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ABOVE AND BEYOND

VHF and Above Operation

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10 GHz Gunn Oscillator Cavity

With more time in these winter evenings to build projects, I thought I would detail a 10 GHz construction project that can be quite useful. It sports a varactor controlled Gunn diode oscillator cavity. I have built several of these units from information provided by Chuck Swedbloom WA6EXV, who worked out the details presented here.

This cavity oscillator is intended for wideband FM. This is compatible to the Solfan burglar alarm units with the exception that the Gunn diode is operated from fixed voltage. The varactor in the cavity is a variable voltage capacitance diode (varicap), and shifts the frequency as the voltage to it is varied from 0 to 10 volts. Construction cost is minimal for the Gunn diode and waveguide parts. The varactor is, however, somewhat expensive if you can't find it surplus.

Construction with Solfan Devices

This cavity can be constructed with a drill press and ordinary hand tools. See Figure 2 for a list of tools (taps and dies needed). One of the items, a 3/48 tap, is not common, but is available in better machine shops. This tap size is standard for a lot of microwave devices, including the varactor and Gunn diodes I used.

Possibly a brief history of 10 GHz units might be in order. Normally, for low cost operation 10 GHz Gunn transceivers were constructed using a Solfan or similar type burglar alarm, or a door opener microwave device. Cost was about $5 to $20 each, with availability in most larger cities. The primary difficulty with the simple Gunn transmitter using one of the Solfan devices was the method of frequency adjustment. You had to vary the voltage of the Gunn oscillator in order to make small changes in frequency.

This Gunn voltage varied from about 7.5 to 9.5 volts, and resulted in a change in frequency of about 5 to 10 MHz or so at 10 GHz. The only other frequency adjustment was mechanical and touchy to adjust in the field. By substituting the varactor controlled cavity for a Solfan device the Gunn oscillator is run at a fixed 10 volts. This improves basic stability and makes fixed mechanical adjustment something to be set in the home station. Modulation and variable voltage is now fed to the varactor instead of to the Gunn device as in Solfan units.

Varactor Diode

Selection of a suitable varactor from surplus is touch and go. You have to try them out and see what happens. Most varactors will work, but the frequency spread per voltage tuning range will differ. If you can locate a varactor that will give you a 50 to 60 MHz tuning range, it will make wideband FM (WBFM) operation a lot smoother.

For example, you can set up two WBFM 10 GHz transceivers for full duplex operation with each other. One station must be 30 MHz different in frequency on transmit from the received station's own transmitter. Frequencies commonly used are 10.220 GHz, 10.250 GHz, and 10.280 GHz. This assumes a 30 MHz IF system in common use. Operation on other IF frequencies are just as possible; 10.7 MHz and 88 MHz have been used.

By having varactor control, you can vary a DC voltage that adjusts the cavity quite accurately, and you do not need to spend lots of time re-calibrating. Instead, you re-set the varactor voltage to a calibrated frequency/voltage reference. In contrast, much time was needed to calibrate the frequency in the single Solfan units, due to the narrow adjust frequency of the Gunn diode. This made mechanical adjustments in the field necessary. Another benefit of the varactor controlled unit is that the Gunn diode is optimized for maximum, as it is now running on a fixed voltage supply.

Varactor control gives a swift method of frequency adjustment in the field. When used in conjunction with a beacon, frequency errors can be almost eliminated on field operations. To calibrate your frequency using a beacon, aim your system at the beacon, and if it does not agree with your previous chart, make a small mechanical adjustment. Thereafter refer to your frequency/voltage chart for operations. In this way the varactor system and beacon confirmation go hand and glove with each other, setting a frequency standard for the area of interest. Many stations that can copy the beacon can use it to set the frequency without expensive test equipment.

Cavity Construction

Construction of the cavity is straightforward. The unit is built on a piece of bar stock that acts as a base and heat sink (see Figure 1). The cavity itself and varactor diodes are mounted in small holders in the bottom of the unit. Electrical connection to the diodes is provided through bias chokes. Frequency operation is determined by two main factors: the physical dimensions of the cavity and the capacitance of the varactor diode. The 6/32 COARSE TUNE screw moves in and out of the cavity, changing the physical dimensions and center frequency.

The voltage on the varactor diode varies its capacitance, giving a frequency spread of upwards of 60 MHz (depending on the diode used). Construction of the cavity is not difficult if the work is taken in steps to ensure proper fitting prior to final assembly and soldering. Care must be taken not to allow any solder to flow into the cavity during assembly. Solder acts as an attenuator and must be removed. Either soft or silver solder may be used, but you'll find soft solder easier to work with if you need to correct a part mounted in error. None of the cavity components are difficult to obtain, and can be found in a well-stocked hardware store.

The quantity and size of the brass needed for this project are such that the possibility of making them out of scrap stock is good. Once the necessary parts and tools are collected, construction can begin. The heat sink is made larger than the waveguide to provide extra capacity for a high power Gunn diode. Use a piece of brass 1" x 1/4" x 2" long. A piece of brass 1/8" to 3/16" serves as the waveguide flange, which will allow mounting to a feed horn.

The very small RF bias chokes can be turned on a lathe (Figure 2) or assembled from pieces of stock as shown in Figure 3, which were constructed on a drill press. Using a hacksaw, I cut

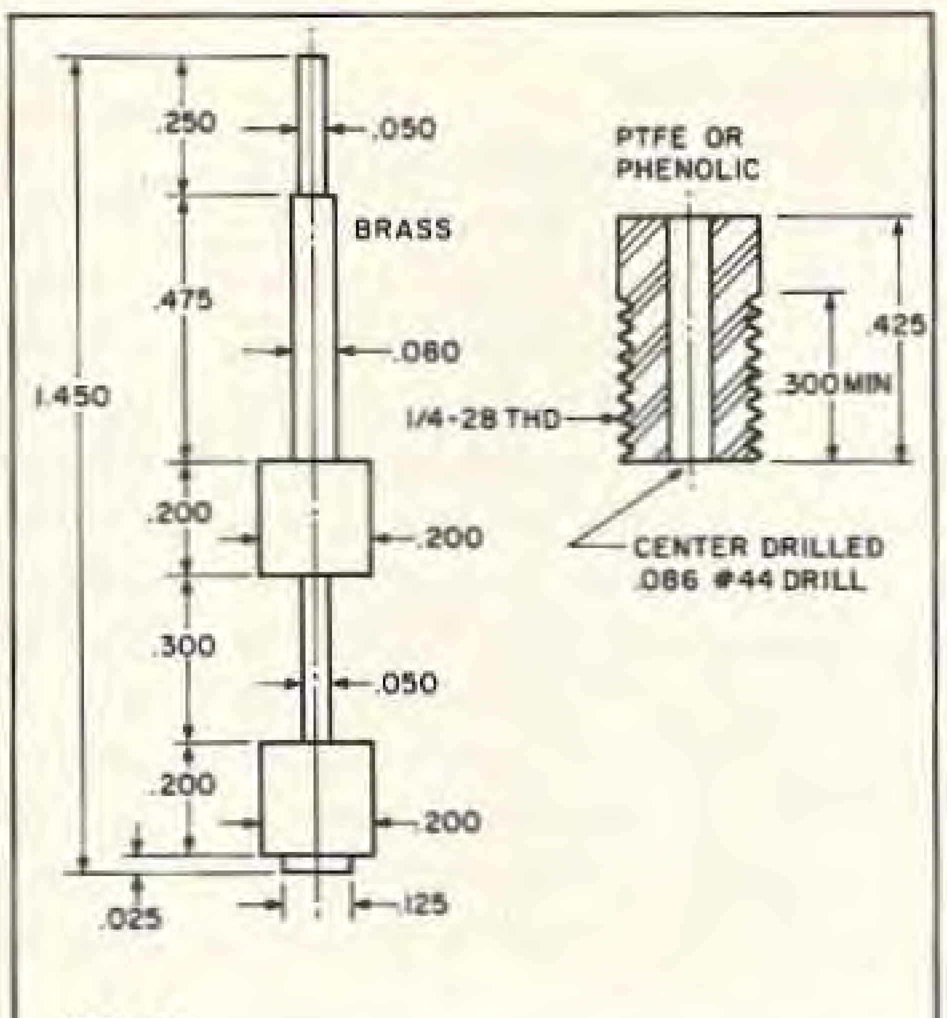

TABLE I.

TAPS	DIE	DRILLS
3-48 6-32 10-32 1/4-28	1/4-28	#3 REMAINDER STANDARD DRILL SET

Figure 2. Construction details of the RF bias choke and choke retainer.

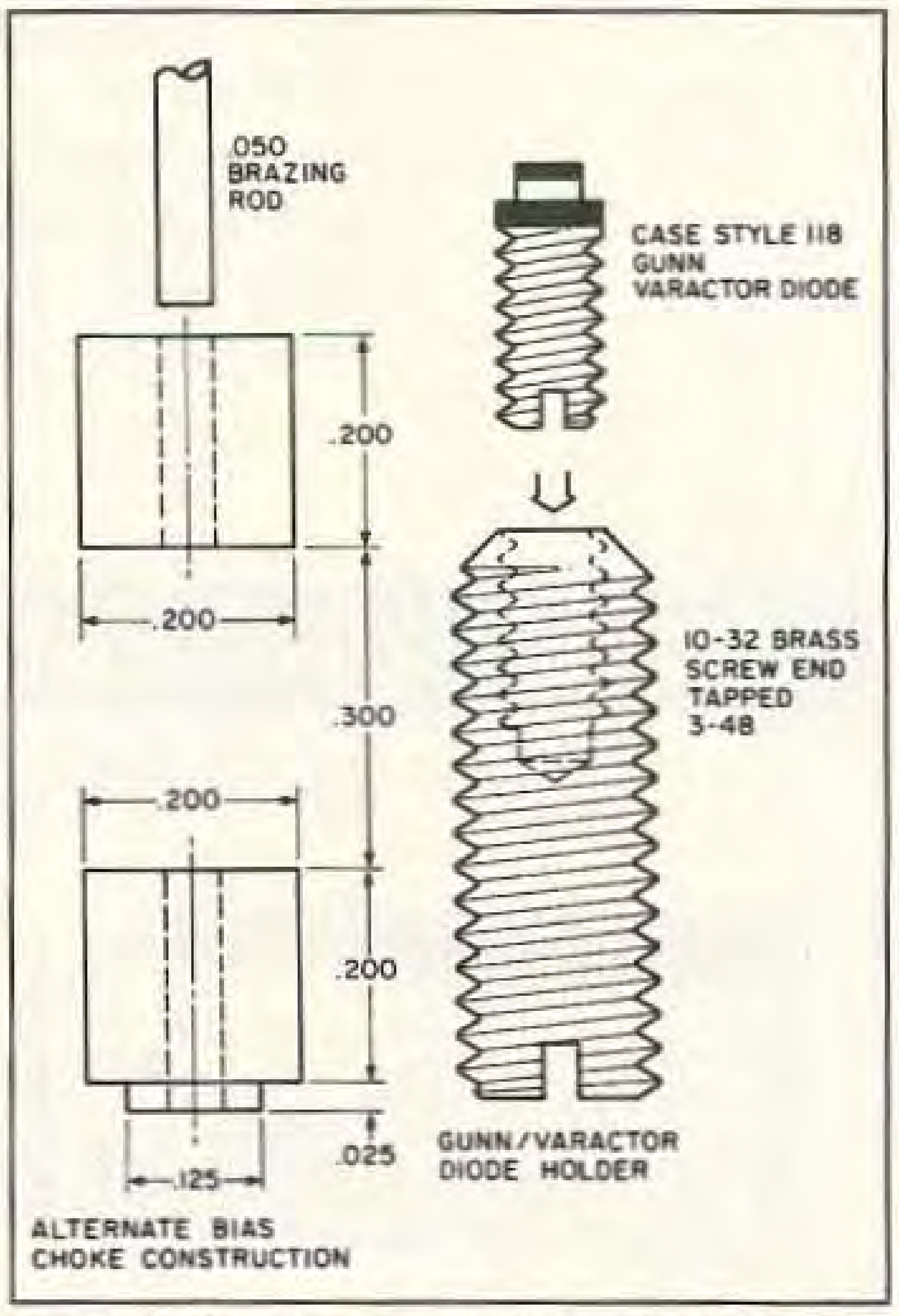

Figure 3. Alternate construction method of the bias choke. Drill out the center of some 0.200" stock to fit 0.050" brazing rod and solder as shown. A diode holder can be built as shown.

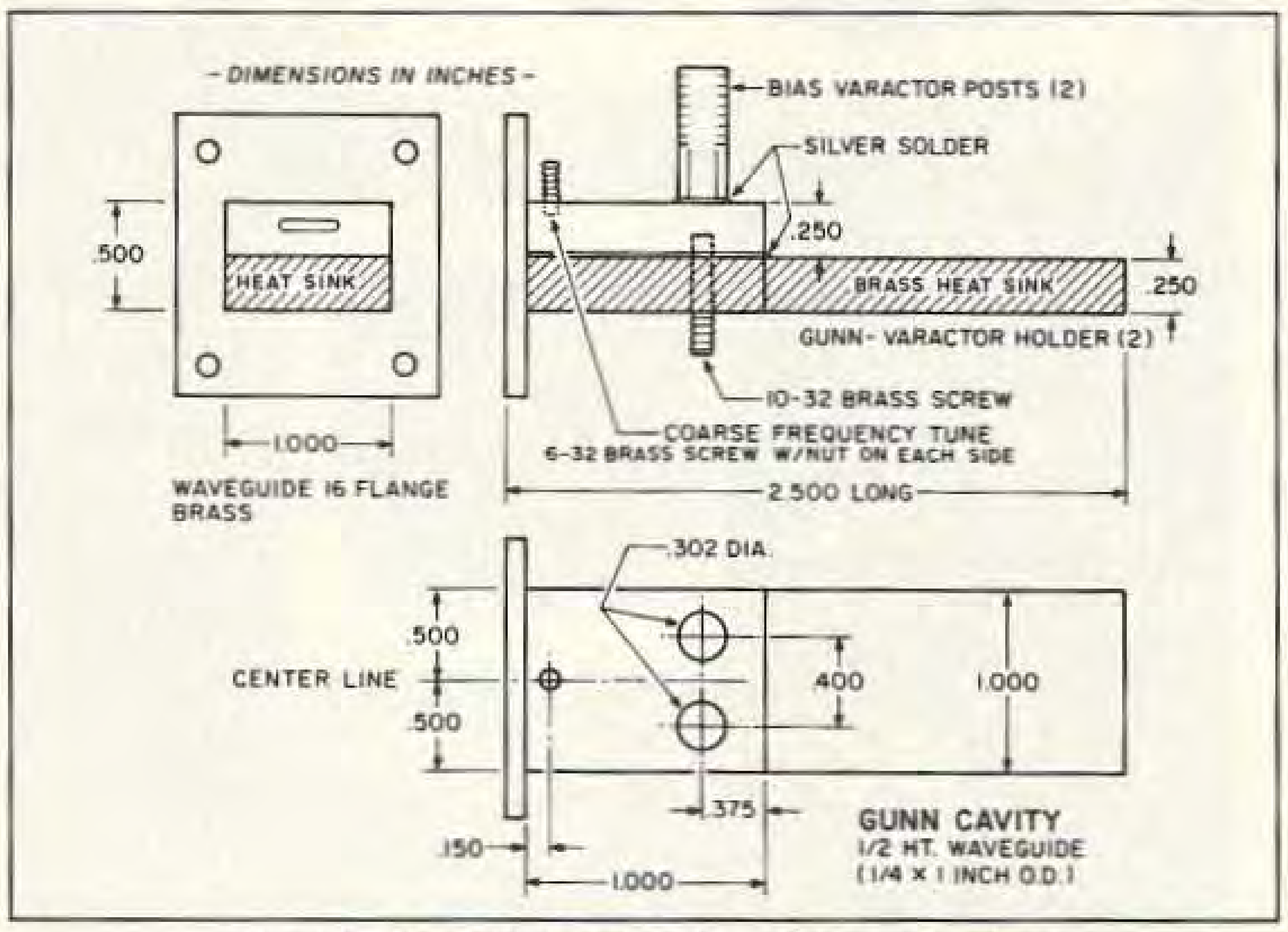

Figure 1. The 10 GHz cavity; front, side and top views.

short pieces of 0.200 brass rod, and drilled these through the center with a 0.050 bit. Inserting a brass brazing rod through each hole completed the chokes. The bottom of the choke should be turned down to 0.125", and points in mind. First, don't use a center punch. This can deform the soft brass of the cavity. Mark the holes with a scribe and start all holes with a very small drill bit. Move up to larger bits as needed. This prevents the larger bits

Photo A. Paul N1BWT and Matt KB1VC operate from Jay Peak, Vermont during the 10 GHz contest.

should be smooth where the chokes meet the diodes. The RF chokes were then soldered, which proved just as satisfactory as the lathe-produced chokes.

The hardest item to obtain is the "half-height waveguide" (Figure 4). If you can't find one, you can make it out of a short piece of standard waveguide. Use a hacksaw very carefully, making clean cuts. Any piece of brass waveguide can be cut open to retrieve the 1" piece needed. The half-height section of waveguide is then soldered directly to the top of the heat sink, taking care to keep solder out of the cavity. Once soldered to the heat sink, there is no difference between it and an actual piece of half-height waveguide.

Bob W6RHV came up with this method, and we've used it very successfully. Now that the cavity and heat sink are assembled into one solid assembly, the holes can be drilled to allow total alignment between between the Gunn/varactor screw holders and the upper RF choke bias posts. Proper alignment is important here. Keep two

from wandering, which would change alignment.

Once the small pilot holes are drilled, the next holes to be drilled are the bias posts. These holes should be drilled through the top of the cavity and down through the heat sink in one motion, ensuring proper alignment. The drill used should be the proper size for the 10/32 tap. The heat sink is then tapped to accommodate the 10/32 diode holders. Now drill out the holes in the cavity top to 0.302" to accept the bottom recess of the bias posts.

Finally drill the hole for the tuning screw and tap for 6/32. A 6/32 nut is soldered over the hole to provide additional threads for the tuning screw to bite into, for a tight fit. The bias posts are made from the 3/8" solid brass rod cut to about an inch. They are drilled through the center with a #3 drill. Again, start with a smaller bit and work up to #3 bit. Drill completely through the rod, and finish its length to 0.950". The top portion of the bias posts are threaded with a 1/4-28 tap, to a depth of 0.400". This thread will accept the bias choke retainer, which is made from 1/4" insulated rod and threaded with the same 1/4-28 thread.

The bottom of the bias post must be reduced to allow it to fit into the 0.302" hole in the cavity. This is done by placing the post in the chuck of a drill press, and using the drill press as a vertical lathe. Using a small file, turn the edge down from 0.375" to 0.302", so that they fit tightly into the top of the cavity. The tight fit holds the posts in place while soldering, maintaining proper alignment. Both bias posts are prepared in the same manner.

Take the finished bias chokes and insulate them with a single turn of mylar or Scotch™ tape. Insert them into the bias posts to check the fit. They should fit through the posts with little friction. Once all the necessary fitting has been checked and rechecked, solder the posts to the cavity. At this point, the waveguide flange can be soldered to the assembly. The output slot, or iris, can now be drilled. This is easily accomplished by scribing a line and drilling a series of 1/16" holes along it.

The material between the holes is filed out to form a perfect slot. (In actual operation, I've found that more power can be coupled out of the cavity by enlarging the slot slightly in the center.) This is a custom adjustment peculiar to each device. Don't enlarge this hole too quickly; work in small increments. If it's too large, it will over-couple, and a new front plate will need to be constructed.

Check the alignment of the center of the bias posts and the 10/32 diode holder screws. Ensure that they are in perfect alignment. Insert the bias chokes, with the insulating tape, and position with the choke retainer just entering the cavity top by about 0.050". The Gunn and varactor diodes are inserted in the holders one at a time, to check for proper contact with the diodes and chokes. I suggest using a "DUD" until all fit OK, lest you damage a good device. Check for shorts. When all is well, seal off the end of the cavity with a section of brass stock.

Testing the Cavity

To test the cavity, use a closed environment. Connect the cavity to a waveguide attenuator with either a dummy load (waveguide type) or a directional coupler, to allow sampling of output power. (Always prevent stray radiation from escaping from the unit. Never look into the open end of a radiating waveguide. The eyes are susceptible to microwave damage—SAFETY FIRST—!!)

Frequency is set by varying the position of the coarse tune screw, and varying the voltage on the varactor diode. This will set your varactor tuning range, first mechanically then electrically. If you use surplus varactors, the amount of tuning excursions will vary with the type of varactor used. You will have to experiment to find the device best suited to your cavity.

The varactor diode I used was obtained surplus, and had a capacitance of 0.35 pF. Several types performed well. These were all similar to Microwave Associates part number MA-45225, and parts #46602 thru 46604. These devices are rated at approx. 30 volt breakdown 0.5 pF, 10 to 12 GHz operation. All parts are available in many case styles, with case 30 (drop-in package) and case style #118 (3/48 thread) mount. See Figure 3, case #118 style.

I can supply Gunn devices for this project. Fifty mW Gunn diodes are $5 each, and 100 mW devices, $10 each, postpaid U.S. destinations. I am running out of the 100 mW devices, as they are harder to gleen from existing stocks that the 50 mW types. If I come up with some suitable varactors, I will let you know.

New Products

Waveguide 16 (1" x 1/2" O.D. brass) has, as you know, been difficult to obtain in small quantities for amateur use. However, Ed Emich of Emcom Industries is willing to make small quantity purchases of both waveguide 16 and waveguide flanges. Flanges cost $4 each, and the brass waveguide is priced at $4 a foot plus shipping. This should rescue quite a few microwave construction projects waiting for materials. Contact Ed at Emcom Industries, 10 Howard Street, Buffalo NY 14206. Tel. (716) 852-3711.

As always, I will be glad to answer questions relating to our VHF/UHF microwave frequency bands. Please enclose an SASE for a prompt reply.

73's, Chuck WB6IGP.

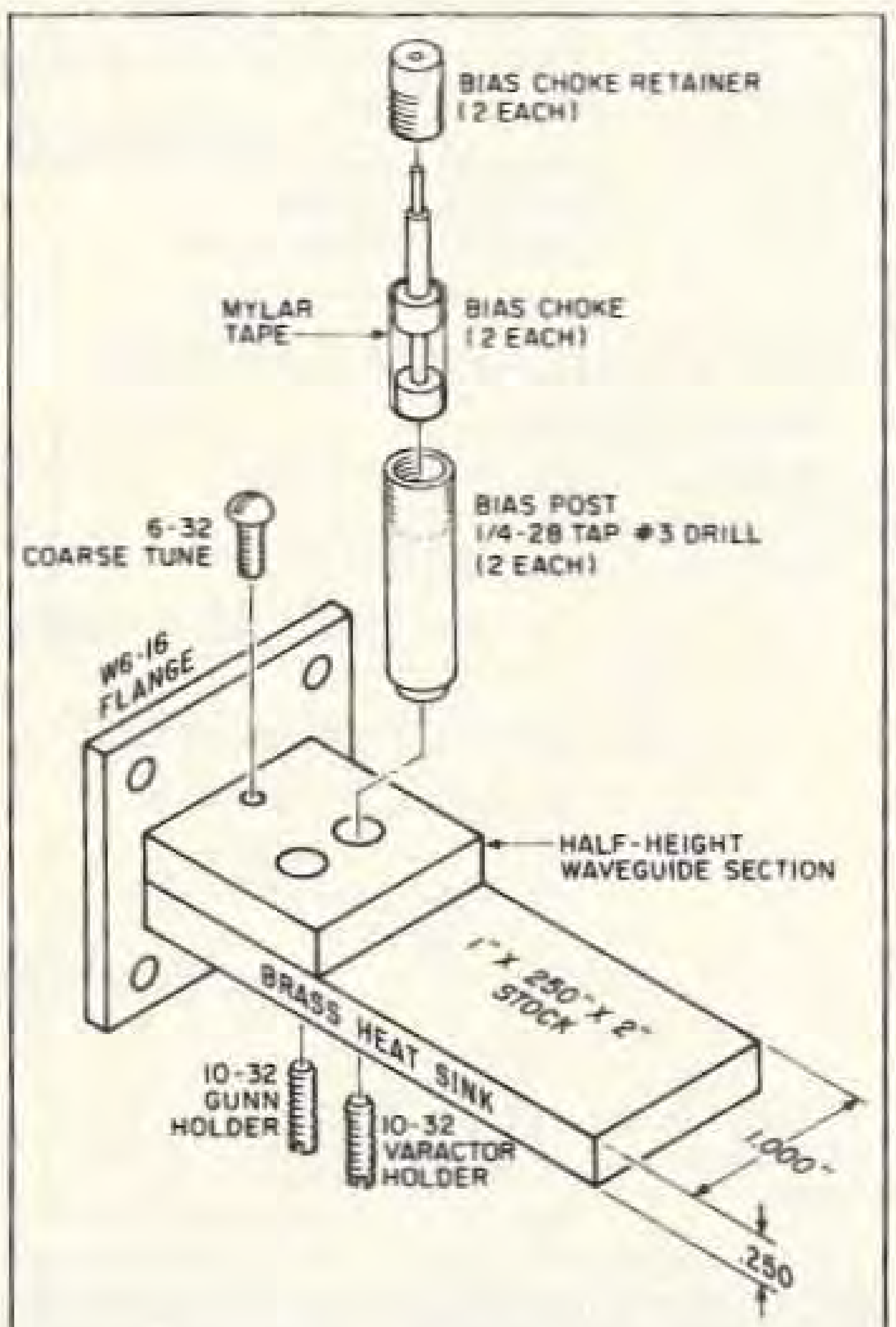

Figure 4. The complete 10 GHz varactor controlled Gunn oscillator cavity.