certain: Microwave radiation can damage the tissues of the eye. The effects are cumulative, so treat the Gunnplexer with the same respect afforded a high voltage plate supply. *Never* look into the horn of an operating microwave transmitter. Avoid looking at the mixer diode in a Gunnplexer while it is operating; if you see it you're being exposed. I personally do not stand in front of a Gunnplexer at distances under 25 feet. When operating indoors, I use a cheap

police radar detector to monitor the Gunnplexer — it's too easy to leave the Gunn supply connected ... no noise is generated by a Gunn diode! Happy experimenting!

Interesting effects are liable to occur if you operate your Gunn transceiver mobile in a police radar zone. Their radar is broadband by nature, and will respond to your legal microwave transmission, exactly as my detector responds to "out of band" signals from the Gunnplexer. Have a copy of your amateur ticket available — I would hate to learn that your transceiver was impounded. New-fangled devices, what's the world coming to?

I would like to thank Dana Atchley, Jr. of Microwave Associates and Bob Brown of VHF Engineering for their advice and suggestions. ■

References

Gunnplexers are available from: Microwave Associates, Inc., Burlington MA 01803. VHF Engineering products from: VHF Engineering Corp., 320 Water St., Binghamton NY 13901.