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TRANSISTOR CHARACTERISTICS CURVE TRACER

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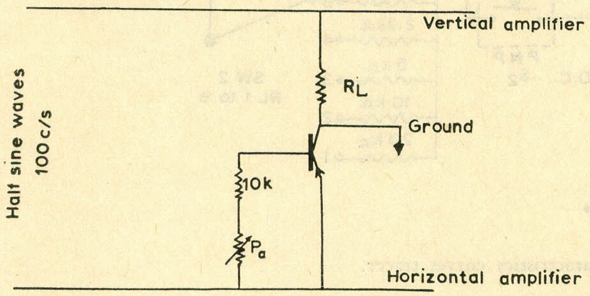
A mains-operated, reliable and inexpensive transistor characteristics curve tracer, has been designed for use in the laboratory. The instrument embodies a saw-tooth generator, staircase generator, differnt load and base resistances and a regulated power supply. The characteristic curves of PNP or NPN (silicon or germanium) transistor are displayed on an oscilloscope, when the instrument is connected to its horizontal and vertical amplifier.

Before using transistors in most of the electronic circuits, it is necessary to know its characteristic curves. An instrument has been developed in Special Electronics Division of Atomic Energy Centre, Lahore, which can display a family of transistor characteristic curves, when connected to the horizontal and vertical amplifiers of an oscilloscope.

Theory

The diagram shown below explains the basic principle involved in displaying transistor characteristic curves on an oscilloscope.



A series of half sine waves, with a frequency of 100 c/s and 10V in amplitude, is applied to a load R_L. If the horizontal terminal is grounded, full 10V will be applied to the vertical amplifier and a vertical sweep will appear on the cathode ray tube (CRT). In the same way horizontal sweep can also be produced by grounding the vertical terminal. Under these conditions, if the voltage across R_L increases, a vertical trace will be produced. When $I_c = BI_b$, the voltage across R_L will remain constant, and would increase across the transistor. This will make the sweep to deflect horizontally unless the supply voltage reaches its peak value. As the supply voltage decreases to zero, the trace will retrace its path. Now if the potentiometer P_a is varied, every setting of P_a will produce different base currents, the curve for which will appear on the oscilloscope. To produce a family of V_c/I_c curve, on the oscilloscope, a d.c. potential increasing in steps is applied to the base of a transistor, which is synchronized with the sine-wave or saw-tooth wave applied to the collector of a transistor under test (saw tooth wave is used in this case).

Description of the Circuit Diagram

It consists of following circuits:

(1) Saw tooth generator (1 kc/s).

(2) Staircase generator followed by an emitter follower.

(3) (a) SW_1 selects different base resistances.

(b) SW_2 selects different load resistances.

(c) S_2 selects the desired polarity for PNP and NPN transistor.

(d) J_1 and J_2 transistor connecting points.

(e) J_3 connecting points for oscilloscope.

(4) 28 volts d.c. regulated power supply.

With reference to the circuit diagram Q_1 is a unijunction transistor, being used as a free running saw-tooth oscillator, the frequency of which can be varied by potentiometer P_1. The saw-tooth produces current pulses across P_2, which charges capacitor C_2 in steps. The step frequency is controlled by potentiometer P_2. After C_2 reaches its peak value, it discharges through Q_3 (another unijunction) and thus a staircase is produced. Q_2 is also followed by an emitter follower Q_4.

The stair-wave is being fed through SW_1 to the base of a transistor under test.

Q_5 is another emitter follower which feeds saw-tooth wave through SW_2 to the collector of a transistor under test.

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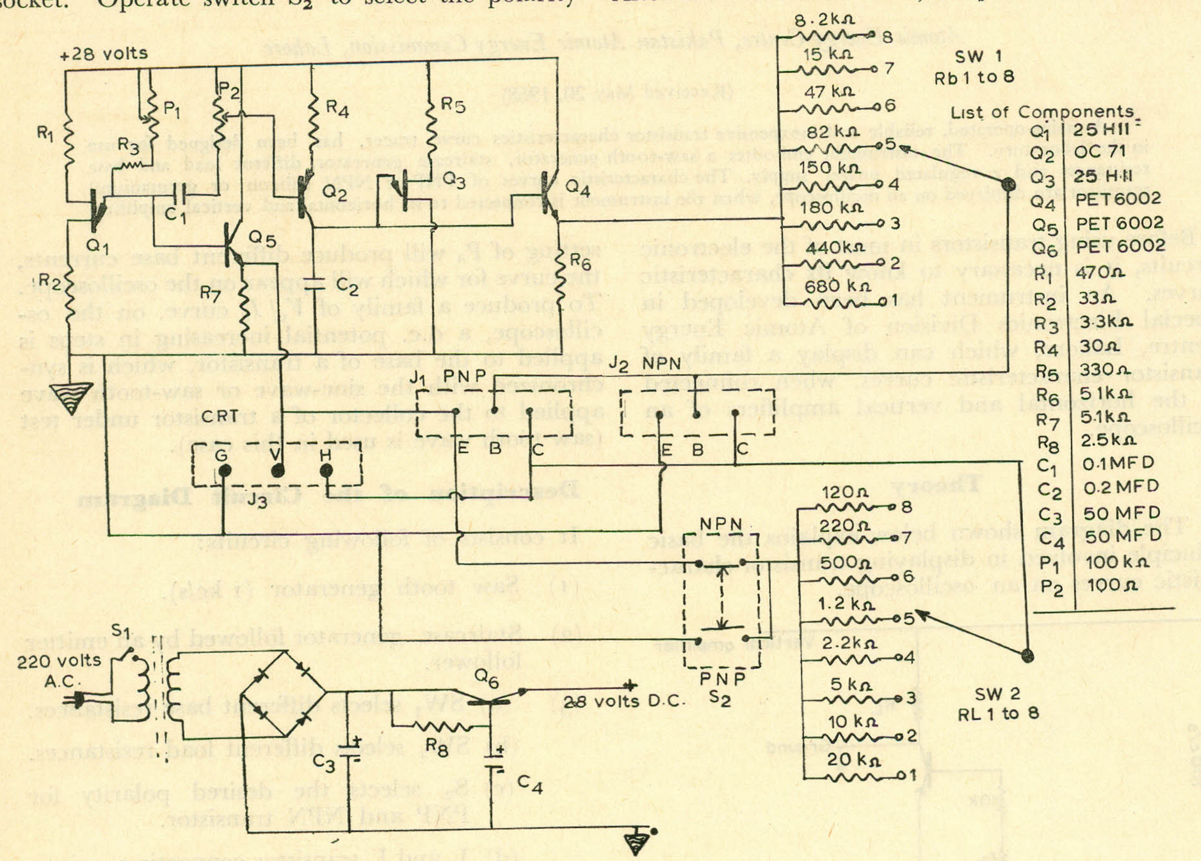
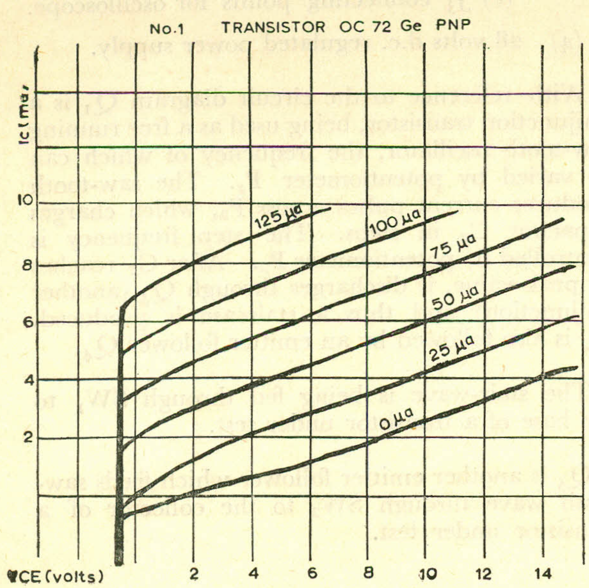
Operation.—The instrument described above is very simple to operate by connecting three terminals to an oscilloscope as shown in the circuit diagram. Insert transistor in a PNP or NPN socket. Operate switch S_2 to select the polarity for NPN and PNP.

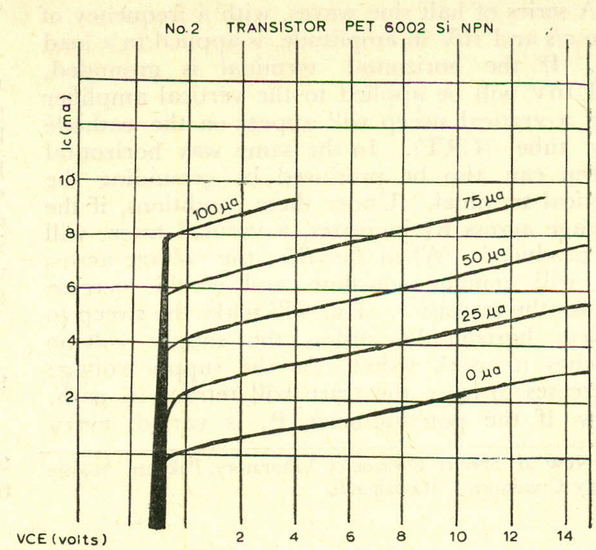
Before putting on the instrument, rotary switches SW_1 and SW_2 should be kept on position I. After the instrument is on, SW_1 and SW_2 should



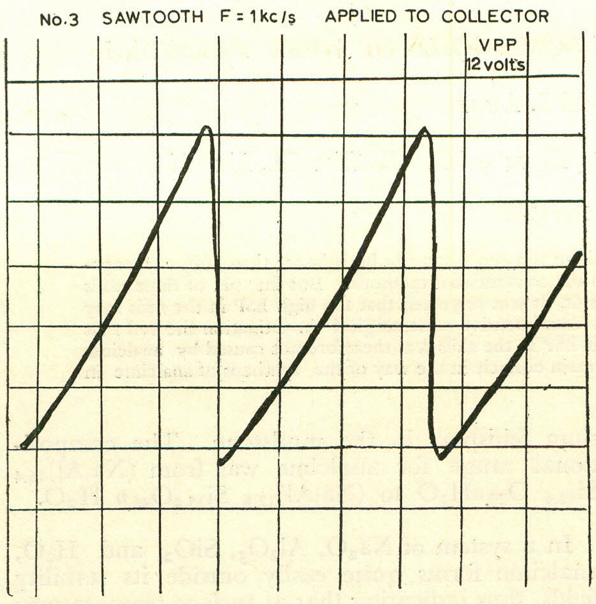
Circuit diagram of transistor charactristics curves tracer.



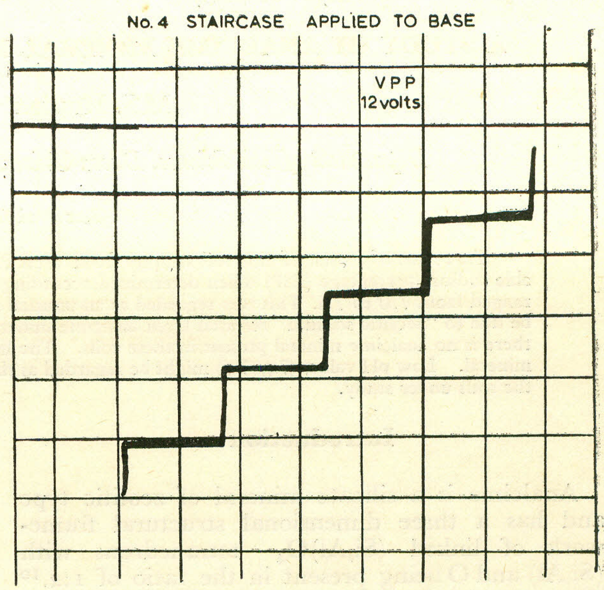
Exposure 1.



Exposure 2.



Exposure 3.



Exposure 4.

be rotated to a position, where the curves just appear on CRT. The number of curves depends upon the number of steps, which can be controlled by potentiometer P_2.

Results

(1) *Exposure No.* 1 shows family of characteristic curves V_c/I_c of a germanium transistor OC72.

(2) *Exposure No.* 2 shows family of characteristic curves V_c/I_c of a silicon transistor (NPN).

(3) *Exposure No.* 3 staircase applied to the base of transistor under test.

(4) *Exposure No.* 4 shows the saw-tooth applied to the transistor under test.

TABL 1

Position of SW_1, and SW_2	Base current ma	Collector load ohm
1	0.0045	20,000
2	0.012	10,000
3	0.021	5,000
4	0.053	2,000
5	0.14	1,000
6	0.2	500
7	0.52	200
8	1.02	100

Table 1 shows the base current associated with the last curve, displayed on the oscilliscope on different positions. The base current divided by the number of curves, would give the current associated with each curve.

The collector current associated with the last curve can be calculated as under:

$$I_c = B \times I_b$$

$$I_c = \frac{V_{pk} \text{ (peak volts)}}{R_L}$$

Then d.c. current gain (beta) can be calculated as under

$$B = \frac{V_{pk}}{R_L \times I_b}$$

Application.—The instrument is very much useful in electronics laboratories, where research and development work is being carried out. This enables the engineer and technician to detect a faulty transistor and to choose a desired operating point. This also can be utilized in semiconductor industry.

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