Modulator & power supply for the novice transmitter

Here is the second article describing our Novice Transmitter, and it gives details of the power supply and modulator unit. While designed to go with the transmitter described last month, it would be equally suitable for use with other small transmitters.

by IAN POGSON

Last month we described the transmitter proper of our new 3.5MHz Novice Transmitter and we come now to the power supply, with the speech amplifier and modulator integrated on the same chassis. Those of you who may have built the transmitter already, will find this second part somewhat easier to make.

Before proceeding with other aspects of this part of the project, let us have a look at the circuit. The speech amplifier is split into two stages, each using one half of a 12AX7 twin triode. The first half takes its input from the microphone and to make the input as versatile as possible with respect to microphone types, the grid resistor has been kept to a high value of 2.7M. This means that crystal, ceramic, or dynamic microphones could be used. Bias for the valve is obtained with a 3.3k cathode resistor, bypassed with a 10uF electrolytic capacitor. The plate load is a 220k resistor.

Output from the plate of the first stage is fed via a .0068uF coupling capacitor to a 470k potentiometer, which serves as the audio level control and in turn sets the modulation depth. The rotor of the potentiometer feeds into the grid of the second stage, with bias and plate load conditions the same as the first stage. HT supply to both stages is decoupled via a 10k resistor and 8uF 300VW electrolytic capacitor.

Output from the second stage is fed via another .0068uF coupling capacitor to the grid of the 6BQ5 modulator valve. Cathode bias is obtained with a 180 ohm 1W resistor bypassed with a 10uF capacitor. The plate load is one winding of the modulation transformer and the screen grid is supplied directly from the HT line. The .001uF capacitor shunting the transformer winding restricts the audio high frequency response. Low frequency response is restricted by the two coupling capacitors and the three cathode bias resistor bypass capacitors.

The secondary winding of the modulation transformer has one end connected to the HT side of the primary winding. The HT supply is fed to this common point via one pole of a DPDT toggle switch. This switch selects either the "Phone" or "CW" mode of transmission. The other end of the secondary winding is routed to the modulated RF amplifier in the transmitter assembly, via pin 5 on the outlet socket. It may also be seen that there is an ordinary power diode connected in series with the secondary circuit just referred to and that there is a connection from the cathode of the diode to the mode switch. This arrangement is adopted to avoid transients being developed across the secondary of the modulation transformer when the transmitter is keyed for CW.

The other pole of the mode switch runs via pin 8 of the socket and connects to a set of relay contacts on the transmitter chassis. Pin 3 of the socket is the HT line to the crystal oscillator of the transmitter, while pins 2 and 7 carry the 6.3V AC heater supplies to the transmitter valves.

The power supply is very simple but adequate for the job. The high tension voltage is derived from the transformer secondary winding in a full wave voltage doubler arrangement and with a current rating of 125mA. There are two 6.3V heater windings, each rated at 3A, one being used for the RF part of the transmitter and the other for the audio section. To reduce the hum level to an economical minimum, a 47uF electrolytic capacitor is added across the HT line. Also, a bleed consisting of three 15k 1W resistors in series is added across the HT line. This discharges the capacitors after switching off, thus avoiding the possibility of electric shock from storage.

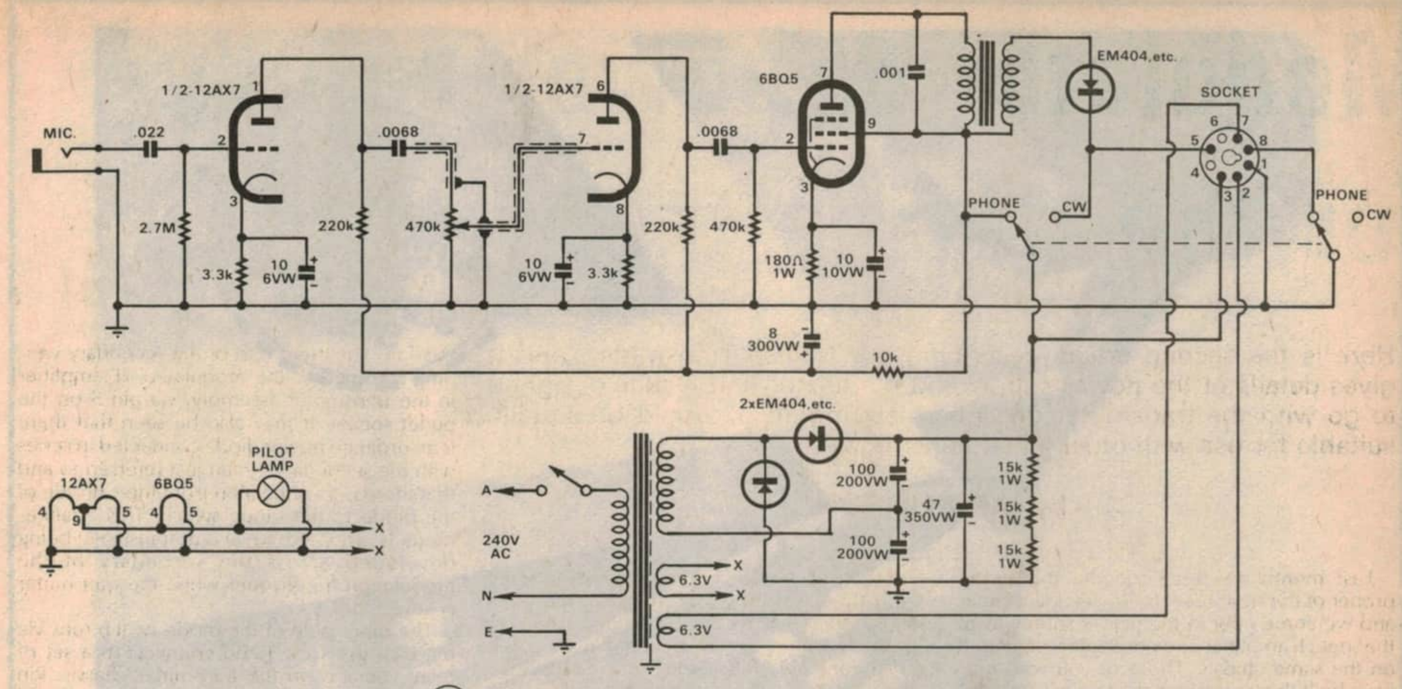
All of the components used on this unit are fairly straightforward and no difficulty should be experienced in this regard. However, a few comments on some of the components used may be useful.

Resistors and capacitors are commonly used types and there should be no problems here. The toggle switches, in common with those used on the RF section described last month, are made by McMurdo and this particular design is ideal for our purpose. The knob is the same as used on the RF section.

The indicator lamp is one which we have used before on a number of projects and should be readily available. It may be seen that we have specified a lamp rated at 14V. This is used across one of the 6.3V supplies and obviously the lamp will not glow very brightly. However, it gives sufficient light as an indicator and it should last almost indefinitely under these conditions.

The power transformer which we used is type PVD104, made by Ferguson. An equivalent transformer in another brand should be all right. Indeed, if you have a transformer in your junk box which will give about 275 volts DC at about 125mA and it has two 6.3V heater windings capable of delivering the current required in each case, then this could be used.

At left is the completed prototype, designed around a simple dish-shaped chassis. Circuit details are shown on the facing page.



3.5MHz NOVICE TRANSMITTER
(MODULATOR AND POWER SUPPLY)

The modulation transformer which we used is a power transformer. It is also one made by Ferguson, type PF201. It has two windings of interest—the usual 240V primary winding and a secondary winding giving 225V each side of a centre tap. As we will see in a moment, these windings can be used such that they give quite a good impedance match between the modulator (6BQ5) and the modulated amplifier (6CM5).

To find the load which the modulated amplifier presents to the modulator, we take the plate supply voltage and divide it by the combined plate and screen current of the valve. We will consider the voltage between the supply line and the cathode of the modulated amplifier to be 250V and the combined plate and screen current to be 42mA. Now 250 x 1000/42 results in a load of near enough to 6000 ohms. On consulting the characteristics and operating conditions for the 6BQ5 modulator valve, we find that the required load is 5200 ohms. Under some conditions this amount of mismatch may be tolerated but we do not have much audio power to spare, so we must take steps to get a closer match.

The circuit shows that each of these valves is fed through a separate winding on the modulation transformer. By manipulating the transformer turns ratio between the two windings, we can obtain the proper match. The impedance ratio is 6000/5200, which is equal to 1.15. Now the turns ratio is proportional to the square root of the impedance ratio, and the square root of 1.15 is just about 1.07.

The voltage ratio given for the windings of a transformer is proportional to their turns ratio. Let us see what our transformer can offer. The ratio of 240/225 is just a little under 1.07—just about as close as we could possibly hope for. This means then, that if we use the 240V winding to feed the modulated amplifier and one of the 225V windings for the feed to the 6BQ5, we will have achieved our matching objective.

The example just given for our particular purpose shows how the calculation is made and if you have the need to find the transformer ratio for another set of circumstances, then it is only necessary to follow the example given.

Before leaving the subject of modulation transformers and matching, there is an old trick which may be used where circumstances permit. In days gone by, there were many power transformers about which had a centre-tapped secondary, not unlike the one which we have used. Instead of using the primary winding, this is left unused and both halves of the centre-tapped secondary winding are used. The centre-tap would be connected to the common high tension power supply and one side feeds the modulator valve and the other side feeds the modulated amplifier.

This idea may be used where the impedance ratio required is exactly one, or very close to it, or in cases where a certain amount of mismatch could be tolerated. The idea also has the advantage that the two lots of DC flowing through the windings are such that their magnetic effects cancel in the core, or very nearly so.

The chassis in blank form is available from at least some components stores and if the correct size is not readily available to you, then one close to the wanted size should not be difficult to come by. We drilled and punched the holes in the chassis for the prototype.

As may be seen from the photographs, we have not fitted the modulator and power supply into a case as was done for the transmitter. There is no particular need for a case for the modulator, whereas the transmitter must be covered for safety reasons, as well as for shielding against unwanted radiation directly from the transmitter. However, if you wish to fit the modulator into a case to match the transmitter, then there is no reason why this should not be done.

Construction of this unit is fairly straightforward but there are some points which could be discussed and which should make the job that much easier.

We will assume that you have a ready drilled chassis and all the components. It is always a good idea to assemble the small and light components first. These include the valve sockets, microphone jack, indicator lamp, volume control, switches, electrolytic capacitors and mains terminating strip.

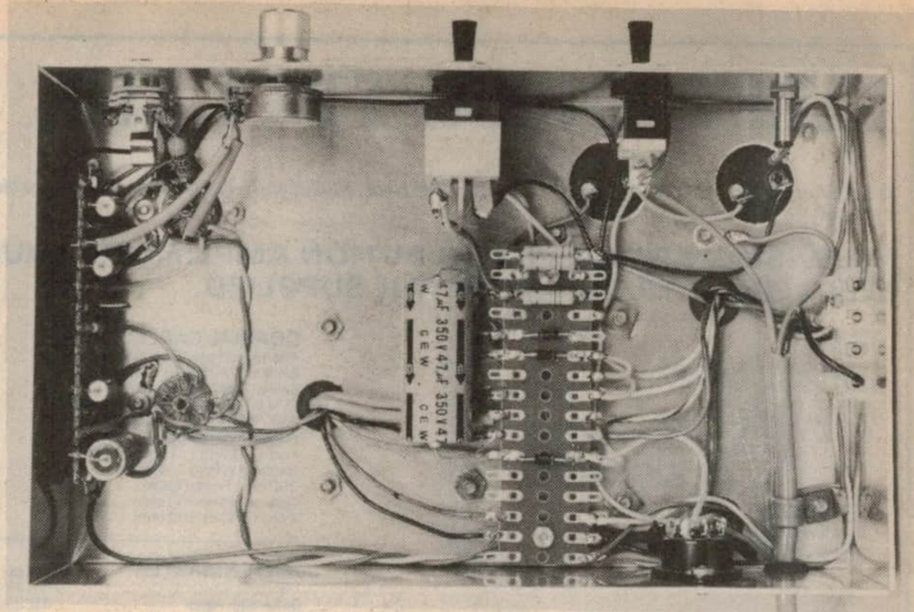
Before attempting to fix the two transformers, make sure that you have the rubber grommets in place. When the transformers are screwed in place, all the flying leads will be left sticking through the holes and vertical to the chassis. The next job is to get rid of these leads as soon as possible. As may be seen from the underneath picture, we used a miniature tag strip with 16 pairs of tags in about the middle of the chassis. All of the tags are not used. We fitted this tag strip mainly to terminate the transformer flying leads. In addition to terminating these leads, we also mounted the three 15k 1W resistors, the three EM404 silicon diodes and the 47uF electrolytic capacitor. This is not a complex job and so we are leaving it to the individual to wire it as he sees fit.

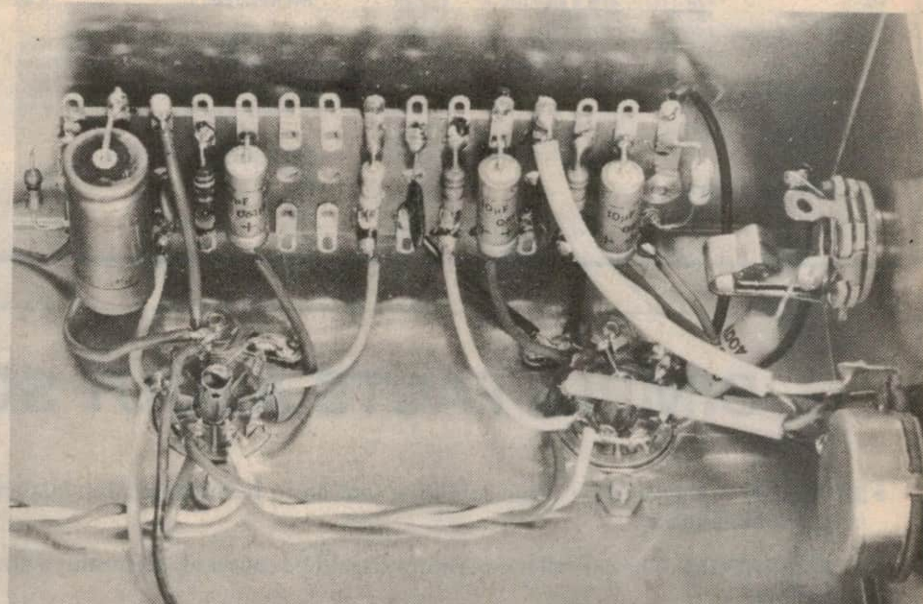
Before leaving this board, there is one point which we observed and which we think it would be wise to include in your wiring. We brought all earth connections involving the power supply to one tag on the board, near the electrolytics. This point is later wired to another point on the chassis and near the microphone input. The mains earth lead is connected to the chassis to a solder lug under one of the electrolytic fixing screws.

Having disposed of the transformer flying leads and having done the rest of the wiring on the terminating board, we are now in a position to extend the terminated leads to their destination. These include heater wiring, both to the audio valves on the chassis and the other heater circuit to pins 2 and 7 on the octal outlet socket. The high voltage supply and modulation transformer wiring completes this part of the job.

By now you may have already done the heater wiring to the two valves. This circuit will still be floating and it should now be earthed to a solder lug under one of the valve socket screws for the 12AX7. The centre spigot for both sockets should also be earthed, that for the 6BQ5 to another lug at its socket.

Most of the components for the two valves are mounted on a piece of miniature tag board with 15 pairs of tags. All of the tags are not used but we made the strip long enough so that components could be placed to keep





View at top shows the simple nature of the under-the-chassis layout. Below is a detailed view of the tagboard mounted on one side of the chassis, together with its associated wiring.

leads as short as possible. No drawing has been made for this board either but to help the builder, this is the order of the components from the input end. 2.7M resistor, 10uF capacitor with its 2.2k resistor underneath, 220k resistor, .0068uF capacitor, 10uF capacitor with its 2.2k resistor underneath, 220k resistor, .0068uF capacitor, 470k resistor, two blanks, 10uF capacitor, 180 ohm resistor, .001uF capacitor, 8uF capacitor and 10k resistor.

With the components mounted, interconnecting wiring is done. We kept the components to be earthed such that all items for the 6BQ5 are kept together and an earth lead run direct to the earth lug on the 12AX7 valve socket. Similarly, all items to be earthed and associated with the 12AX7 were connected together and another separate lead run to the common earth lug. Other leads are run to the respective valve socket pins. The two leads from the volume control are run in light coaxial cable. The braid of each cable is connected to the earth lug on the volume control and the braid is cut short and not terminated at the other end. A lead from the volume control earth lug is run to the common earth point. Similarly, the earth lug on the microphone input socket is earthed to the common point.

You may notice that we have used a .022uF coupling capacitor between the microphone input socket and the grid of the valve. This is not strictly necessary and under most circumstances it may be omitted. It may also be noted that we have not taken any precautions against RF getting into the audio amplifier. This was found not to be necessary on the prototype. However, if you wish, or find it necessary, a small capacitor of 100pF or so may be shunted across the 2.7M resistor. A 47k resistor may also be connected in series with the lead between the microphone and the grid of the valve. Another method which is sometimes used, is to slip a ferrite bead over the lead right at the valve grid pin.

Having completed the wiring, before proceeding with tests, it is essential to make a thorough check to make sure that there are no errors or omissions in the wiring. Care should be taken to make sure that all pin connections on valve sockets are correct. The polarity of diodes and electrolytics should also be checked.

We are now in a position to test the complete transmitter and put it into operation. While there may be many ways of going about this, I will run through a procedure which should make the task quite straightforward.

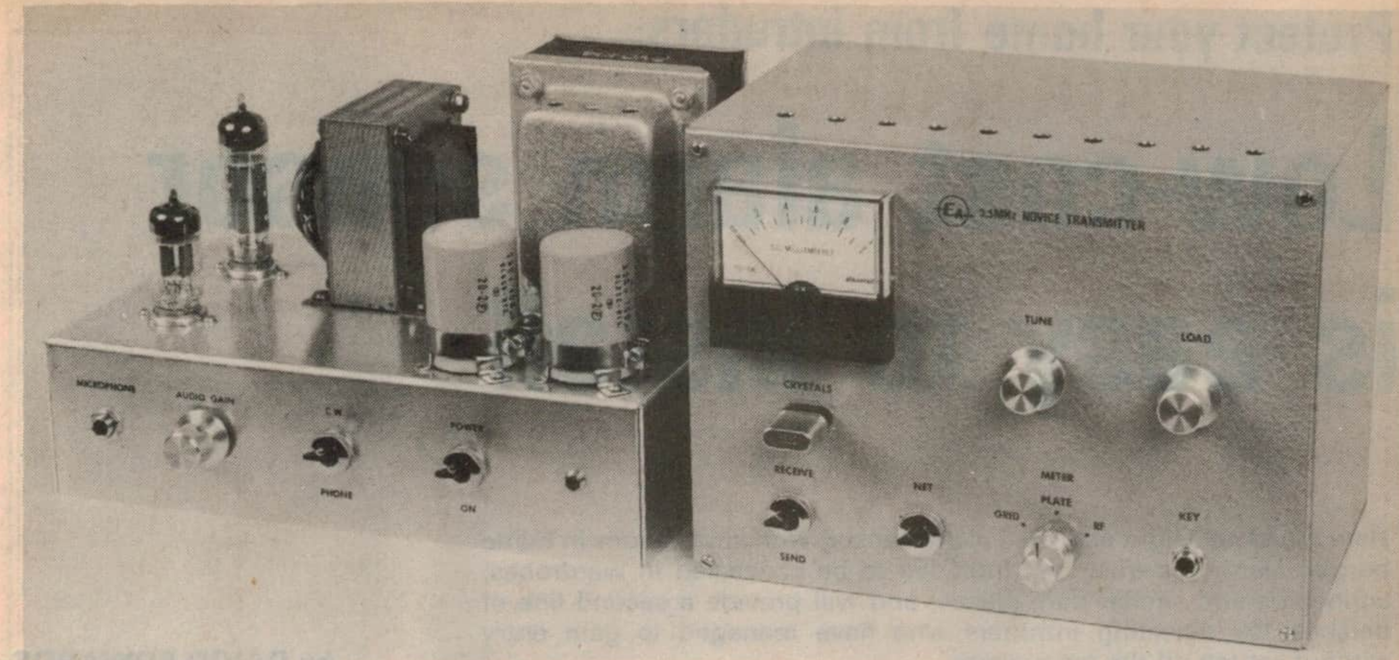
The transmitter should be left out of its case for testing and the valves may be left out of the modulator chassis for the initial stages. Connect up the cable between the units and connect a dummy load to the transmitter output, equal to the characteristic impedance of the feedline which you intend to use e.g., 50 or 75 ohms. Set the "power" and "net" switches to the off position and the other two switches to "receive" and "phone". The audio gain should be turned off, the meter switch set to "grid" and the "tune" and "load" capacitors set right in. The crystal which you intend to use should be plugged in.

Break the HT lead feeding the plate and screen of the 6CM5 valve and make sure that the lead is kept out of harm's way. Turn on the power switch and wait for about half a minute for the valves to warm up. Now throw the switch to "send". The relay should operate and you should get a small reading of grid current. Adjust the slug in the oscillator plate coil for maximum grid current reading. This should be about 1.5mA. Switch back to "receive" and switch off the power; then connect up the HT lead which you just disconnected.

Switch on again and wait for warm-up. Set the neutralising capacitor to minimum capacitance. Set the meter switch to "plate", and switch to "send". The plate current will rise to a high value of about 80mA or so and this condition should not be allowed to persist. Carefully rotate the "tune" control until a dip is obtained in the plate current reading. Tune for maximum dip. This should be somewhat less than 40mA. Now rotate the "load" control which will cause the plate current to rise again. Stop at 40mA and touch up the "tune" control for dip again. It may not have altered very much. If you are unable to load up to 40mA then the .0018uF capacitor needs to be reduced. If you cannot get down to 40mA then the capacitor will have to be increased.

You now have the transmitter running with about 10 watts input to the final, which is the power authorised. We will come back to this a little later on to make more precise adjustments to the HT voltage and the meter reading accuracy. Meanwhile, we will neutralise the final and this is an interesting operation. If you have a wavemeter, or a GDO which can be used as a wavemeter, then this can be used as an aid to neutralising. If you do not have one, then we can do without it.

Switch to "receive" and switch off the power. Again disconnect the HT line to the plate and screen of the final as before. Do not touch the "tune" or "load" settings. Switch on again and after warm-up, switch to "send". Bring the coil of the wavemeter near to the final tank coil and adjust the wavemeter to the frequency of the crystal, such that an indication is given on the wavemeter. Adjust the neutralising capacitor for minimum indication on the wavemeter. Now slightly adjust the "tune" control for an increase in the wavemeter reading and adjust the neutralising capacitor for a minimum reading. Repeat this process until the minimum possible reading has been obtained on the wavemeter.



The modulator and power supply unit together with the transmitter described last month.

At this point the final is neutralised for all practical purposes but this can be checked and indeed, there is a second method which may be used by those builders who do not have a wavemeter.

To check the latest adjustment for correct neutralisation, or to actually carry out the process from the beginning, the following procedure is suggested. Before starting however, the HT lead to the final which was disconnected must be restored.

Switch on and tune for a precise dip in plate current as previously described. Now set the meter switch to "grid". To carry out this procedure it will be necessary to switch the meter from "grid" to "plate" as required. With the final correctly dipped, carefully watch the grid current reading and slowly detune the "tune" control in one direction. The grid current should fall. Now dip the plate current again and repeat the procedure, this time turning the "tune" control in the opposite direction. If neutralising is "spot on", the grid current will fall again, and you have a properly neutralised transmitter.

Should the grid current rise and then fall as you slowly tune away from resonance in one direction, then the stage is not properly neutralised and the neutralising capacitor should be given a slight adjustment in one direction. If a subsequent check shows that the situation is worse, then you have moved the neutralising capacitor the wrong way. Pursue this course until the grid current falls on both sides of resonance.

If you have not made any preliminary neutralising adjustments using a GDO as previously discussed, then follow the subsequent procedure just described. The only difference this time is the possibility that the neutralising capacitor will have to be adjusted by a greater amount than if you had made the preliminary adjustment.

Having neutralised the transmitter, before we go on to the modulator, we hinted that the meter plate current readings may be somewhat in error. This may be checked by making a comparison with a multimeter of known accuracy. The HT line will have to be broken say between the 100 ohm resistor and the 22k screen resistor and the multimeter inserted in series with the line. With the transmitter switched on, the multimeter should indicate approximately 40mA and this should be compared with the reading on the transmitter meter. If the reading is low, then the 10k resistor must be shunted with a high value of resistor such that the reading is correct. On the prototype, we shunted the 10k resistor with a 100k resistor. If the meter reads high, then the 10k resistor will need to be increased.

So far, we have not checked the HT voltage. Ideally, this should be about 265 to 270V. If not, and the transformer has some taps which will allow you to effect a voltage adjustment, then we suggest that you aim for this voltage. If your transformer does not allow for any adjustment, then the voltage should be taken between the HT point and the cathode of the 6CM5, with the transmitter properly adjusted. The plate current of 40mA which we quote is on the assumption that the effective plate voltage is 250. If it deviates in either direction from this value, then the plate current should be adjusted accordingly, to give an input power to the plate of 10 watts.

With the transmitter adjusted, the valves may now be fitted to the modulator chassis. Switch on and bring up the transmitter and still with the dummy load attached, tune into the signal on a receiver, preferably fitted with a pair of headphones. Turn the volume control off, plug in the microphone and slowly advance the volume control while speaking into the microphone. Your voice should be heard in the headphones. Continue to advance the volume control until the plate current meter on the transmitter starts to kick and then back off a little. This should give about the right setting for the audio level.

If you have a CRO or some other means of checking modulation, then it is a good idea to check for depth of modulation. This done, and with your Novice licence in one hand, pull out the cable to the dummy load and plug in the aerial feedline with the other hand. Switch on the transmitter. It may be necessary to re-adjust the "load" and "tune" controls a little to get the right value of plate current again. You are now "on the air", and I wish you good DX!

LIST OF COMPONENT PARTS

1 Chassis, 10in x 6in x 2½in
1 Transformer, primary 240V, secondaries 120V, tapped 110V, 100V at 125mA, 6.3V at 3A, 6.3V at 3A. PVD104 or similar
1 Transformer, primary 240V, secondary 225V-CT-225V. PF201 or similar (see text)
1 Switch, SPST, McMurdo
1 Switch, DPDT, McMurdo
1 Jack socket, 6.4mm
1 Indicator lamp, 14V type BFB-6G, Rodan
1 Knob, Jabel etc
1 4-way mains terminal strip
1 Miniature tag board, 16 prs tags
1 Miniature tag board, 15 prs tags
2 Valve sockets, 9-pin miniature
1 Valve socket, octal
4 Rubber grommets
1 Valve, 12AX7
1 Valve, 6BQ5
3 Silicon diodes, EM404 or similar

RESISTORS (½W unless stated otherwise)

1 180 ohms 1W	*2 220k*
2 3.3k	*1 470k*
1 10k	*1 470k log pot*
3 15k 1W	*1 2.7M*

CAPACITORS
1 .001uF 630V ceramic
2 .0068uF 400V polycarbonate
1 .022uF 400V polycarbonate
1 8uF 300VW electrolytic
2 10uF 6VW electrolytics
1 10uF 10VW electrolytic
1 47uF 350VW electrolytic
2 100uF 200VW electrolytics

MISCELLANEOUS
Hookup wire, solder, solder lugs, screws, nuts, 3-core power flex, 3-pin plug, cable clamp, 15cm shielded or light coaxial cable.