3. Basic Circuit of Tunnel Diode Discriminator.

3.1 Tunnel diode monostable circuit. See Fig. 3.1

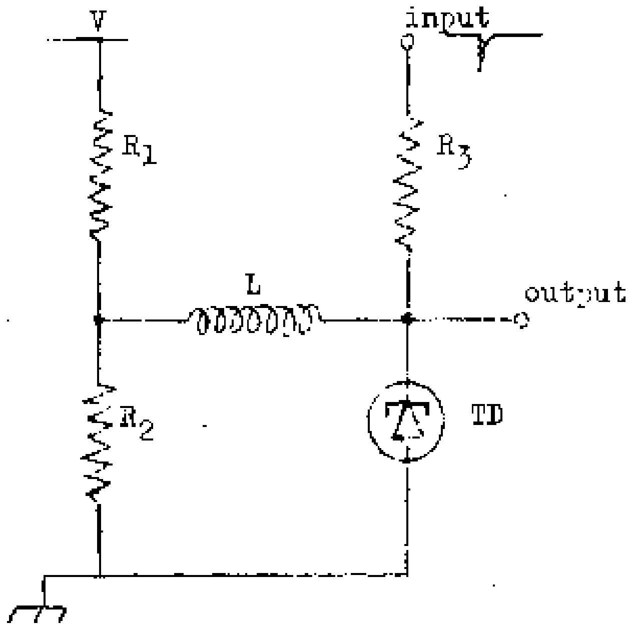
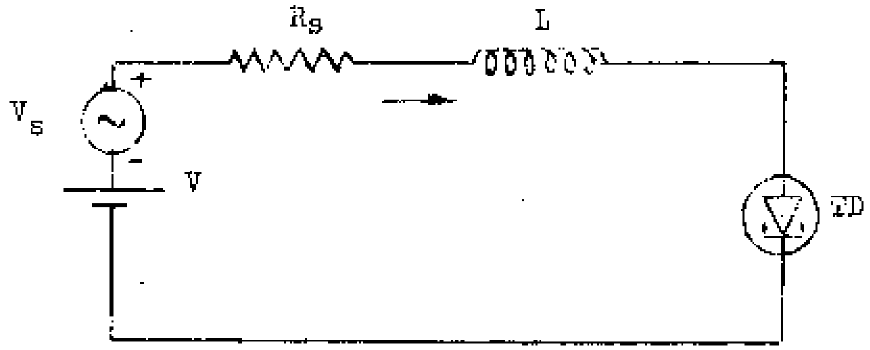
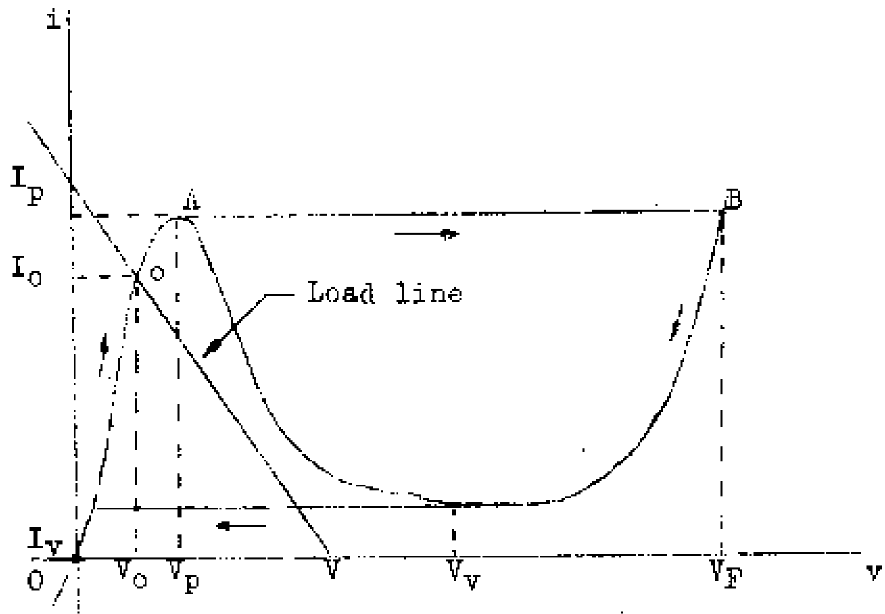


Fig. 3.1 Tunnel diode monostable circuit.

A monostable circuit biased by the voltage source V which is adjusted so that the load line intersects the diode characteristic at one point on the positive resistance portion either at high voltage or low voltage. See Fig. 3.2 a.,b.



a) Simplified circuit of Fig. 3.1



b) Switching operation

Fig. 3.2 Monostable operation of a tunnel diode.

Suppose the operating point is initially at point 0 where v = Vo and the diode current is i = Io. A negative voltage pulse v_s is applied to raise the load line so that it clears the peak at A. This trigger must have a time duration t_p adequate to allow the current in the inductor L to change from Io to I_p. The operating point having been raised to A, the circuit, of its own accord, follows the path indicated by the arrows, returning eventually to the starting point at 0.

A calculation of the duration T of the quasi - stable state, which agrees with experiment about 10 percent, can be easily carried out if the tunnel diode characteristic is represented by the piece-wise linear approximation with a reasonable fit if;

$$V_P' = 0.75\,V_P \qquad V_V' = \frac{V_F + V_V}{2}$$

See Fig. 3.3 If the diode resistance of the portion passing through the origin is called R_1 and if the second positive resistance region is designated by R_2 then

$$R_1 = V_P' / I_P \qquad R_2 = \frac{V_F - V_V'}{I_P - I_V}$$

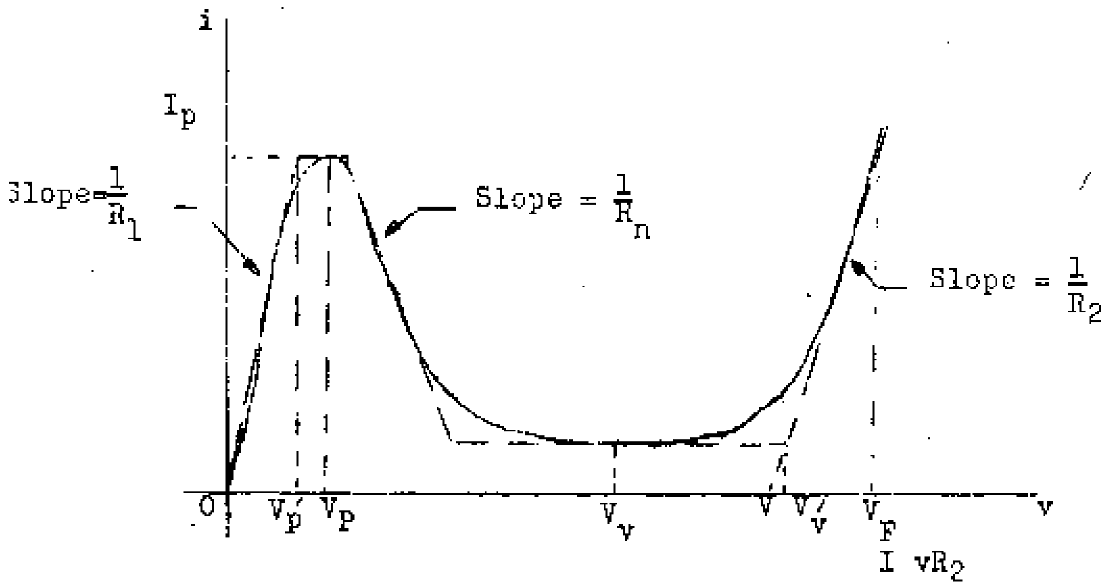


Fig. 3.3 A linear piece-wise approximation

To calculate T, the time duration from I_P to I_V we replace the device by a resistor R_2 in series with a battery $V' = V_V' - I_V R_2$ (as dictated by the piece - wise linear approximation the equivalent circuit is

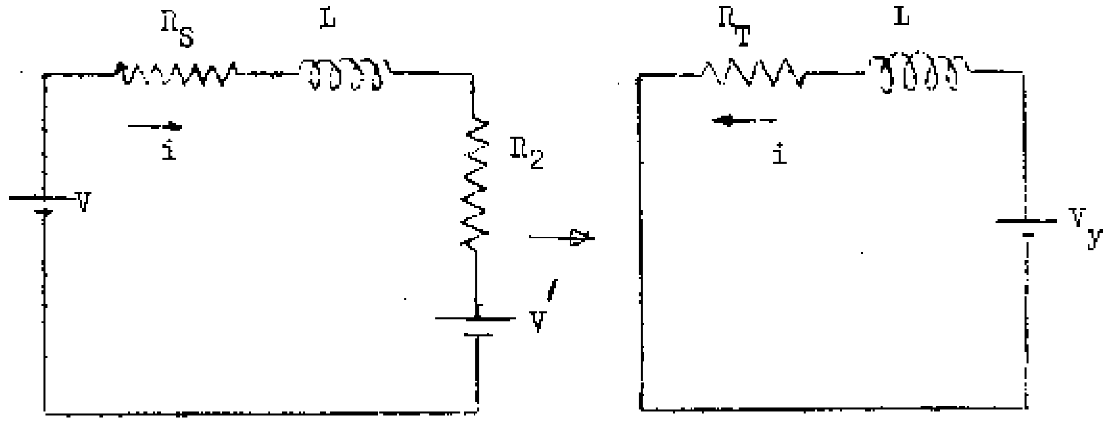


Fig. 3.4 A linear piece-wise approximation equivalent circuit.

$$R_T = R_s + R_2, \quad V_y = V' - V = V'_V - V - I_V R_2$$

at $t = 0$ $\qquad i = I_P$

$\quad t = \infty$ $\qquad i = -V_y/R_T$

$$\therefore \quad i = -\frac{V_y}{R_T} + \left(I_p + \frac{V_y}{R_T} \right) e^{-R_T t/L}$$

since i decreases to Iv at $t = T$

$$\therefore \quad T = \frac{L}{R_T} \ln \left(\frac{V_y + I_p R_T}{V_y + I_v R_T} \right)$$

$$= \frac{L}{R_T} \ln \left(\frac{V_y + I_p R_T}{V_y} \cdot \frac{V_y}{V_y + I_v R_T} \right)$$

$$= \frac{L}{R_T} \ln \left[\left(1 + \frac{I_P R_T}{V_y}\right) \Big/ \left(1 + \frac{I_V R_T}{V_y}\right) \right]$$

but $\ln(1+x) = x$

for $x \ll 1$; T

$$= \frac{L}{R_T}\left\{1 + \frac{I_p R_T}{V_y} - 1 - \frac{I_V R_T}{V_y}\right\}$$

$$= \frac{L}{R_T}\left(\frac{I_p - I_v}{V_y}\right) . R_T$$

$$= L\left(\frac{I_p - I_v}{V_y}\right)$$

The transition time is the time required to change voltage from V_p to V_F. It is limited by the inherent junction capacitance of the tunnel diode which can be calculated by

$$t_r = \frac{C}{I_p}(V_F - V_p)$$

for Ge - tunnel diode $V_F - V_p = 0.5$ volt.

$$\therefore \; t_r = \frac{C}{2I_p}$$

3.2 Tunnel diode bistable circuit. See Fig. 3.5

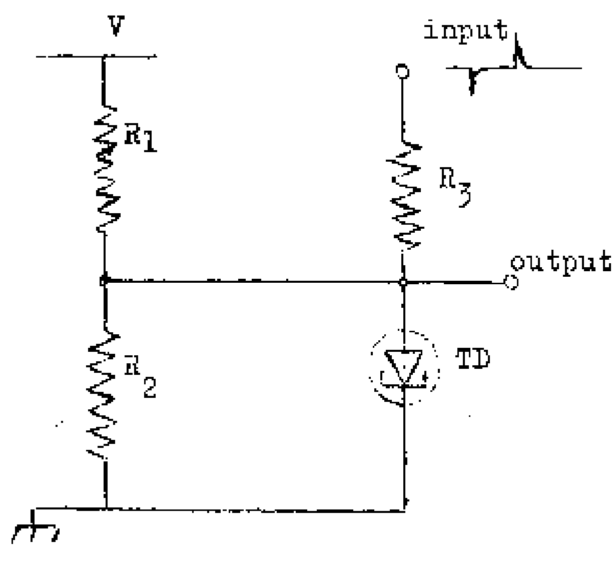


Fig. 3.5 Tunnel diode bistable circuit.

With the load line selected as indicated in Fig. 3.6. It has two stable states at the point of intersection of the load line with the positive resistance portions of the device characteristic at 1 and 2

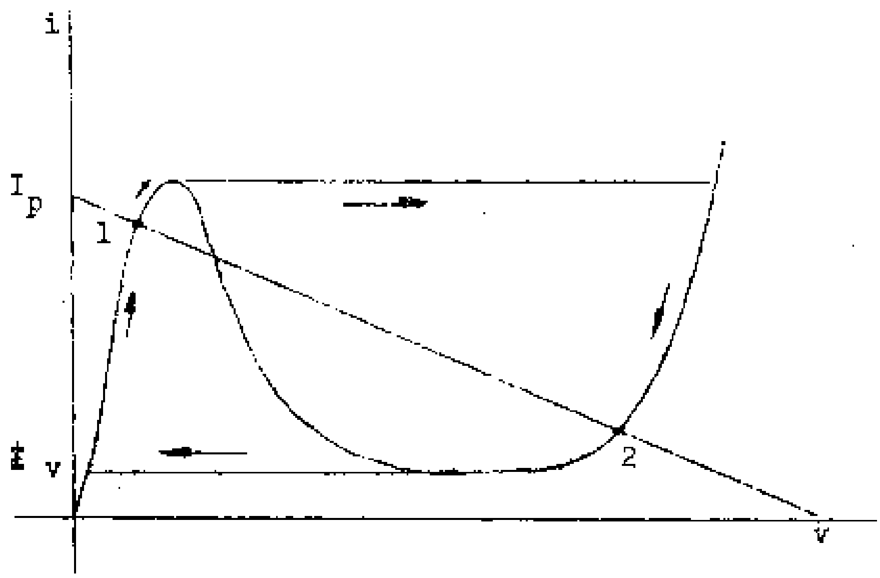


Fig. 3.6 Switching Operation of tunnel diode bistable circuit.

If the circuit is at 1 and the signal source furnishes a negative pulse adequate to raise the load line above I_p, the transition will occur as indicated by an arrow, the circuit will be at 2. Similarly, a positive pulse adequate to drop the load line below I_V will reset the circuit to 1. Thus the circuit has two permanent stable states and may be used to store binary information. The pulse repetition rate is governed by the sum of transition time and the resettting time which is approximately equal to the delay time in section 3.1

3.3 Tunnel diode - Transistor hybrid Circuit.

See Fig. 3.7

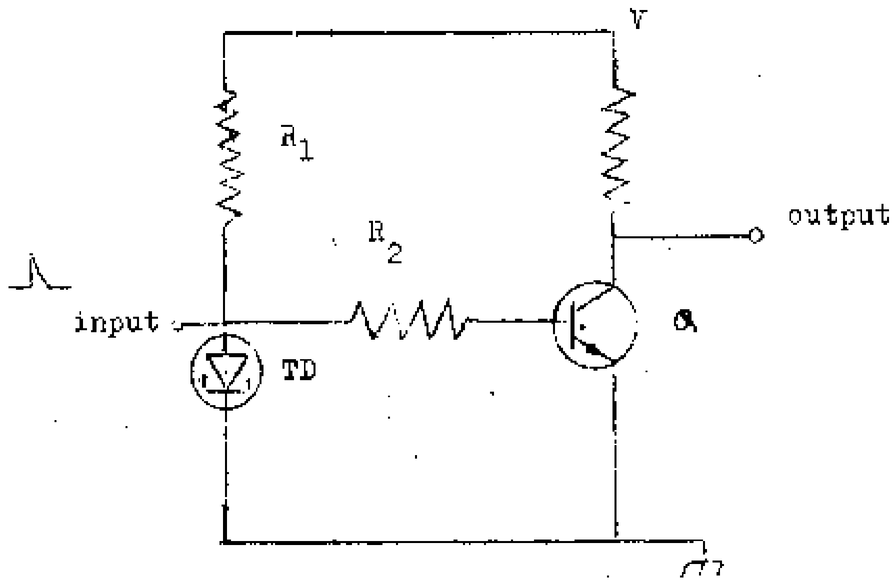


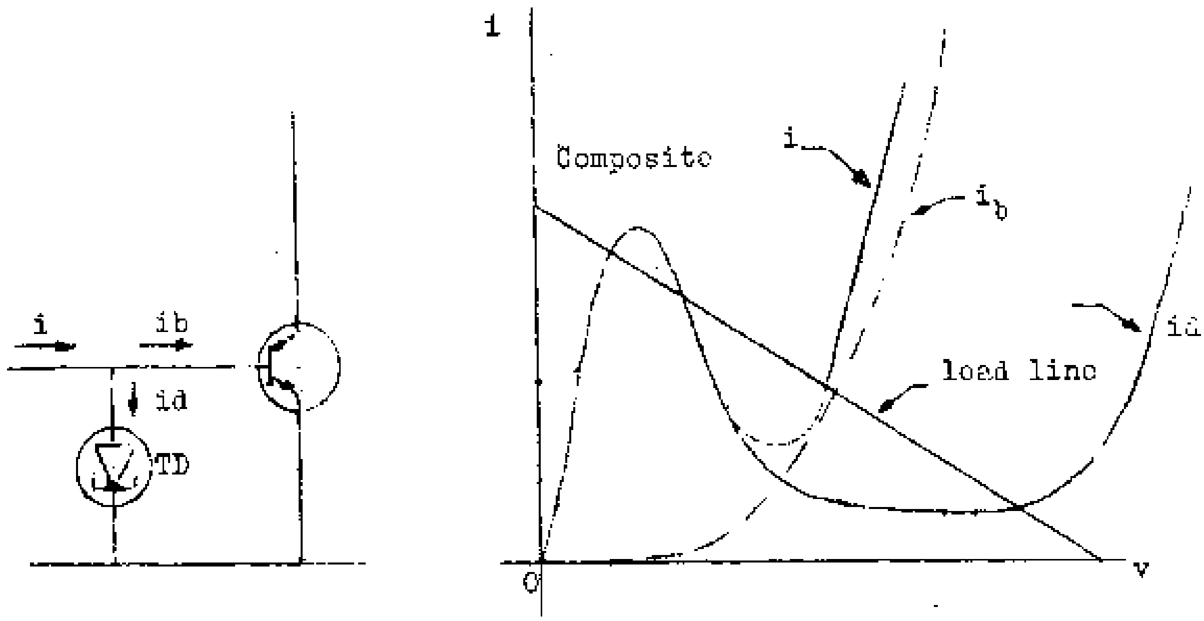
Fig. 3.7 Tunnel diode - transistor hybrid circuit.

A tunnel diode has two quantities of great merit in switching applications. It switches extremely rapidly (with switching time = 1 ns.) and responds to a pulse of very small energy.

In comparison, a transistor may require a pulse of 10 times larger energy to switch one to other state. Moreover, a single tunnel diode may be used to construct a circuit with two stable states, where two transistors are required for this purpose.

On the other hand, a transistor has the advantage over the tunnel diode that the transistor operates at appreciably higher voltages. The voltages and voltage - changes encountered in tunnel diodes are of the order of a few tenths of a volt, but in transistor circuits these voltages are at least tens of volts. Additionally, the tunnel diode has the very disconcerting feature that, having only two terminals, the input and output ports are not isolated from one another. As a consequence, in circuits that involve cascades of tunnel diodes, it is difficult to ensure that the signal will proceed in one direction only. It is not surprising that advantages in combination of two devices is obtained.

A basic **fixed** bias circuit of a tunnel diode transistor hybrid is shown in Fig. 3.8 with its composite characteristic.



a, Basic circuit b, Composite characteristic

Fig. 3.8 **Fixed** bias tunnel diode - transistor hybrid discriminator.

The composite characteristic retains the general shape of a tunnel diode characteristic thus we may adjust the load line for all types of switching functions as in Fig. 3.7 but however, Fig.3.8 a b is prefered because of its simplicity. The input pulse must be large enough to switch the tunnel diode and the base emitter of the transistor must be less than the high voltage portion of the tunnel diode to ensure operating condition and to get faster switching time, or else the transistor would not yet be turned on even when the tunnel diode is on the high voltage.