CHAPTER 7

TUNNEL DIODE TEST CIRCUITS

The measurement of tunnel diode parameters requires considerable care to insure that the test circuit is in a stable state while performing the test. Oscillation or switching is usually avoided by appropriate "loading" or "damping" of the circuit while in some special cases it may even be encouraged in order to measure a specific parameter more accurately.

The parameters to be tested depend on the application. For example, if the device is used as an oscillator or amplifier, the negative conductance $|g_d|$, the capacitance C, the inductance L_s and the series resistance R_s must be known (see the tunnel diode equivalent circuit in Figure 2.5).

As a switching circuit element, it might be more desirable to know I_p, I_v, V_p, V_v, V_{fp} and switching speed (t_r). The following test circuits are designed to measure these parameters. Some of these circuits will yield readings with accuracies of only $\pm$ 10 to 20% and are quite simple in nature. Others are designed for high accuracy and naturally will be more complex.

7.1 V-I Curve Tracer

Observing the tunnel diode V-I characteristic is not always an easy task. Conventional curve tracers usually have enough series resistance in their sweep circuits as to appear as a current source to the tunnel diode under test, that is,

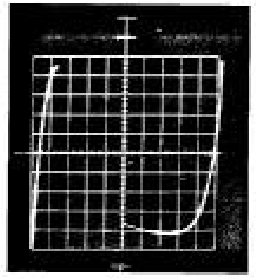
$$R_T > \frac{1}{|g_d|} \qquad (7.1)$$

where R_T is the total DC resistance in series with the tunnel diode being tested. As a result, the displayed V-I characteristic lacks the negative conductance portion as shown in Figure 7.1.

This figure shows that as the sweep passes the peak point current, the diode switches very quickly from V_p to some value of forward voltage dependent on the load line, without ever going through the negative conductance region.

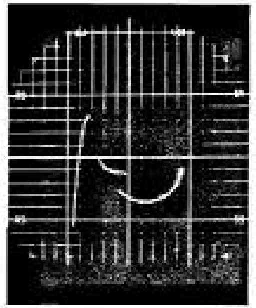
This problem becomes even worse when testing larger peak current units as they will exhibit smaller values of negative resistance. The sweep circuit will thus look more like a current source to such units enabling them to "switch" more readily.

Even when the sweep circuit resistance is small compared to $|-rd|$, still another problem might prevent the undistorted display of the V-I curve. Figure 7.2 illustrates this problem which is caused by ex-



V-I CHARACTERISTIC AS DISPLAYED BY CURVE TRACER WITH LARGE INTERNAL SERIES RESISTANCE
FIGURE 7.1

cessive series inductance in the test circuit. As the sweep goes through the negative conductance region, this inductance will resonate with the diode and circuit capacitances, making the circuit oscillate and causing a display as shown in Figure 7.2.



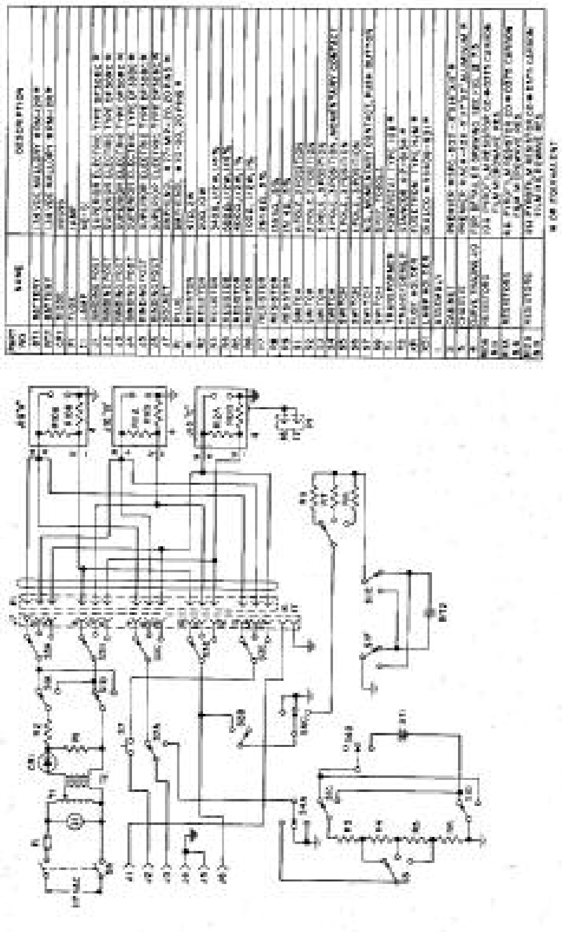
V-I CHARACTERISTIC OF OSCILLATING TUNNEL DIODE
FIGURE 7.2

If the total circuit inductance (including the diode inductance L_s) is kept at a minimum, this oscillation will not occur. Actually, if the circuit self-resonant frequency $f_{xo\ (circuit)}$ is made larger than its cut-off frequency, $f_{ro\ (circuit)}$, no oscillations can occur. To meet this criterion, the total circuit inductance must be smaller than:

$$L_{total} < \frac{R_{Total} \times C_{total}}{g_d} \qquad (7.2)$$

Here again larger peak current units will be more troublesome to test, as one can see from equation 7.2 that if $|g_d|$ is increased, the maximum permissible circuit inductance is further reduced.

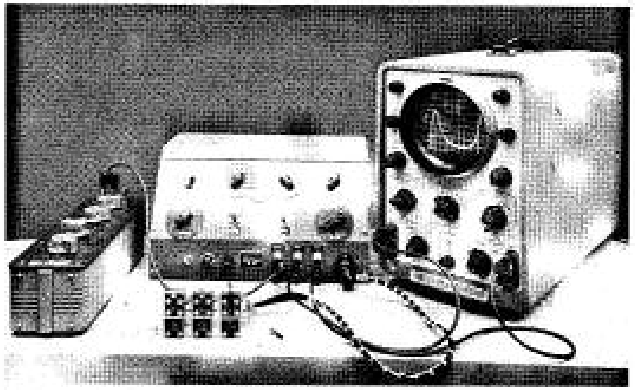
The main features of a well working V-I curve tracer capable of displaying the full V-I characteristic of tunnel diodes with a wide range of peak currents, are thus:

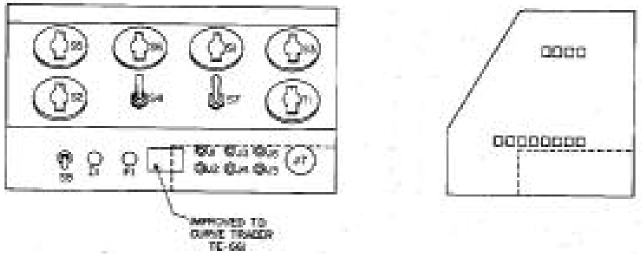


V-I CURVE TRACER CIRCUIT DIAGRAM
FIGURE 7.3

1. A low series resistance sweep circuit and,
2. Low inductance test heads.

The curve tracer circuit shown in Figure 7.3 and pictured in 7.4 covers a range of units from a fraction of one milliampere to 22 ma. With appropriate calibration (see Table of Calibration Procedures), this test set will determine, I_p, I_v, I_p/I_v, V_p, V_v, V_{fp}, V_r as well as to give a rough idea of the positive slopes and the negative

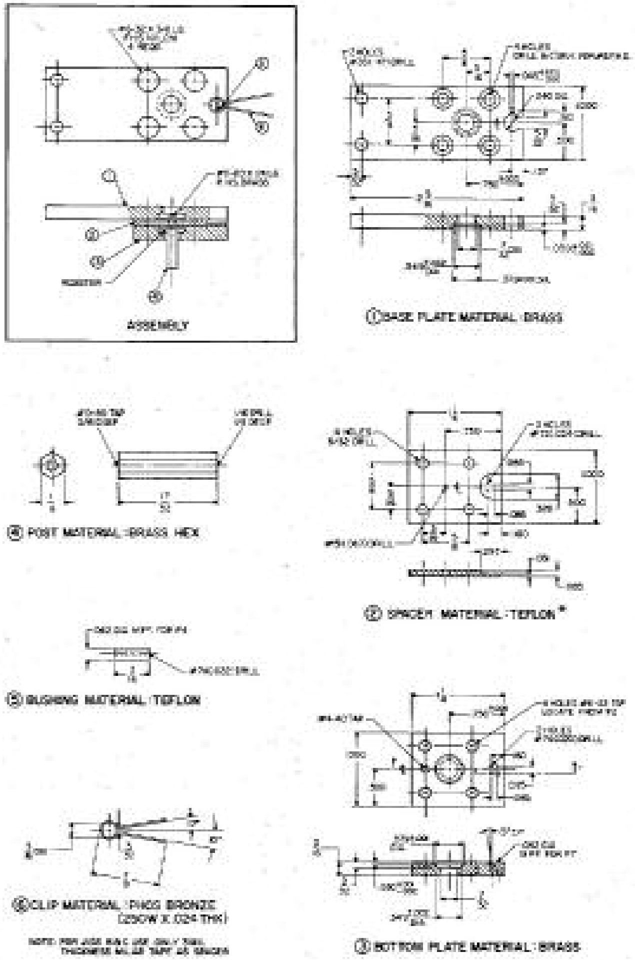




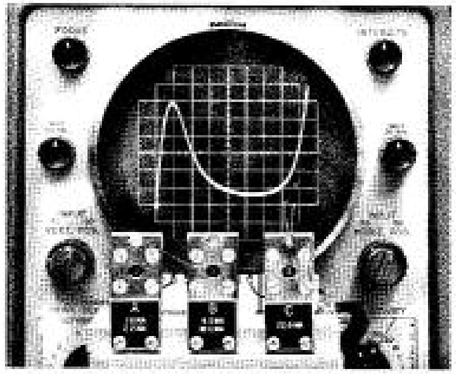
PHOTOGRAPH OF CURVE TRACER TEST SET UP
FIGURE 7.4

conductance slope. By the use of the shunting decade box, a rough idea can also be obtained of the average value of the negative resistance ($1/g_d = d_v/d_i$).

Figure 7.5 is a mechanical drawing detailing the construction technique of the jigs.



OUTLINE DRAWING OF LOW INDUCTANCE TEST JIGS
FIGURE 7.5



CLOSE-UP PHOTOGRAPH OF JIG AND SCOPE PRESENTATION
FIGURE 7.6

This instrument is made more versatile by the small size, low inductance test heads. Since the bias resistors are incorporated in the test heads, these may be connected with long cables to the main chassis and the decade box. As a result, one can conveniently and stably test tunnel diodes in a temperature chamber at some distance from the test set. Figure 7.6 is a photograph of the V-I curves of a 22 ma germanium tunnel diode.

Operating Instructions for Curve Tracer

The three outputs of the curve tracer are connected to the Vertical and Horizontal inputs of a scope (HP 130B or equivalent) and a Resistance Decade Box. Note: To display the V-I characteristic "right side up", the vertical scope input must be inverted and the ground strap removed from what is then the "hot" lead.

The Selection Switch must be in the germanium (Ge) or gallium arenside (GaAs) position, depending upon the type of unit under test.

The Range Switch must be in the A, B or C position, depending upon the jig in use.

Jig A is for 1.0 and 2.2 ma units. Jig B is for 4.7 and 10.0 ma units. Jig C is for 22.0 ma units.

The Function Switch must be in operating position.

With the Curve Tracing Voltage Control in the counter-clockwise position, insert the diode. Increase the voltage until the trace is beyond the valley region.

Press the Decade Switch and adjust the decade box until the negative slope is parallel with the horizontal axis. This setting on the decade box is then the terminal negative resistance of the unit being tested. Figure 7.7 shows the resulting curve trace and the setting of the resistance box for a 10 ma unit.

Scope Calibration

To calibrate the horizontal axis of the scope, the Function Switch must be in the calibration position. In this position, the scope output terminals are shorted and the calibration voltage switch in either the .1v, .5v or 1.0v position. The "Calibrate Voltage-Calibrate Current" switch is then pressed in the "Cal. Voltage" position. The calibrated voltage will then appear across the output terminals.

The same applies to the calibration of the vertical axis, with the exception that, if a 1 ma calibration is desired, the Range Switch must be in the A position and the diode in Jig A removed. If the 5 ma calibration is desired, the Range Switch must be in the B position and the diode in Jig B removed. For 10 ma calibration, the Range Switch must be in the C position and the diode in Jig C removed.