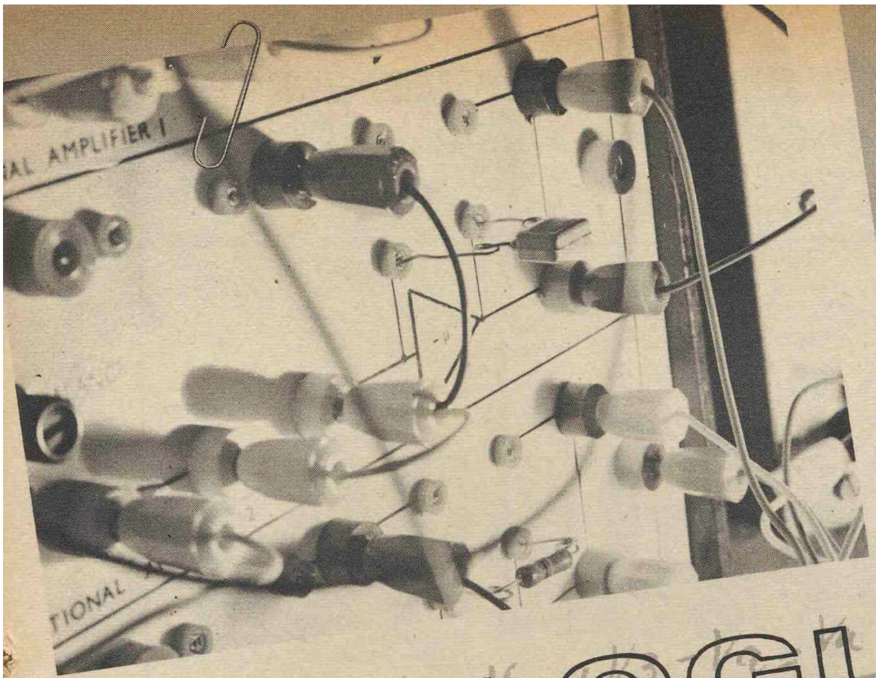


PEAC ANALOGUE COMPUTER

By D. BOLLEN

BEFORE embarking on constructional details, a few words must be said concerning measuring and test equipment required.

VOLTAGE STANDARD

It is necessary, at an early stage of computer construction, to establish a voltage standard for setting up the PEAC circuits.

Since *relative* voltage levels are more important than *absolute* levels, one particular voltmeter of proven reliability can serve as a voltage standard, and this might well be a reputable testmeter which has a large scale conveniently calibrated in terms of 0–10 volts, with a d.c. sensitivity of not less than 20,000 ohms per volt. Even if the testmeter has an error of 2 per cent of the indicated reading on d.c. ranges, it should be capable of reproducing a given reading, from day to day under similar room temperature conditions, with much greater accuracy.

In addition to use as a voltage standard, the testmeter can, of course, be employed for setting up problems, answer readout, comparative resistance checks, and for general testing of all circuits. There is nothing to prevent re-calibration of the computer to laboratory voltage standards at a later date, and this has been allowed for in the overall design of PEAC.

COMPUTER INSTRUMENTATION

Analogue computer instrumentation has much in common with electronic workshop equipment. Among those instruments likely to be of use to the computer operator are: an oscilloscope, a small collection of d.c. voltmeters, an audio oscillator, an a.c. voltmeter, and a component measuring bridge.

The oscilloscope need not conform to a modern specification, and could be a government surplus item. However, it is often an advantage to have a large screen area, and redundant television sets can be converted for computer readout purposes with excellent results. The limited bandwidth of magnetic deflection is no disadvantage at normal computer operating speeds.

D.C. voltmeters with centre zero scales are very useful for rough checks on the terms of a computer equation, where, for example, the wish is to see how y varies in relation to x when manipulating a simultaneous equation.

A sine wave oscillator, with attendant a.c. voltmeter, will often be employed for work on transfer functions, and for general electronic circuit simulation.

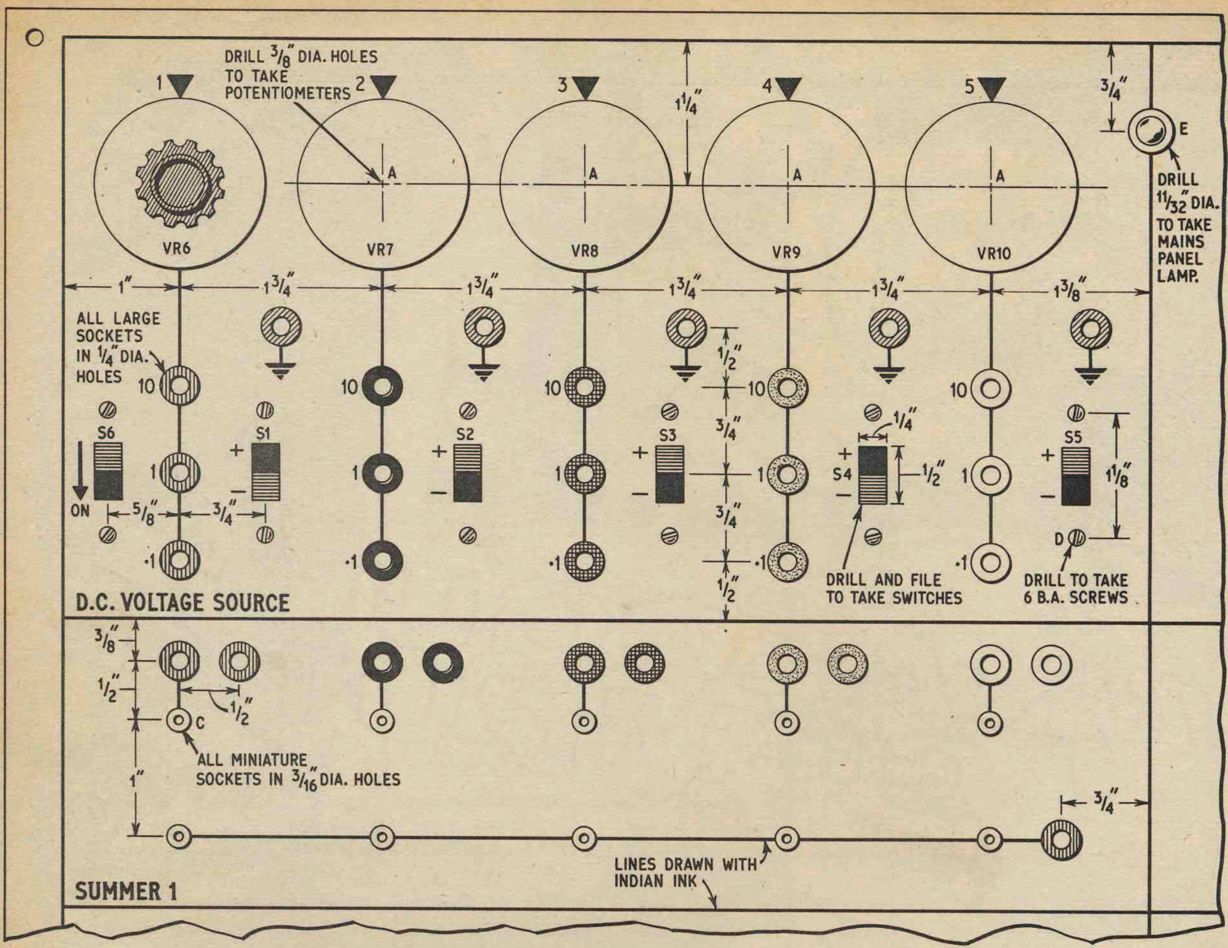
Finally, the component bridge is a help when making-up plug-in computing components, and for locating possible sources of error.

It is assumed that special classes of equipment, such as the XY plotter, will not be available to the amateur, and they are therefore excluded from further mention.

UNIT "A" CONSTRUCTION

The general form of construction adopted for PEAC is based on a series of boxes made with laminates of white Armaboard or Formica and hardboard. The resulting box is rigid and durable, with a surface which easily takes panel transfers and lines drawn in Indian ink. With such a construction, it is possible to achieve a professional appearance using only simple woodworking tools.

It is advisable to start with the UNIT "A" front panel and case. This slightly unusual procedure, of building the box before starting on internal circuits,



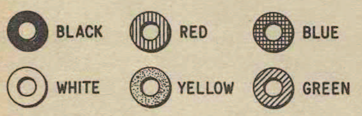


Fig. 2.2. Left-hand portion of front panel. Drilling details, layout of components, and panel engraving. (Below the broken line, there are two further sections, each a replica of "Summer 1")

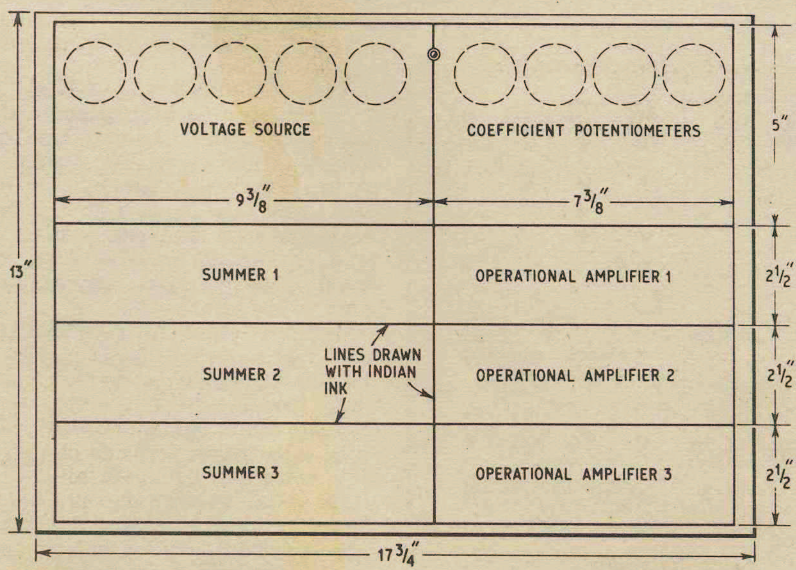


Fig. 2.1. UNIT "A" front panel. Overall dimensions and sectional dividing lines

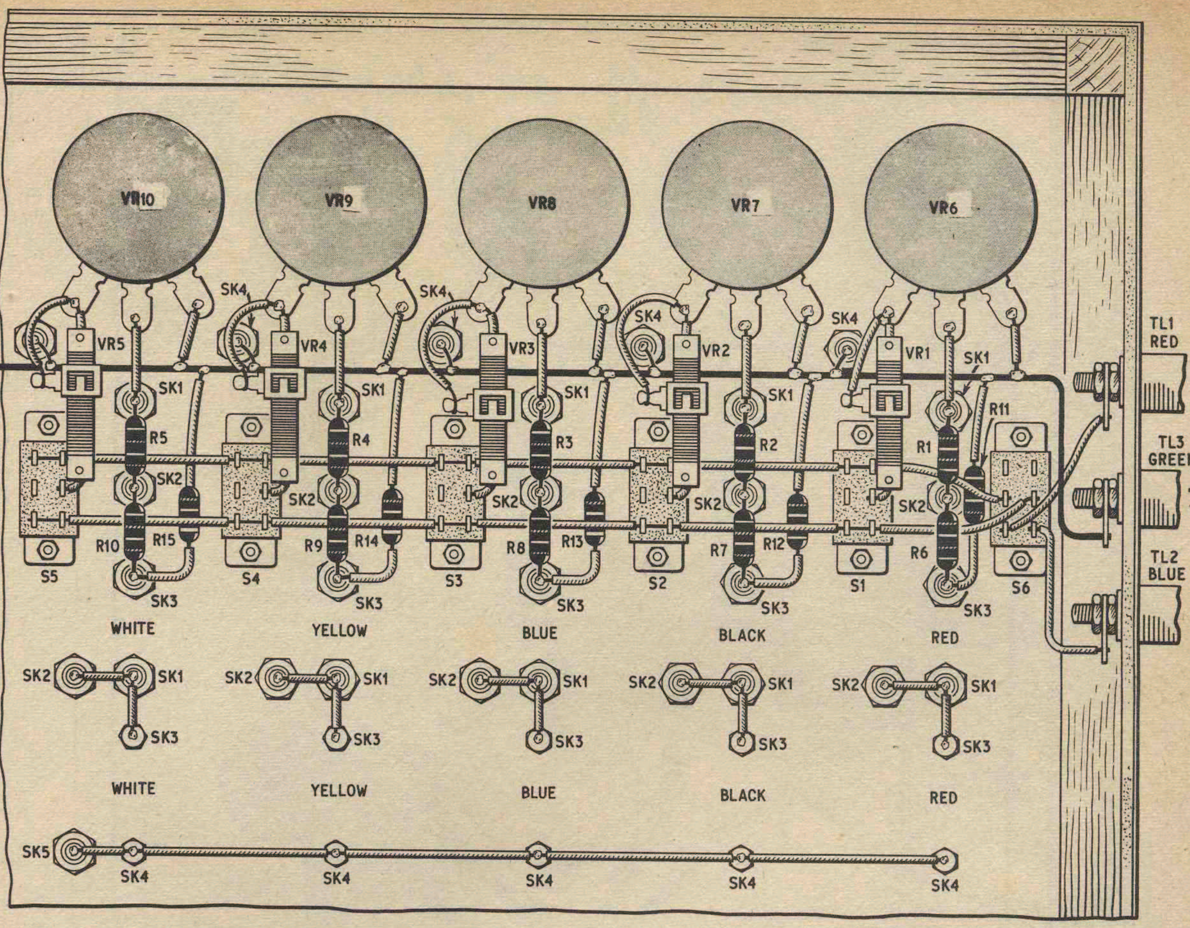
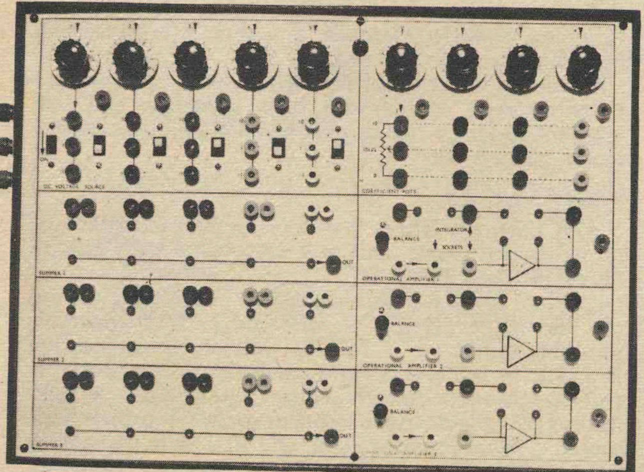


Fig. 2.3. Reverse side of front panel, left-hand portion (Fig. 2.2), showing components and wiring. Summer 2 and 3 are wired exactly as Summer 1 shown here. The three terminals TL1, 2 and 3 are mounted on the side of the box



UNIT "A" front panel

may be justified on two counts: firstly, the front panel really forms a circuit which is designed to be accessible, and is an important part of the unit; secondly, the method of construction chosen brings economy by dispensing with a self-supporting internal chassis assembly, and much of the internal gear is actually mounted on the front panel, or to the box itself.

UNIT "A" FRONT PANEL

To prepare the front panel, a sheet of white plastic laminate, slightly larger than its finished size of 13in $\times$ 17$\frac{3}{4}$in, is glued to a sheet of hardboard of the same measurements with Evostick or a similar adhesive. When firm, the panel edges can be planed, rasped, or sandpapered down to size, while making sure that all is square. Next, taking Fig. 2.1 and the photograph of the front panel as a guide, mark out the main dividing lines with a pencil.

The positions of all holes and slots may be found by referring to panel drawings Fig. 2.2 and Fig. 2.5. Establish hole centres by first marking with a pencil, then indenting with a sharp spike. Note that all drilling should be carried out from the plastic laminate side of the panel, to avoid chipping the white surface. It is important to handle tools carefully, and prevent them skidding across the plastic surface and scoring it. When all holes have been drilled, deburr them on the reverse side of the panel with sandpaper, and check that components will fit correctly before applying a coat of clear varnish to the hardboard backing.

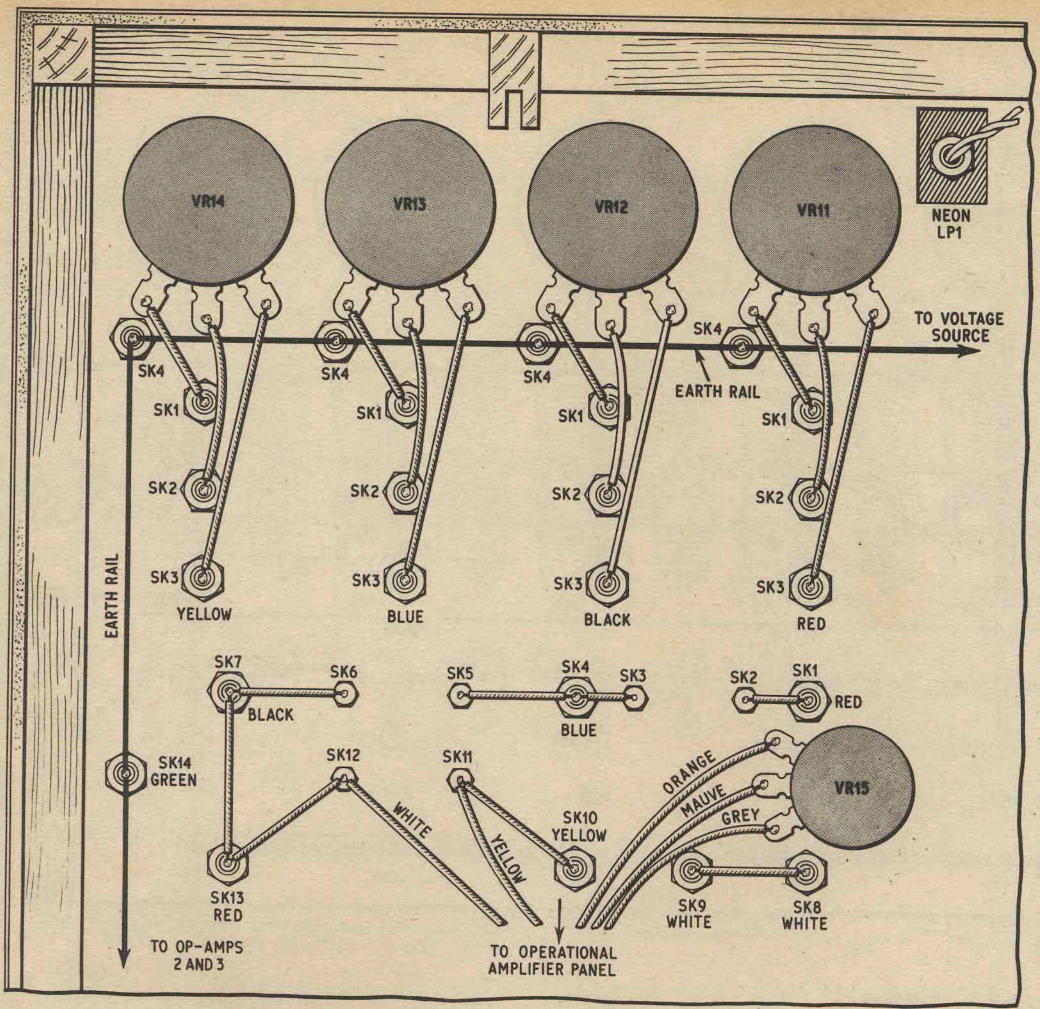
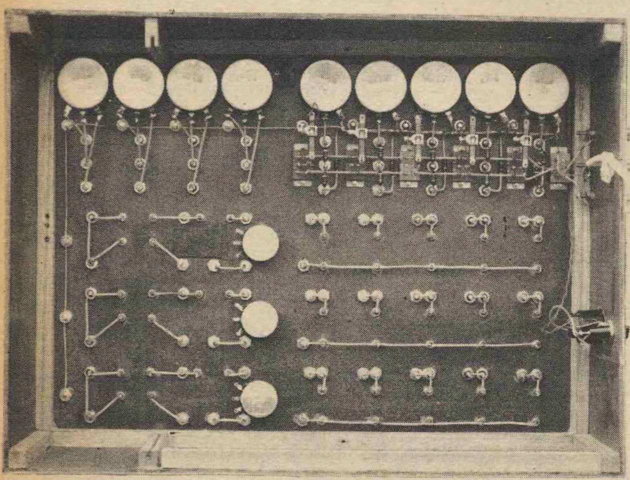


Fig. 2.4. Right-hand portion of front panel viewed from rear, showing components and wiring. Operational Amplifiers 2 and 3 are wired exactly as "Operational Amplifier 1" shown here



Rear view of UNIT "A" front panel

To finish the panel, draw in all lines and symbols with a nib pen and Indian ink. If any mistakes are made, the ink can be removed—when dry—with a typewriter eraser, and surface shine restored with metal polish. Lettering can be applied by the "rub-on" or "stick-on" transfer methods, and should be protected by a thin layer of clear varnish.

When the panel decor has dried, mount all sockets, potentiometers, knobs with dials, switches, and the neon mains lamp. Dials may be lined up on potentiometer spindles later.

UNIT "A" BOX

This time, the box is first constructed of hardboard on a wooden frame, and is later covered with plastic laminate. See Fig. 2.12.

Cut and finish the four hardboard panels to size, and cut the various lengths of softwood. The manner of assembly could be as follows: attach wood lengths *A* and *C* to top and bottom panels with panel pins or countersunk woodscrews, gluing all joints. Attach lengths *B* to side panels, bring panels together and secure. Next, position *D*, *E*, and *F*. Note that there is no length *D* at the back portion of the top panel so the slotted amplifier mount *F* should be lined up vertically with its companion *E*. All drilling must be left until the plastic laminate is in place.

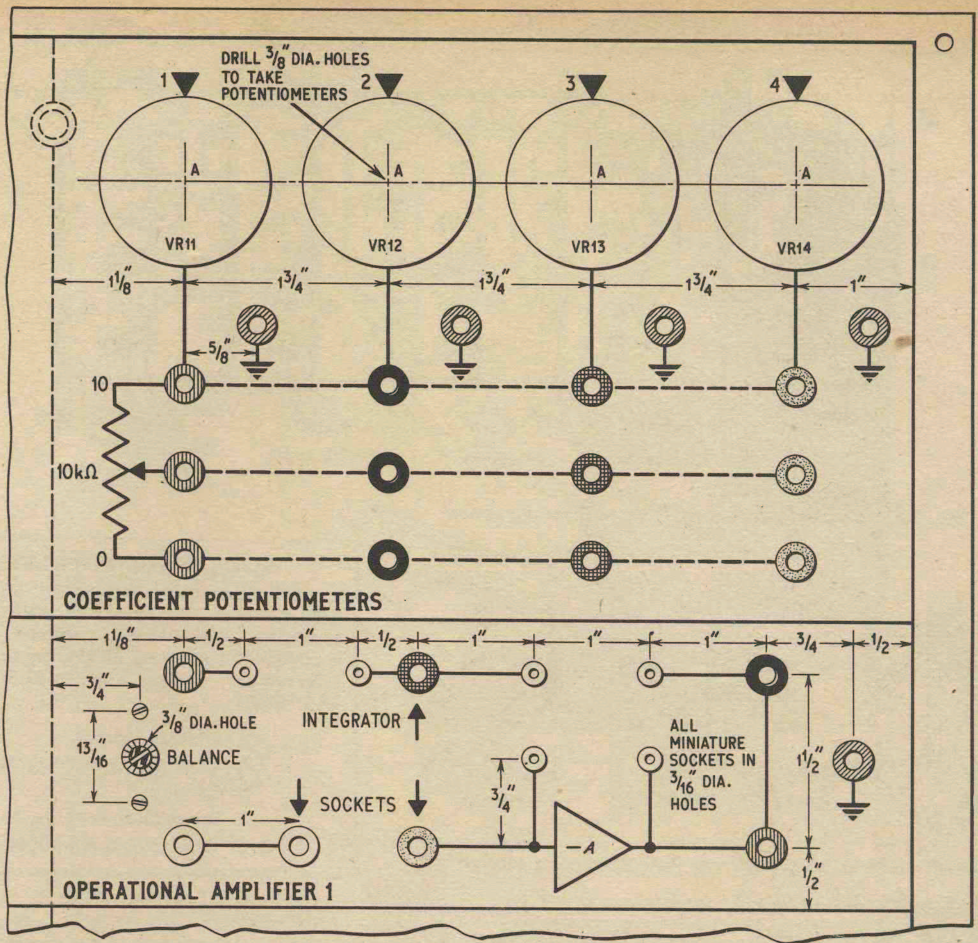


Fig. 2.5. Right-hand portion of front panel. Drilling details, layout of components, and panel engraving. Below the broken line there are two further sections, each a replica of "Operational Amplifier I"

COMPONENTS . . .

UNIT "A" FRONT PANEL AND BOX

Resistors
- R1–R5 9·1kΩ (5 off)
- R6–R10 910Ω (5 off)
- R11–R15 100Ω (5 off)
- All 5%, ½W carbon film

Pre-set Potentiometers
- VR1–VR5 250Ω miniature wirewound slider type (5 off)
- VR15–VR17 50Ω wirewound panel mounting type (3 off)

Potentiometers
- VR6–VR10 1kΩ 3W linear wirewound, ±20% or better, 270° effective rotation (5 off)
- VR11–VR14 10kΩ 3W linear wirewound, ±20% or better, 270° effective rotation (4 off)

Switches
- S1–S6 Double-pole, on/off slide switch (Radiospares) (6 off)

Plug
- PL1 3 way panel mounting mains plug and cable connector

Fuse
- FS1 1·5A cartridge fuse and 20mm fuseholder

Lamp
- LP1 Neon indicator lamp (Radiospares "miniature 200–250V panel neon" with self-contained resistor)

Sockets
- 21 Red, 15 Black, 15 Blue, 15 Yellow, 15 White, 12 Green (painted green, see text)
- 48 miniature sockets, black or red to choice

Terminals
- Insulated screw, to take 4mm stackable plugs (Radiospares). 1 Red, 1 Green, 1 Blue

Miscellaneous
- Material for panel and box: Hardboard: 2 off 13in × 5in, 2 off 18in × 5in, 1 off 13in × 17¾in. White plastic laminate: 2 off 13in × 5in, 2 off 18in × 5in, 1 off 13in × 17¾in. Softwood: 52in × ½in square, 4in × ⅞in × ⅜in.
- 20 s.w.g. tinned copper wire. Insulated sleeving

Dials and knobs
- Nine 0–10 270° dial knobs (Bulgin type K400), black or grey

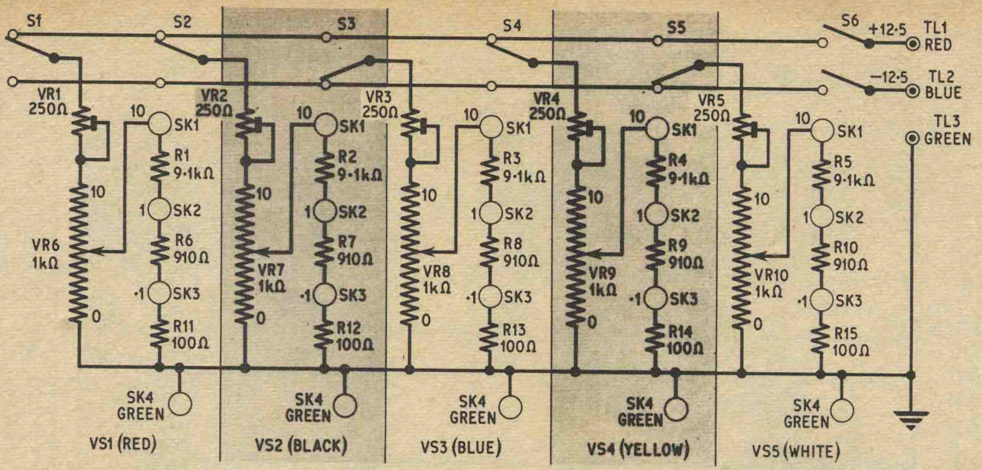


Fig. 2.6. Circuit diagram of Voltage Source section

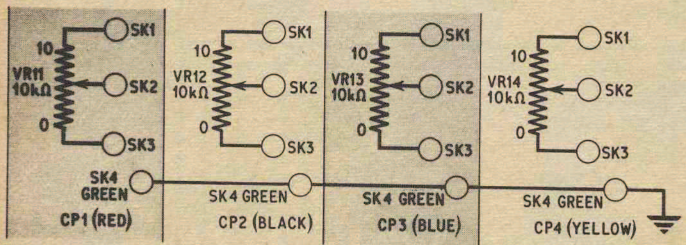


Fig. 2.7. Circuit diagram of Coefficient Potentiometers section

SOCKET IDENTIFICATION

The following abbreviations will be used in the programming instructions for PEAC. Applied as prefixes to socket (SK) numbers, they clearly establish the identity of the particular socket referred to. For example, "VS2/SK1"; "CP1/SK3" etc.

VS	Voltage source
CP	Coefficient potentiometers
S	Summer
I	Input (Summer)
OA	Operational Amplifier

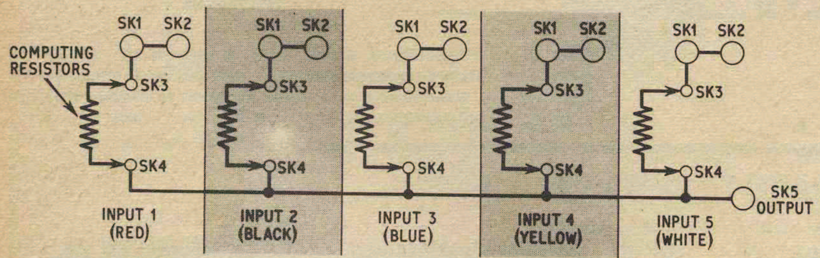


Fig. 2.8. Circuit diagram of Summer 1, 2, and 3

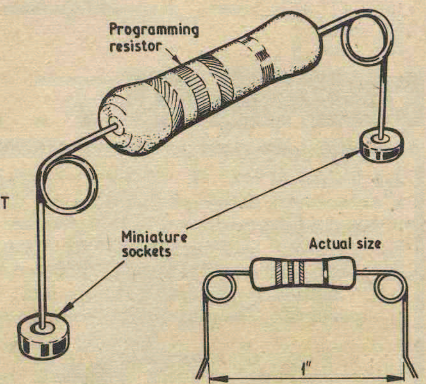


Fig. 2.11. Method of bending leads to make plug-in programming resistors

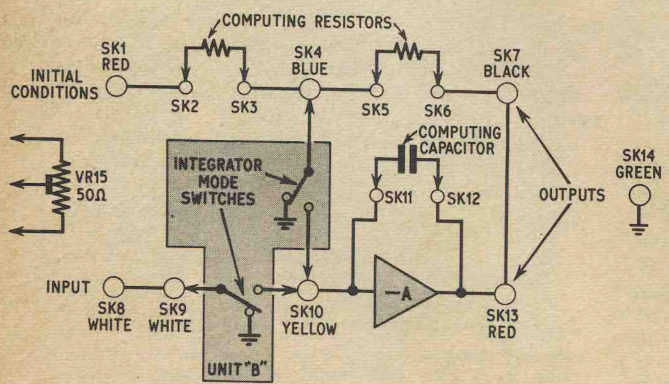


Fig. 2.9. Circuit diagram of Operational Amplifier 1, 2, and 3

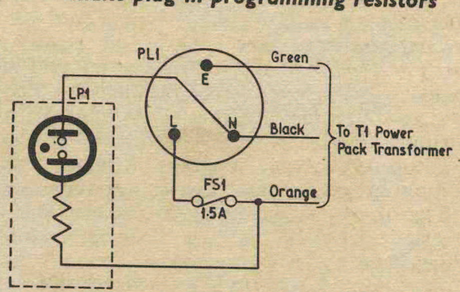
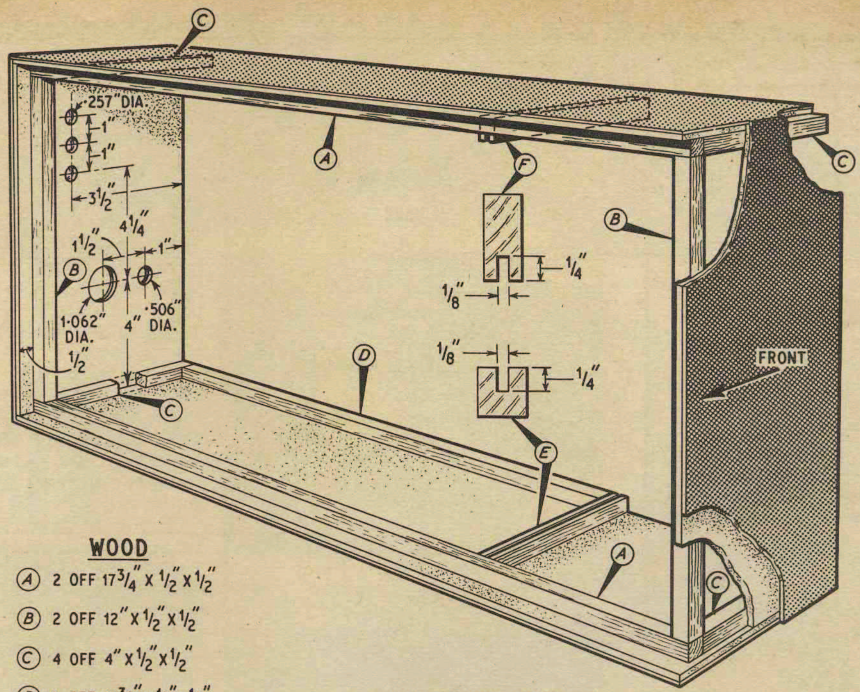


Fig. 2.10. Circuit diagram of mains supply



WOOD

- (A) 2 OFF 17¾" x ½" x ½"
- (B) 2 OFF 12" x ½" x ½"
- (C) 4 OFF 4" x ½" x ½"
- (D) 1 OFF 12¾" x ½" x ½"
- (E) 1 OFF 4" x ½" x ½" WITH SLOT
- (F) 1 OFF 4" x ⅞" x ⅜" WITH SLOT

HARDBOARD PANELS

- 2 OFF 13" x 5" (SIDES)
- 2 OFF 18" x 5" (TOP AND BOTTOM)

Fig. 2.12. Constructional details of UNIT "A" Box

Cut plastic laminate to fit hardboard panels with $\frac{1}{16}$in overlap, and glue to the box sides first. Reduce the overlap to size when the laminates are firm, before fitting the top and bottom surfaces. When trimming the top and bottom panels down to size, take care not to scratch and score the side pieces. For economy, the bottom plastic laminate layer can be omitted.

When satisfied with the laminated exterior, the 1·062in dia. hole can be made by a series of small drillings and finished with a half-round file. The box interior and wood may be varnished, but the raised lip at the front of the box is best painted black, or some dark colour, to contrast with the front panel.

The finished box is quite strong, and will support the full weight of a normal adult when the front panel is in place. However, it is recommended that this test should not be applied too often!

FRONT PANEL WIRING

Attach the front panel to its box, which will act as a convenient mount when wiring the back of the panel.

The bare earth wire linking all green sockets runs along the top half of the front panel and down its left-hand side, looking from the back; this should be soldered in place before embarking on the sleeved wiring. (No matching green sockets were available for the prototype, so odd coloured sockets were painted green with cellulose model aeroplane dope.)

The 4mm red, green, and blue terminal sockets on the side of UNIT "A" are designed to take stackable plugs, and will make available the power supply outputs to external sub-units. Wiring can proceed from the terminal sockets along the voltage source (see Fig. 2.3) and then to the rest of the front panel.

Circuit diagrams for all the various "sections" incorporated in the front panel are given in Figs. 2.6 to 2.10 inclusive. Wiring details are given in Fig. 2.3 and Fig. 2.4.

The summer and operational amplifier sections are triplicated—although only one of each of these sections has been shown in the diagrams Fig. 2.2 to Fig. 2.5 inclusive.

The purpose of the miniature sockets, which appear in the above mentioned diagrams, is to take the plug-in programming components; explained by Fig. 2.11. Resistor leads are preformed in the manner shown. The distance between miniature sockets is standardised at 1in, to allow the use of a special made-up two pin plug to support the bulkier components, such as large polyester capacitors.

When wiring up the operational amplifier sockets, ignore for the time being the coloured flexible wires shown in Fig. 2.4 as these are the flying leads from the operational amplifier panel, and will be referred back to when the time comes to mount the amplifiers.

Fit the mains connector PL1 and fuseholder for FS1 to the side of the box. Wire up the neon lamp LP1 and the fuse FS1 to PL1 as shown in Fig. 2.10.

CORRECTION.

In Part 1, Page 40, last line of the equation in the example at top of right-hand column should read:

$$E_0 = -\left(5\frac{10}{10} - 3\cdot5\frac{10}{2} + 2\frac{10}{100}\right) = -(5 - (3\cdot5 \times 5) + 0\cdot2),$$

therefore $E_0 = 12\cdot3$.

Next month: Power supply and operational amplifiers