Price $1.00

THE DYNAMIC
TRANSISTOR CURVE TRACER

JUD WILLIAMS

MODEL A

P. O. BOX 671, WINTER HAVEN, FLA. 33880

MODEL A

MODEL A TRANSISTOR CURVE TRACER

The one and only instrument that checks transistors in-circuit regardless of circuit impedances. Not only does the D. T. C. T. work with bipolar transistors but it also checks FETs, diodes and zeners in-circuit. Simply attach the Model A to any general purpose oscilloscope and you have the most complete semiconductor testing facility possible and at a budget price. At a glance you can determine such parameters as gain, linearity, saturation, avalanch point and the leakage of any transistor by observing its family of characteristic curves. Touch the three prong probe to a transistor in-circuit and immediately the "signature pattern"tells if it is good or bad. No zeroing or balancing is necessary with this simple to use instrument. The twin sockets allow you to match transistors with a flick of a switch and for the first time semiconductors may be tested to manufacturers specifications making it possible to select proper replacements. This amazing instrument performs the all-important breakdown voltage test on transistors and it does so non-destructively. The Model A will tell if a transistor is silicon or germanium and whether an FET is a junction type or an MOS device and then it will tell the polarity. In no way can the curve tracer damage a transistor even if it is plugged in backwards.

GENERAL

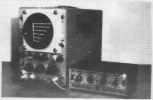
The Model A Dynamic Transistor Curve Tracer is a dual purpose instrument in that it checks several of the more important parameters of transistors at a glance and is able to check transistors in-circuit on a go, no-go basis. The instrument is quite simple to use and is conclusive in its tests. It requires an oscilloscope as a monitor and virtually any type of scope may be used as long as it has a horizontal input. The pattern that appears on the CRT of the scope is a Lissajous pattern since the signals are fed into both the horizontal and vertical axis of the scope. The scopes sweep function is not used.

Many types of semiconductor devices may be tested on the curve tracer such as bipolar transistors, Junction and MOSFETs, zeners, diodes, rectifiers, tunnel diodes, etc. Among the tests that can be performed are DC Beta, AC Beta, voltage breakdown, zener avalanch point, leakage, and linearity. The instrument supplies all the necessary signals to perform the tests as indicated. The tests are all non destructive even if the device to be tested is inserted incorrectly. By the same token the instrument is short circuit proof and is generally immune to external effects. The controls on the instrument are designed for easy interpretation and no prior knowledge of semiconductors is necessary in order to use the instrument effectively. Its use is an education in itself.

The curve trac comes equipped with two cables, one terminating in alligator cl and the other a three prong probe. With these an operator may eck transistors and diodes in-circuit using the "signature pa ern" technique.
The Model A is accurately calibrated and it requires that the scope that is being used as a monitor be accurately calibrated, particularly in the vertical direction so that a positive determination of BETA may be made.

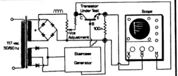
The special three prong probe contacts a transistor in circuit to display the telltale "signature pattern."

The Dynamic Transistor Curve Tracer teams up with a general purpose oscilloscope to become a complete semiconductor testing facility.



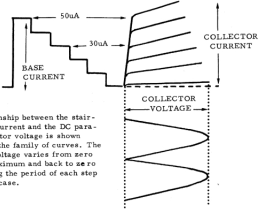
HOW THE CURVE TRACER WORKS

The Dynamic Curve Tracer does its work by sweeping the transistors collector to emitter with a 120 Hz pulsating dc voltage. Synchronized with this is a staircase generator supplying the base with calibrated steps of current. This turns the transistor "on" and displays a family of characteristic curves on an oscilloscope. The pulsating dc collector to emitter voltage starts at zero and rises to its maximum test voltage and then returns to zero at a 120 Hz rate. It is the usual waveform seen at the output of a full wave rectifier. At the beginning of each sweep cycle the base is turned on by the current level produced by one step of the staircase generator. Since the steps operate at a 120-Hz rate they are synchronized with the voltage sweeping across the collector to emitter.



FUNCTIONAL DIAGRAM

The staircase generator is calibrated in microamperes and volts and produces six steps. Each step produces one curve in the family of curves and because the system operates at a 120-Hz rate all the curves appear simultaneously. The oscilloscope is operating as an XY scope when used with the curve tracer and the display is a Lissajous pattern.



The relationship between the stair-case base current and the DC parabolic collector voltage is shown relative to the family of curves. The collector voltage varies from zero volts to maximum and back to zero again during the period of each step of the staircase.

SPECIFICATIONS

Vce (Voltage, collector to emitter). Variable from 0-80Volts peak. Full wave rectified pulsating DC @ 120Hz.

I_B (Base current) Six steps displayed simultaneously. Variable from luA/step to lmA/step (5mA max.) in a 1-2-5 sequence. Attenuator accuracy is 5%.

V_{GS} (Gate-Source Voltage)Six voltages displayed simultaneously with ranges of 0.2V/step, 0.5V/step and lV/step. Divider accuracy is 5%.

Dissipation limiting: Collector current limited by 1000 ohm load resistor.

Collector current sensing resistor: 100 ohms, 5% accuracy.

Staircase Generator: Six steps, 1V/step calibrated to 10%.

Bias Adjustment: Establishes zero base line and is variable over a range of 5 volts.

Power: 105-125V, 50/60 Hz.

CONNECTION TO SCOPE

The curve tracer has three leads coming from the rear of the chassis. They connect to the oscilloscope as follows.

RED LEAD: SCOPE VERTICAL INPUT.

WHITE LEAD: SCOPE HORIZONTAL INPUT.

BLACK LEAD: SCOPE COMMON OR GROUND.

For some oscilloscopes it may be necessary to insert a 1 to 10 megohm resistor in series with the Horizontal input to prevent over driving the horizontal amplifier of the scope. If your scope is triggered but has AC coupling into the horizontal axis it is suggested that the input capacitor be shorted so that it becomes DC coupled. In this way the pattern will be more stable because it will retain a fixed reference. IMPORTANT!!! The scopes sweep function is not used when viewing the curve tracer Lissajous pattern. Switch your scope selector to EXTERNAL or HORIZONTAL INPUT.

FOR BEST RESULTS IT IS SUGGESTED THAT THIS INSTRUMENT BE USED WITH A DC COUPLED, CALIBRATED SCOPE SUCH AS THE TRIGGERED SWEEP VARIETY.

CONTROLS

SWEEP VOLTAGE: Level control for the 120 Hz pulsating DC voltage that appears across the collector to emitter of the transistor under test. This control also adjusts the forward and reverse voltage for testing diodes and other two terminal devices.

STEP GENERATOR; Supplies the base of bipolar transistors with six steps of base current ranging from luA/ step to 1000uA/step. Also supplies the gate voltage to FETs in six steps ranging from 0.2V/step to 1V/step. OPEN BASE position allows for breakdown tests without physical removal of the base lead. ZERO GATE shorts the gate to source to show the zero bias drain current.

SWEEP POLARITY: Reverses the polarity of the sweep voltage and the staircase generator to selectively apply the proper signal conditions for the testing of transistors and diodes.

STEP POLARITY: Inverts the step generator independently from the sweep polarity control when testing FETs.

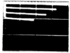
SOCKET SELECTOR: Switches between the two semiconductor sockets to match or compare transistors. The third position switches to probe for in-circuit testing.

BIAS ADJUSTMENT

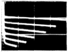
The BIAS control shifts the staircase generator so that the family of curves may be positioned properly. The photos show how the pattern looks when incorrectly positioned. When testing bipolar transistors always be certain that the STEP POLARITY is in the "normal" position and the BIAS control is near the center of its rotation. In the section on FETs it is explained how the family of curves is shifted in its position by use of the BIAS control.

To be certain that the BIAS is set to the correct position rotate the control so that the zero base current curve forms a right angle to the vertical portion of the family of curves and so that the remaining curves are relatively evenly spaced. With the Base Current set at 10uA/step keep your eye on the third curve up from the bottom (20uA) and switch the STEP GENERATOR control back and forth between the 10uA/step and the 20uA/step positions. The 20uA curve should not change position if properly adjusted.

IMPROPERLY ADJUSTED BIAS CONTROL



BIAS SETTING IS FULLY CCW.



BIAS SETTING IS FULLY CW.

SIMPLE OPERATING PROCEDURE

(1) Attach to scope as describe on a previous page and plug into the AC power line. Turn curve tracer on.

(2) Set SWEEP VOLTAGE to 10 or15 Volts.

(3) Set STEP GENERATOR to 10 uA/step.

(4) Select proper socket and insert transistor. .

(5) Select the proper SWEEP POLARITY if known. Since the curve tracer cannot damage the transistor it is not harmful to insert the transistor improperly or to select the wrong polarity.

(6) Set the BIAS so that the zero base current curve is properly positioned. About mid point in the BIAS rotation will set it for silicon transitors. SEE SECTION on Bias adjustment.

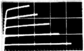
(7) Be sure that the STEP POLARITY switch is in the NORMAL position.

NOTE: It is <u>not</u> necessary to turn the curve tracer off when inserting or removing transistors. The curve trácer cannot damage your transistor.

WHAT TO LOOK FOR

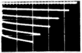
When testing transistors there are several immediate conditions to be observed on the scope display.

OR



NORMAL PNP TRANSISTOR

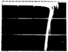
OR



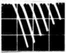
NORMAL NPN TRANSISTOR

OPEN

SHORT

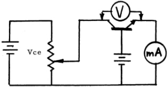


INSERTED WRONG

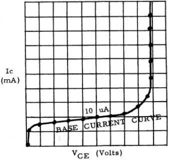


WRONG POLARITY

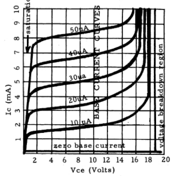
Since the family of characteristic curves tells a great deal about the transistor it is necessary for the user of the curve tracer to be familiar with the make up of the pattern. Of primary importance is the understanding that the curves are actually a graph representing the effect that a fixed amount of base current has upon a transistor as the collector voltage and current vary. By using the simplified curve tracer shown below the points of intersection of each of the meter readings would develop into a complete characteristic curve as shown on the opposite page. The family of curves would be developed if the process of plotting curves were repeated while changing the amount of base current for each series of readings.



SIMPLIFIED CURVE TRACER



Characteristic curve of a transistor plotted using a simplified curve tracer.



A complete family of characteristic curves as developed by a dynamic transistor curve tracer.

CALIBRATION

Calibration of the oscilloscope is best accomplished by viewing the staircase output of the curve tracer. This signal is present between the emitter and base connections on the curve tracer. Turn the SOCKET SELECTOR to probe and plug the alligator clip lead into the probe socket. Attach the shielded (emitter) lead to the scope ground and the white (base) lead to the scope vertical input. Adjust the scope sweep speed to view the staircase. The steps are factory adjusted to 1 Volt per step so by adjusting the scopes vertical gain control so that the staircase is superimposed onto the graticule, the scope will be calibrated to 1 Volt per division. Next, reset the vertical input of the scope to 0.1 Volt per division taking care not to upset the position of the vernier gain control of the scope. The collector current sensing resistor within the curve tracer is 100 ohms and is the basis of calibration of the scope. With the scope calibrated to 0.1 Volt per division, the vertical display on the CRT will read 1 mA per division of collector current.

In order to read Beta directly from the CRT of the scope observe the spacing between the curves as related to the scope divisions. When the Base Current control is set at 10 uA per step each division on the scope face will represent a Beta of 100. By switching to 20uA/step, each division then becomes a Beta of 50. The chart gives other setting equivalents.

READING BETA DIRECTLY FROM THE C. R. T.

Scope Calibrated to 0.1 V/ div. = 1 m A of collector current per division.

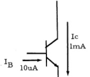
BASE CURRENT SETTING	EQUIVALENT Beta PER DIVISION
1 uA/ step	1000
10 uA/ step	100
20 uA / step	50
50 uA/ step	20
100 uA / step	10
200 uA / step	5
500 uA / step	2
1000 uA / step	1

When inserting the transistor, be sure that it is oriented properly because it is possible to put a transistor in backwards and by increasing the base current to a high value (500 to 1000 uA/step) a family of curves will develop. The Beta of the transistor will be somewhere between 0.5 and 3.

A TRANSISTOR PLUGGED IN BACKWARDS WITH A BASE CURRENT OF 500 uA/step. THE BETA MEASURES 3.

BETA or GAIN: The parameter of most interest in testing transistors is h_{FE} (Static Forward Current Transfer Ratio)-Common Emitter, better known as DC Beta. Beta is most commonly thought of as the ratio of current gain between the base and collector. Its formula is:

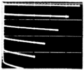
$$\text{Beta} = \frac{I_C}{I_B} \quad \frac{\text{Collector Current}}{\text{Base Current}}$$



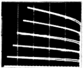
In the curve tracer the transistor is tested in the common emitter configuration thus the letter "E" in the h parameter notation h_{FE}. The published specifications on transistors refer to tests performed using the Dynamic Transistor Curve Tracer.

The primary concept concerning transistor action is that a transistor is a current controlling device. The collector-emitter junction will conduct current as a result of the valve action of its base and by virtue of the presence of a voltage potental on the collector. As the base current increases, so does the current flow through its collector-emitter junction. To best understand "gain" we should look at the values of current flowing through the transistor in the sketch above.

The collector of the transistor is conductiong 1000uA due to the potential across it plus the presence of 10uA of base current. We can see therefore that 100 times as much collector current is flowing as base current, thus the transistors Beta is 100. Among the advantages in using the curve tracer for determining gain is that it produces a graph that follows each of the transistors irregularities which would be impossible to detect using a meter type of transistor checker.



A NORMAL N-P-N BIPOLAR TRANSISTOR DISPLAY



A NORMAL P-N-P BIPOLAR TRANSISTOR DISPLAY

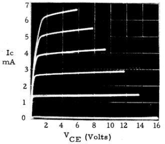
The grid in the photo on the next page is calibrated in the horizontal axis as V_{CE} which is the potential across the Collector-Emitter junction. The vertical axis represents the magnitude of the Collector current flow.

In determining the Beta for a transistor a Collector-Emitter voltage that will satisfy the particular application must be chosen. A voltage of 8V will be used in our example. The illustration shows that the applied base current is 10uA per step so that the family of curves is made up of ZERO, 10uA, 20uA, 30uA, 40uA and 50uA. By tracing the 10uA curve along its path we see that it intersects 8 volts at 1.4mA. Dividing the base current of 10uA into 1.4mA results in an answer of 140, which is the DC Beta at that point.

The AC Beta represents a change in Beta or more simply put, the difference of Beta between two different base current curves. Curves are not always as evenly spaced as shown here due to the non-linear characteristics of transistors. For that reason the AC Beta and the DC Beta will not always be the same. Nor will the AC Beta always be uniform.

The tendency of the curves to slope upward (in the direction of increasing collector current) is caused by decreasing collector output resistance. This rise is interpreted as the output admittance of the transistor.

The "h" parameter notation is h_{oe} and is specified as mhoes. It is determined by dividing the change in collector current by the change in collector voltage.



CHARACTERISTIC CURVES OF A BIPOLAR TRANSISTOR WITH A BASE CURRENT OF 10uA PER STEP. THE BETA IS 140 AT A V_{CE} OF 8 VOLTS.

NOTE: This photo has been inverted from what would normally be seen on a monitor scope.

IDENTIFYING THE TRANSISTOR LEADS

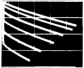
If you are having difficulty identifying the leads of the transistor so that it may be oriented in the socket properly, a procedure may be followed that will assist in identifying the leads. This procedure specifically applies to silicon transistors.

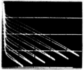
Check between each pair of leads by plugging them into the C-E holes in the socket. Set the SWEEP VOLTAGE to 20 Volts. Switch the SWEEP POLARITY control back and forth between NPN and PNP. If the transistor is not defective and if it is silicon, a distinct "L" shaped pattern will appear in contrast to either a straight line or a "j" pattern. This identifies the Base-Emitter junction. The third lead is the collector. Insert the transistor into the socket with the collector in its correct hole. Insert the other two leads into the remaining holes and switch the SWEEP POLARITY between NPN and PNP. A family of curves should appear. Be sure that the STEP POLARITY switch is in the "normal" position, the BIAS control is near the center of its rotation and the STEP GENERATOR is set at 10uA/ step.

The "L" shaped pattern that was observed in this procedure is actually a zener junction within the transistor. The presence of this zener junction identifies the transistors alloy as silicon.

LEAKAGE

When the ZERO base current curve deviates away from a horizontal direction as shown in the photographs below it is an indication of I_{CEO} leakage which is usually more pronounced in germanium transistors than in silicon. If the leakage is more than slightly visible in a silicon transistor it would be considered excessive. The amount of leakage increases as the collector voltage increases until the transistor reaches Voltage Breakdown.





EXAMPLES OF TRANSISTORS WITH VERY HIGH LEAKAGE. THE LEFT PHOTO IS SILICON AND THE RIGHT IS GERMANIUM.

BREAKDOWN VOLTAGE

Breakdown voltage is checked by sweeping the collector-emitter junction while leaving the base lead open. The curve tracer has an "open base" position one stop CCW from the 1 uA/step position on the STEP GENERATOR control. This will open the base lead of the transistor being tested. The SWEEP POLARITY control is to be set so that a horizontal line appears on the scope. The SWEEP VOLTAGE level control is increased gradually as the operator observes the trace on the scope. A point is reached where a vertical trace will appear. This is the avalanch point or the voltage breakdown point. The voltage may be read directly from the SWEEP VOLTAGE control. This test is NON-DESTRUCTIVE although the transistor may heat up if the test is performed with base current present as illustrated below. When selecting a transistor for original design or for replacement purposes, it is advisable to select one whose Breakdown Voltage is twice the systems power supply. The MODEL A is limited to 80 Volts for safety reasons and there will be instances where the Breakdown Voltage of the transistor under test will exceed the range of the instrument so that no indication of the avalanch point will be present. Diodes may be tested in the same manner as transistors.

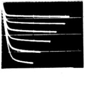
TRANSISTOR ENTERING BREAKDOWN REGION

DETERMINING THE SEMICONDUCTOR ALLOY

Diodes and transistors may have their alloy determined by using the same testing procedure in either case. They are both tested as two terminal devices so that the component leads are plugged into the C and E holes in the test sockets. If the clip leads are used, use only the shielded lead and red lead. In either case the staircase is not being used. The component is being tested by applying the parabolic waveform that is controlled by the SWEEP VOLTAGE control. The polarity of this waveform is controlled by the SWEEP POLARITY switch.

When a device is inserted into the test socket and the voltage applied to it, it will appear to be a straight horizontal line if the applied voltage is sweeping the junction in the reverse direction. By changing the SWEEP POLARITY the trace will go in the vertical direction and will take on a "j" shape. The small hook on the end of the trace is the "barrier voltage". This barrier voltage varies from 0.2V in maginitude for Germanium devices to 0.7V for Silicon devices when being swept in the forward direction.

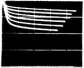
A second and more rapid method of checking for Silicon transistors is to check the Base-Emitter junction in the forward and reverse direction as described above. When the junction is being swept in the reverse direction the appearance of an "L" shaped zener pattern identifies the transistor as Silicon.



N-CHANNEL MOSFET

A word of caution from semiconductor manufacturers concerning FET testing. They say that insulated gate FETs should NOT be tested for voltage breakdown as this may damage the device. Junction FETs may be tested by applying voltage between the gate and either the source or drain. A second method would be to short the Source and Drain together and test between that point and the gate. An FET may be tested for Gm by applying gate voltages of either 0.2V per step, 0.5V per step or 1V per step. These voltages are controlled by the STEP GENERATOR switch. An additional position called "zero gate" shorts the gate to source to establish the location of the zero bias drain current curve. When this curve is located and related to the family of curves, the BIAS control may be adjusted so that the longest curve of the family of curves is located in the same position on the scope display. Refering to the photographs on the opposite side of the page you will see that when the STEP POLARITY switch is in the "normal" position the FET will be in the enhancement mode of operation.

In the enhancement mode of operation the curve tracer is applying positive sweeps of voltage to the Drain-Source and the steps of gate voltage are operating in the positive direction. By switching the STEP POLARITY into the inverted position, the steps will operate in the negative direction causing the FET to operate in the depletion mode. When operating in the depletion mode the "pinch off voltage" can be seen as the voltage required to turn off drain current.



JFET OPERATING IN THE DEPLETION MODE

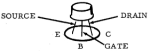
JFET OPERATING IN THE ENHANCEMENT MODE.

In some instances you will find FETs that will function with the Drain and Source leads reversed. This seems to be peculiar to junction FETs.

In order to determine whether an FET is a junction FET or a MOSFET rotate the STEP GENERATOR control through the "base current" ranges while observing the family of curves. If the pattern remains unchanged throughout the entire range the device under test is a MOSFET. If the curves draw closer together toward the low current range then the device is a junction FET.

The FET may be identified as either an N-channel or P-channel by noting the position of the SWEEP POLARITY switch. If in the NPN position, the FET would be an N-channel where as the PNP position would identify a P-channel device.

If a dual FET is to be checked, one set of leads may be plugged into one of the transistor sockets while the cable with the alligator clips are attached to the remaining leads. For dual gate devices, check one gate at a time using conventional techniques.



PROPER ORIENTATION OF AN FET IN THE SOCKET

ZENER DIODE TESTING

Zener diodes may be tested and sorted very accurately using the curve tracer. Since the scope is calibrated in the vertical direction it stands to reason that zeners may be tested more precisely by taking advantage of this. Prior to conducting any tests on the zener the connecting leads from the curve tracer to the scope must be changed around as follows;

WHITE LEAD TO SCOPE VERTICAL
RED LEAD TO SCOPE HORIZONTAL
BLACK LEAD TO SCOPE GROUND

As the SWEEP VOLTAGE is increased it will deflect in the vertical direction on the scope face. When the zener avalanch point is reached, the deflection will change to the horizontal direction. Changing the SWEEP POLARITY will change the direction in which the junction is swept. In the forward direction the display will appear as a "j". The scope may be most conveniantly calibrated to 2V/ division.

SOFT KNEE

IRREGULAR ZENER POINT

UNEVEN VOLTAGE

IN-CIRCUIT TESTING OF TRANSISTORS

The testing of transistors in-circuit using the dynamic transistor curve tracer is a technique that was discovered by our firm. It was concluded that since the curve tracer tests a transistor out of circuit by "turning it on" it should do the same in-circuit. On the following pages are examples of the "signature patterns" that result from transistors being turned on in-circuit by the curve tracer. The shapes of the patterns vary from one circuit to another but are the same for all other circuits that are alike. Because of this, the patterns may be photographed and used as standards for comparative trouble shooting.

The desirable thing about using the "signature pattern" method of trouble-shooting is its utter simplicity. No technical skill is necessary to use the technique.

Not only may transistors be checked but FETs, diodes and zeners will show up good or bad using the curve tracer in-circuit. As with all other things, practice and experience enhance an operators ability in the use of this technique.

This trouble shooting technique does not indicate the quality of any components in-circuit as the patterns defy analysis thus the technique is offered as strictly a go, no-go test.

IN-CIRCUIT TESTING PROCEDURE

No changes are made in the way the curve tracer is connected to the scope. If the scope is DC coupled, switch it to AC input.

CURVE TRACER SETTINGS

STEP POLARITY............... NORMAL

SWEEP POLARITY.............. WILL VARY ACCORDING TO THE DEVICE BEING TESTED.

STEP GENERATOR.............. 20uA per step, may be varied later. (1V/step for FETs)

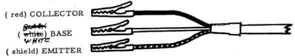
SOCKET SELECTOR............. PROBE

SWEEP VOLTAGE............... 20 Volts.

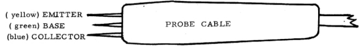
BIAS............................ CENTER OF ROTATION

Either the PROBE containing the three color coded prods may be used or else the cable with the alligator clips may be used depending on the accessibility of the components being tested.

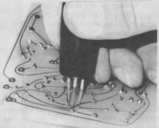
PROBE COLOR CODING



CLIP LEAD CABLE



HOW TO HANDLE THE PROBE

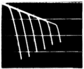


HOLD THE PROBE SO THAT THE BLUE PROD IS TO THE LEFT, GREEN IN THE CENTER AND YELLOW IS TO THE RIGHT. PRESS DOWN FIRMLY FOR GOOD CONTACT.

The probe is the most efficient way to obtain the "signature patterns" due to its unique design. It requires a bit of practice in order to use it rapidly. Holding it properly is most important. In the photograph the collector (blue) prod is to the left, the base (green) is in the center with the emitter (yellow) to the right. The base prod is the shortest so that the collector and emitter prods are brought into contact with the transistor first and by rolling the probe over, bring the base prod into contact. When all three prods are touching, press down firmly and the spring loading effect of the prods will force the sharp points through the built up oxidation on the solder pad. The curve tracer may be manipulated with the free hand.

HOW TO OBTAIN SIGNATURE PATTERNS

Only two controls need to be manipulated while testing transistors in-circuit. The SWEEP POLARITY will apply collector voltage to the transistor under test and may be switched back and forth to determine the polarity of the transistor. Applying the wrong polarity cannot damage the transistor. The STEP GENERATOR is the signal fed to the transistors base which turns it on. The setting of the STEP GENERATOR is directly related to the impedances encountered in the test circuit. The best procedure to use if no standard is being followed is to rotate the base current control so that the amount of current being supplied to the transistor under test is being increased. Attempt to obtain the maximum number of curves possible.



WRONG POLARITY BEING APPLIED IN-CIRCUIT.

If the wrong polarity of SWEEP VOLTAGE is being applied to the transistor a pattern similar to the one illustrated will appear, otherwise a pattern similar to the examples shown on the following pages will develop.

Certain types of circuits will present difficulties. Output transistors require that the scope have a very sensitive Horizontal amplifier. Sometimes the vertical axis of the scope may be used to achieve the necessary sensitivity to be able to develop a signature pattern. for such low impedance circuits.

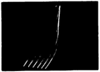
UHF OSC.

V_{CE}8v I_B200μa

Q200 1ST PIX IF

V_{CE}24 I_B100μa

Q202 2ND PIX IF



V_{CE}25 I_B100 μa

Q304 AGC GATE

V_{CE}35 I_B100μa

Q300 AGC AMP

Q306 NOISE GATE

V_{CE}32 I_B50μa

Q208 2ND VIDEO AMP

V_{CE}35 I_B200 μa

Q102 1ST AUDIO AMP

V_{CE}35 I_B100 μa

Q104 AUDIO OUTPUT

V_{CE}35 I_B200 μa

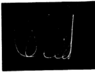
Q612 2ND CHROMA AMP

V_{CE}34 I_B100 μa

Q606 CHROMA OUTPUT

V_{CE}35 I_B100 μa

Q600 ACC AMP



V_{CE}32 I_B100 μa

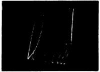
Q204 3RD PIX IF

$V_{CE}34$ $I_B500\ \mu a$

Q604 BLANKER

$V_{CE}24$ $I_B100\ \mu a$

Q610 1ST CHROMA AMP



$V_{CE}34$ $I_B100\ \mu a$

Q308 SYNC SEP.

$V_{CE}30$ $I_B50\ \mu a$

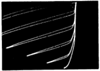
Q602 COLOR KILLER

$V_{CE}35$ $I_B50\ \mu a$

Q614 BURST AMP

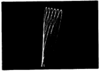
$V_{CE}10$ $I_B500\ \mu a$

Q1102 AFC AMP



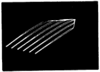
$V_{CE}26$ $I_B20\,\mu a$

Q1000 OSC. IN REMOTE HAND BOX (TRANSMITTER)



$V_{CE}35$ $I_B50\,\mu a$

Q1050 1ST IF AMP

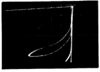


$V_{CE}17$ $I_B10\,\mu a$

Q1308 SOUND B+ REG. + MUTE

$V_{CE}35$ $I_B50\,\mu a$

Q1310 AFC OVERRIDE

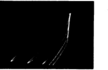


$V_{CE}35$ $I_B200\,\mu a$

Q1312 AFC OVERRIDE

$V_{CE}35$ $I_B50\,\mu a$

Q1008 4TH REMOTE IF AMP

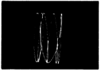


V_{CE}34 I_B50 μa

Q1010 FUNCTION REVERSING

V_{CE}33 I_B50 μa

Q1012 UHF MOTOR REVERSING



V_{CE}34 I_B100 μa

Q1 FM AMP

V_{CE}22 I_B200 μa *

Q2 MIXER

V_{CE}35 I_B200 μa

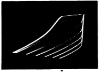
Q3 OSC.

V_{CE}34 I_B200 μa

Q616
Q608 X & Z DEMOD.

V_{CE}25 I_B100 μa

Q1100 AFC IF



V_{CE}32 I_B200 μa

Q302 20V FILTER

V_{CE}25 I_B1000 μa

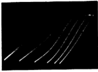
Q1054 3RD IF AMP,
Q1056 4TH IF AMP

V_{CE}25 I_B200 μa

Q1300 SYNC COUPLER

V_{CE}34 I_B50 μa

Q206 1ST VIDEO AMP



V_{CE}35 I_B50 μa

WARRANTY

Should this instrument give you trouble we suggest that you return it to our facility for repair and calibration. During the first year of ownership, repairs will be done at our expense at our facility as long as the unit has not been abused or tampered with. After one year the instrument will be repaired for any electrical failure for a fee of $10.00. Replacement of damaged parts such as chassis, sockets, knobs, leads and switches will be billed extra as replacement parts.

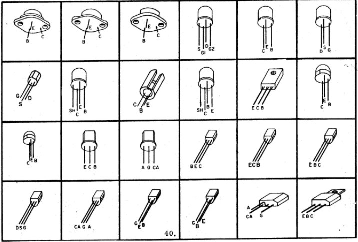
When shipping to our facility be sure to pack carefully and include the two probes. The best method of shipping is via UPS. You may use our P.O. Box number as the address or if you wish you may drop us a card requesting our street address.

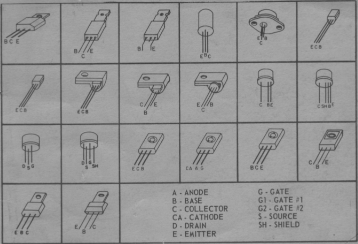
If you wish to ask any questions regarding the Model A Curve Tracer please drop us a line or phone us at the numbers given below.

JUD WILLIAMS
P.O. BOX 671
WINTER HAVEN, FLA. 33880

TELEPHONE.
(813) 293-2940
OR
(813) 293-5215

TRANSISTOR BASING




B C E
B C E
B E
E B C
E B C
ECB
ECB
ECB
C E B
E B C
C BE
CSHBE
D S G
D G S SH
ECB
CA A G
BCE
C E B
EBC
E C B
A - ANODE
B - BASE
C - COLLECTOR
CA - CATHODE
D - DRAIN
E - EMITTER
G - GATE
G1 - GATE #1
G2 - GATE #2
S - SOURCE
SH - SHIELD