A Four-watt Quality Amplifier

By G. W. Bolton

Describing an easily built high fidelity unit

HUNDREDS, possibly thousands, of enthusiasts have during the past few months acquired some Government surplus radio gear.

Much of this cannot be used in its present state, and most of it has to be stripped down for component parts. Here is an article describing the construction of a versatile and compact amplifier, built almost entirely of surplus materials. Its uses are many and varied, being equally suitable for all types of pick-ups and radio inputs.

Arrangements are made to supply voltages from a socket in the amplifier to enable experimenters to try out various ideas, such as Pre-amplifier unit for Sound-on Film, microphone, Broadcast or short-wave tuner units.

All valves are ex-Government surplus, the line-up being as follows, input VR55 (EBC33) Schmitt phase inverter using 2 VR56 (EF36) driving 2 VT52 (EL32) in push-pull triode connected; rectifier is a 6X5G or OZ4, being interchangeable without alteration.

The circuit is simple, easy to construct, and is capable of really excellent reproduction, using moving iron, E.M.1 Lightweight, and Moving Coil units.

Maximum output approx. 4 watts undistorted for about .3 volt input. A close speech microphone, using suitable transformer gives good results, but an extra stage must be used for the Concert Type microphone. By substituting larger valves in the Output Stage, and using suitable modulation transformer (Plus higher D.C. volts as required) this circuit would be ideal for 25 to 30 w. modulator unit.

Now let us dissect the circuit:—

Input is via co-axial plug and socket, the screening being very effective—an essential owing to the high gain of the amplifier. There is an equaliser circuit R1, R2 and C1 (between input plug and volume control) to compensate for bass attenuation in recordings.

The one megohm potentiometer volume control (R3) has been placed well up in the front as it is not possible to tell what inputs you will use, and as excessive inputs

will overload the first valve, the distortion caused will be amplified considerably, maybe leading one on a false trail.

The input valve is used as a high gain triode, the diodes (Pins 4 and 5) being connected to cathode. The anode circuit is decoupled with 50 K ½ w. resistor (R6) and 8 μF electrolytic capacitor (C5) the case of which must be isolated from earth.

Use has been made of this as a feed-back device involving no extra components. The principal is that the voltage appearing across the secondary of the output transformer is fed back as a degenerative voltage into the anode circuit of the input valve. Something cannot be got for nothing, and this voltage feed-back decreases sensitivity but it has the advantage of flattening the response curve of the amplifier, increasing the power output rating with minimum distortion, and cancelling hum and valve noises to a marked degree.

If you should experience any instability, reversing either the primary or secondary connections to the output transformer will effect a cure.

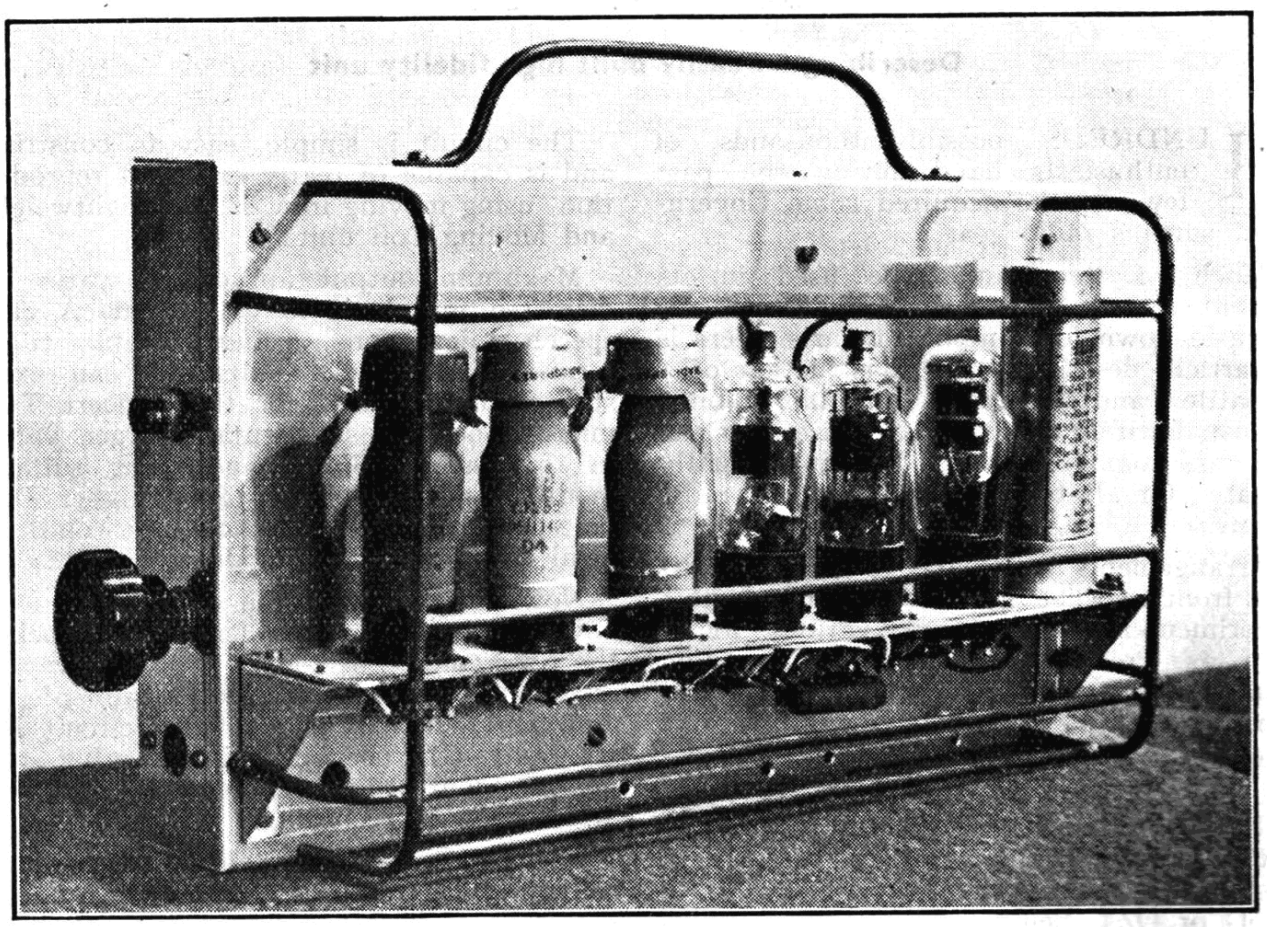
A .1 μF capacitor is used for coupling to the grid of Schmitt phase inverter. The input voltage appearing across R10 being 90 degrees out of phase with the input and is fed into the bottom half of the phase inverter stage, this giving equal volts 180 degrees out of phase to both valves, and self-balancing push-pull action.

The Schmitt is a well tried circuit, and considerable tolerance can be allowed in resistor values, R7 and R8 should be within 10 per cent. of each other, as also R11 and R12.

As these valves are used as pentodes (R5 acting as degenerative feed-back) the voltage gain is about 90, this being ample to drive PX25's or KT66's if required. Both anodes are capacitance coupled to the grids of the output valves. A common bias resistor of 1 watt rating 500 ohms (R16) should be used.

The output valves are capable of 8 watts output as pentodes, but in this particular case they are used as triodes (screen connected to anode through 100 ohms) as this improves results tremendously, and at the same time, gets rid of that excessive top response allied to pentodes. No tone control has been found necessary under these conditions. The output transformer of 5 watt rating, should be 10,000 ohms anode to anode matched to speaker impedance.

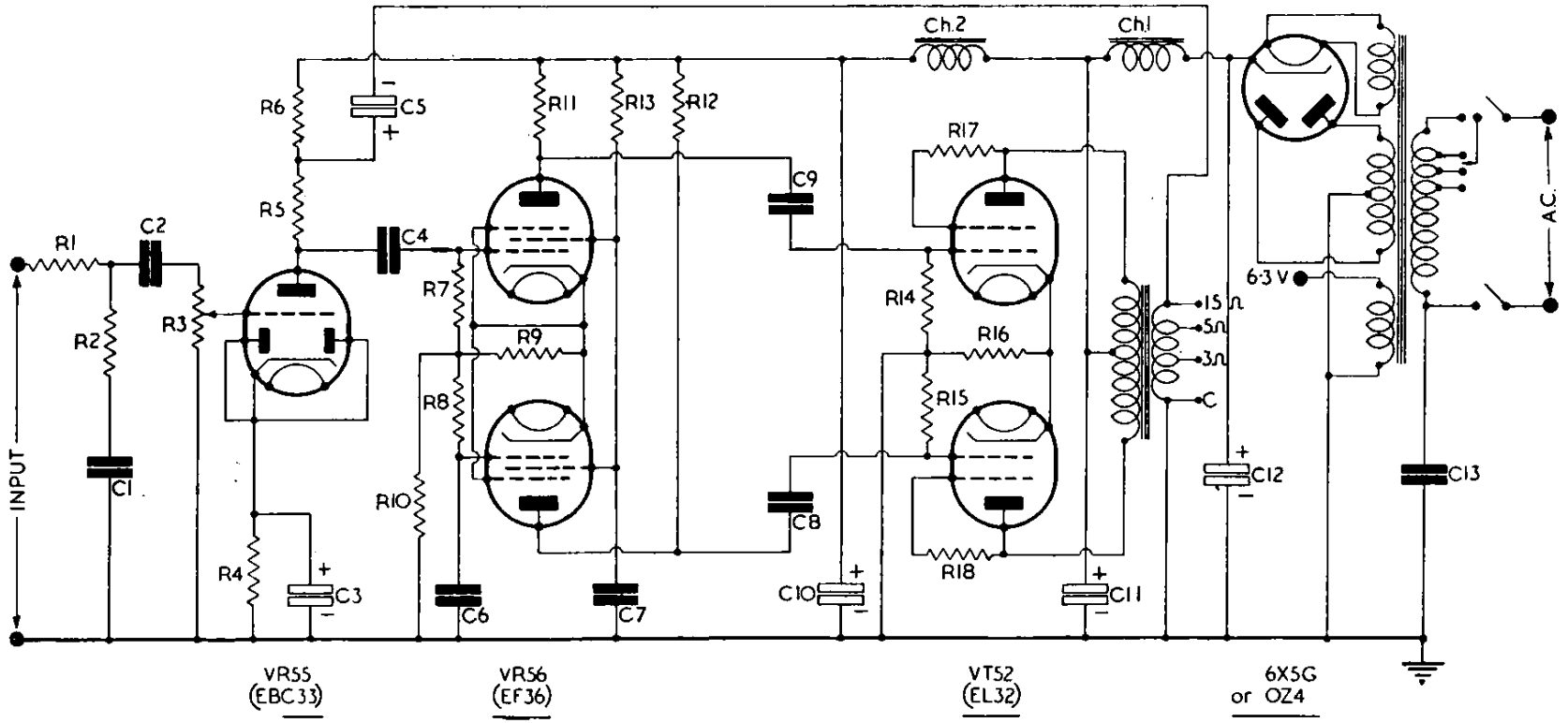
Formula for this $\sqrt{\frac{\text{anode load impedance}}{\text{speech coil impedance}}}$



Front view of the amplifier. Note the construction of the tubular protective grill

Parts List

R1	100K~	½ w
R2	100K~	½ w
R3	1 Megohm Potentiometer	
R4	2.2K~	½ w
R5	220K~	½ w
R6	50K~	½ w
R7	2 Megohms	½ w
R8	2 Megohms	½ w
R9	220 ohms	½ w
R10	10K~	½ w
R11	100K~	½ w
R12	100K~	½ w
R13	220K~	½ w
R14	220K~	½ w
R15	220K~	½ w
R16	500 ohms	1 w
R17	100 ohms	½ w
R18	100 ohms	½ w



C1	.01 μF
C2	.1 μF
C3	25 v. x 25 μF Electrolytic
C4	.1 μF
C5	8 μF Electrolytic 350 v.
C6	.1 μF
C7	.1 μF
C8	.1 μF
C9	.1 μF
C10	8 μF Electrolytic 350 v.
C11	16 μF Electrolytic 350 v.
C12	16 μF Electrolytic 350 v.
C13	.1 μF 500 v. working
CH1	10H 70 mA.
CH2	10H 40 mA.

Input Plug and Socket Co-Axial
Output Plug and Socket
Mains Plug and Socket. 2 pin Flex Connector
Mains On/Off Swith. DP/ST Toggle
17 pair Tag Board
Screened Top Caps
Screened Lead
Octal V/Holders
Plastic covered .028 in. tinned copper wire
Brackets for fixing back cover
Chassis 14 in. x 2½ in. deep x 8 in. wide
V/Panel 14 in. x 2½ in.

Brackets 3½ in. x 3½ in. cut diagonally
3/16 in. Copper Tube approx. 6 feet.

Specification for Mains Transformer

0-210-230-250 v. input 50cps.
250-0-250 v. 60 mA. Secondary
6.3 v. 1 Amp. for Rectifier
6.3 v. 2 Amp. for Valves

Output Transformer (5 W)

10,000 ohms Anode to Anode
0-3, 5, 15 ohms Secondary

Say you have a 3 ohm speaker then work out as follows:

Square root of

$$\frac{10{,}000}{3} = 3{,}333 = \text{approx. } 58 \text{ to } 1.$$

See separate sheet for valve holder connections, and voltage analysis of all stages.

Constructional details:—

The chassis is split up into individual assemblies and it is possible to complete each section as is convenient, and allowing a final assembly without any possible doubt.

Valve Panel:—

Size 14 in. x 2½ in. 7 ⅛ in. holes are drilled or punched into this strip, being spaced equidistant from the centre. Mount the six octal valve holders, with the locating slots to the front. Place a soldering tag under fixing nut of all valve holders, nearest to pin No. 1. This is to earth the metallising around the input and phase inverter valves, and metal case of the OZ4 rectifier (if used). The earth tags are also used to earth pin No. 2 on all valves (except rectifier) this being the return path of filament circuit.

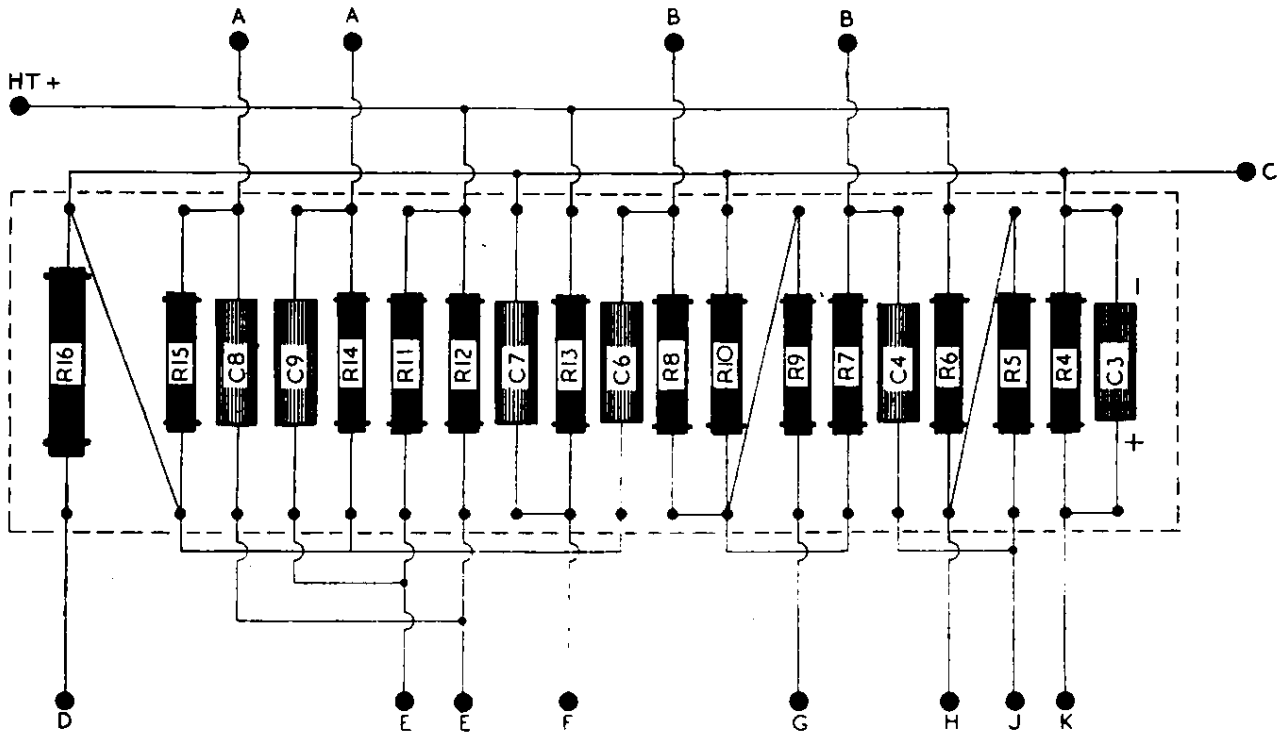
The last hole (i.e. to the right from the front), is for mounting the 16+16 μF electrolytic capacitor. This also has an earth tag, as although the capacitor can is metal it is usually isolated, so make sure and earth the negative connection. Now fix the two side brackets, and that completes the assembly of the valve panel.

Next item is to drill the chassis proper.

Spot off for the mains transformer, smoothing chokes, input and output sockets, mains input and volume control. The sketches and photographs should not leave any doubt as to position of components. When these items are assembled, get valve panel, mount the valves, and check position of holes for grid leads, taking a line direct from grids to chassis. Dimensions given are approximate, and rests entirely on valve mounting. The same applies to holes under the panel used for connections to component panel. When the holes are drilled—mount the valve panel, and leave this until the next operation has been completed.

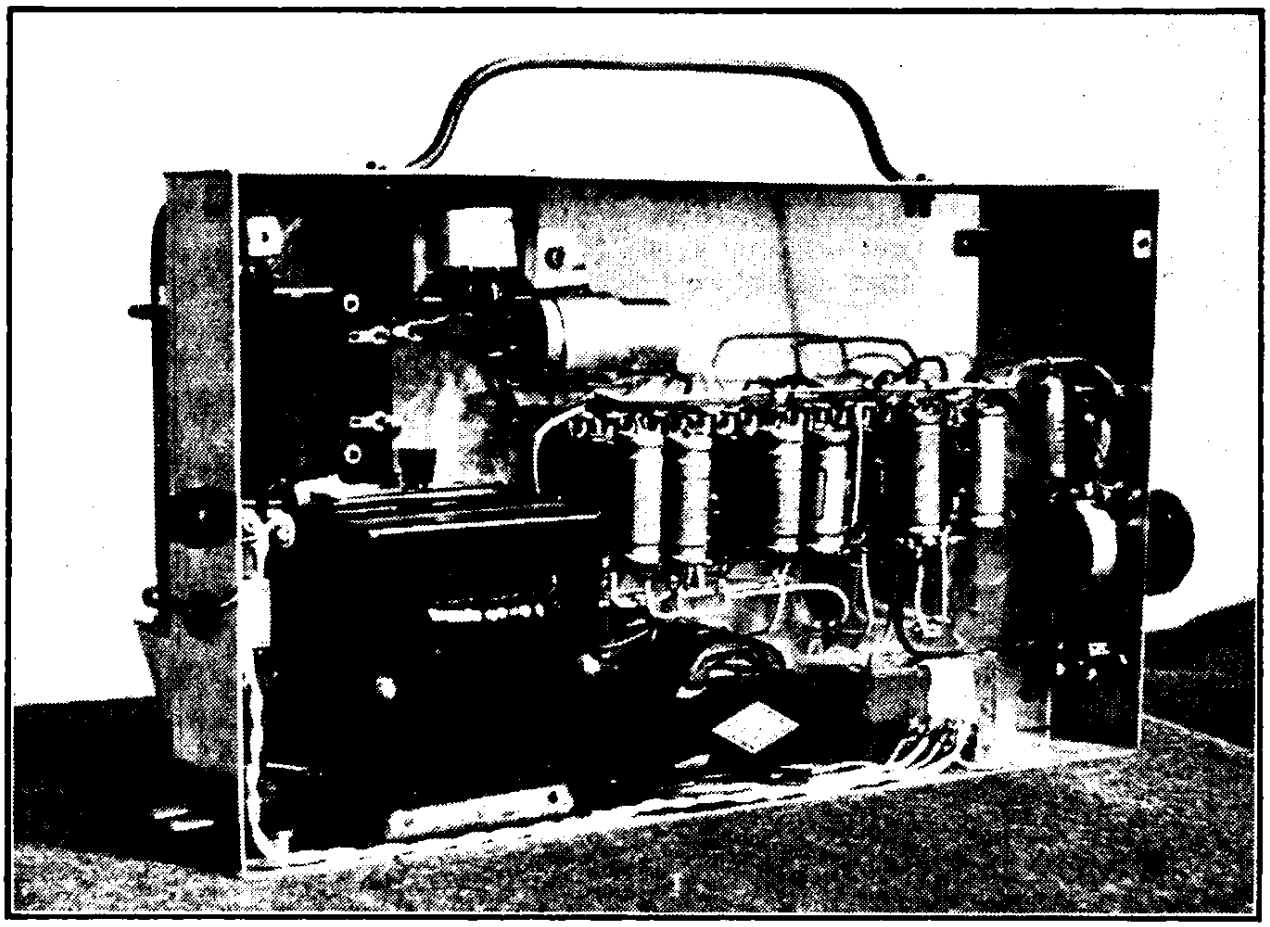
The main item is the component panel, the size as used being 6½ in. x 2⅛ in. and carrying 17 pairs of tags.

A soldering iron is now required, and resistors and capacitors should be wired to tag board in the order shown on the sketch. Take care to clean all wires by scraping, tinning them before cutting to length required. Make firm clean soldered points,



Sketch showing wiring of resistor and capacitor tag-board. External connections are as follows:—

A—A: Grids VT52
B—B: Grids VR56
C: To volume control and input socket
D: Cathodes VT52
E—E: Anodes VR56
F: Screens VR56
G: Cathodes VR56
H: Feed back capacitor (+)
J: Anode VR55
K: Cathode VR55



Rear view of amplifier with back removed

twisting the wires round the tags, not relying on the solder for mechanical strength.

Next a small quantity of 22 s.w.g. tinned copper wire and sleeving, or some of the .028 plastic covered bell wire is cut to make the links that are required between the various components. Again consult the sketch.

It is important that the earth line should run on the component panel as in the sketch, or eddy currents circulate through the chassis causing hum troubles. Now allow about 6 in. length of wire for those going through chassis to valve panel. When these are all complete, mount the component panel on the chassis (using 2 x ½ in. spacers behind panel) and push connecting leads through their respective holes in the chassis (see photographs). Carefully check when connecting to the valve holders. All No. 7 pins on valve holders (except rectifier valve) are linked and taken to 6.3 v. winding on mains transformer, other links being Pins 4-5 and 8 on input valve. These are all connected together and go to cathode resistor R4.

The phase inverter valve holders have a link between Pins 5 and 8 on both valves —then connected together and taken to R9.

A further link is between both No. 4 pins of the phase inverters and taken to R13 and C7.

The output valves have a link across the No. 8 pins and this is taken to R16.

The only other link is from Pin No. 8 on rectifier valve to the positive terminal of 16 μF capacitor and then through chassis to choke No. 1. The remaining connections are all single wires.

Now for the screened leads.

Three of these are required, and here are some hints on making a neat job of this.

Get the screened lead and with a fine point (a pair of compasses would do) unravel screening about ¾ in. Twist this screening wire together, and then cut about ¼ in. of insulation away from centre lead. You now have an easy means of soldering the screening and centre leads without damaging insulation. Repeat process the other end after checking length required, and connect centre lead to grid connection inside cap, and poke twisted end of screening through the small hole in the earthing clip of the top cap screen. Apply solder and trim the ends, and you have a really neat top cap lead.

For the rest of the wiring, the mains input, switch and transformer should be wired first, and then the rectifier filaments and anodes.

Be careful of insulation of all leads, owing to the voltages concerned.

Next we have the smoothing circuit, to be followed by the output transformer and output socket. The earth lead of the 8 μF feed-back capacitor should be made now, allowing sufficient length to change over the leads if instability is present. Now wire up the input stage, and that should complete the whole job.

Testing:

Don't be too impatient:

Have a check over, lead by lead (crossing them off the diagram as you go) to make sure there are no mistakes. With everything correct, connect speaker, and then the mains and switch on. Filaments should glow almost immediately, and if you have a D.C. volt-meter this should be connected to centre tap of output transformer and earth. The reading should be round about 250 volts. Allow about 45 seconds and the volts should be there. If not switch off immediately and check H.T. line, checking this to ground, also continuity of chokes, output transformer, etc.

Assuming all is well after the initial warming up, turn volume control to maximum for check on instability.

This is present as a high pitched howl, and method previously mentioned should be taken to correct it.

After this, listen for hum.

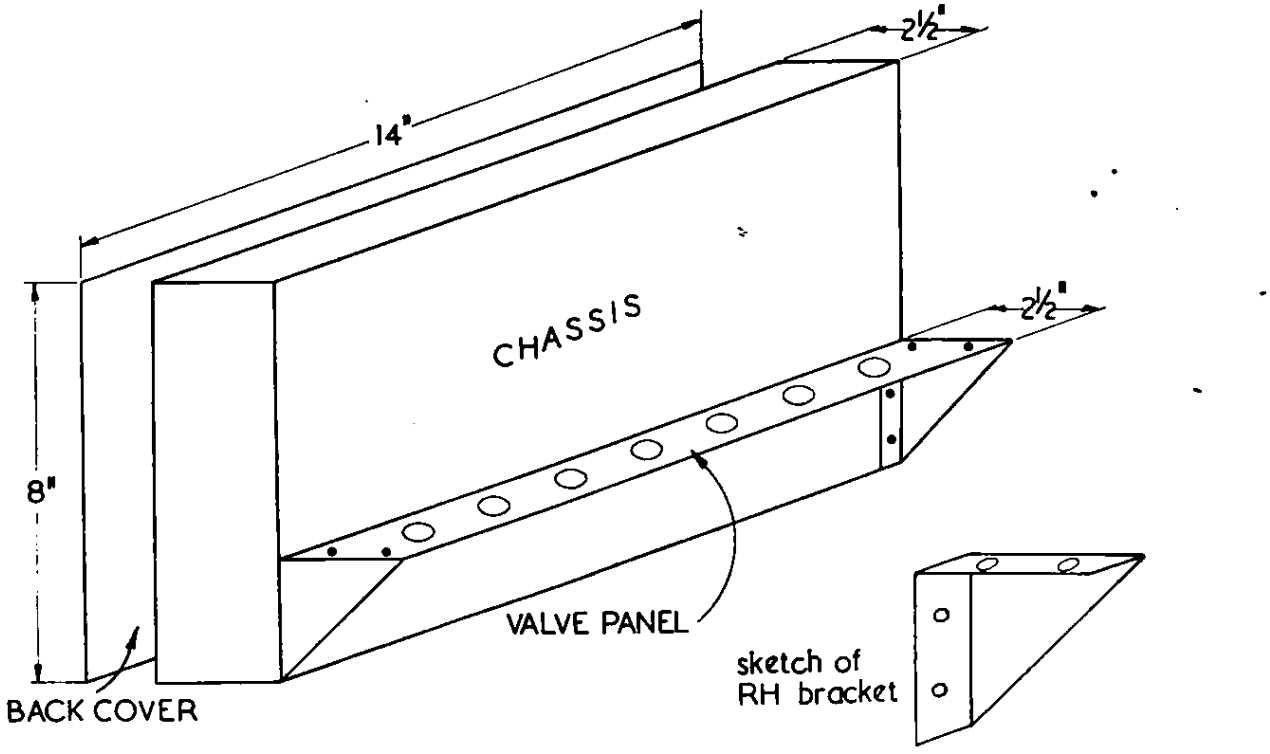
With the back off and volume control (do not have any external connection to input plug) flat out, hum should be audible, and when the hand is placed within 6 in. of component panel, should show a marked increase. Place back panel on chassis—all hum should disappear, and there should only be a slight hissing sound in the speaker.

Should you have trouble, make a careful check on all earth connections. It was not necessary to use external earth on the prototype model, the only trouble encountered being modulation hum, when on radio. The cure was a .1 μF capacitor (C15) from one side of mains to chassis, and is shown in the circuit diagram.

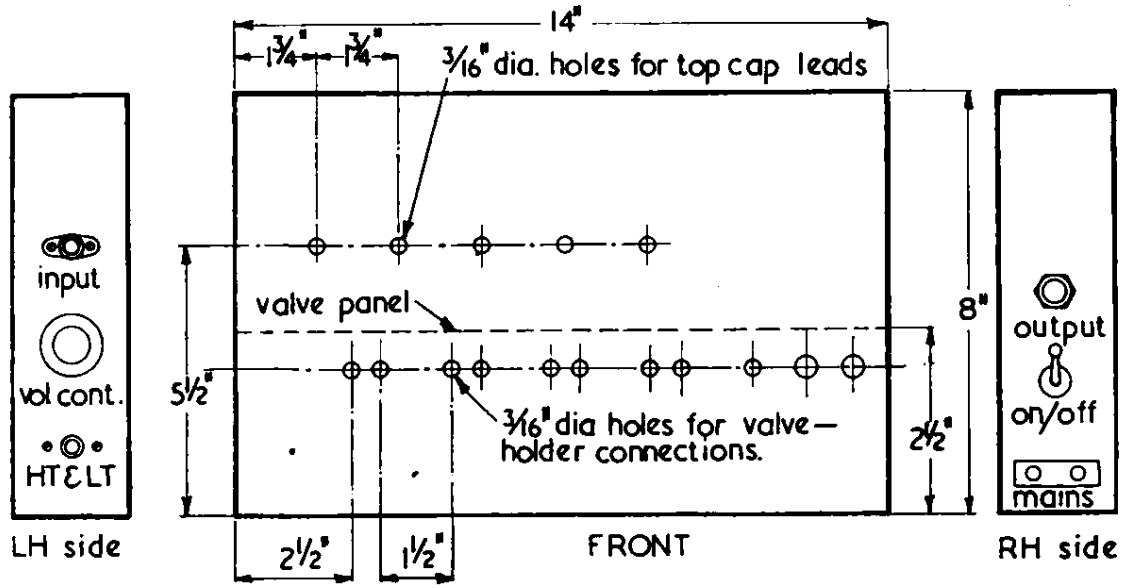
Finally, the protective grill: This was a problem, as perforated metal is not easy to obtain. However the solution was found in

VOLTAGE ANALYSIS		Volts
Input Valve	Anode	40
	Cathode	1.4
Phase Inverters	Anode	120
	Screen	60
	Cathode	30
Output Valves	Anode	240
	Screen	240
	Cathode	18
Rectifier	Anode (A/C)	250
	Cathode	250

(Points mentioned to Chassis)
230 v. A/C Input



Sketch showing construction of metal work



Main drilling dimensions for the main chassis

using 3/16 in. copper tube. The photographs show the final arrangement. A round file was used to cut in about 3/32 in. where the soldered joints are made. This makes the whole thing rigid and it is possible to lay the amplifier down without damage.

A further advantage is that of being able to check volts, etc. on valve panel, should this be necessary.

No originality is claimed for the circuit, the lay-out and final details being the result of many weeks experimenting to produce a stable and easily constructed high quality amplifier.

Pin Connections For The Valves Used

VR55

Pin. No.	1	Earth
	2	Earth (Fil)
	3	Anode
	4	Diode to Cathode
	5	Diode to Cathode
	6	Blank
	7	Filament
	8	Cathode
T/Cap		Grid

VR56

Pin No.	1	Earth
	2	Earth (Fil)
	3	Anode
	4	Screen
	5	Suppressor
	6	Blank
	7	Filament
	8	Cathode
T/Cap		Grid

VT52

Pin No.	1	Earth
	2	Earth (Fil)
	3	Anode
	4	Screen
	5	Blank
	6	Blank
	7	Filament
	8	Cathode
T/Cap		Grid

6X5G

Pin No.	1	Blank
	2	Filament
	3	Anode
	4	Blank
	5	Anode
	6	Blank
	7	Filament
	8	Cathode

OZ4

Pin No.	1	Earth
	2	Blank
	3	Anode
	4	Blank
	5	Anode
	6	Blank
	7	Blank
	8	Cathode

(N.B.—Pins are numbered reading in a clockwise direction from the spigot when viewed from underneath.)