terms of Eq. 4.5 (I_2). To see how the problem is set-up on the computer, refer to Fig. 4.5, and note the changes of sign involved.

Routine. Switch off S6 and insert all computing resistors and patching leads, except the link between OA3 output and OA1 input, which carries the voltage analogue of I_2. Zero-set OA1, OA2, and OA3 in that order, using a voltmeter applied to each operational amplifier output socket in turn. Now patch the link between OA3 output and OA1 input into circuit. Set VS1 to "0", and VS2 to "+10". The voltmeter method of Fig. 4.3 is employed to set CP1 and CP2 both for a coefficient of 0·5. Temporarily remove the patching leads from CP1/SK1 and CP2/SK1, and connect the "top end" of the potentiometer tracks to a 10V reference voltage. Adjust CP1 and CP2 for outputs of 5V. Exactly the same procedure is adopted when it is necessary to "read off" values for R1 and R2, although approximate readings can be taken from CP1, CP2 dials.

The check voltages in the diagram of Fig. 4.5 correspond to the above voltage source and coefficient potentiometer settings, and provided that there is general agreement with Ohm's law, any desired values can be given to the voltages, currents, and resistances in Fig. 4.4a. The check voltages could apply to actual voltage divider quantities of, say, $V_1 = 10V$, $V_2 = 5V$, $I_1 = 0mA$, $I_2 = 1mA$ (1 machine volt = 1mA), $R_1 = 5$ kilohm, and $R_2 = 5$ kilohm, where VS1 covers the range 0–10mA, VS2 0–10V, CP1 0–10 kilohm, and CP2 0–10 kilohm. Suppose instead that V_1 had been assigned the value of 1,000V, when R_1 and R_2 were both only 5 ohms. One machine volt would now be equivalent to 100A, and V_2 would equal 500V. The ranges covered by computing potentiometers in the latter case would then be VS1 0–100A, VS2 0–1,000V, CP1 0–100, and CP2 0–10 ohms.

Unless informed otherwise, the computer assumes that V_1 is an ideal voltage which originates from a source of infinitely small resistance. Hence, if $V_1 = 0$, this corresponds to a short-circuit, and gives the variation of Fig. 4.4c. Alternatively, if I_2 is made equal to nought, the voltage divider circuit is transformed into a load resistor R_2 in series with a source resistor R_1. given by Fig. 4.4d.

One further variation will serve to show the flexibility of the programme. In Fig. 4.4e the resistance network R_1 and R_2 is made to couple two sources of voltage V_1 and $-V_2$, and this occurs when I_1 is made larger than $I_1 + I_2$, or in other words, when I_2 swings negative.

The layout of Problem Example 2 is an instance of indirect simulation, where the computer solves equations and imitates the behaviour of the simulated circuit. In this indirect "model" of a voltage divider, relationships between governing equations and actual circuit parameters are made obvious, and the abstractions of mathematics are brought to life as tangible voltmeter and dial readings.

Another way of simulating the Fig. 4.4a circuit is by a direct "model", shown in Fig. 4.4b, which employs coefficient potentiometers for R_1, R_L, and R_L, voltmeters for V_1 and V_2, and current meters for I_1 and I_2. Although feasible, the direct model is less elegant, is not so adaptable to extreme cases, and is subject to errors which do not occur when the voltage divider is simulated indirectly.

Next month: Using UNIT "A" to solve a second order differential equation. Indirect simulation of LC circuits, spring pendulums, and servo-mechanisms by means of integrators.

REGULATED POWER SUPPLY

continued from page 284

	VOLTS A	VOLTS B	VOLTS C	VOLTS D	VOLTS E	VOLTS F	mA I_2	A I_1
No load current	1·0	0·17	14·2	0·68	0·47	2	65	2·7
	2·88	0·145	11·4	0·5	0·38	6	40	2·1
	5·8	0·12	7·0	0·36	0·28	12	18	1·4
1A Load	0·99	0·165	14·1	0·61	0·40	2	36	1·9
	2·86	0·143	11·3	0·41	0·30	6	18	1·3
	5·78	0·119	6·9	0·23	0·17	12	3·5	0·32

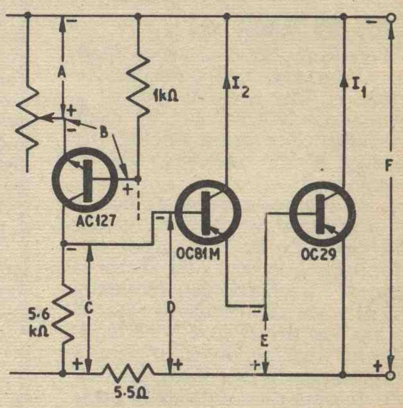

Fig. 10. Test measurements for fault-finding

CALIBRATION OF OUTPUT VOLTAGE

After checking the voltmeter accuracy against an AVO or similar instrument known to have good accuracy itself, the Regulated Volts dial should be adjusted as follows.

Switch S2 to "Regulated" and S3 to "Volts" and turn VR1 until 1V is obtained at the output (best seen on the AVO). Loosen the knob and rotate to indicate 1V on the calibrated dial. Lock the pointer knob grub screw while indicating the correct 1V. Rotate VR1 until the dial indicates 12V output. Now adjust VR2 until 12V output (measured) is obtained.

VOLTAGE CHART

Fig. 10 gives typical voltages at six points in the d.c. amplifier circuit for three different output voltages. Reference to these voltages and to the currents of the super-alpha pair TR2, TR3 should assist in any fault-finding. ★