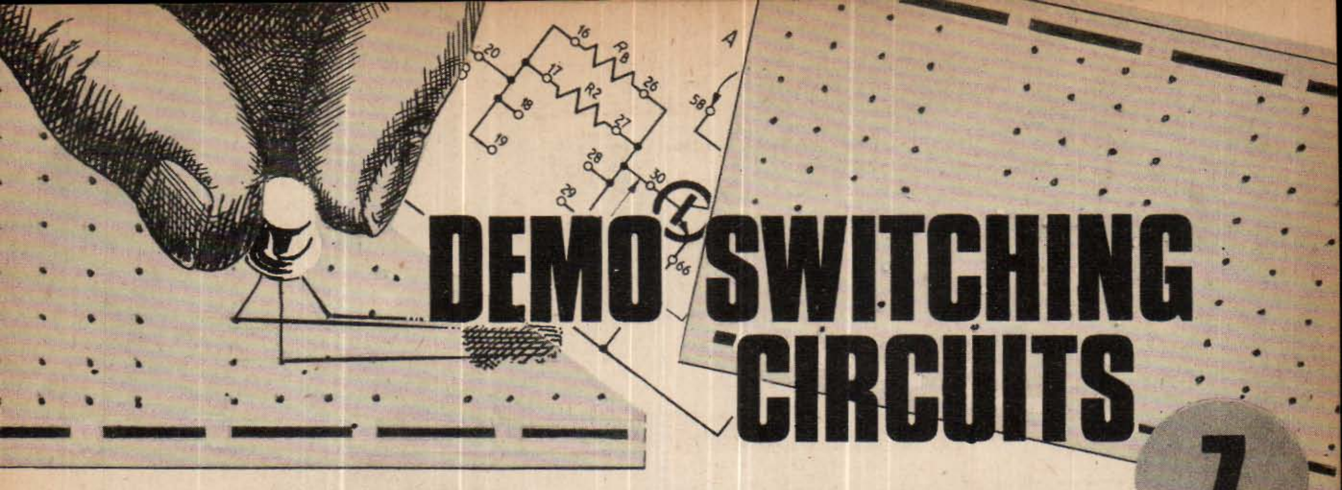

DEMO SWITCHING CIRCUITS 7

BINARY DIVIDER

By B. Pounder

Continuing the discussion on dividers, this month's article (the last) looks into the use of binary dividers for decimal counting.

BINARY CODED DECIMAL COUNTER

It is frequently necessary for a counter to work to a base of 10. This can be achieved by means of feedback loops included in the binary chain. See Fig. 7.1.

Immediately after receipt of the eighth input pulse, the $\overline{Q}$ outputs are 0 0 0 1. Further, the $\overline{Q}4$ output has changed to the "1" state from a "0" state; that is, the collector voltage on TR1 of binary 4 has dropped from V_{CC} to almost zero. Because this change is negative-going, it can be made to switch other binaries in the chain.

Suppose $\overline{Q}4$ output is fed back to inputs T2 and T3, then the negative-going change on $\overline{Q}4$ causes binaries 2 and 3 to switch so the outputs of these two change state. In so doing, Q3 changes from "1" to "0" so it has no effect on binary 4. These changes are illustrated in Table 7.1 which shows a state 8′ immediately following state 8.

On receipt of the trigger pulse number 9, all the Q outputs are "0"s and all the $\overline{Q}$ outputs are "1"s, so the system is returned to its initial state by trigger pulse 10 and ready to repeat its output sequence over the receipt of another ten pulses. Because the circuit reverts to its initial state every ten trigger pulses, it can be used as a decade divider. Two such cascades divide by 100, three by 1,000, and so on.

Note that in order for the decade dividers to operate satisfactorily, there must be a time delay built into the feedback loops in order that state 8 is set up before the feedback pulses arrive at T2 and T3 to cause switching to state 8′.

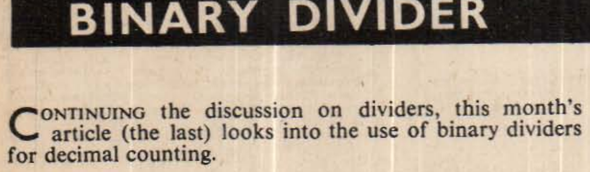

Fig. 7.1. Application of feedback to a binary chain to give a decimal counting system

Table 7.1. BINARY CODED DECIMAL LOGIC OUTPUTS

Input	$\overline{Q}_1$	$\overline{Q}_2$	$\overline{Q}_3$	$\overline{Q}_4$	Q_1	Q_2	Q_3	Q_4
7	1	1	1	0	0	0	0	1
8	0	0	0	1	1	1	1	0
8′	0	1	1	1	1	0	0	0
9	1	1	1	1	0	0	0	0
10	0	0	0	0	1	1	1	1
11	1	0	0	0	0	1	1	1
12	0	1	0	0	1	0	1	1

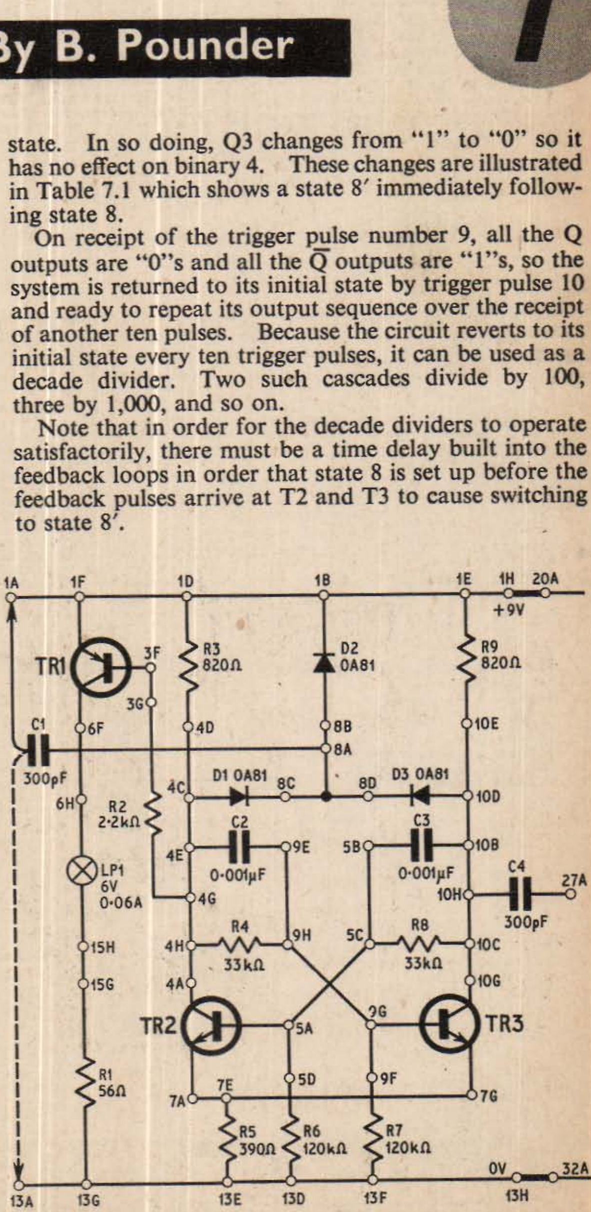

Fig. 7.2. Circuit of two stage binary counter with T-Dec connections. Two of these can be built on one board

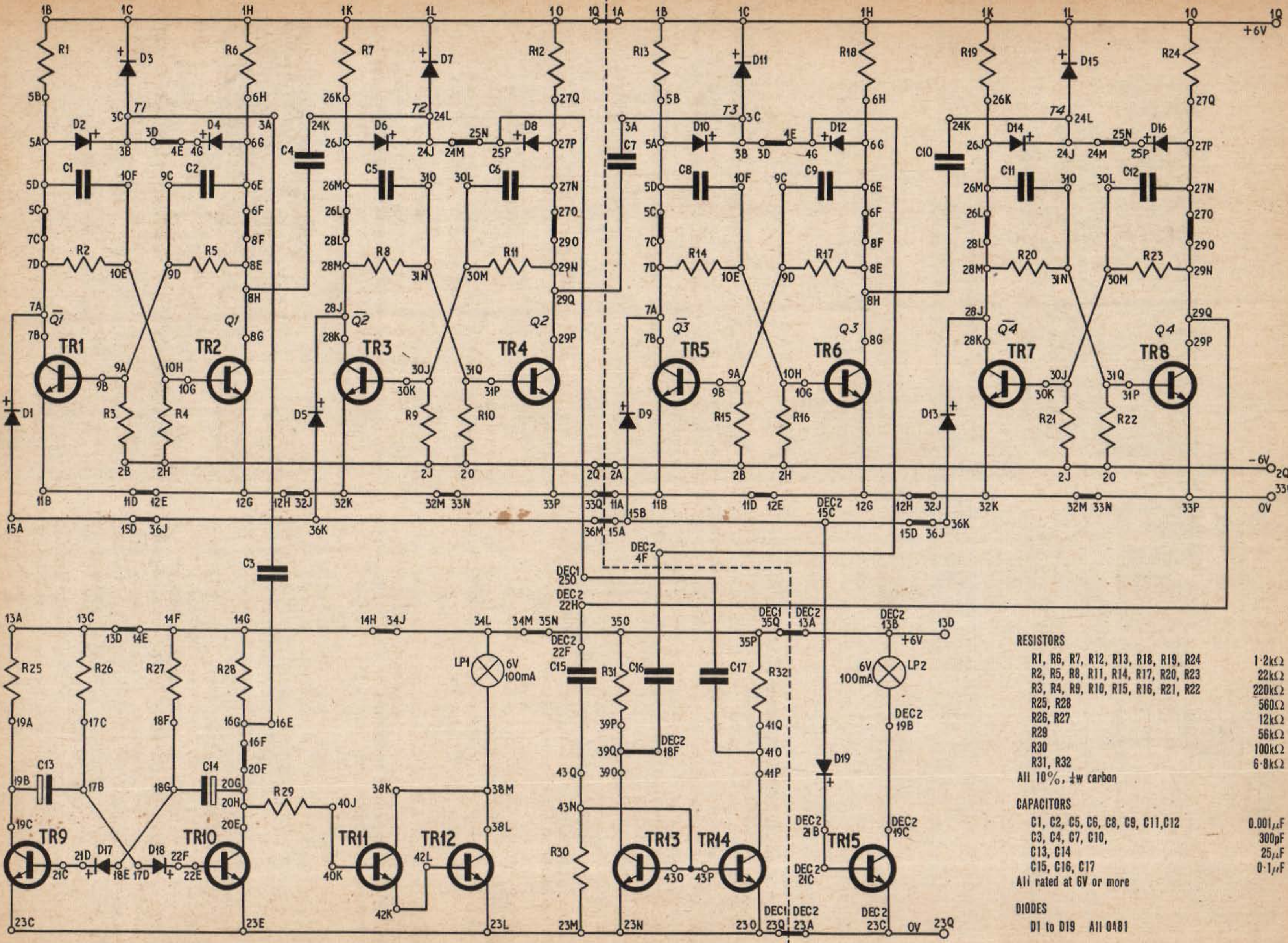

Fig. 7.4. Circuit of the decade divider with μ-Dec connections. Dec-1 is left and Dec-2 is right of the dotted line except where otherwise indicated

RESISTORS

R1, R6, R7, R12, R13, R18, R19, R24	1·2kΩ
R2, R5, R8, R11, R14, R17, R20, R23	22kΩ
R3, R4, R9, R10, R15, R16, R21, R22	220kΩ
R25, R28	560Ω
R26, R27	12kΩ
R29	56kΩ
R30	100kΩ
R31, R32	6·8kΩ

All 10%, ¼w carbon

CAPACITORS

C1, C2, C5, C6, C8, C9, C11, C12	0.001μF
C3, C4, C7, C10,	300pF
C13, C14	25μF
C15, C16, C17	0·1μF

All rated at 6V or more

DIODES

D1 to D19 All OA81

TRANSISTORS

TR1 to TR15 All npn silicon type (see Part 1)

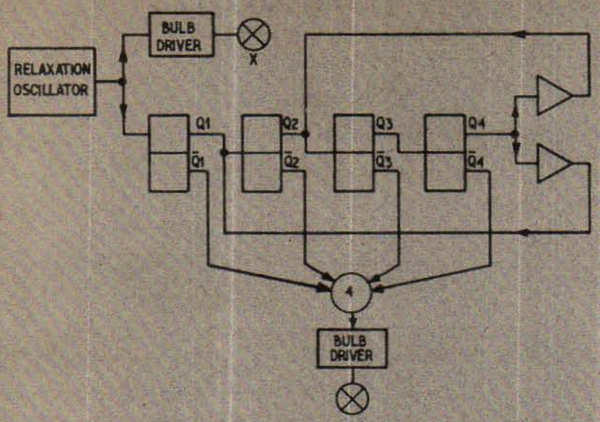

Fig. 7.3. Block diagram of a decade divider

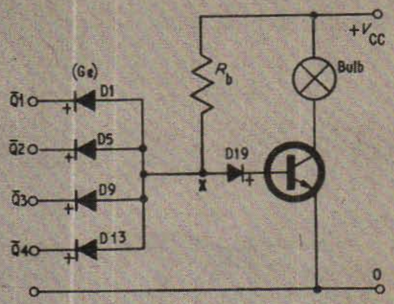

Fig. 7.5. NAND gating circuit used in the decade divider

BINARY DEMONSTRATION CIRCUIT

A circuit for a 9V emitter-coupled two-stage binary counter with lamp bulb indication is shown in Fig. 7.2. This can be built on half a T-Dec as shown, with the similar layout to that in Fig. 6.4. Two circuits can then be built on one T-Dec. Component values are calculated according to the design procedure given previously.

If the bulb driver transistors are TO5-canned types capable of dissipating a few hundred milliwatts, the base current resistors can be made large enough to under-run the bulbs. If necessary, a 56 ohm resistor could be included in series with each of the bulbs.

DECADE DIVIDER

As can be seen from the block diagram of Fig. 7.3, the decade divider is a complex system and would need about six S-Decs for a neat assembly. However, it can easily be accommodated on two μ-Decs. A μ-Dec layout is shown in Fig. 7.4 on the previous page.

Referring to Fig. 7.4, the relaxation oscillator output from TR10 is indicated by means of a 6V bulb and is fed into four binaries in cascade. The oscillator, lamp driver, the first two binaries and feedback amplifiers TR13 and TR14 are assembled on one of the μ-Decs. The other two binaries are assembled in exactly the same way, proceeding from left to right across the board and using corresponding socket connections.

The second Dec takes the third and fourth binaries and the decimal indicator lamp driver TR15.

On receipt of the eighth input pulse, stage Q4 turns from on to off so its collector voltage rises as a "step", which is differentiated by the CR coupling between Q4 and the feedback amplifiers. Thus negative-going spikes appear at the collectors of these stages. The spikes are fed-back directly to the collectors of $\bar{Q}2$ and $\bar{Q}3$ in order to switch off stages Q2 and Q3, and achieve the 8′ state shown in Table 7.1.

The NAND circuit is used to provide a visual indication whenever all the $\bar{Q}$ outputs are at the supply voltage, so operates at a frequency of one tenth that of the relaxation oscillator. The operation is as follows.

If any one or more of the input diodes D1, D5, D9, and D13 shown in Fig. 7.5 is at zero potential, it or they will conduct through R_b so that the potential at point X will be V_f, the diode forward bias voltage drop. Now X is connected to the bottom rail via D19 and the base-emitter junction of the transistor. Hence the base current will be negligible and the transistor essentially cut-off.

However, when all the input diodes are at the supply voltage, none will conduct since they are all reverse biased. Hence D19 will conduct through R_b and the transistor turns on. The system should be assembled in stages and each stage tested before proceeding to the next.

First, the operation of the relaxation oscillator can be checked by means of its bulb driver circuit. The same bulb circuit can be coupled to the output of each binary as they are assembled in turn to check their operation by seeking an indication of successive division by two of the train of input pulses.

Note that this and other circuits, which consist of a cascade of binaries, will not operate satisfactorily unless a very low impedance power supply is used. A half exhausted battery will not be good enough! ★

POINTS ARISING

MINIATURE CONVERTER *(April 1970)*

The Mullard pot core used in the minature converter consists of the following parts:

FX2243 Ferroxcube pot cores (2 off)
DT2206 single section coil former (1 off)

The above numbers and quantities must be quoted when ordering, *not just* FX2243 as given in the components list.