WS No. 19 Mark III

HARD VALVE TRIGGER CIRCUITS

1. Hard valve circuits are often used as switching devices because of their fast action and the very low power inputs required to initiate this action. They may be operated over a wide range of supply voltages and are called trigger circuits. The circuits may consist of units of two valves so interconnected that when one is 'on', or conducting, the other is 'off', or non-conducting. The application of pulses or potentials of the correct amplitude and polarity to the grids of the valves changes the circuit over so that the valve which was initally conducting is cut off and vice-versa.

2. The signals applied to the grids of the trigger valves are generally greater in amplitude than the grid base so that the valves are either cut-off completely by a large negative voltage or driven into grid current by a large positive signal.

3. Three types of trigger will be described. They may be classified by their on-off action as follows:-

(a)	Eccles-Jordan circuit	'On' state initiated by first input pulse. 'Off' state initiated by second input pulse. Succeeding pulses give on and off states alternately.
(b)	Schmitt trigger circuit	'On' state initiated by beginning of input. 'Off' state initiated by end of input.
(c)	Flip-flop circuit	'On' state initiated by beginning of pulse. 'Off' state occurs at a time fixed by circuit constants and is not controlled by the input.

4. Eccles-Jordan circuit

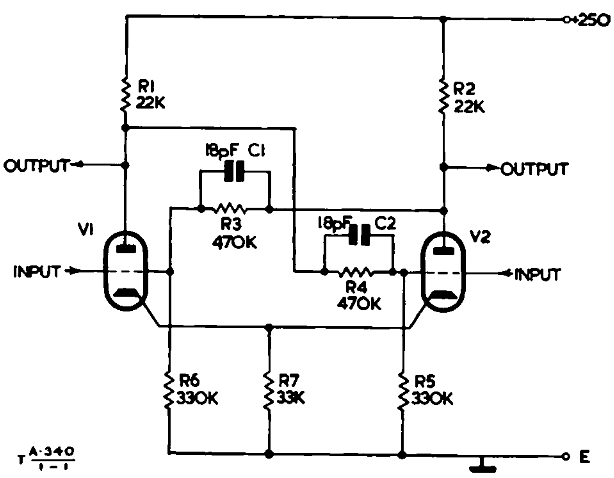

Fig 1 - Circuit of Eccles-Jordan trigger with typical component values

(a) Fig 1 shows the circuit with typical values. It is symmetrical; that is, the corresponding components connected to each valve have the same value. When h.t. is applied, the grids of both valves are positively biased by potential dividers R1-R4-R5 and R2-R3-R6 connected between h.t. +ve and earth. Both valves will therefore conduct. Due to slight inequalities in the valves and associated circuits one valve will, at some instant, begin to pass more current than the other.

(b) Assume that V2 conducts slightly more than V1. The anode voltage will drop and this decrease will

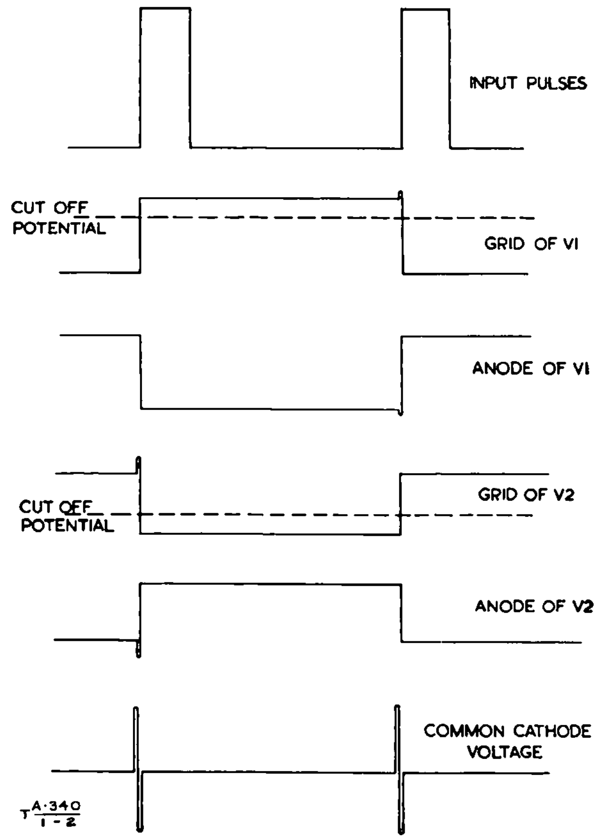

Fig 2 - Waveforms of the Eccles-Jordan trigger circuit

be communicated to the grid of V1. V1 anode voltage will rise and this rise will, in turn, be passed to the grid of V2 which will conduct even more heavily. The grid voltage of V1 will quickly fall below the common cathode potential and the valve will be cut off. The normal quiescent state is therefore with V1 cut off and V2 conducting.

(c) In order to trigger the circuit into the opposite state (with V1 on and V2 off) positive or negative pulses may be applied to one or both grids. There are several methods of triggering and three of the more common ones are described below.

(d) Triggering by positive (or negative) pulses to both grids simultaneously will produce the following effects, assuming that initially V1 is cut off and V2 conducting.

(i) Positive pulses will have little effect on V2 which is at present conducting. On the other hand the grid voltage of V1 will rise above the common cathode potential (due at this stage to the current in V2) and, by the cumulative action of the circuit, V2 will now be cut off and V1 will be on. The next positive pulse will trigger the circuit back to its original state.

(ii) Negative pulses applied to both grids will have no effect on V1 which is cut off. The current through V2 will be reduced however and the common cathode voltage lowered. V2 anode voltage will rise and this rise will be passed on to V1 grid. Eventually the grid to cathode voltage of V1 will rise above cut-off and the valve will conduct. The ensuing cumulative action will cut V2 off and cause V1 to conduct heavily. The next negative pulse will trigger the circuit back to its original state.

(e) Capacitors C1 and C2 in the grid circuits of the valves ensure that the speed of rise or fall of voltage from anode to grid is maintained and the trigger action is kept rapid. These capacitors also provide that the circuit, once the triggering action has started, will proceed in the same direction until the action is completed. Without these capacitors the trigger action, particularly with small input pulses, may become uncertain.

(f) The circuit reverts to its original state after every two pulses and may therefore be used as a 'divide-by-two' circuit. If a series of such circuits is arranged in cascade with the last one connected back to the first a binary counter results. When there are, for example, three trigger circuits so connected, the last one changes over for every 2^3 or 8 input pulses; the circuit then divides the input by 8, ie it produces an output after every eight input pulses. N trigger stages connected together in this way provide a counter or divider for every 2^N input pulses.

(g) A second method of triggering is by separate pulse inputs to the two grids. The inputs must be either both positive or both negative and the circuit conducts in either of its two possible states by a pulse applied to the appropriate grid. A third way of triggering is by pulses applied to one grid only; in this case the circuit will change over only if the polarity of the input changes over. Fig 1 shows a method of obtaining negative grid bias through cathode coupling but it should be noted that bias may be obtained by a negative voltage in the normal way. Fig 2 shows the waveforms associated with the Eccles-Jordan circuit.

5. Schmitt trigger circuit

(a) The basic circuit of the Schmitt trigger is shown in Fig 3. When the grid of V1 is held at earth potential the valve will be cut off by cathode bias due to V2; as soon as its grid potential rises to within a few volts of the cathode V1 conducts. The anode voltage of V1 falls and takes the grid of V2 down owing to the d.c. coupling R1, R4 and R5. C1 across R4 ensures that the rapid change in potential of V1 anode is maintained on the grid of V2. The common cathode voltage falls but this fall is quickly checked by the rise in current through V1; as soon as the grid of V2 falls to a few volts below the common cathode potential V2 is cut off.

(b) The circuit will remain in a static state with V1 on and V2 off whilst the input voltage on V1 grid remains above a certain value determined by circuit constants, say 100V. When the input voltage is lowered to this value again the circuit does not return to its former static condition with V1 off and V2 on. The circuit only triggers back to the initial condition when the input falls to, say, +95V.

(c) Fig 4A shows graphically the relationship between the input voltage on the grid of V1 and the common cathode potential. The input voltage is increased to E1 when V1 conducts and V2 is cut off. The cathode potential drops rapidly at this point and then rises steadily as the input voltage is increased. When the latter is once more decreased no change occurs until E2 is reached at which point V2 conducts and V1 is cut off; thus restoring the circuit to its original condition. The heavy line indicates the cycle of events on increasing the input voltage and the dotted line the cycle when the input is decreased.

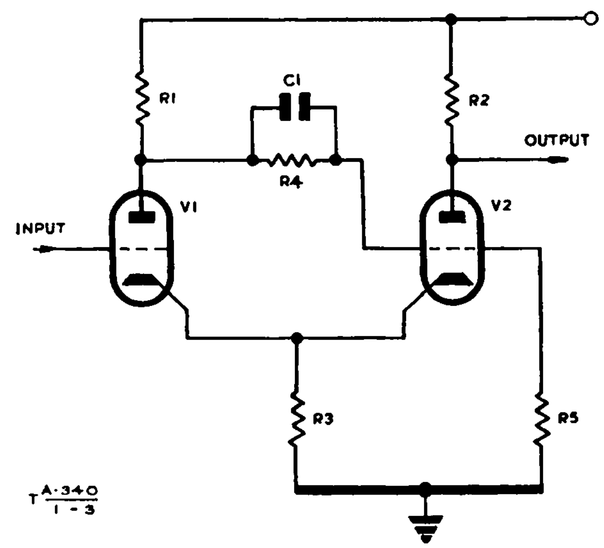

Fig 3 - Basic Schmitt trigger circuit

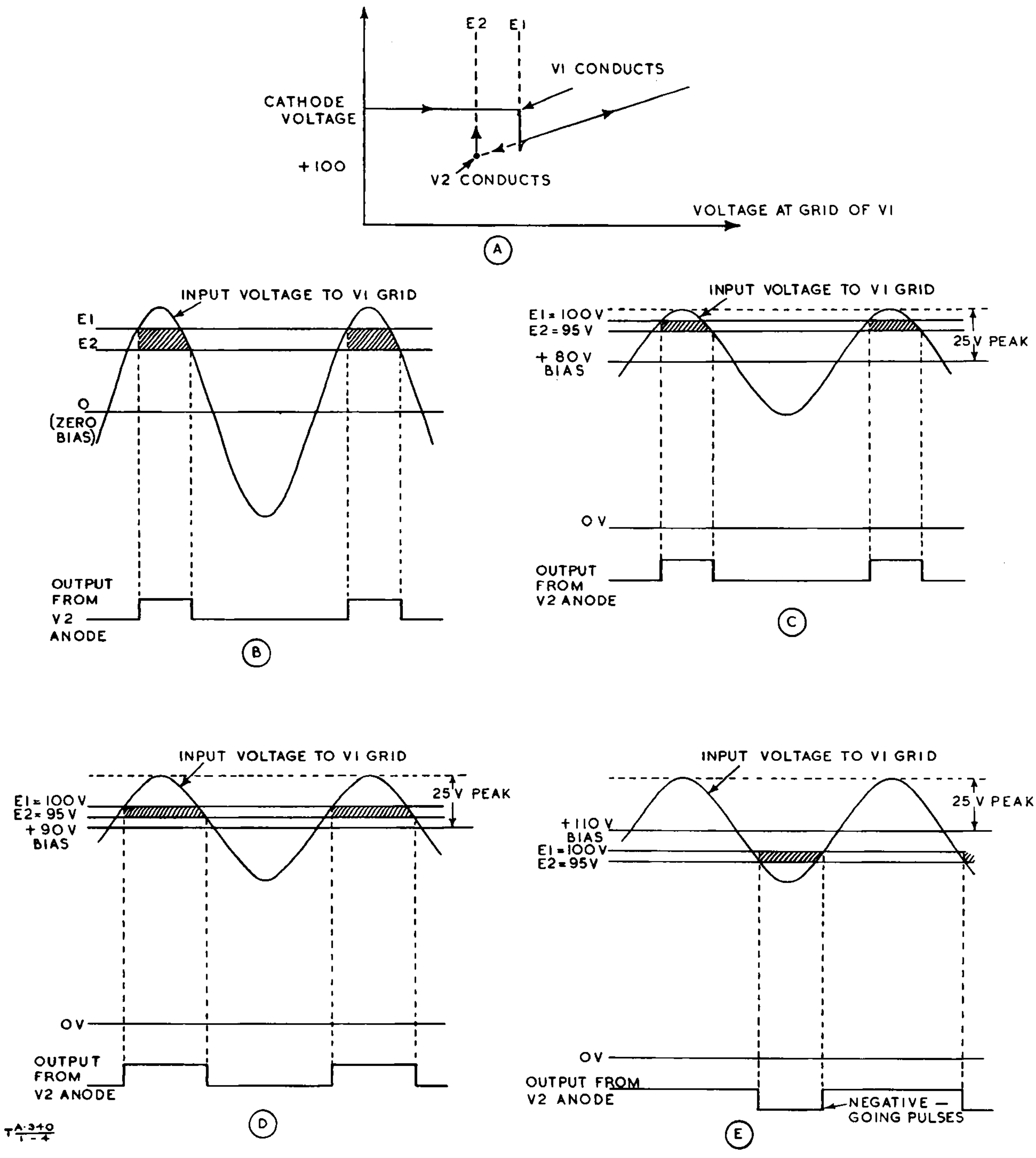

Fig 4 - Graphs showing the action of the Schmitt trigger circuit

(d) The difference in voltage between E1 and E2 is called the hysteresis of the circuit. It may be reduced to approximately 1V by circuit design. Fig 4B shows how a sinusoidal input may be 'sliced' to produce a square wave output at the anode of V2. Only the shaded part between voltages E1 and E2, of the input is effective in producing an output.

(e) If the grid of V1 is initially biased positively by a potentiometer connected between h.t. and earth, the 'slicing' action may be varied. As shown in Figs 4C and 4D the effect of changing the bias is to alter the width of the output pulse. The peak amplitude of the input sine wave is the same in each case but when the bias is increased the 'slicing' action occurs on a lower part of the input signal; the output pulse is therefore wider.

(f) The Schmitt trigger circuit may be used to convert a low frequency input into a square-wave output at the same frequency, the width of the output pulse being controlled by a potentiometer. The circuit for this is the same as Fig 3 with the addition of a potentiometer between h.t. and earth, the slider of which is connected to the grid of V1. The output is taken from the anode of V2. By arranging for the positive bias voltage on the grid of V1 to be above the upper change-over voltage (E1) a negative-going output can be obtained. Fig 4E indicates how the slicing of the negative half of the input can be achieved in this way.

6. Flip-flop circuit

(a) The basic flip-flop circuit (or Kipp relay) is a multivibrator with one valve biased beyond cut-off. The circuit completes only one normal multivibrator cycle if the bias is lifted for a very short time, the width of the output pulse being dependent on the constants of the circuit and not on the input.

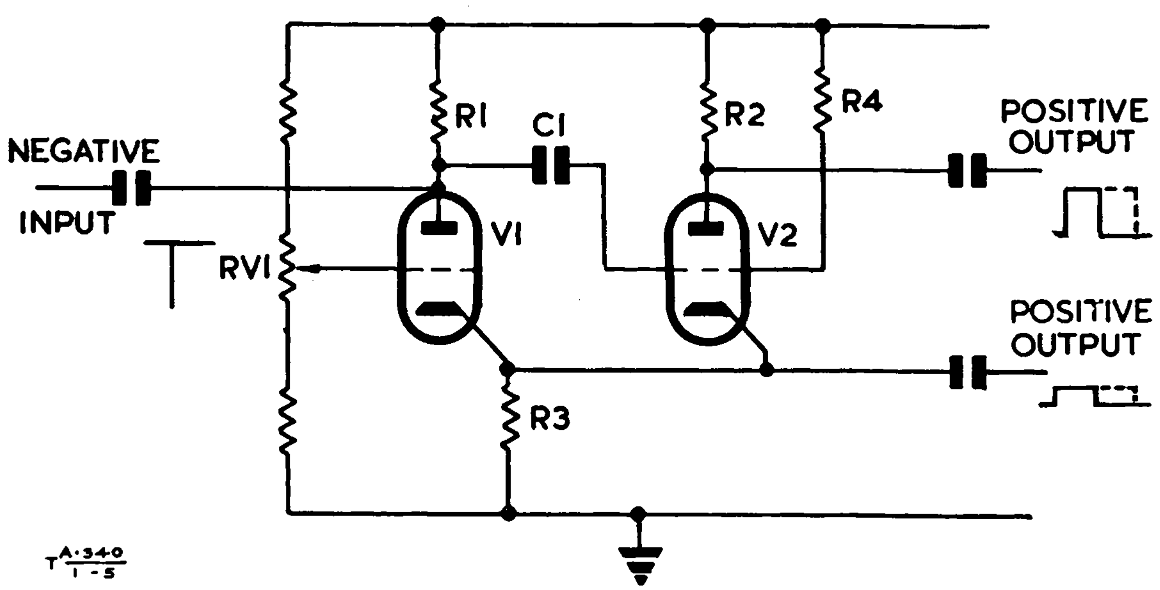

Fig 5 - Cathode-coupled flip-flop circuit

(b) Fig 5 is a cathode-coupled flip-flop; the back-coupling from V2 to V1 is achieved through the common cathode resistor R3. The grid of V2 is connected to h.t. +ve via R4 and sufficient grid current flows in R4 to keep the grid voltage down to that of the cathode. RV1 is set so that the voltage at the grid of V1 is below that of the common cathodes and V1 is therefore cut-off.

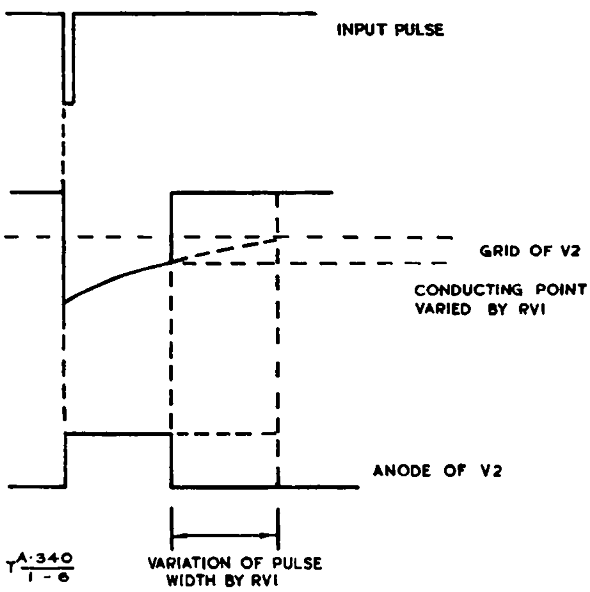

Fig 6 - Typical waveforms associated with the circuit shown in Fig 5

(c) Negative pulses applied to V2 grid (or positive pulses to V1 grid) lower the common cathode voltage relative to V1 grid so that V1 conducts. The anode voltage of V1 falls and V2 is cut off. The circuit will remain in this state until C1 has partially discharged through R4, and the grid voltage of V2 has returned to approximately that of the common cathodes. When this point is reached the flip-flop rapidly reverts to its original condition with V1 off and V2 on. Fig 6 shows typical waveforms associated with the circuit.

(d) The position of RV1 determines the anode current of V1 which, in turn, fixes the common cathode voltage when this valve is conducting. When C1 is discharging through R4, the grid voltage at which V2 conducts again is determined by the common cathode voltage. The point at which the circuit returns to its original state is thus dependent on the setting of RV1. The width of the output pulse can therefore be controlled by RV1 and this control is practically linear over a range of voltage.

(e) Other circuits are possible for a flip-flop but the basic principle of one valve being biased to beyond cut-off is always maintained. The flip-flop is used

(i) to provide a wider pulse than the input pulse
(ii) to provide a delay relative to the input.

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