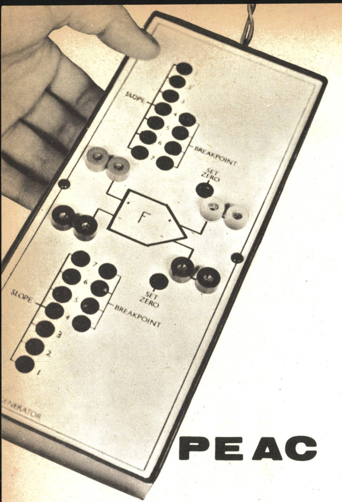


The natural forward voltage drop of D1 and D2 furnishes self-bias, and bias conditions for D3 are satisfied by a fixed resistor R1. The values of slope adjusters VR1, VR2, VR3, VR4, VR6, VR8 and VR10 were selected to give a parabolic function approximating to $E_0 = E_{in}^2$ when all sliders are at mid-track, and appropriate bias values for that function are provided by mid-track settings of breakpoint adjusters VR5, VR7, VR9 and VR11. The combination VR12 and R3 serves to eliminate offset voltages resulting from diode leakage currents, and VR12 is therefore used for zero-setting.

With so many possible adjustments, including amplifier closed-loop gains determined by R_f or R_{in} computing resistors, it is obviously impossible to catalogue the coverage of the Fig. 8.1 circuit. As a rough indication though, powers of E_{in} ranging from about $E_{in}^{1\cdot1}$ to beyond E_{in}^3 are available. If both branches are cascaded in series with operational amplifiers, the upper limit will extend beyond E_{in}^6. Corresponding root functions $\sqrt[1\cdot1]{E_{in}}$ to $\sqrt[6]{E_{in}}$ may also be generated. It is sometimes possible to use the UNIT "C" function generator for certain trigonometrical functions, and logs to the base 10 or *e*.

UNIT "C" BOX

A wood and plastics laminate box, of small dimensions compared with other PEAC units, will serve to house the two function generator circuit panels. The suggested form of construction is shown in Fig. 8.2. Softwood blocks are glued to a 9½in × 4in × ¼in plywood frame, which has its centre cut out, and white plastics laminate side pieces are then glued to the blocks. The front panel sits on the wooden blocks and is recessed.

PEAC ANALOGUE COMPUTER

By D. BOLLEN

LAST month the Function Generator UNIT "C" was introduced. The principle of operation and some of the uses of the function generator were explained. We are continuing with a description of the practical circuit, constructional details, and application information.

FUNCTION GENERATOR CIRCUIT

The function generator circuit of Fig. 8.1 is designed to display a nominal resistance of 100 kilohm when the input voltage is ±1V. A typical resistance variation with applied voltage is from 500 kilohms at 0·2V to 10 kilohms at 10V. In the Fig. 8.1 circuit, components forming the positive branch are identified by the letter A after a component number, and the letter B is appended to negative branch numbering. As both branches are identical, except for diode and bias polarities, it is not necessary to describe them separately.

D1 is a gold-bonded diode, for a low voltage drop with small input voltages. All other diodes (D2–D7) are of silicon construction to keep reverse leakage low.

UNIT "C" FRONT PANEL

The only items to be mounted on the 9½in × 4in plastics laminate front panel are eight coloured sockets; the layout is given in Fig. 8.3. A series of ¼in holes are drilled in the front panel to allow screwdriver access to slope, breakpoint, and set-zero controls. Panel markings are similar to previous PEAC units.

FUNCTION GENERATOR CONSTRUCTION

Two 3¾in × 3¾in s.r.b.p. panels are drilled and shaped according to the Fig. 8.4a diagram. Before inserting turret tags, lay the prepared panels out as shown in Fig. 8.5, so that one panel is turned over in relation to the other, and components are clearly seen to be mounted on opposite sides. The underside wiring of the positive branch panel is shown in Fig. 8.4b, and the wiring of the negative branch is in Fig. 8.4c.

All diodes are mounted on turret tags to allow them to be disconnected for special purposes, where for

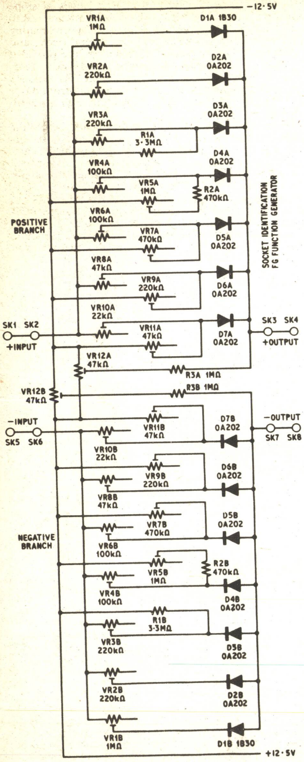
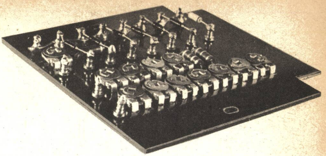


Fig. 8.1. UNIT "C" function generator circuit diagram



Function generator circuit panel

example it is desired to reduce the number of breakpoints, or combine a curved and straight line function. It is advisable to check the polarity of all diodes with a meter before mounting them on the circuit panels.

After completing the underside wiring, bolt the two circuit panels on the plywood frame, as in Fig. 8.5, and make sure that the front panel holes are aligned with the pre-set miniature potentiometer slots.

SETTING UP THE FUNCTION GENERATOR

Patching leads for the function generator should preferably be terminated at one end by miniature plugs, to permit connection to the UNIT "A" computing component sockets. As the generation of powers and roots is the main area of interest, functions related to the square or cube of a number are used in the following setting-up instructions.

To patch the function generator to OA1, join FG/SK5 to S1/I1/SK3, FG/SK8 to S1/I1/SK4, S1/SK5 to OA1/SK8, and link together OA1/SK9, SK10, and SK4. Insert a 100 kilohm computing resistor into OA1/SK11 and SK12. Take a patching lead from S1/I1/SK1 to VS1/SK2, and ensure that S6 is off.

The task of setting up the function generator is made easier if two voltmeters are used, one for E_{in} connected to S1/I1/SK2, and the other for E_0 to OA1/SK13. The Unit "B" readout meter is ideal for monitoring E_0 because it can indicate voltages down to 0·01V. Switch on the computer power supply and zero OA1 by means of its balance control VR15. Set all function generator slope and breakpoint potentiometer sliders to mid-track, and connect the red and blue wires from the function generator to the power supply terminals on the side of the UNIT "A" box (TL1 and TL2). Adjust VR12B (zero-set) for zero output from OA1.

Because of the interdependence of slope and breakpoint adjustments, a systematic approach is called for when setting up a function. Start with the lowest E_{in} and VR1 and proceed in an orderly fashion towards VR11 and the maximum E_{in} value. It is a help to tabulate specific input and output voltages and relate them to particular slope or breakpoint controls. To assist the reader, two tables have been prepared covering square and cube functions, Table 8.1 and Table 8.2.

If a square function is to be set up on the function generator, switch on S6 (Voltage Source) and set VS1 for an output of −0·2V, then adjust VR1B for an OA1 output of 0·04V. Next set VS1 for −0·5V and adjust VR2B for an output of 0·25V, and so on, according to Table 8.1. After application of $E_{in} = -2·0V$, and adjustment of VR4, change the 100 kilohm computing resistor in the feedback loop of OA1 to 10 kilohm, to prevent the amplifier overloading when E_{in} exceeds $\sqrt{10}$.

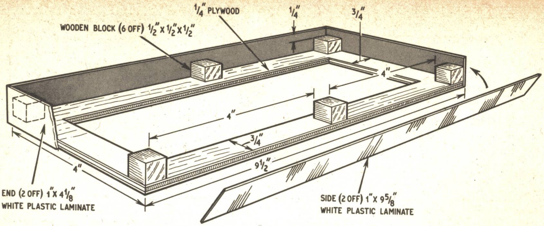


Fig. 8.2. Details and measurements of UNIT "C" function generator case

TABLE 8.1

Diode	E_{in}	Adjust slope	Adjust break-point	E_o	
1	−0·2V	VR1	—	+ 0·04V	$E_o = E_{in}^2$, $R_f = 100k\Omega$
2	−0·5V	VR2	—	+ 0·25V	
3	−1·0V	VR3	—	+ 1·0V	
4	−1·5V	—	VR5	+ 2·25V	
	−2·0V	VR4	—	+ 4·0V	
5	−2·5V	—	VR7	+ 0·625V	$E_o = \frac{E_{in}^2}{10}$, $R_f = 10k\Omega$
	−3·5V	VR6	—	+ 1·225V	
6	−4·0V	—	VR9	+ 1·6V	
	−6·0V	VR8	—	+ 3·6V	
7	−6·5V	—	VR11	+ 4·225V	
	−9·0V	VR10	—	+ 8·1V	

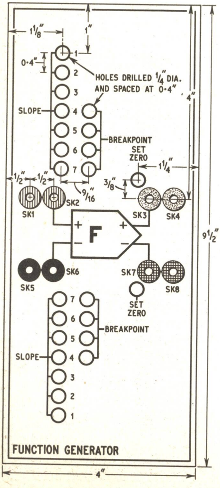


Fig. 8.3. Front panel layout of UNIT "C" function generator

COMPONENTS . . .

UNIT "C" BOX

Plywood 9½in × 4in × ¼in
Softwood ½in × ½in × 3½in
White plastics laminate 9⅝in × 1in (2 off),
4⅛in × 1in (2 off)
Rubber grommet ¼in × 5/32in

UNIT "C" Front Panel

White plastics laminate 9½in × 4in. Sockets: 2 red, 2 yellow, 2 black, 2 blue.

UNIT "C" Function Generator Components

Resistors

R1 3·3MΩ (2 off)
R2 470kΩ (2 off)
R3 1MΩ (2 off)
All 10%, ½W carbon composition

Pre-set Potentiometers

VR1, VR5	1MΩ	(4 off)
VR2, VR3, VR9	220kΩ	(6 off)
VR4, VR6	100kΩ	(4 off)
VR7	470kΩ	(2 off)
VR8	47kΩ	(2 off)
VR10	22kΩ	(2 off)
VR11, VR12	47kΩ	(4 off)

All miniature horizontal mounting

Diodes

D1 1B30 (2 off) (Radiospares)
D2–D7 OA202 (12 off)

Miscellaneous

S.R.B.P. 3¾in × 3¾in (2 off). Small turret tags
4mm stackable plugs, one red, one blue (Radiospares)

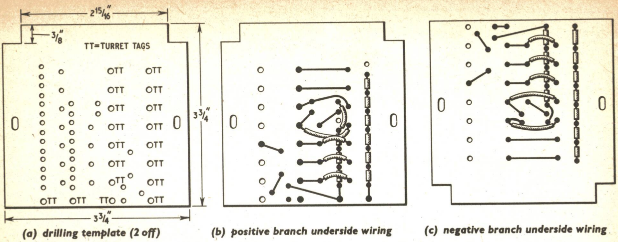
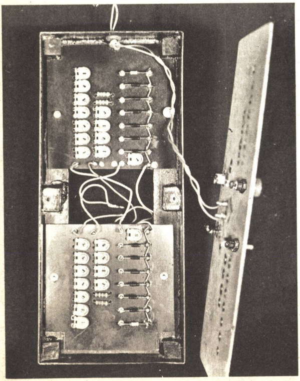


Fig. 8.4. Function generator circuit panels (2 off)

TABLE 8.2

Diode	E_{in}	Adjust slope	Adjust break-point	E_o	
1	−0·3V	VR1	—	+0·027V	$E_o = E_{in}^3$; $R_f = 100k\Omega$
2	−0·5V	VR2	—	+0·125V	
3	−0·75V	VR3	—	+0·421V	
4	−1·0V	—	VR5	+1·0V	
	−1·25V	VR4	—	+1·953V	
5	−1·5V	—	VR7	+3·375V	
	−2·0V	VR6	—	+8·0V	
6	−2·5V	—	VR9	+1·56V	$E_o = \frac{E_{in}^3}{10}$; $R_f = 10k\Omega$
	−3·0V	VR8	—	+2·7V	
7	−3·5V	—	VR11	+4·287V	
	−4·64V	VR10	—	+10·0V	



Interior view of UNIT "C" function generator

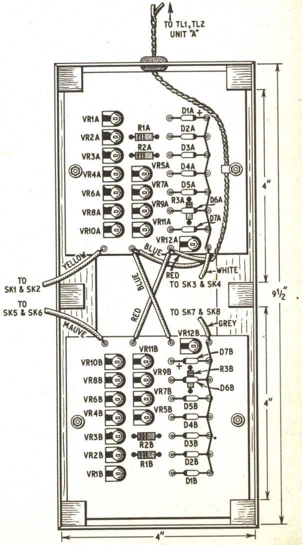


Fig. 8.5. Topside and interconnecting wiring of function generator panels. The circuit boards are shown in position inside the UNIT "C" case

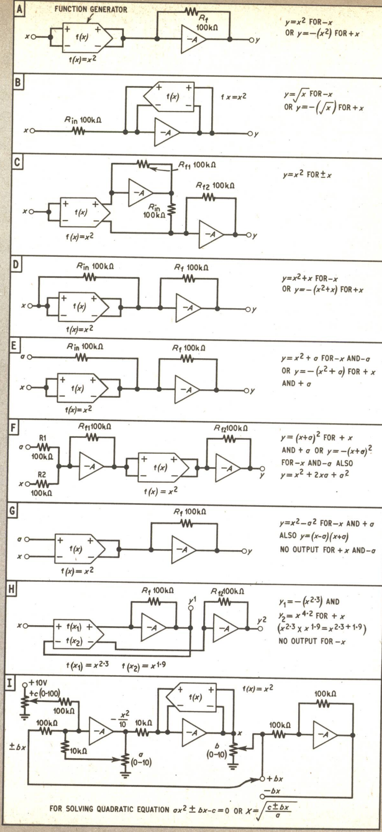
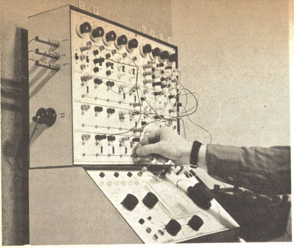


Fig. 8.6. The function generator used for equation solving



This photograph shows PEAC being used to solve simultaneous equations

After the entire range of input voltages listed in Table 8.1 has been covered, return to $E_{in} = -0{\cdot}2$V and go through the procedure again, to achieve optimum accuracy. The positive branch can be set up for the same function as the negative branch by transferring patching leads from FG/SK5 to SK1, and FG/SK8 to SK4, but this time trim VR12A for zero-set, and apply positive values of E_{in}. It may be necessary to slightly re-adjust slope controls VR1–VR3 when the two branches are connected in parallel, if there is some small bias voltage imbalance.

THE FUNCTION GENERATOR IN EQUATION SOLVING

The fact that an analogue computer can produce and handle imaginary numbers will be particularly evident when the function generator is applied to equation solving, see Fig. 8.6. One type of function generator circuit configuration will produce consistant outputs for, say, the cube of a number, but not for its square, or vice versa, because $\pm x^2 = +y$, but $+x^3 = +y$, and $-x^3 = -y$. The computer operator must therefore choose, or devise, the appropriate circuit for a given task.

Output y in Fig. 8.6a will be of the required sign when the input is $-x$, but the sign of y with an input of $+x$ cannot be reconciled with mathematical convention. However, the circuit of Fig. 8.6a does provide a consistant output when the function is x^3, with inputs of $\pm x$. Much the same applies to the Fig. 8.6b circuit, which shows the function generator arranged for square root operations. Circuit Fig. 8.6c reverses the above situation and gives consistent outputs for a square function, but not for a cube function, by employing an extra sign reversing amplifier.

Getting away now from the complexities of square roots of negative numbers and other mathematical anomalies, Fig. 8.6d can be made to give outputs of $y = x^2 + x$, or some other combination such as $y = x^{2.5} - 3x$, depending on the choice of function, voltage polarities, and computing resistor values. The purpose of other circuits E–H will be self-evident in Fig. 8.6. Fig. 8.6i gives the symbolised layout for solving a quadratic equation, where x is unknown and a, b, and c are constants. The function generator can also be introduced into problem set-ups where integrating amplifiers are used, as its frequency response is well in excess of any frequency likely to be encountered.

Next month: The final item of the PEAC equipment, UNIT "D", will be described.

NEWS BRIEFS

All Change at British Rail

PROGRESS of trains over 47 miles of track in the Leeds area is being monitored and controlled with the aid of a computer recently installed at Leeds City station.

The system is unique in that it uses a standard commercial computer (an Elliott 903) which can easily be adapted to new needs. Older systems using Post Office relays and uniselectors have to be extensively rewired when changes are called for.

The Leeds signalmen never see the trains they control. Each locomotive is given a code number which appears on one of 67 cathode ray tube readouts on a large track diagram, and its progress is traced by coloured lights. When the train reaches a new stretch of track, the computer transfers the code number to a fresh readout.

British Rail say future developments could include automatic signal route setting and automatic train announcing.

Lincompex Goes Afloat

LINCOMPEX, a Post Office invention which improves the intelligibility of high-frequency radio telephone services, has gone into service on three Cunard Liners. Lincompex, for "Linked compressor and expander" uses a compressor at the sending end to maintain the caller's voice at maximum level thus preserving a good signal-to-noise ratio, while an expander restores the original dynamics at the receiving end for more natural reproduction. A control signal links the two.

Slow Motion Tube

ENGLISH ELECTRIC VALVE have developed the electronic equivalent of a high-speed cine camera. It consists of an electrostatically-focused triode image-converter tube which can present on its integral fluorescent screen a sequence of frames showing the development of a high-speed event. The shutter action is achieved by deflection of the electron beam over a slit in an aperture plate in the tube. Speeds of 20 million frames per second can be obtained, and, dependent on image size, the number of frames to be recorded can be from eight to 32.

(below) Control panel of the "windowless" signal box at Leeds City station