TABLE 5.1

C_f	R_{in}	t
1μF	100kΩ	2·8sec
	10kΩ	800ms
0·1μF	100kΩ	280ms
	10kΩ	80ms
0·01μF	100kΩ	28ms

Maximum value of t for an error of 1%

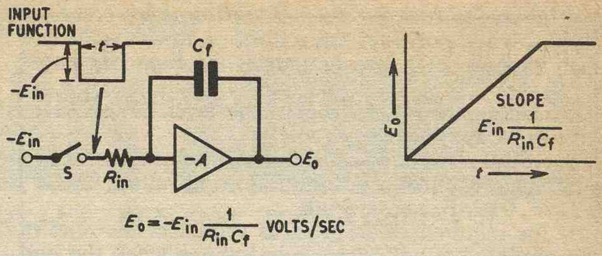

Fig. 5.1. The operational amplifier as an integrator

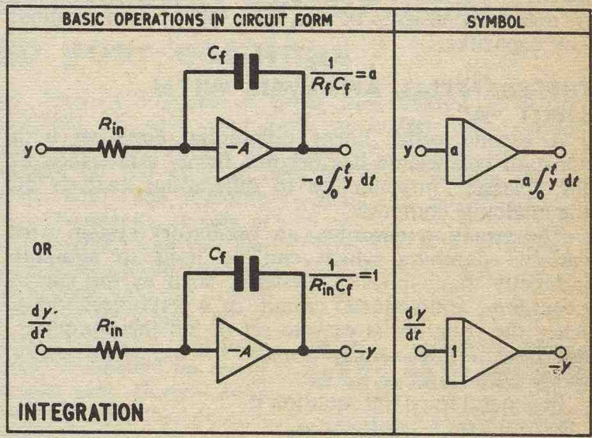

Fig. 5.2. The handling of equation terms by a simple integrator

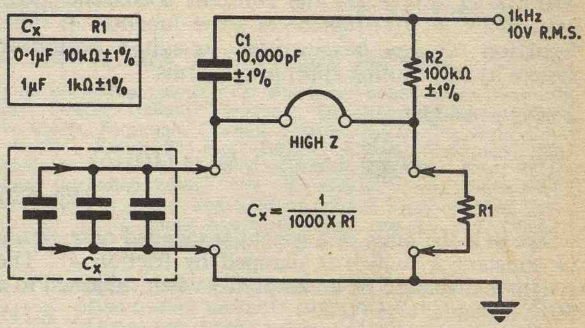

Fig. 5.3. Bridge circuit used for making up computing capacitors

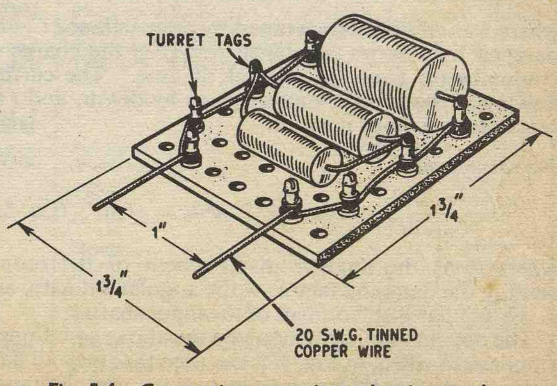

Fig. 5.4. Computing capacitor plug-in panel

the situation is much more complicated than with, for example, a summing amplifier (Fig. 3.8) since the amplifier error can no longer be defined in terms of the simple relationship between closed-loop and open-loop gains.

As a guiding principle, integrating amplifiers may have very large values of closed-loop gain provided that the time t of an input function remains small. Closed-loop integrator gains of 1,000 or more are not uncommon in transistor computers, since low voltages and low impedances discourage the use of computing resistors of more than 100 kilohm, and capacitors of more than 1μF are too bulky. Table 5.1 is calculated for UNIT "A" amplifiers, and sets out the maximum allowable interval t for selected values of C_f and R_{in}, where the amplifier transfer error must not exceed one per cent.

Errors due to unwanted drift voltages also become significant when t is long and C_f is small. The greatest care must be exercised when zero-setting integrators to eliminate offset voltages, for good accuracy at long time intervals. Also, the computer should not be subjected to fluctuations of ambient temperature when computations cover several hours of integrator use.

COMPUTING CAPACITORS

The computing capacitors used for PEAC will normally lie within the range 0·01–1μF, and the three values most commonly employed are 0·01μF, 0·1μF, and 1μF. Polystyrene is the preferred capacitor dielectric, for high insulation resistance, but polyester makes an acceptable second best. Mica, paper, and ceramic capacitors should be avoided.

Small value polystyrene capacitors of ±1 per cent and ±2 per cent tolerance are easily obtained, but 0·1μF and 1μF precision components are rare and expensive. To get around this difficulty, the bridge circuit of Fig. 5.3 was devised to allow computing capacitors to be made up from specially selected low cost ±20 per cent capacitors.

The circuit of Fig. 5.3 can be constructed in breadboard form on Veroboard or s.r.b.p., with miniature sockets to take C_x and R1. If an audio signal generator is not available to supply the bridge with about 10V r.m.s. at 1kHz, a signal could be obtained from a transistor multivibrator powered by the 25V computer power supply. Headphones serve to detect the null point when the bridge is in balance, and should have an impedance of about 2 kilohms.

The method of making up a computing capacitor of, say, 1μF is as follows. A capacitor panel of plain or perforated s.r.b.p. is fitted with small turret tags as in Fig. 5.4. A ±20 per cent capacitor of about 0·68μF is wired into position on the capacitor panel before it is plugged into the bridge C_x sockets, and a 1 kilohm