

Microwaves for the radio amateur — 5

Continuing his short series of articles written to stimulate more activity by radio amateurs on the microwave bands, the author this month begins the description of a complete and practical 10,000MHz station.

by DES CLIFT, VK2AHC*

The September, 1971 issue of "Electronics Australia" gave some details of the prototype solid state equipment in use at the author's station, then VK5CU. The microwave side follows the lines of Fig 2(c) in the May article, and is a single parabola, circulator coupled arrangement. The power supply as a DC/DC converter transformer with a single high voltage winding, and this dictated that the klystron heater supply be run direct from the 12V car battery. This in turn precluded the use of earthed cavity (waveguide output) type klystrons, and therefore a 2K25 was used.

The second set of equipment about to be described uses the two parabola microwave system of Fig 2(d), and has separate units for the power supply, other electronics, and the microwave side. The fact that two DC/DC converters are used is solely due to the fact that the writer happened to possess two small toroidal transformers ex mobile radio sets which were suitable for the job. A single transformer with suitable output windings would be better since it would save a pair of power transistors and give higher efficiency.

Fig 19 shows a photograph of the complete assembly, while Fig 20 gives a circuit diagram. The reason for separating the power supply was twofold. Some trouble was experienced in the prototype due to audio pick-up from the relatively large and fast edged square waves which occur in this type of DC/DC converter, and separating the power supply solved this problem while also serving to keep the weight of the main framework to a minimum. This was required in order to cater for the possibility of it being mounted on a car roof rack for transport.

The use of two similar DC/DC converters operating in parallel did not give rise to any low frequency beats appearing in the ripple voltages of the outputs, as had been anticipated. Both converters use linear core transformers (T1 and T2) with RC timing, and operate at about 1600 Hz. Note that the 5uF capacitor is a non polarised type, rated at 100V working. T1 and T2 both have windings giving about 200V and 20V RMS which are used, plus one 3.15V CT winding which is unused.

T1 provides, via a voltage doubling bridge rectifier using 750V or 1KV PIV diodes, a supply of 380V. The output is smoothed by a low resistance, high frequency choke L5 and

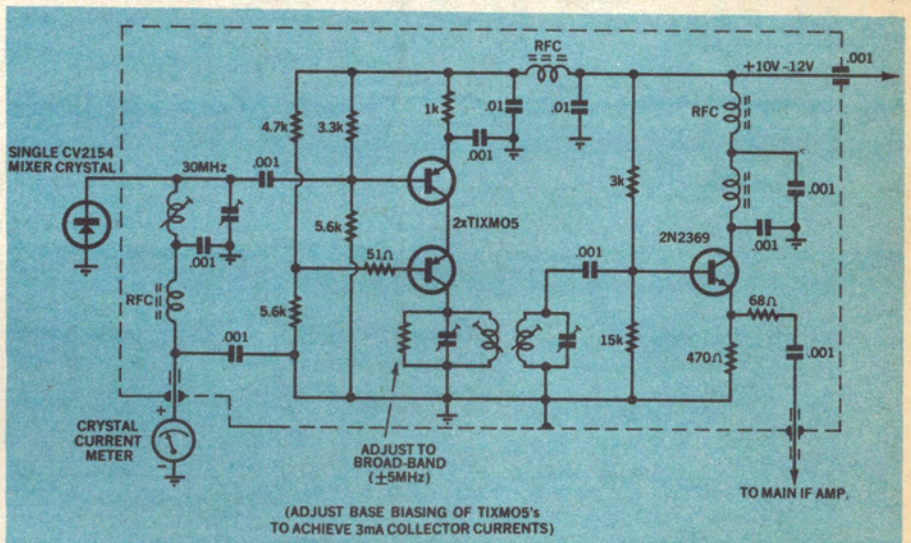
an 8uF / 600V paper capacitor before being fed, via a limiting resistor, to two high voltage zener diodes connected in series. This constitutes the cavity supply.

For CV 2282 / K308 / K311 and other klystrons designed to operate from a 300V to 350V cavity supply, this supply can be obtained from one IN3015 (200V) and one IN3011 (150V). For 2K25 / 723A / B / 726A and other klystrons designed to operate from a 250V to 300V cavity supply, it is suggested that 280V be used, from one IN3011 (150V) and one IN 2011 (130V). In either case, the current through the zener diodes, with the load disconnected, should be adjusted, by selection of R (series) to about 40 mA.

run at earth potential and therefore the positive of the 350V supply is earthed, the negative being connected to the positive of the 300V reflector supply, and also to the cathode/heater of the klystron. The negative of the 300V supply (thus at -650V with respect to the earth cavity), is fed out of the power supply unit to a potentiometer network in the control panel.

The low voltage winding on T2 is fed to a conventional bridge rectifier with smoothing provided by 470uF capacitors and approximately 10 ohm resistors. This is fed to a high power 6.2V zener diode 10Z6.2, which has its unloaded current adjusted to about 0.8A by adjustment of one or both of the 10 ohm resistors. Note that the whole of this bridge rectifier, smoothing, and Zener diode circuit is tied to the -350V rail (Cathode of klystron) and must therefore be well insulated from the earthed chassis.

The low voltage winding on T1 is fed to a voltage doubling bridge rectifier which provides supplies of about +22V and -22V



The cascode IF preamplifier used in the author's prototype 10,000MHz station. This may be used as an alternative to that shown overleaf.

The corresponding circuit connected to T2 supplies a second high voltage, which is used for the klystron reflector. This voltage is arranged to be approximately 300V by a further pair of series connected high voltage zener diodes. In this case RC smoothing is used and the no load current is adjusted to approximately 15mA by means of the series R. (This current is purposely made several times the load current to secure reflector voltage stability under conditions of low battery voltage).

In the klystron in use in this equipment, (as opposed to the prototype) the cavity is

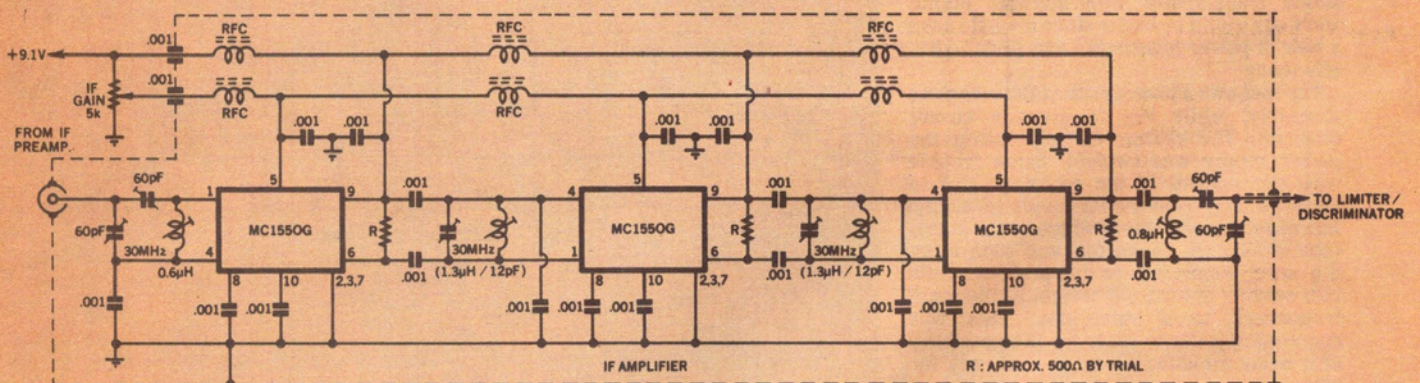
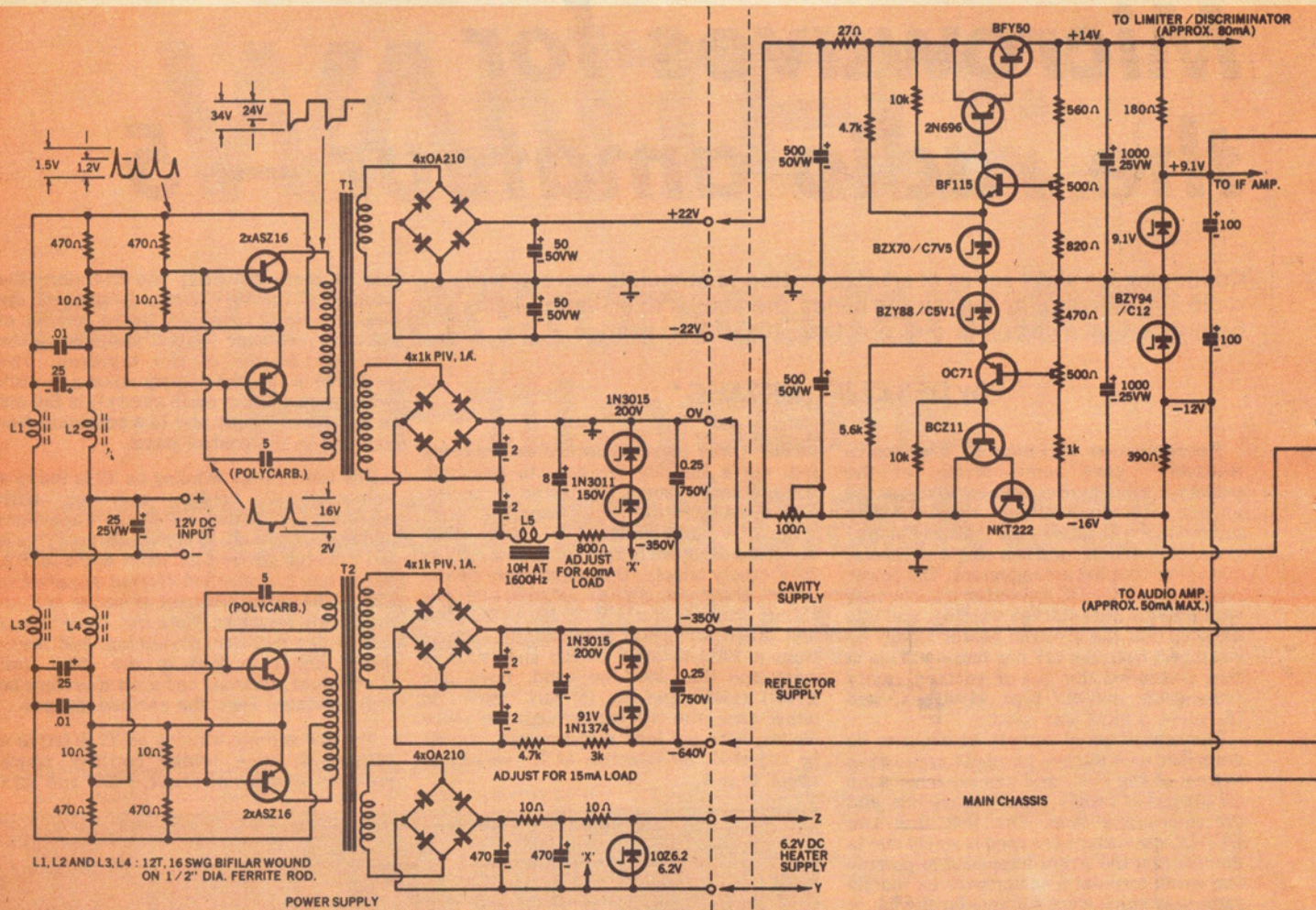
with respect to earth. After further smoothing and regulation these supplies are used for all the transistors in the equipment. Under 100mA is drawn from each supply.

Providing reasonable sized heatsinks are used for the four power transistors and the five zener diodes, the power supply will run quite cool.

The main electronic assembly serves several purposes, a very important one

The full circuit diagram of the 10,000MHz station being described by the author in these articles is shown overleaf.

* 12 Romford Rd, Frenchs Forest 2086



4xASZ16 MOUNTED ON 1/4" AL. HEATSINK

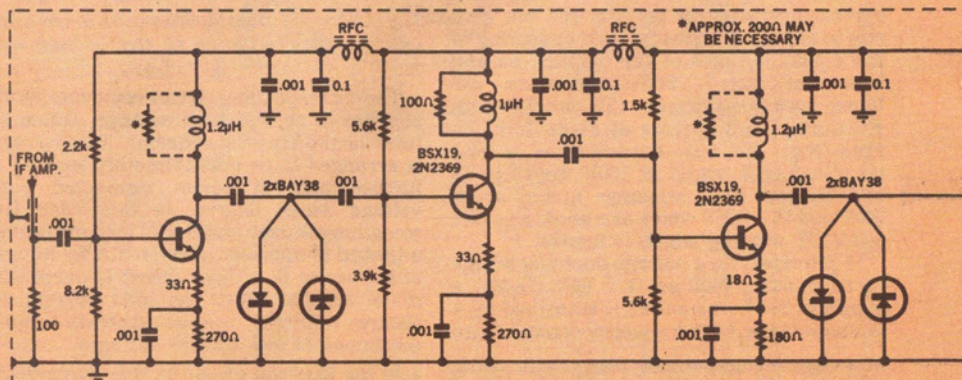
5x ZENER DIODES IN POWER SUPPLY MOUNTED ON 1/4" AL. HEATSINK

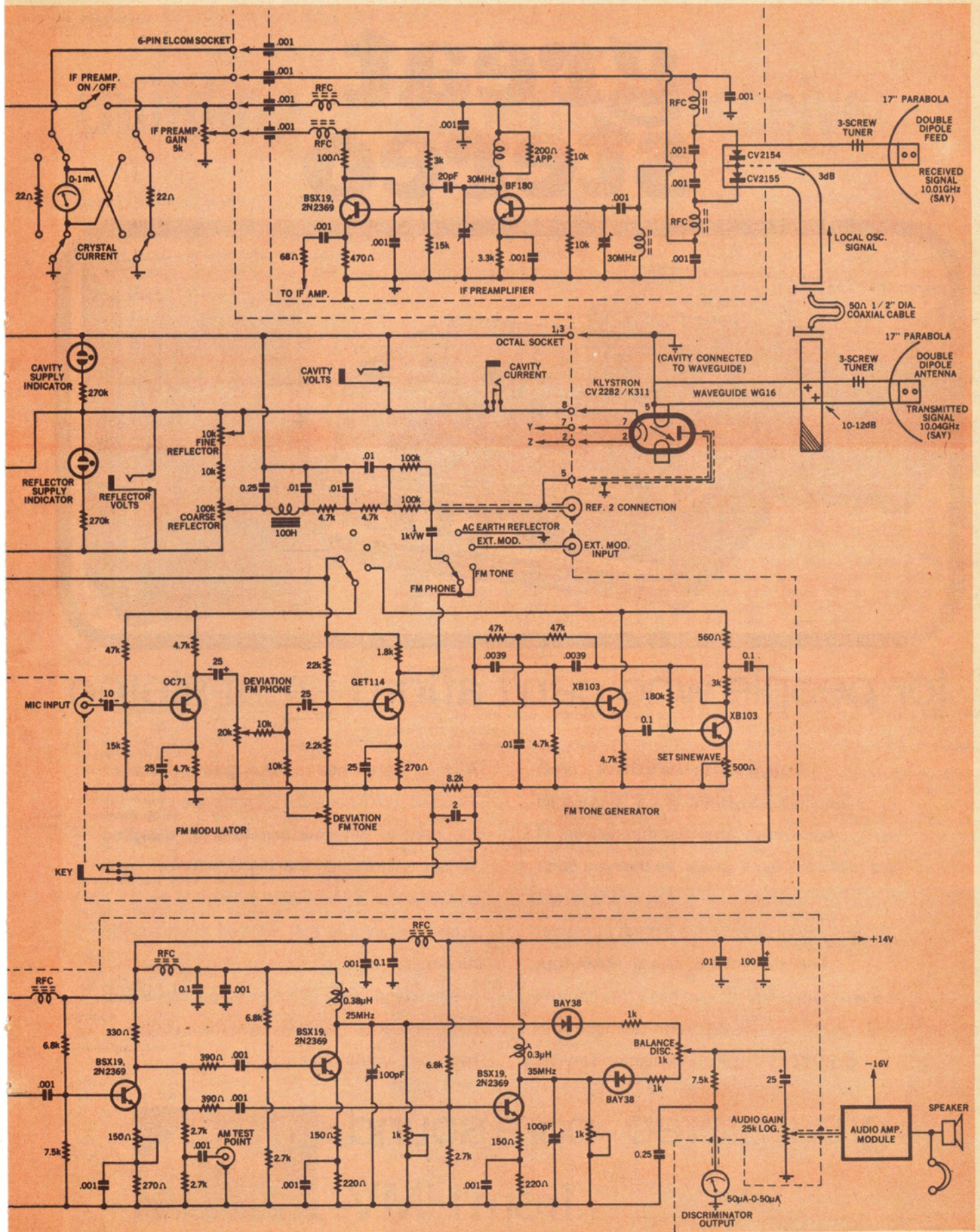
CAVITY SUPPLY ZENER DIODES SHOWN FOR OPERATION OF K311 OR CV2282 KLYSTRONS. USE 280V FOR 732A / B OR CV1792 KLYSTRONS

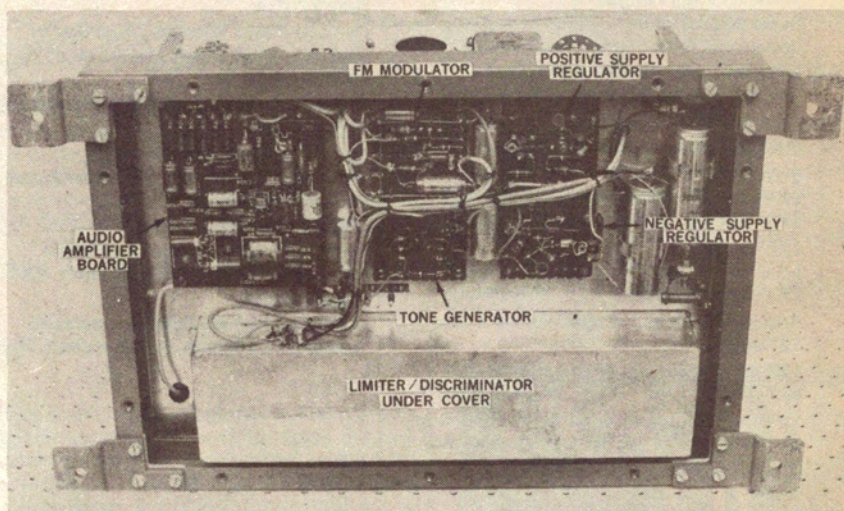
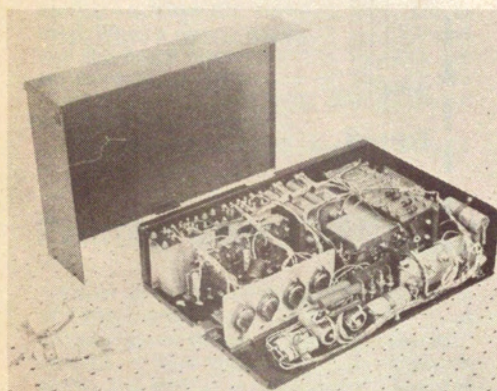
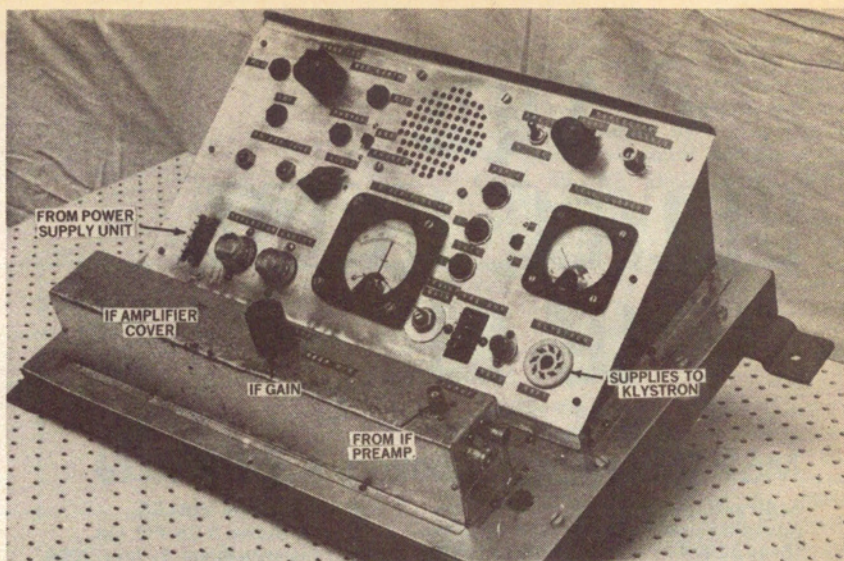
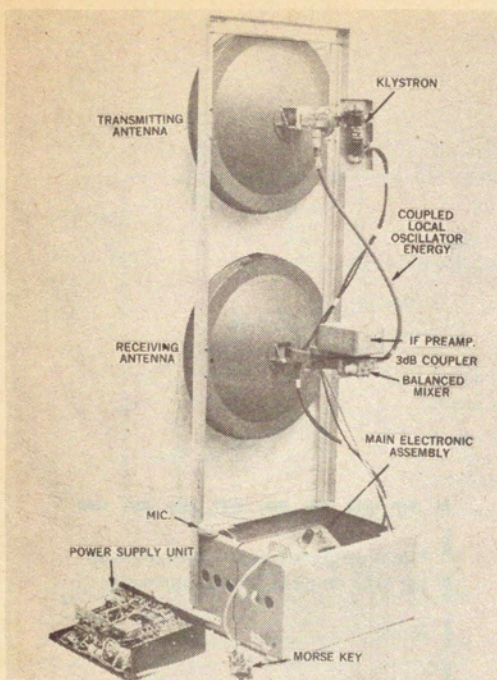
IF BF115s ARE USED IN LIMITER / DISCRIMINATOR ADJUST BIASING SO THAT EACH STAGE DRAWS 5mA. EARTH CANS OF BF115s BUT NOT BSX19 / 2N2369s.

RFC : 3T ON FX1115 BEAD

10GHz TRANSMITTER/RECEIVER







being that it provides a very rigid, but easily removable, support for the framework (made from angle aluminium) holding the two parabolic reflectors. This support is attached to the outer cover of what was a wall mounting electrical unit of unknown origin, obtained from disposals. The outer cover and its added framework are attached to a main base plate and support by four DZUS fasteners. A flat aluminium chassis covers the open centre of this base plate and now houses, on its underside, two stabiliser units for the low voltage supplies, the modulator and tone generator of the transmitter, and the audio amplifier module and the limiter discriminator unit of the receiver.

The upper face of this chassis houses the IF amplifier of the receiver, and an angled panel which houses all the controls, meter and connections of the system. These are accessible through a removable top plate, which completes the outer cover. The connections to the klystron and the mixer / IF preamplifier, which are mounted at the rear of the parabolic antennae, and to the power unit, are all made through this removable top plate. A surplus gun sighting telescope is mounted on the angle framework, and is used for initial alignment of the microwave link.

At top left is the complete station, set up for operation, and beneath it is a closeup of the power supply. Upper and lower views of the main electronic assembly are shown at right.

The electronic modules of the main assembly are as follows.

+14V Stabiliser. This is a very simple and conventional regulator which is fed with +22V from the power supply unit, and provides a pre-set voltage at +14V which is permanently connected to the limiter discriminator of the receiver. A second output of +9.1V is derived from a zener diode fed from the +14V. This +9.1V supply is used for the IF amplifier and preamp. For convenience during alignment an on/off switch is fitted in the supply to the IF preamp. Both the IF amplifier and the preamp have a potentiometer network across the +9.1V supply. These potentiometers provide manual gain controls. A small heat sink is fitted to the series transistor, a BFY50. The load current is approximately 100 mA.

-16V Stabiliser. This is virtually the same as the +14V stabiliser except that it uses PNP transistors. The stabiliser feeds a permanently connected audio amplifier for the receiver, and, via a zener diode connected to provide -12V, the switched FM 'phone and tone generators. A small heat-sink is fitted to the series transistor which in

this case is an NKT222. The load current of the -16V Stabiliser is between 50 mA and 75 mA depending on the audio output.

The only reason for using a -16V stabiliser was that the writer had a complete audio amplifier unit ex a dictating machine. As it was desired to use this, it was decided to operate the modulator from the same supply. If an alternative positive supply audio amplifier were contemplated, then the modulator should also use NPN transistors and run from the +14V Stabiliser. This would make the -16V Stabiliser redundant, and simplify the unit significantly.

The Control Panel. This acts as the distribution board and control panel for the system. Power from the supply is fed to the panel via a really reliable multi way plug (intermittent connections in the reflector leads of klystrons can cost you the valve!). The cavity and heater supplies are routed to a second plug and socket and thence to the klystron. As part of this routing process the cavity voltage and current are fed to insulated metering jacks, and the cavity voltage also is made to illuminate a reasonably large neon lamp. Screened wire

is used throughout so as to prevent pickup.

The reflector supply (also screened throughout) is first fed to a potentiometer network providing a coarse variation (-50V to -300V), and a fine electronic tuning control which simply alters the current taken by the potentiometer, and in fact produces a reflector voltage change of about 5V from value determined by the coarse control. The output of this potentiometer is then filtered by an LC section filter consisting of a 100H choke and 0.25uF capacitor followed by a two section RC filter.

Virtually no current is flowing through this filter, which reduces any ripple and stray pick up to a very low value. Audio from either the FM 'phone generator or the FM tone generator, which can be keyed, is fed, via a 1uF 1 kV working capacitor and 50k high stability resistor (in fact 2 x 100k in parallel for safety reasons) and is thus superimposed on the DC reflector voltage. Ripple and stray pick up voltages appear as unwanted modulation and should be eliminated.

A neon similar to that placed across the cavity supply is also fitted across the reflector supply, and mounted adjacent to the other. The purpose of these is again a safety feature. On initial switch on, observe both neons, which should light immediately. If both do not light, switch off immediately and investigate the fault. Providing this observation takes place before the klystron heater warms up, the chances are that the klystron will not have come to grief. A further insulated jack monitors the incoming (full) reflector supply. A coaxial socket, in parallel with the reflector connection through the plug and socket carrying supplies to the klystron, allows the actual reflector voltage and its modulation to be monitored if desired.

The modulation switch has four positions:

1. FM PHONE, by which the output from the two stage amplifier (fed by a microphone ex dictating machine), is fed to be superimposed on the reflector voltage as per Fig 18 curve B. The level is set by the "FM Deviation" pre set, which is arranged so that the average deviation of the 10,000 MHz is about ± 2 MHz. This is secured by between 3V and 5V of audio.

2. FM TONE, which is again fed by the second stage of the amplifier of (1) above. In the "FM Tone" position the first stage of this amplifier has its HT removed, and a separate 800 Hz sine wave tone generator is energised and has its output fed, via the "FM TONE Deviation" pre-set, to the second amplifier stage. In this way equality of deviation in the two positions is secured. Interaction between the two preset controls is minimised by the two 10K series resistors. The 500 ohm emitter preset resistor (set at about 220 ohms in the writer's unit) in the tone generator is used to secure a good sine wave, and at the same time assists in making the oscillator key well. Keying is performed by the insertion of a large resistor in the HT return of the tone generator.

3. EXT MOD: External modulation, either a low voltage audio suitable for producing FM as previously described, a larger voltage of approximately 15V for producing AM (as per Fig 18 curve A), or an even larger square wave for producing MCW (as per Fig 18 curve C) can be introduced into the "Ext Mod" socket.

4. REFLECTOR EARTHED: In this

position the modulator "side" of the 1uF coupling capacitor is earthed, thus earthing the reflector as far as AC is concerned. A large value of this capacitor was necessary to achieve a very low reactance path for this facility, which is very useful in determining how much of any residual unwanted FM is being produced by the reflector. If this facility is not fitted the value of this capacitor can be reduced to about 0.1uF.

Metering. The insulated jacks referred to previously are wired such that no polarity switching of the external multimeter used for the measurement is necessary. Two meters are provided for normal operation of the unit. One reads the discriminator output voltage — this is used for tuning the klystron for a separation of 30 MHz with the incoming signal, ditto from a microwave test signal from a signal generator, or for alignment of both the limiter discriminator and the IF amplifier when these are fed from a tunable signal generator covering 20-40 MHz.

Under all these conditions, when the test signal is in the region of 25 MHz to 35 MHz the meter can be used to indicate that the level is in the limiting region — it becomes the warning of when the limit of microwave communications is being approached. The permanent inclusion of this quite sensitive (50-0-50 uA) meter may seem a little extravagant, but it has more than justified its use in practice.


The second meter is a 0-1 mA movement which is used to indicate the DC crystal current flowing in the microwave mixer, due to the local oscillator injection. One meter, and an associated reversing switch are provided and caters:

(a) In a single mixer — for reading current

from two alternative types (polarity) of crystals likely to be encountered.

(b) In a balanced mixer, for reading the current from either of the two active opposite polarity crystals which are used. Under these conditions, in order to maintain the circuit of the crystal current not being measured, (but still in use), a low resistance is inserted in place of the meter. Crystal currents of approximately 0.7 mA are to be aimed at for cartridge IN23B types and 1.0 mA for the coaxial CV2154 / 5 types.

Other Controls. The control panel houses the FM phone and tone deviation controls previously referred to, the Audio Gain control, which is a potentiometer in between the limiter discriminator and the audio amplifier, and the speaker and its associated headphone switch and jack. All leads to these controls are in screened cable, bonded to the chassis except for the screen on the TONE Deviation which is returned to the semi-floating earth return lead. The IF preamp gain control and an 8 pin socket carrying HT and crystal current circuits to the outboard head amplifier is fitted adjacent to the socket carrying supplies to the klystron.

Further details of the system will be given in the next article. 

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