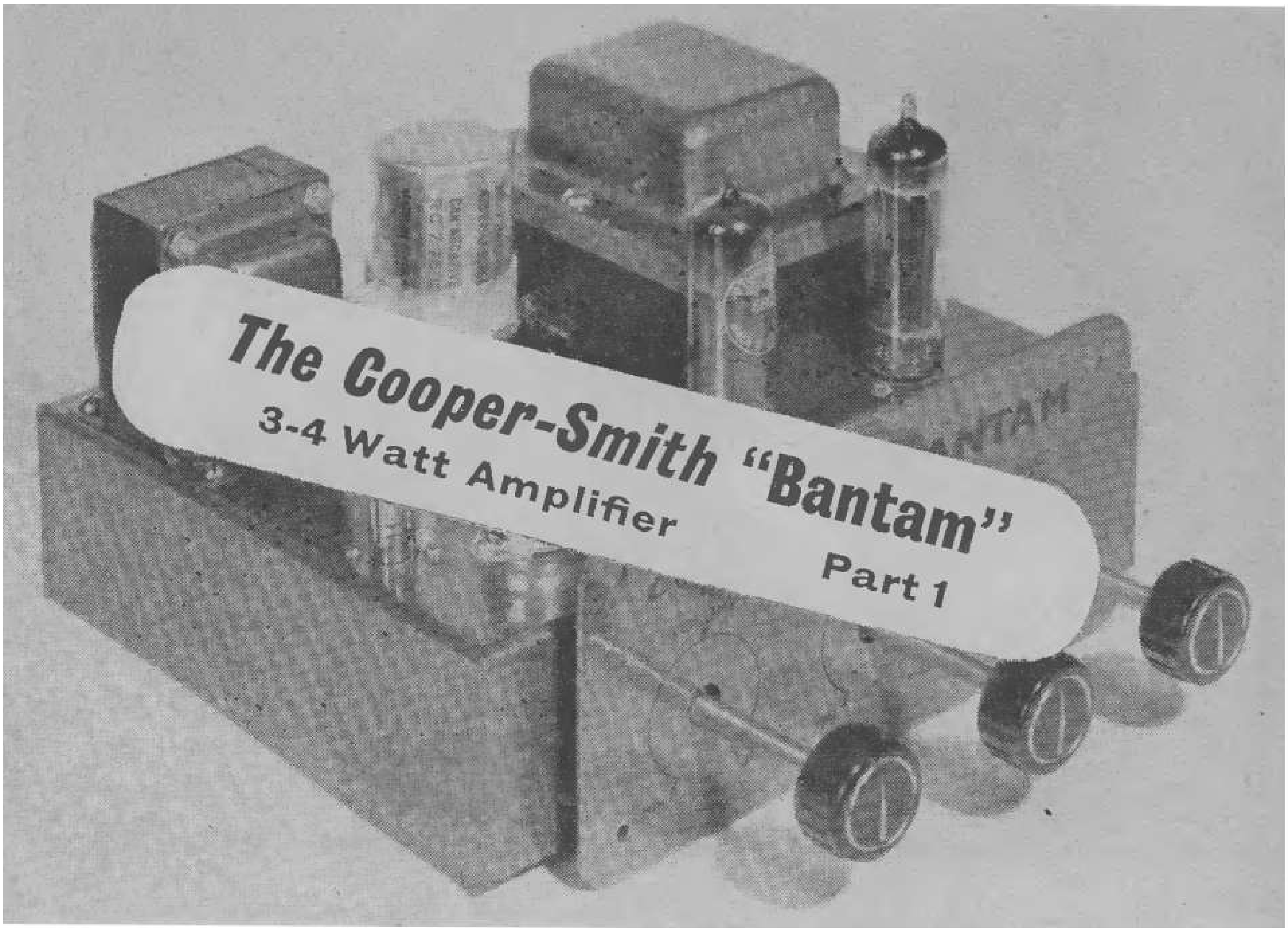



**Described by W. Holmes**

*This article gives full constructional details of an inexpensive amplifier which is capable of a very high performance level*

DESPITE THE FACT THAT PRESENT-DAY audio amplifying and reproducing equipment tends to be centred on complex and relatively costly amplifiers there is a very considerable demand amongst constructors for amplifiers which, whilst being capable of offering a high performance level, are smaller and less expensive. The Cooper-Smith "Bantam" falls into this category, and it has been designed to give a quality of reproduction which is considerably in advance of that provided by standard radios and radiograms. The "Bantam" possesses all the features normally found in much more complex equipment: it has continuously variable bass and treble controls, it contains its own mains power unit, it can provide heater and h.t. power for ancillary equipment such as f.m. tuner units and the like, and it is capable of driving speakers at either 15Ω or 3.75Ω impedance. The output stage is single-ended, the output valve specified being rated at a high power figure. This valve works into an output transformer having a generously heavy core, negative feedback from its secondary being applied to the stage preceding the output valve.

As may be seen from the photograph at the head of this article, the completed amplifier presents a very neat and professional appearance. A separate escutcheon, also shown in the photograph, enables the amplifier to be mounted in a cabinet, if desired, the control spindles protruding through the escutcheon.

Technical features for the "Bantam" are as follows:

Power Output: 3–4 watts.
Frequency Response: 40–25,000 c/s ± 1dB at 1 watt (tone controls flat).
Tone Controls: Bass and treble cut and boost, continuously variable.
Output Impedances: 3.75Ω and 15Ω.
Input Sensitivity: 60mV for 3 watts output.
Valves: ECF80, EL84 (or 6BQ5), EZ81.
Spare Power: 250V at 45mA, 6.3V at 2A.
Weight: 8¾lb.
Size: 8 x 6½ x 4½in.

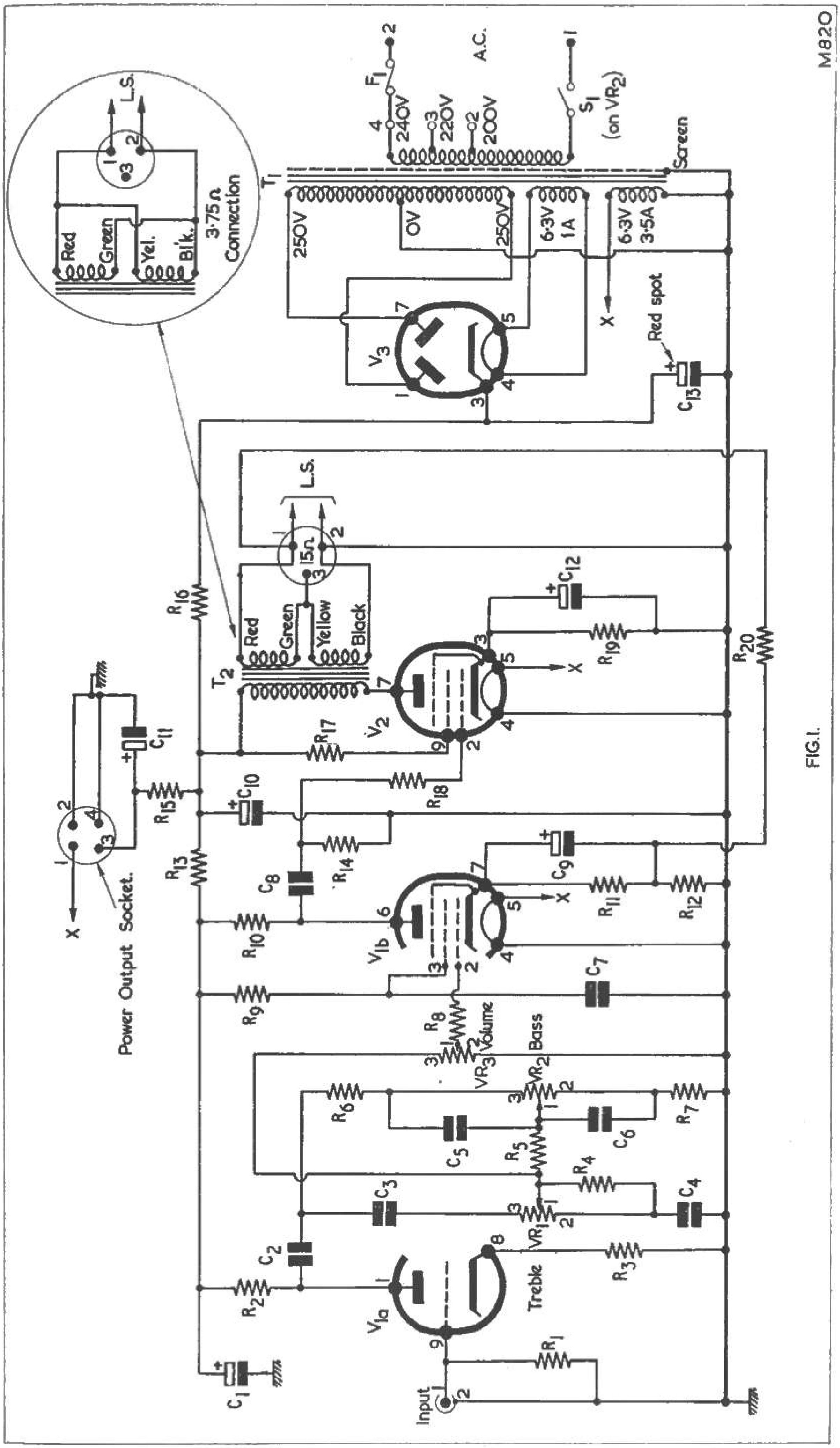



FIG.1.

*Fig. 1. The theoretical circuit of the Cooper-Smith "Bantam". The identification numbers on potentiometers and sockets apply to the similarly numbered tags in Fig. 2*

## The Circuit

The circuit of the Bantam appears in Fig. 1. The input signal is applied to the grid of $V_{1(a)}$, this being the triode section of an ECF80. $V_{1(a)}$ functions as a triode voltage amplifier and compensates for the loss of signal voltage occurring in the subsequent tone control circuit. A small degree of current negative feedback is applied to the input stage by means of the un-bypassed cathode resistor $R_3$.

### Components List

*Resistors*

- $R_1$ 1MΩ ⅛W 20%
- $R_2$ 100kΩ ½W 20%
- $R_3$ 1.2kΩ ¼W 20%
- $R_4$ 47kΩ ⅛W 20%
- $R_5$ 39kΩ ¼W 20%
- $R_6$ 68kΩ ¼W 20%
- $R_7$ 6.8kΩ ¼W 20%
- $R_8$ 1kΩ ⅛W 20%
- $R_9$ 470kΩ ¼W 20%
- $R_{10}$ 100kΩ ¼W 20%
- $R_{11}$ 1.8kΩ ¼W 20%
- $R_{12}$ 100Ω ¼W 20%
- $R_{13}$ 22kΩ ½W 20%
- $R_{14}$ 1MΩ ¼W 20%
- $R_{15}$ See text
- $R_{16}$ 470Ω 5W 20%
- $R_{17}$ 100Ω ¼W 20%
- $R_{18}$ 10kΩ ⅛W 20%
- $R_{19}$ 150Ω ½W 20%
- $R_{20}$ For 15Ω output 22kΩ ¼W 20%<br>For 3.75Ω output 10kΩ ¼W 20%

*Condensers*

- $C_1$ 16μF 275 W.V. Daly
- $C_2$ 0.02μF 350 W.V. static
- $C_3$ 560pF silver mica, R.B.S.
- $C_4$ 8,000pF silver mica, R.B.S.
- $C_5$ 2,000pF silver mica, R.B.S.
- $C_6$ 0.02μF Moldseal
- $C_7$ 0.1μF 350 W.V. Static
- $C_8$ 0.05μF 350 W.V. Static
- $C_9$ 50μF 12 W.V. Daly
- $C_{10}$, $C_{13}$ 50+50μF, 350 W.V., with clip, Daly
- $C_{11}$ 8μF 350 W.V. Daly
- $C_{12}$ 50μF 25 W.V. Daly

*Potentiometers*

- $VR_1$ 250kΩ Log., A.B. Metal
- $VR_2$ 250kΩ Log with switch
- $VR_3$ 1MΩ Log., A.B. Metal

*Valves*

- $V_1$ ECF80
- $V_2$ 6BQ5 or EL84
- $V_3$ EZ81

*Miscellaneous* (all available from H. L. Smith & Co. Ltd.)

- $T_1$ Mains Transformer, 250–0–250V 100mA 6.3V 3.5A, 6.3V 1A
- $T_2$ Output Transformer, Electro-Voice D91
- Valveholder B9A (2)
- Valveholder B9A with skirt (1)
- Mains plug and socket, Bulgin
- Speaker plug and socket (3-pin), Cinch
- Power output plug and socket (4-pin), Cinch
- Input plug and socket, coaxial
- Mains selector, fused 2A
- Tagstrips, 12-way (pair)
- Wire, sleeving, screws, nuts
- Chassis, punched, bronze
- Control panel, gold hammered
- Control knobs, gold insert (3)

The signal on the anode of $V_{1(a)}$ is fed to the tone control circuit around potentiometers $VR_1$ and $VR_2$. This circuit[1] is one which has been well-proven in practice, and was successfully incorporated in the Cooper-Smith Mark II Control Unit.[2] The output from the tone control circuit is applied to the upper terminal of $VR_3$, the volume control; the signal level tapped off by the slider of this control being fed, via the grid-stopper $R_8$, to the pentode section, $V_{1(b)}$ of the ECF80.

The pentode also functions as a voltage amplifier, the amplified signal appearing across its anode load, $R_{10}$. Due to the choice of valve and operating conditions, $V_{1(b)}$ anode has a relatively low impedance to chassis. The anode of $V_{1(b)}$, working at this relatively low impedance, then drives the grid of the output valve, $V_2$, via the grid stopper, $R_{18}$.

The output valve functions in conventional manner, feeding into the speaker transformer $T_2$, the secondary of which connects to the loudspeaker output socket. In the main circuit diagram the two secondary windings are connected in series, thereby offering an output impedance of 15Ω. In the "inset", the secondary windings are connected in parallel, offering an output impedance of 3.75Ω.

Negative feedback is obtained from the secondary of the speaker transformer via $R_{20}$. This resistor, with $R_{12}$, forms a fixed potentiometer which causes a proportion of the secondary output voltage to be injected

1 "Design for a Pre-Amplifier", D. H. W. Busby, *Wireless World*, July 1955.

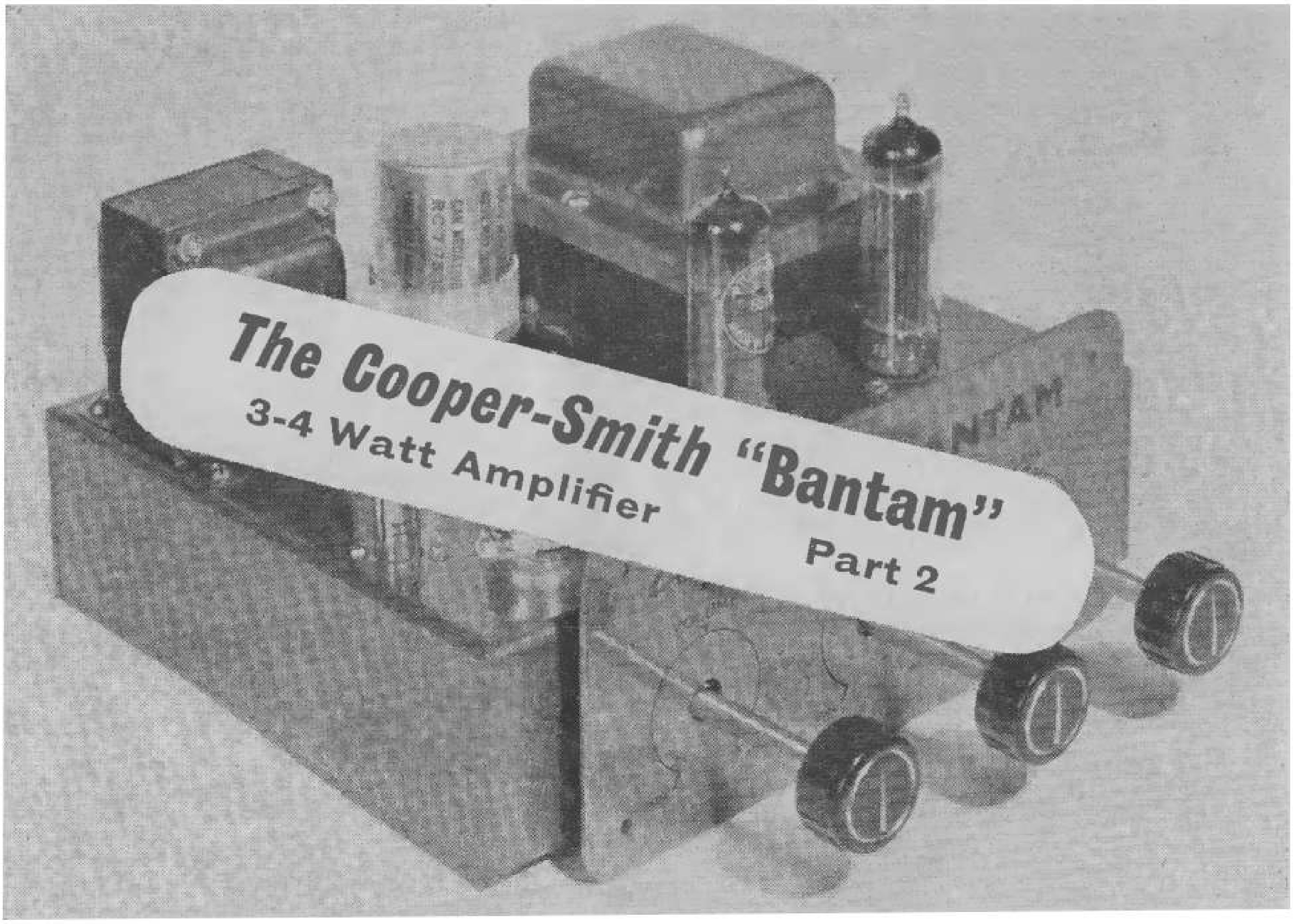
2 "The Cooper-Smith Mark II Control Unit", J. Cooper, *The Radio Constructor*, February, 1958.

into the cathode of $V_{1(b)}$. For 15Ω output operation $R_{20}$ has a value of 22kΩ. For 3.75Ω output operation (in which half the signal voltage given for 15Ω operation is available across the secondary of $T_2$) $R_{20}$ has a value of 10kΩ.

H.T. power in the "Bantam" is obtained by means of a mains transformer having a full wave h.t. secondary, rectification being provided by $V_3$. $V_3$ cathode connects into the filter components $C_{13}$, $R_{16}$, and $C_{10}$, the output valve, $V_3$, obtaining its h.t. supply from the smoothed voltage appearing across the latter condenser. Further smoothing is provided by $R_{13}$ and $C_1$, the voltage across $C_1$ being employed for $V_{1(a)}$ and $V_{1(b)}$.

The power supply has been designed to provide an h.t. output of 250 volts at a maximum current of 100mA. The amplifier current requirement is 55mA only, with the result that an h.t. voltage of 250, with a maximum current of 45mA, becomes available for ancillary equipment such as radio tuners, etc. Such equipment may obtain h.t. and heater power from the power output socket shown in Fig. 1. Since individual requirements may vary, a value for the h.t. series resistor, $R_{15}$, has not been specified; this being chosen to suit the particular needs of the equipment envisaged. If, to take an example, the ancillary equipment were to require an h.t. supply of 200 volts at 40mA, then $R_{15}$ would be required to drop 50 volts (from the 250 volts available in the amplifier) at this current. From Ohms Law $R=\frac{E}{I}$ the required value for $R_{15}$ under these circumstances would be $\frac{50}{0.04}=1{,}250\Omega$. Should the amplifier be purchased in kit form, either the value for $R_{15}$, or the voltage and current requirements of the associated equipment, should be specified.

A 6.3V heater supply is also available at the power output socket, this being obtained from the same heater winding of the mains transformer which feeds the heaters of $V_{1(a)}$, $V_{1(b)}$, and $V_2$. The heater current available at the socket is 2A.




## Described by W. Holmes

*This concluding article gives full constructional details of an inexpensive amplifier which is capable of a very high performance level*

### Construction

Construction of the Cooper-Smith "Bantam" is a relatively simple procedure. The photographs accompanying this article show very clearly the clean and neat layout employed, and they will be of assistance during the process of mounting components and wiring up. A layout and wiring diagram is given in Fig. 2, this showing the position of all components and connections. It will be noted, in Fig. 2, that individual tags on potentiometers, valveholders, sockets and the mains voltage selector panel are numbered. These numbers correspond to those appearing in the circuit diagram of Fig. 1. Also shown numbered are the tags on the two 12-way tagstrips. All these tags are referred to by their numbers in the step-by-step instructions which follow. The rear apron of the chassis in Fig. 2 is shown opened out in order that connections made to the components mounted on it may be illustrated more clearly.

### Step-by-Step Instructions

Construction proceeds as follows:

1. Fit the mains socket, mains selector panel, power output socket and speaker socket to the rear apron. All these are fitted from the inside except for the mains socket.

2. Fit the mains transformer $T_1$, ensuring that its tags take up the position shown in Fig. 2. Also, fit the speaker transformer $T_2$, bringing its leads out as shown in Fig. 2. It is necessary for the lower right-hand nut (adjacent to the tag—fitted later—numbered 23 in Fig. 2) to make good contact to chassis. Ensure good contact by scraping, or cleaning, the underside of the chassis before this nut is fitted.

3. Fit the dual condenser $C_{10}$, $C_{13}$, ensuring that the tag marked red is nearest the mains transformer $T_1$. Make certain of good chassis contact to the condenser clip by scraping the underside of the chassis at the points where the mounting nuts tighten down.

4. Fit the input socket, ensuring correct orientation (its earthy tag, 2, should take up the position shown in Fig. 2). Again, scrape the chassis to ensure good contact to its mounting nuts.

5. Fit the valveholders, ensuring correct orientation. Note that $V_1$ valveholder has a contact) to the hole hear $V_2$. ($R_{18}$—fitted later—is above this hole in Fig. 2.) Mount the two 12-way tagstrips as shown in Fig. 2. The lower tagstrip is mounted over the 6BA bolt just fitted, and over the outside bolt securing the input socket. The upper tagstrip is mounted over the lower right hand

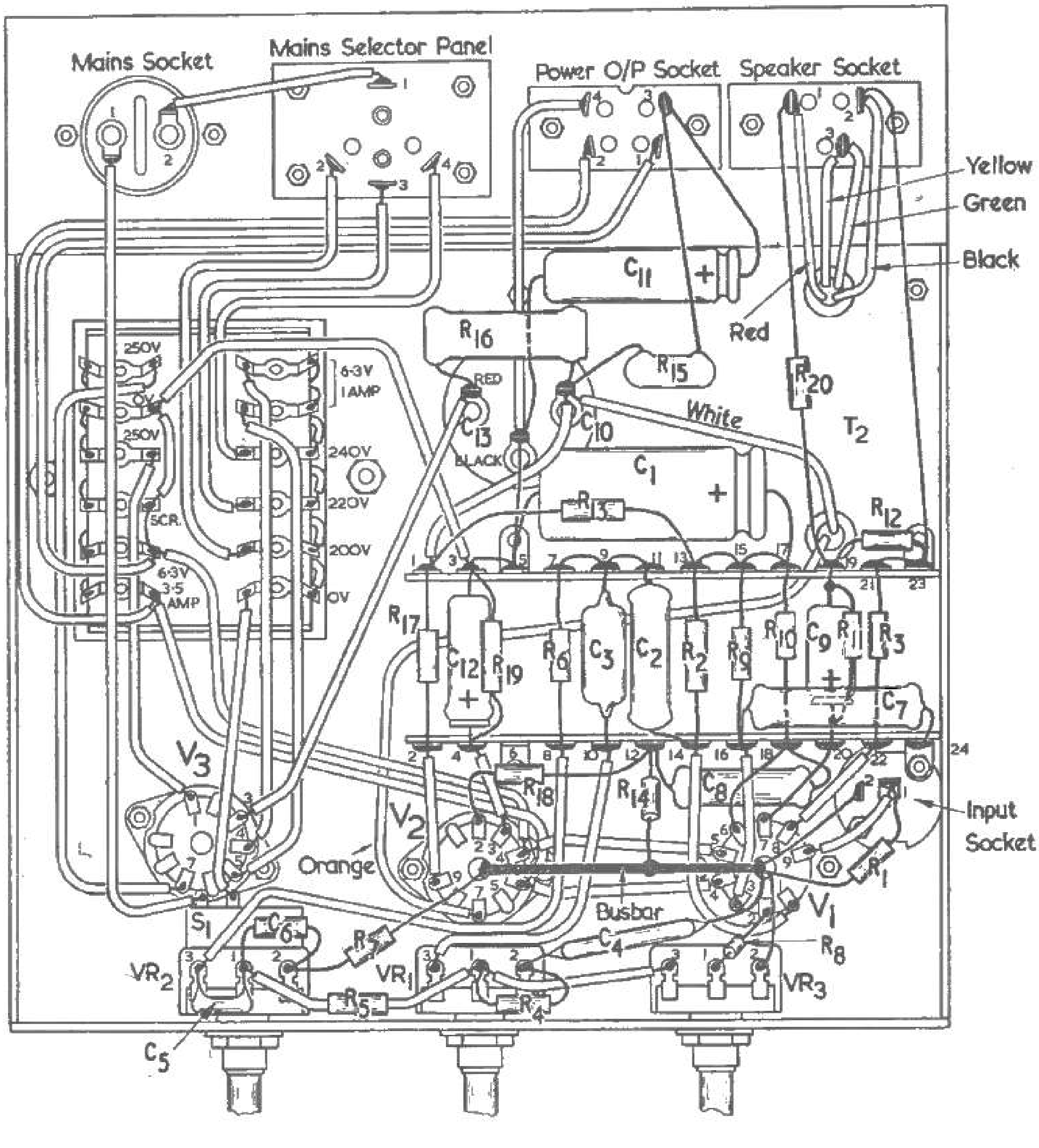


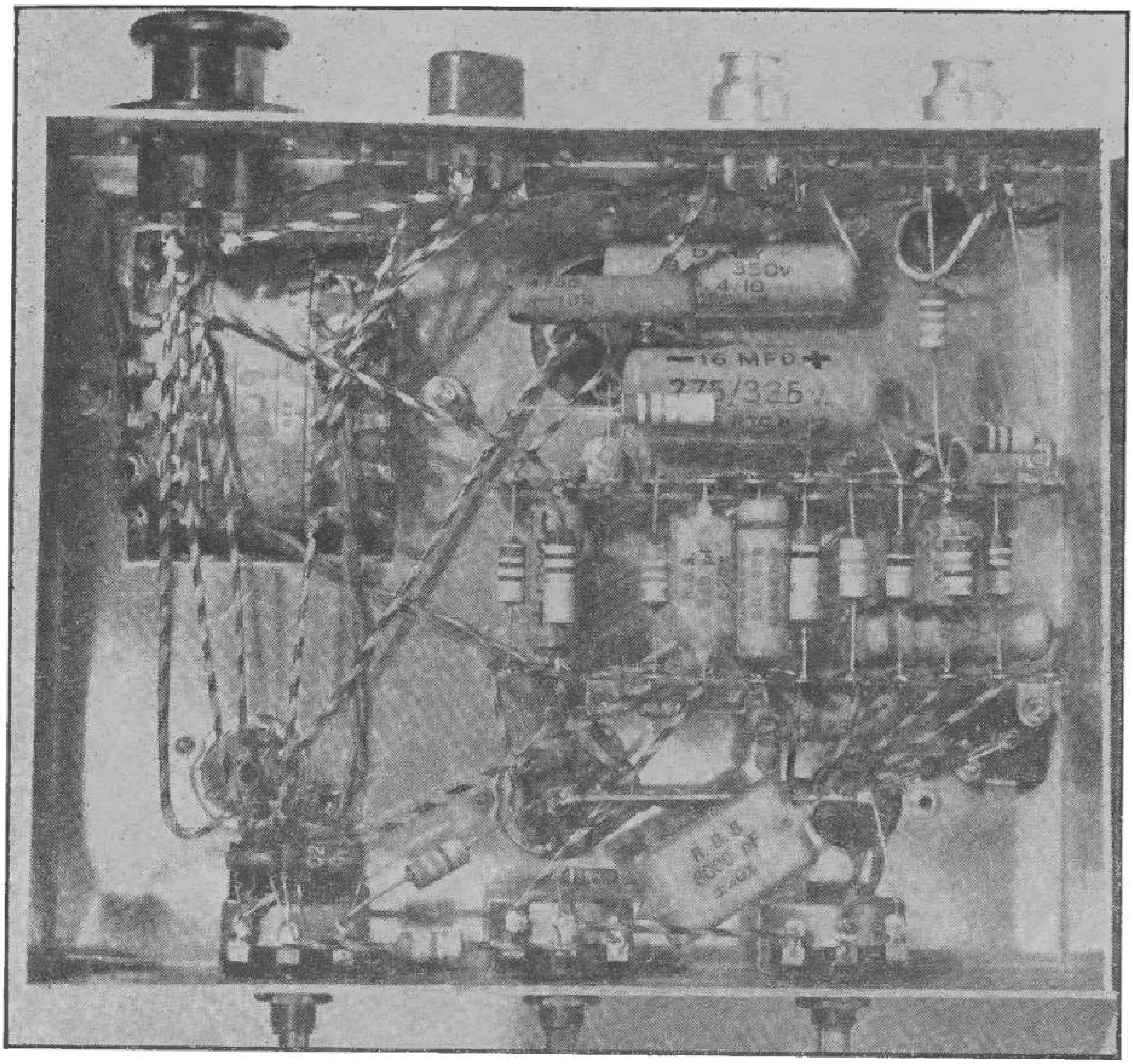

FIG.2.
Layout and Wiring Diagram.
M821

*Fig. 2. Layout and wiring diagram. The rear apron of the chassis is laid flat to show the connections to the rear sockets and the mains selector panel more clearly*

skirt (see photographs) and is mounted above the chassis, and that $V_2$ and $V_3$ valveholders are mounted below. Scrape the chassis to ensure good contact to the securing nuts for $V_1$ valveholder.

6. Fit a 6BA nut and bolt (again scraping the underside of the chassis to give good bolt securing the speaker transformer (referred to in step 2) and the lower bolt securing the dual condenser $C_{10}$, $C_{13}$. Both tagstrips are mounted over the nuts which have previously been tightened, and are secured by fitting additional nuts.

7. Fit the three potentiometers $VR_1$, 2



*Under-chassis view of the "Bantam". This view, which demonstrates the clean wiring layout, may be compared with Fig.* 2

and 3, to the front panel as shown in Fig. 2 (noting the locating holes in the chassis).

### Wiring Up

Wiring up now commences. In order that all connections may be made to each individual tag before they are soldered to that tag, soldering should only be carried out where stated.

8. Using twisted wiring, connect in parallel pins 4 and 5 of $V_1$, pins 4 and 5 of $V_2$, the 6.3V 3.5A tags on $T_1$, and tags 1 and 2 on the power output socket. Solder all these joints except the 6.3V 3.5A tag on $T_1$ adjacent to the "SCR" tag. Also using twisted wiring, connect in parallel, and solder, pins 4 and 5 of $V_3$ and the 6.3V 1A tags on $T_1$. (Fig. 2 shows this wiring step with untwisted wire for ease of circuit tracing.)

9. Carefully following Fig. 2, connect the 6.3V 3.5A tag on $T_1$ adjacent to the "SCR" tag to that tag, carrying on to the 0V tag (h.t. secondary) on $T_1$, and to tag 3 of the tagstrips. Solder all joints except tag 3.

10. Carefully following Fig. 2, connect 0V tag (mains primary) on $T_1$, to one tag of switch $S_1$ and solder. Connect 200V tag on $T_1$ to tag 2 of mains selector panel and solder. Connect 220V tag on $T_1$ to tag 3 of mains selector panel and solder. Connect 240V tag on $T_1$ to tag 4 of mains selector panel and solder. Connect the two 250V tags on $T_1$ to pins 1 and 7 of $V_3$ and solder.

11. The speaker transformer, $T_2$, is next connected into circuit. Connect its orange lead (following route in Fig. 2) to pin 7 of $V_2$ and solder. Connect its white lead (following route in Fig. 2) to C10.

12. *For* 15Ω *output only.* Connect red lead

of $T_2$ to tag 1 of speaker socket. Connect black lead of $T_2$ to tag 2 on speaker socket. Connect yellow and green leads to tag 3 on speaker socket, soldering at tag 3. These connections are shown in Fig. 2.

13. *For* 3.75Ω *output only*. Connect red and yellow leads of $T_2$ to tag 1 on speaker socket. Connect green and black leads of $T_2$ to tag 2 on speaker socket. These connections are **not** shown in Fig. 2.

14. Tagstrip connections come next. Connect $R_{17}$ (100Ω) between tags 1 and 2.

15. Connect $R_{19}$ (150Ω) and $C_{12}$ (50μF, 25 W.V.) between tags 3 and 4, observing correct polarity in $C_{12}$. Join tags 3 and 5. Solder tag 3.

16. Connect $C_1$ (16μF, 275 W.V.) between tags 5 and 17, observing correct polarity.

17. Connect $R_6$ (68kΩ) between tags 7 and 8.

18. Connect $C_3$ (560pF) between tags 9 and 10.

19. Connect $C_2$ (0.02μF) between tags 11 and 14. Join, and solder, tags 7, 9 and 11.

20. Connect $R_2$ (100kΩ ½W—as opposed to the ¼W $R_{10}$) between tags 13 and 14.

21. Connect $R_9$ (470kΩ) between tags 15 and 16.

22. Connect $R_{10}$ (100kΩ) between tags 17 and 18. Join tags 13, 15 and 17, soldering at 15 and 17.

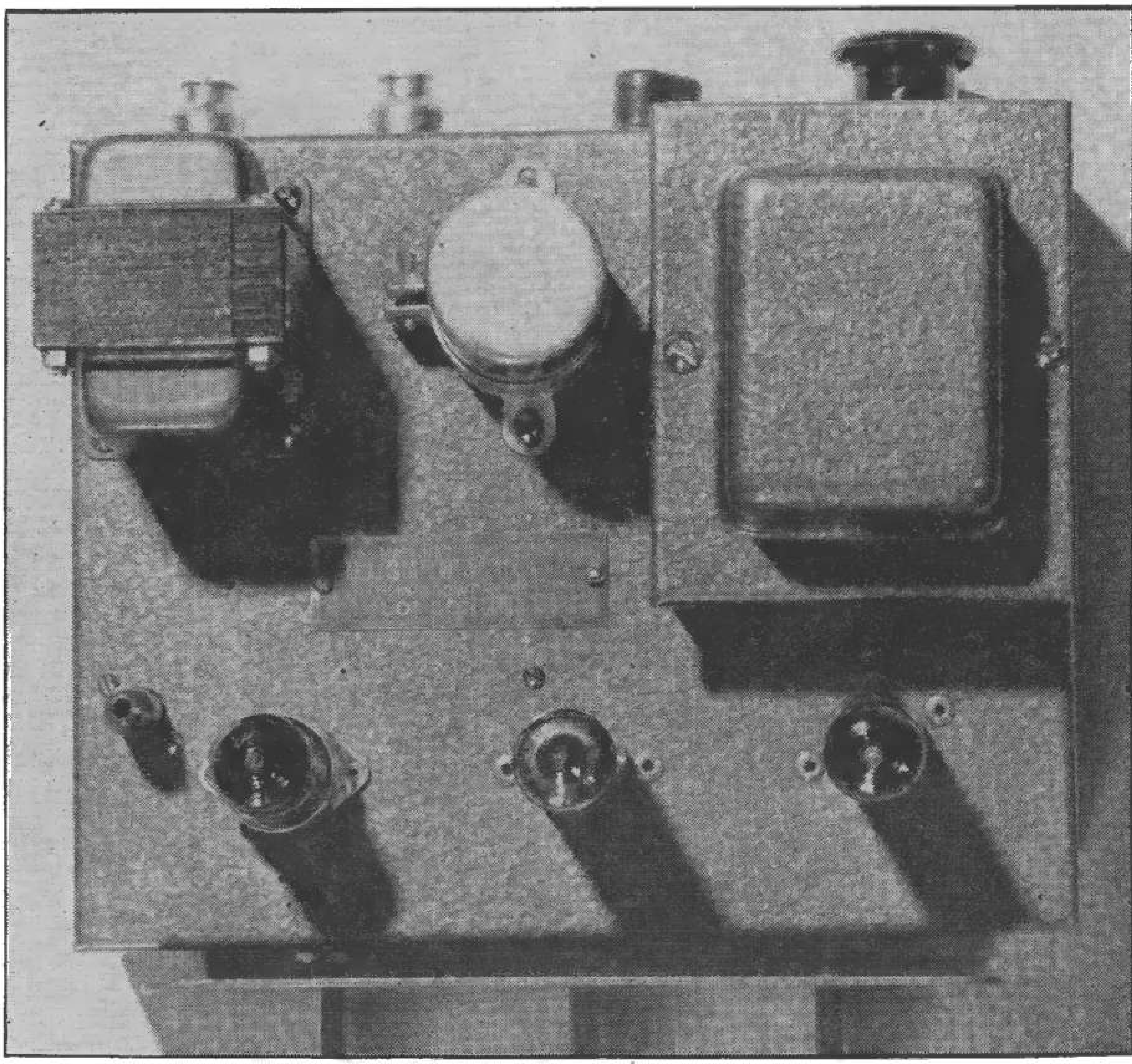
23. Connect $C_9$ (50μF, 12 W.V.) and $R_{11}$ (1.8kΩ) between tags 19 and 20, observing correct polarity of $C_9$.

24. Connect $R_3$ (1.2kΩ) between tags 21 and 22.

25. Connect $R_{12}$ (100Ω) between tags 19 and 23. Join tags 21 and 23, soldering at 21.

26. Connect $R_{13}$ (22kΩ ½W—as opposed to the ¼W $R_{20}$ when 15Ω output is used) between tags 1 and 13, soldering at 13.

27. Connect $C_8$ (0.05μF) between tags 12 and 18.



*Top view of the chassis, illustrating its neat appearance. The rectifier, $V_3$, is at the mains transformer end of the chassis, whilst $V_2$ is in the centre*

28. Connect $C_7$ (0.1μF) between tags 16 and 24, soldering at 24.

29. The rest of the wiring is now continued. Following the route shown in Fig. 2, connect pin 3 of $V_3$ to $C_{13}$, soldering at pin 3.

30. Following Fig. 2, connect and solder the remaining tag of switch $S_1$ to tag 1 of the mains socket.

31. Connect and solder tag 2 of the mains socket to tag 1 of the mains selector panel.

32. Following Fig. 2, identify the negative (black) tag of $C_{10}$, $C_{13}$. All the following connections involve this tag. Connect the negative tag of $C_{10}$, $C_{13}$ to tag 5 on the tagstrips, soldering at tag 5. Connect the negative tag of $C_{10}$, $C_{13}$ to tag 4 on the power output socket, soldering at tag 4. Connect $C_{11}$ (8μF, 350 W.V.) between the negative tag of $C_{10}$, $C_{13}$ and tag 3 on the power output socket, observing correct polarity. Solder at negative tag of $C_{10}$, $C_{13}$.

33. Following Fig. 2, connect $C_{10}$ to tag 1 on the tagstrips, soldering at tag 1.

34. Following Fig. 2, connect $R_{16}$ (470Ω) between $C_{10}$ and $C_{13}$, soldering at $C_{13}$.

35. Following Fig. 2, connect and solder $R_{15}$ (value according to requirements—see above) between $C_{10}$ and tag 3 on the power output socket.

36. Connect and solder $R_{20}$ (22kΩ for 15Ω output, 10kΩ $\frac{1}{4}$ watt, as opposed to the $\frac{1}{8}$ watt R18, for 3.75Ω output) between tag 19 of the tagstrips and tag 1 on speaker socket.

37. Join, and solder, tag 23 of the tagstrips to tag 2 on speaker socket.

38. Join tag 1 on input socket to pin 9 of $V_1$. Solder at pin 9.

39. Bend the supplied thick piece of wire at right angles, $\frac{3}{4}$in in from each end, and solder to centre spigots of $V_1$ and $V_2$ to form a busbar between them. (The bent ends enter the spigots, and the the busbar is shown in heavy line in Fig. 2.) All connections made to the busbar which follow are soldered at the busbar.

40. Join and solder pin 2 on the input socket to the busbar.

41. Connect and solder $R_1$ (1MΩ $\frac{1}{8}$W —as opposed to the $\frac{1}{4}$W $R_{14}$) between tag 1 of the input socket and the busbar.

42. Join and solder pin 8 of $V_1$ and tag 22 of the tagstrips.

43. Join and solder pin 7 of $V_1$ and tag 20 of the tagstrips. Use sleeving (omitted from Fig. 2 for clarity).

44. Join and solder pin 6 of $V_1$ and tag 18 of the tagstrips. Use sleeving (omitted from Fig. 2 for clarity).

45. Join and solder pin 3 of $V_1$ and tag 16 of the tagstrips.

46. Join and solder pin 1 of $V_1$ and tag 14 of the tagstrips.

47. Connect and solder $R_8$ (1kΩ) between pin 2 of $V_1$ and tag 1 of $VR_3$.

48. Connect $R_{18}$ (10kΩ) between pin 2 of $V_2$ and tag 12 of the tagstrips. Solder at pin 2.

49. Join and solder pin 3 of $V_2$ and tag 4 of the tagstrips.

50. Join and solder pin 9 of $V_2$ and tag 2 of the tagstrips.

51. Join tag 3 of $VR_2$ to tag 8 of the tagstrips, and solder at tag 8. Follow route shown in Fig. 2.

52. Join and solder tag 3 of $VR_1$ to tag 10 of the tagstrips. Follow route shown in Fig. 2.

53. Connect and solder $R_{14}$ (1MΩ) between tag 12 of the tagstrips and the busbar.

54. Connect $C_5$ (2,000pF) between tags 1 and 3 of $VR_2$. Solder at tag 3.

55. Connect $C_6$ (0.02μF) between tags 1 and 2 of $VR_2$.

56. Connect and solder $R_7$ (6.8kΩ) between tag 2 of $VR_2$ and the busbar.

57. Connect $R_5$ (39kΩ) between tag 1 of $VR_2$ and tag 1 of $VR_1$. Solder at tag 1 of $VR_2$.

58. Join tag 1 of $VR_1$ and tag 3 of $VR_3$. Solder at tag 3.

59. Connect $R_4$ (47kΩ) between tags 1 and 2 of $VR_1$. Solder at tag 1.

60. Connect and solder $C_4$ (8,000pF) between tag 2 of $VR_1$ and the busbar.

61. Join and solder tag 2 of $VR_3$ to busbar.

62. Fit valves and knobs.

**Operation**

The Cooper-Smith "Bantam" is now complete and ready for operation.

The voltage selector panel should be set to the mains voltage with which the amplifier is to be used. The main input fuse (rating 2A) is housed in the bridging plug of the panel. The speaker should be connected to pins 1 and 2 of the speaker socket (tag 3 of this socket, used for the 15Ω output impedance connection, is an anchoring tag only).

The input sensitivity of the amplifier is 60mV for 3 watts output, and care should be taken to avoid applying excessive inputs. If the associated radio tuner or pick-up provides an output considerably in excess of 60mV it will be necessary for this to be attenuated before coupling to the amplifier. Suitable attenuation will normally be given by providing a pre-set potentiometer before the input socket, this being adjusted until a smooth control is provided by $VR_3$. As a rough guide to the correct setting of such a potentiometer, the amplifier should begin to overload when $VR_3$ is some three-quarters advanced.