Both power transistors should have a solder tag attached to their upper mounting bolts to make convenient connection to transistor collectors. Without insulating washers, TR3 and TR4 heat sinks will be "live", but damage is unlikely to result in the event of an accidental short-circuit.

Insert capacitors C1–C4 in clips, with polarity as indicated on Fig. 3.4. Also observe correct polarity when mounting diodes D1–D4. Before wiring up all components, insert R3 in the panel, alongside TR3 heat-sink.

COLOUR CODED WIRE

Wiring can start at the input end of the panel, with 6in lengths of orange, black, and green multi-stranded wire soldered to the live, neutral, and screen tags on the mains transformer. Red and blue wires are reserved exclusively for 12·5V d.c. positive and negative supply rails, with green wiring as the common earth throughout the computer.

Wire colour coding is almost essential for computer circuit interconnection, as it enormously simplifies fault tracing and assembly. However, the wiring of individual circuits, such as the power pack panel, can take the form of single colour sleeved 20 s.w.g. tinned copper wire.

It will be noticed (Fig. 3.4) that TR1 and TR2 are supported only by their leads, and this is to allow best positioning for good ventilation, well away from heat sinks. In the prototype R7 was made up from two 0·7A power resistor sections, to allow for the optional extra current facility mentioned earlier.

When power pack wiring is completed and checked, multiple solder tags can be fitted to the three output terminal screws.

TESTING THE POWER PACK

Connect the transformer input leads to the mains socket on the side panel of the UNIT "A" box, with the organge lead taken via FS1 (see Fig. 2.10 and Fig. 3.1), and, also join the neon indicator leads to the live and neutral mains socket screws.

Turn VR1 and VR2 fully anticlockwise and switch on. A quick check with a voltmeter will show if there is any serious departure from the voltages shown in Fig. 3.1. If any overheating of heat sinks or mains transformer seems imminent, switch off immediately and locate fault.

To set up the power pack, apply voltmeter leads to earth and positive output terminal, and advance VR1 for a reading of 12·5V. Repeat the procedure for the negative output and VR2. If it is impossible to bring an output to 12·5V, this will indicate a wiring fault or trouble with a regulator diode.

After the power pack has been left on for some time, VR1 and VR2 can be finally trimmed for exact outputs of $\pm$12·5V. With no external load on the power supply, TR3 and TR4 heat sinks can be expected to run fairly warm.

To ensure that power pack regulation conforms to the curve of Fig. 3.2, positive and negative outputs can be loaded by a selection of 5W resistors in series with an ammeter, while voltage is still being monitored. A worst case variation of 2 per cent change in voltage for 300mA change in current should be taken as an acceptable performance limit. When one half of R7 is temporarily shorted out, at least 50 per cent more current should be available before voltage drops beyond 2 per cent.

Locate the power pack inside the UNIT "A" box, and wire outputs to the main terminals TL1, TL2, and TL3. Voltage source dial alignment and setting up details will be discussed later, but a few rough checks with power on are in order, to see that all voltage source sockets and switches are functioning correctly.

OPERATIONAL AMPLIFIER

The most important analogue computing circuit is the operational amplifier; so named because it will perform a number of mathematical operations, such as addition, subtraction, change of sign, multiplication by a constant, division by a constant, and integration. All the thinking behind "op-amp" design is concerned with making the circuit as unobtrusive as possible, so that it can be regarded purely as an operational "black box".

An analogue computer d.c. operational amplifier should comply with the following general requirements.

(a) Direct coupling between all stages to handle d.c. signals. Input and output terminals at earth potential in the absence of a signal, with 180 degree phase change (inversion) between input and output. Output voltage swings both positive and negative in relation to earth, and as large as the computer reference voltage ($\pm$10V).
(b) Large voltage gain in the open-loop configuration.
(c) Low output impedance.
(d) High input impedance.
(e) Very low input current.
(f) Sufficient bandwidth to cause negligible phase shift or attenuation of a signal up to the highest frequencies encountered.
(g) Insignificant output voltage drift over several hours.
(h) Good margin of stability when subjected to a wide range of different input, output, and feedback conditions.

Performance figures for UNIT "A" operational amplifiers are given in the Table 3.1, but to fully understand how some of the design problems are solved it is necessary to consult the actual "op-amp" circuit of Fig. 3.7.

OPERATIONAL AMPLIFIER CIRCUIT

The input stage of circuit Fig. 3.7 consists of a long-tailed pair (TR1, TR2), offering the advantages of high voltage gain, near zero input offset voltage relative to