MODEL 3B

H8

TEST EQUIPMENT CORPORATION

DALLAS, TEXAS

TEC

MODEL 3B

IN-CIRCUIT TRANSISTOR AND DIODE TESTER
(MEASURES TRUE AC BETA)

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IN-CIRCUIT
TRANSISTOR AND DIODE TESTER

TEST EQUIPMENT CORPORATION

2925 Merrell Road - P.O. Box 20215 - Dallas, Texas 75220
Area Code 214 - FL 7-6271

WARRANTY

Test Equipment Corporation warrants that each new standard product sold by the corporation or by its appointed representative is free from defects in material and workmanship and when properly used will perform in full accordance with applicable specifications for the period of one year after date of shipment to the original purchaser.

Any product found defective covered by this warranty after examination by our factory or authorized representative will be repaired or, at our option, replaced without charge except for tubes, transistors, or batteries that have given normal service. Written authorization must be obtained from the factory before return shipment to the factory or authorized repair agency is made. All return shipments must be prepaid, and the repaired product returned FOB factory or repair agency. A service charge will be made for defects which the factory or its appointed representative determines to be due from improper handling or abuse of the product.

Test Equipment Corporation is not liable for any damage to components or consequential damages incurred by the use of any product.

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INTRODUCTION

This manual is intended for use by the operator of a Test Equipment Corporation (TEC) Model 3 In-Circuit Transistor and Diode Tester. The Model 3 is a portable test instrument which measures the critical characteristics of transistors and diodes either in-circuit or out-of-circuit.

The Model 3 measures the true ac current gain of transistors at a frequency of 1 kHz in circuits with impedances as low as 20 ohms. The dc operating conditions are set by switching the transistor on and off with a low frequency signal. This signal is controlled to adjust the dc collector current to any value up to 1000ma. Superimposed on this low frequency signal is a 1 kHz signal. The ac currents flowing in the collector are measured by taking the in-phase difference of the 1 kHz currents between the conducting and non-conducting modes of the transistor. The effect of circuit currents is cancelled out in the phase measurement. Diodes between the emitter and base do not effect the accuracy. The meter scale is calibrated directly in ac current gain (H_{fe}).

The Model 3 also measures the saturation voltage of transistors ($V_{CE(SAT)}$) and the forward drop (V_F) of diodes and silicon controlled rectifiers. The $V_{CE(SAT)}$ measurement is valuable for testing high frequency transistors in rf and if amplifier circuits since the transistor is not operated in a region of high gain and is therefore stable during the test. Shorts and opens in diodes and silicon controlled rectifiers can readily be determined by this test.

The Model 3 may also be used to measure the collector-to-emitter leakage current with the base shorted to the emitter (I_{CES}), the collector-to-base leakage with the collector open (I_{EBO}). These measurements should be made with the device out-of-circuit to avoid errors caused by dc current paths in the circuit.

S P E C I F I C A T I O N S

A C CURRENT GAIN TEST:

A C Current Gain Range: 3 to 100 and 30 to 1000 A C test frequency: **1kHz±10%**
D C Collector Current: Adjustable with transistor in-circuit to **1000 ma** maximum at 5v nominal collector voltage.

Test Conditions:

Minimum Circuit Impedance at 1 kc	A C Collector Current	D C Current Range	**Base-to-emitter Drive Voltage**
20 ohms	30 ma	0-1000 ma	**0-.5v**
200 ohms	3 ma	0-100 ma	**or**
2000 ohms	0.3 ma	0-10 ma	**0- 2v**

SATURATION TEST:

Saturation Voltage Range: 0.3 and 3 volts full scale
Minimum Transistor Gain Under Test: dc current gain of 2
Saturation Test Conditions:

Test Current	Minimum Circuit Resistance
500 ma	20 ohms
50 ma	200 ohms
5 ma	2000 ohms

V_{SAT} measurements are made at a known value of I_{SAT} regardless of shunting circuits.
Maximum Controlled Rectifier Gate Current:
100 ma at 2 volts with 20 ohm circuit resistance

LEAKAGE CURRENT TEST:

Circuit Current Test: Measures up to 30 ma of semiconductor leakage and circuit current at 6 volts except I_{EBO} **(3 Volts).**
Leakage Current Range: 0.03, 0.3, 3, or 30 ma full scale at 6 volts except I_{EBO} (3 Volts).

Test Conditions:

1. Collector-to-emitter with base shorted to emitter (I_{CES})
2. Collector-to-base with emitter open (I_{CBO})
3. Emitter-to-base with collector open (I_{EBO})

ACCURACY:

Out-of-circuit: 3% of full scale deflection at any point on the scale with 6 volts supply.

In-circuit: 5% of full scale deflection at any point on the scale with 6 volts supply.

DEVICE SELECTOR: NPN - PNP - DIODE

METER: 3½ inch, high efficiency 2%, 30 microampere full scale movement (Protected against damage from accidental probe shorting or faulty device).

POWER SUPPLY: Battery compartment for 4 size D cells and 8 size ½ D cells. (Eveready E 94.)
Battery test provided on front panel.

TEST LEAD CABLE: Alligator clip test cable with potential leads supplied.

CONSTRUCTION: Metal film and wirewound resistors are used in all critical circuits for long-term stability and accuracy on all tests. Switches and all other components are of high quality construction.

WEIGHT: 12 lbs with batteries
10 lbs without batteries
14 lbs shipping weight

3.1 GENERAL INFORMATION

This section describes the operating procedures to be followed in testing transistors, diodes, rectifiers and controlled rectifiers. The Model 3 may be used to measure the true small signal ac current gain (H_{fe}), the saturation voltage ($V_{CE(SAT)}$) and leakage currents of transistors It also measures the forward voltage drop (V_F) and reverse current (I_{REV}) of diodes. The device may be tested either in-circuit or out-of-circuit. However, in-circuit leakage current measurements are generally not useful because the dc current paths in the circuit will cause error. Operating voltages must be removed from the circuit for any in-circuit tests.

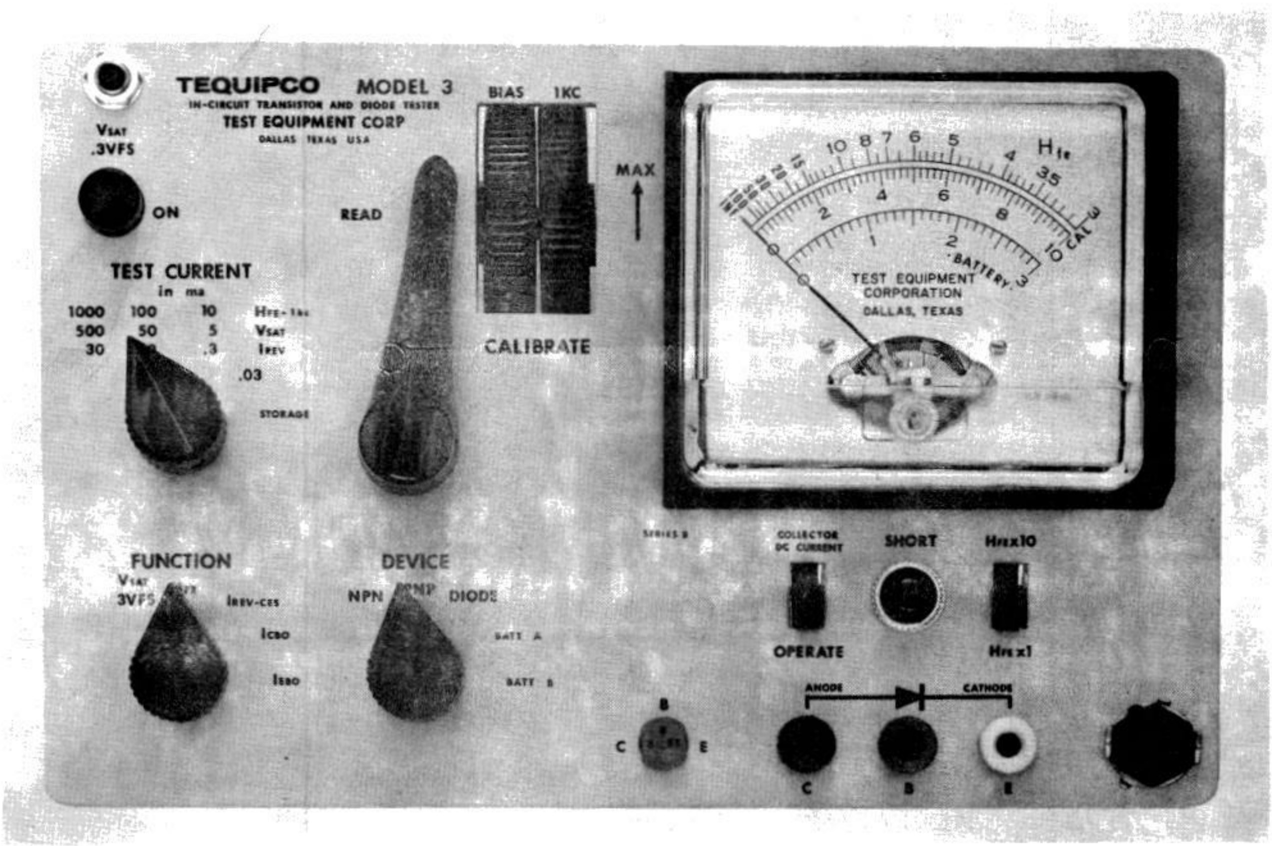


Figure 3-1 MODEL 3B PANEL

3.1.1 Switches (Refer to Figure 3-1)

1. FUNCTION - Used to select the desired test to be performed.
2. DEVICE - Used to select the type of device under test. This switch also is used in testing the internal batteries of the Model 3.
3. TEST CURRENT - Used to select the desired range of the test current to be applied to the device under test.
4. ON - Used to apply power to the device during the calibration step of the H_{fe} and $V_{CE(SAT)}$ tests. It is also used to apply power during the leakage current and battery tests.
5. READ - Used to switch the meter into reading position. It is also wired in parallel with the ON Switch and applies power to the device under test.
6. BIAS CALIBRATE Thumbwheel - Used to adjust the dc collector current to the desired level during the H_{fe} test. During the $V_{CE(SAT)}$ test it is used to balance out the effect of circuit impedance.
7. 1 KC CALIBRATE Thumbwheel - Used to adjust the ac collector current during the H_{fe} test.
8. OPERATE I_C Switch - Used in the H_{fe} test to switch the meter into the collector circuit to measure dc collector current during the bias adjustment.
9. H_{fe} X1-H_{fe} X10 - Used as a meter range multiplier during the H_{fe} test.
10. V_{SAT} .3VFS Pushbutton - Used to change the meter scale from 3VFS to .3VFS during the V_{SAT} test.

3.1.2 Short Lamp

This light will indicate that excessive current is being drawn by the device under test or by the circuit in which the device is located. If the lamp lights with the device out-of-circuit, the device under test is drawing excessive current. Protective circuits are provided to remove power from the device under test when the SHORT lamp is lit.

NOTE: The SHORT lamp will light if, while testing a PNP transistor, the DEVICE switch is in the NPN position; and vice versa. This condition will not damage the instrument or the device under test but must be corrected in order to make the desired measurements.

3.1.3 Battery Check

Battery A consists of 4 size "D" cells and is used for the collector current supply. Battery B consists of 8 size ½ "D" cells and is used to supply power to the signal generator and measuring circuits. Means have been provided to test the condition of the batteries with applied load.

1. Set the TEST CURRENT switch to any position other than STORAGE.
2. Set the FUNCTION switch to V_{SAT}.
3. Set the DEVICE switch to BATT A.
4. Depress the ON switch. This applies an internal load to Battery A. If, while the ON switch is depressed, the meter needle indicates a reading below the lower dot on the BATTERY scale, the 4 cells of Battery A should be replaced with fresh cells.
5. Set the DEVICE switch to BATT B. The BATTERY scale of the meter will now indicate the potential of Battery B.
6. Depress the ON switch. This applies an internal load to Battery B. If the meter needle indicates a reading below the lower dot on the BATTERY scale, the 5 cells of Battery B should be replaced with fresh cells.

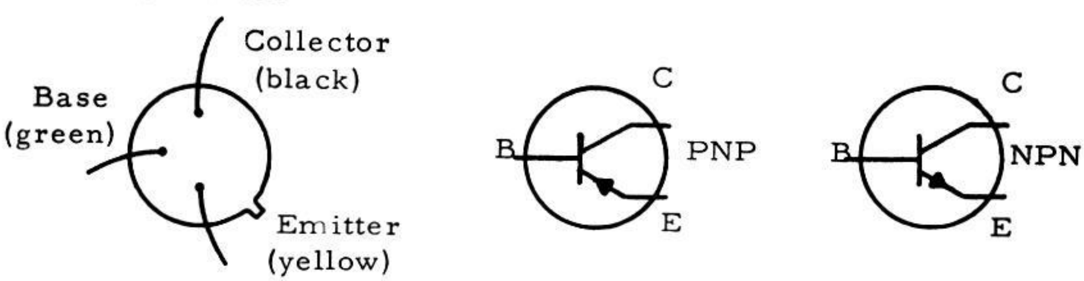
   NOTE: If fresh zinc carbon cells are installed in the instrument, the meter may read off-scale. In either battery test this is a normal condition and will not damage the instrument. The reading will fall within range after normal usage.

3.1.4 Connections

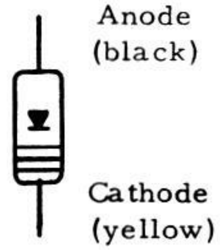
Several means have been provided to connect the device under test to the Model 3. For in-circuit tests, a test cable with miniature alligator clips is provided. The TP-1 Special Test Probe is available for special in-circuit work. For all in-circuit testing, connect the test cable to the receptacle provided on the instrument panel. Connect the test leads to the device under test according to the following conventional color code.

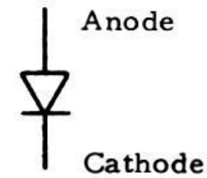
	Transistor	Diode	Controlled Rectifier
Black	Collector	Anode	Anode
Green	Base	–	Gate
Yellow	Emitter	Cathode	Cathode

1. Transistor

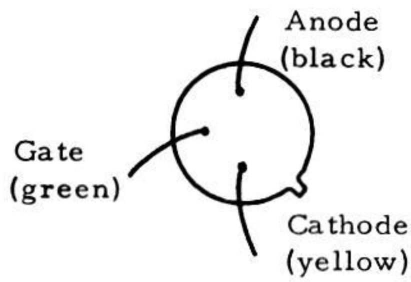


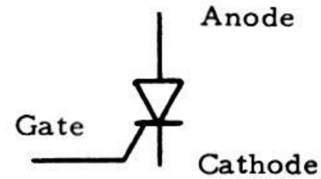
2. Diode





3. Silicon Controlled Rectifier





Standard test leads may also be plugged into the banana jacks provided on the instrument panel. These jacks are marked and color coded to aid the operator in making the proper connections.

For out-of-circuit measurements, a special transistor test adapter (TEC TA-1) is available to plug into the banana jacks on the panel. For short lead transistors an Elco transistor socket is provided on the instrument panel.

NOTE: All receptacles provided on the instrument panel are in parallel except for the potential leads in the test probe receptacle. If either the banana jacks or the transistor socket is used, the test cable must be inserted in its panel connector to provide internal continuity.

3.1.5 Storage

When the instrument is not in use, the TEST CURRENT switch should be set to STORAGE and the DEVICE switch should be set to NPN, PNP, or DIODE.

3.2 AC Current Gain Measurement

1. Set the FUNCTION switch to H_{fe}.
2. Set the DEVICE switch to NPN or PNP according to the type of device under test.
3. Set the TEST CURRENT switch as follows to select the range of dc collector current:

Transistor Power Rating	Range
Low Power (less than 100 milliwatts)	10 ma
Medium Power (100 milliwatts to 1 watt)	100 ma
High Power (over 1 watt)	1000 ma

CAUTION: If in doubt, use the 10 ma range. Too high a range may damage small transistors.

4. Set the H_{fe} multiplier switch to H_{fe} x 10.
5. Set the OPERATE switch to COLLECTOR DC CURRENT.
6. Set the BIAS and 1 KC CALIBRATE thumbwheels to minimum settings.
7. Press the ON switch and observe the 0-10 scale of the meter. The full-scale range will be 10 ma, 100 ma, or 1000 ma corresponding to the setting of the TEST CURRENT switch. The reading observed on the 0-10 scale will be the dc circuit current.

   NOTE: If, when the ON switch is depressed, the needle goes off scale and/or the SHORT lamp lights, check for the following conditions:
   a. The DEVICE switch is improperly set.
   b. The shunting circuit is drawing more than the allowable current for the range selected. Advance the TEST CURRENT switch to the next higher range and repeat the test.
   c. The device under test is shorted. Remove the device and test out-of-circuit. Replace shorted component.

8. While depressing the ON switch, observe the 0-10 scale and adjust the dc collector current by advancing the BIAS thumbwheel until the reading increases by an amount equal to the desired dc collector current. The meter will now indicate the sum of the circuit current and collector current. (For example, if the initial reading is 2 ma and the desired collector current is 5 ma, adjust the BIAS thumbwheel until the meter reads 7 ma.)

NOTE: The H_{fe} may be measured at any desired dc collector current. It is usually measured at the current normally encountered in the circuit. The collector voltage is fixed at approximately 5 volts for the H_{fe} tests.

9. Set the OPERATE switch to OPERATE.
10. Press the ON switch and set the ac collector current by advancing the 1 KC thumbwheel until the meter reads CAL (full scale).
11. Actuate the READ switch and observe the reading on the top meter scale. Multiply the reading by 10 to obtain the H_{fe} of the transistor at the selected dc collector current. The meter scale may be expanded by setting the H_{fe} multiplier switch to H_{fe} x 1. In this case the H_{fe} may be read directly from the top meter scale.

    NOTE: (1) The above test will measure the true ac current gain of the transistor. A simplified test may be used to measure large signal ac current gain. This is accomplished in the following manner:
    a. Set the switches as in steps 1 through 5 above. Also set the OPERATE switch to OPERATE.
    b. Move the 1 KC thumbwheel to maximum setting, depress the ON switch and adjust the meter reading to CAL with the BIAS CALIBRATE thumbwheel (the 1 KC thumbwheel may be used to make fine adjustments).
    c. Actuate the READ switch and multiply the reading of the top scale by 10 to obtain the H_{fe}. The H_{fe} thus obtained will generally be lower than the H_{fe} obtained by the standard procedure outlined above. However, it will be the true H_{fe} for the value of the dc collector current used.

    (2) When H_{fe} multiplier switch is changed AC and DC collector current must be reset in steps 8, 9, and 10.
12. Compare the H_{fe} reading with the manufacture's specification. A faulty transistor will be indicated by an H_{fe} reading which falls below the acceptable range listed by the manufacturer.

3.3 Saturation and Forward Voltage Measurements

1. Insert the test cable in the panel connector. This is required for internal continuity even when the banana jacks are used as test terminals.

2. Set the FUNCTION switch to V_{SAT}.
3. Set the DEVICE switch to NPN, PNP or DIODE according to the type of device under test. For NPNP silicon controlled rectifiers, use PNP. For PNPN bistable devices use NPN.
4. Set the TEST CURRENT switch as follows for the desired collector or forward dc current:

Semiconductor Power Rating	Range Setting
Low Power (less than 100 millivolts)	5 ma
Medium Power (100 milliwatts to 1 watt)	50 ma
High Power (over 1 watt)	500 ma

CAUTION: If in doubt use the 5 ma range. The 500 ma range should be used only with power devices that are capable of carrying one-half ampere.

5. Depress the ON switch and adjust the BIAS CALIBRATE thumbwheel until the meter reads CAL (full scale).

NOTE: If it is impossible to adjust to the full-scale position, check for the following conditions:

a. The DEVICE switch is improperly set.
b. The circuit resistance is below the minimum allowable for the test current selected. Advance the TEST CURRENT switch to the next higher range and repeat the test.
c. The collector of the transistor under test is shorted to the base or the emitter; or the anode of the diode under test is shorted to the cathode. Test the device out-of-circuit.

6. Actuate the READ switch. The saturation voltage ($V_{CE(SAT)}$) of the transistor under test or the forward voltage drop (V_f) of the diode under test will be indicated on the bottom scale. The full-scale reading is 3 volts. This scale may be expanded to 0.3 volts full-scale by depressing the V_{SAT} .3VFS pushbutton.

NOTE: If there is no change in the meter reading (from full-scale) when the READ switch is actuated, check for the following conditions:

a. The device is shorted from base to emitter; or it is open from collector to emitter or anode to cathode. Make leakage measurements on the device out-of-circuit.
b. The transistor under test has no gain. Measure the gain.

7. A qualitative evaluation of the condition of the device under test can be made by comparing the V_{SAT} reading with the manufacturer's specification. A deteriorating transistor will be indicated by a reading which is higher than the acceptable range listed by the manufacturer.

3.4 Leakage Current Measurements

Perform all leakage tests out-of-circuit. Defective semiconductors will be indicated by leakage currents in excess of the manufacturer's specification. I_{REV} is the reverse current of diodes. I_{CES} is the collector-to-emitter leakage current of a transistor with the base shorted to the emitter. I_{CBO} is collector-to-base leakage with the emitter open. I_{EBO} is emitter-to-base leakage with the collector open.

$I_{REV-CES}$

1. Set the FUNCTION switch to $I_{REV-CES}$.
2. Set the DEVICE switch to correspond to the type of device under test.
3. Set the TEST CURRENT switch to .03ma. Readings will be on the 0-3 scale.
4. Depress the READ switch. If the meter reads full scale, increase the setting of the TEST CURRENT switch until the reading is less than full scale. The full-scale value of the meter is indicated by the position of the TEST CURRENT switch (30 ma, 3 ma, or .03 ma).

I_{CBO}

Set the FUNCTION switch to I_{CBO}. Perform Steps 2, 3, and 4 as outlined above.

I_{EBO}

Set the FUNCTION switch to I_{EBO}. Perform Steps 2, 3, and 4 as outlined above.

THEORY OF OPERATION

4.1 AC Current Gain (Refer to Fig. 4-1 and 4-2)

The Model 3 measures the true small signal ac current gain of transistors by driving the base of the transistor with a composite signal consisting of a 1 kc signal, which is superimposed on a 62.5 cps square wave. The low frequency 62.5 cps square wave switches the transistor between conducting and non-conducting modes.

The ac current gain measuring circuit consists of a stable 1 kc oscillator, a divider to develop the low frequency switching signal, a gate circuit to switch the phase of the 1 kc signal 180° at the low frequency rate, a mixer to superimpose the 1 kc signal on the low frequency signal, a base drive amplifier, a set of current measuring resistors, and a phase-sensitive 1 kc meter amplifier. The 1 kc oscillator drives a chain of four flip-flops. The output of this flip-flop chain provides the 62.5 cps switching signal that is used to set the dc operating conditions of the transistor. The 1 kc and the 62.5 cps signals are combined in a mixer and fed to the base drive amplifier. The amount of the 1 kc test signal is controlled by a potentiometer after the mixer. The level of the composite signal is controlled by a potentiometer before the base drive amplifier.

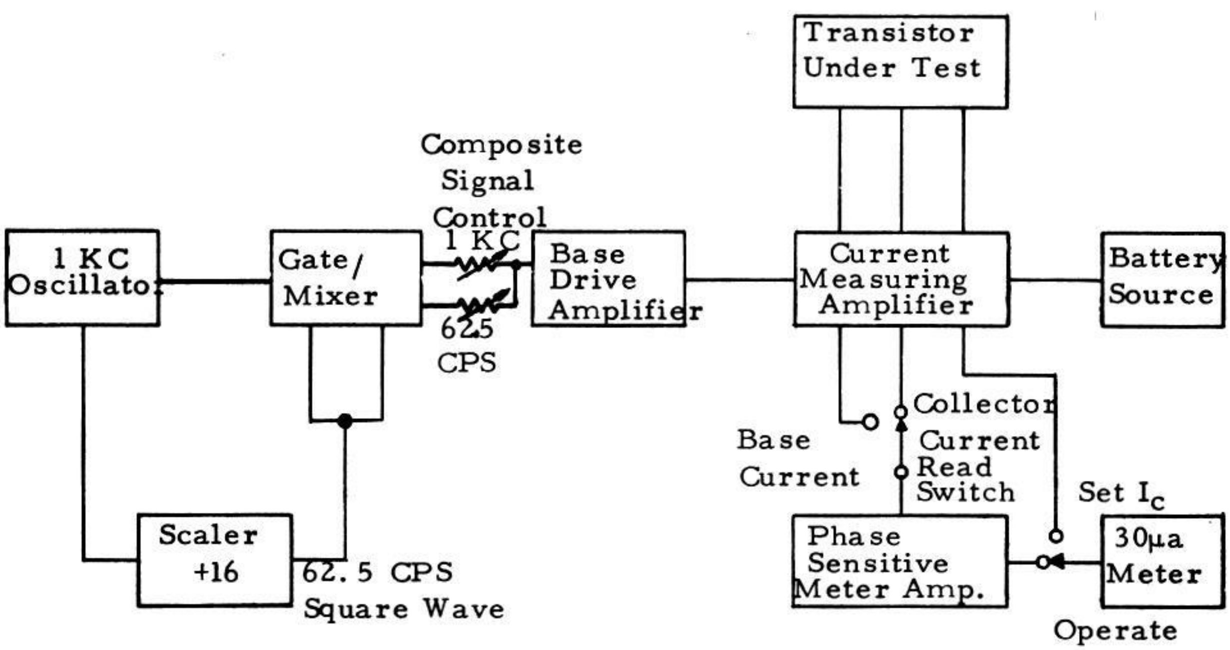


Figure 4-1 Block Diagram - AC Current Gain Measuring Circuit

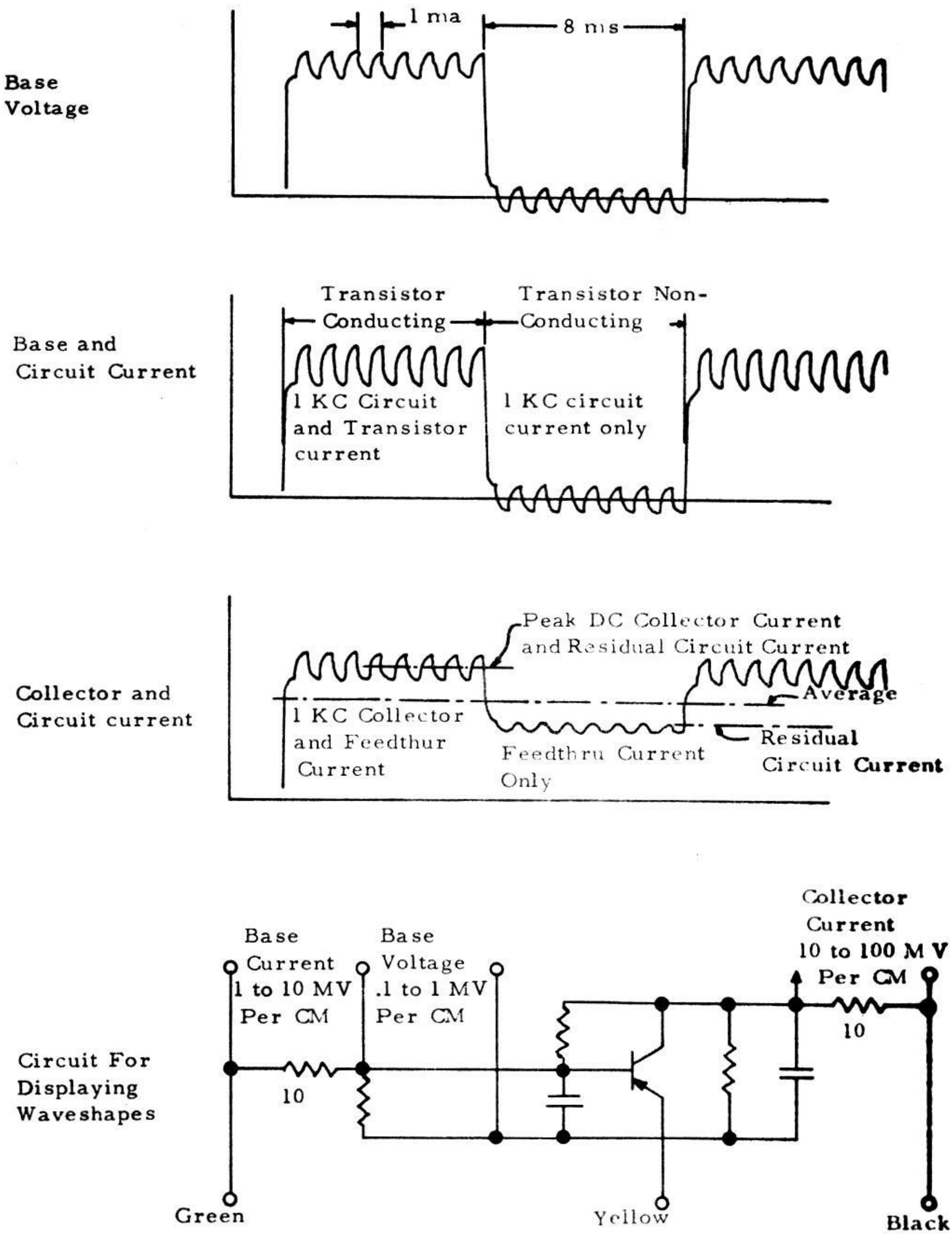


Fig. 4-2 Typical Waveshapes - AC Current Gain Measurement

The transistor under test is driven between the base and emitter with the composite signal from the output of the base amplifier. The base amplifier is capable of supplying a constant voltage drive up to 2 volts with a load as small as 20 ohms impedance at 1 kc. The drive signal is also biased so that the transistor under test will not be reverse biased more than 0.1 volt when it is non-conducting. This reverse bias is sufficient to insure that the transistor is off, but not enough to cause diodes or other commonly used, non-linear elements in the base circuit to conduct. Therefore, non-linearities in the base circuit current, which would affect the accuracy of the measurement, are avoided.

The dc operating condition of the transistor under test is established by the low frequency signal. This low frequency signal is adjusted to control the dc collector current. The low frequency signal switches the base between essentially zero volts and a level up to 2 volts depending on the base voltage required to establish the dc collector current about which the small signal ac current gain is to be measured.

The 1 kc signal, which is superimposed on the low frequency signal, causes ac currents to flow in the base and collector. The in-phase difference of these ac currents between the conducting and non-conducting modes of the transistor is measured by the phase-sensitive meter amplifier. The effect of circuit currents is cancelled out in the phase measurement. Clamping diodes, that may exist in the base circuit, are forward biased less than 0.1 volt and do not affect the linearity of the circuit currents in the base.

When measuring the H_{fe}, the FUNCTION switch is set to the H_{fe} position and the DEVICE switch is set to NPN or PNP depending on the type of transistor under test. The CURRENT switch is then set to 10, 100, or 1000 ma. Setting this switch establishes the full-scale range of the dc current that will flow in the collector of the transistor. For example, when the current switch is in the 10 ma position, the dc collector current may be adjusted from 0 to 10 ma.

When the ON switch is depressed, a constant dc voltage is applied to the collector circuit from a 6 volt battery (Battery A). With the BIAS thumbwheel set on minimum and the OPERATE switch set to COLLECTOR DC CURRENT, the meter will indicate the residual circuit current on the 0-10 scale. The desired dc collector current level may now be set by advancing the BIAS thumbwheel until the meter reading increases by an amount equal to the desired dc collector current.

After the dc collector current has been set, the small signal ac current is introduced by setting the OPERATE switch to OPERATE, depressing the ON switch and adjusting the 1 KC thumbwheel until the meter reads CAL (full scale). By adjusting the 1 KC thumbwheel until the meter indicates CAL, the ac collector current is set to 0.3, 3 or 30 ma depending on the position of the TEST CURRENT switch. If the TEST CURRENT switch is in the 10 ma position, the ac collector current will be calibrated to 0.3 ma when the meter indicates CAL. In order to measure the true small signal ac current gain of a transistor, the ac test current must be small compared with the dc operating current. The Model 3 ranges are adjusted so that the dc collector current may be as large as 33 times the small signal current. However, a factor of 10 between the ac and dc currents is adequate. After the ac collector current has been calibrated, the READ switch is moved to READ, and the H_{fe} may be read directly from the top meter scale.

The 1 kc signal is provided by the 1 kc oscillator in the base circuit. The amplitude of the 1 kc signal, which is superimposed on the 62.5 cps signal, is controlled by the 1 KC thumbwheel. If the base circuit contained only linear elements such as resistors, capacitors, or inductors, there would be no difference in the ac current between the two bias levels created by the low frequency signal. However, the forward biased base-to-emitter junction is non-linear and will conduct different ac currents depending on the bias level. A phase-sensitive amplifier is used to measure the difference of the ac currents about the two bias levels. The dc component of the bias level shift is neglected by the ac amplifier. Only the difference of the ac currents about the two bias levels is measured.

The phase-sensitive meter amplifier circuit is synchronized with the 1 kc base drive oscillator. The synchronous demodulator on the output of the meter amplifier, together with the output filter, accomplishes the averaging necessary to arrive at the difference between the two 1 kc currents. If one bias level causes more output from the ac current measuring amplifier than the other bias level, the meter will be driven in one direction. If the ac currents are exactly the same for both levels, the meter will show no deflection. Even if reactive elements exist in the circuit such that the ac currents are shifted in phase, no output will result as long as the phase is shifted by the same amount for bias levels and the currents are equal in amplitude for both bias levels. Only an inequality of ac currents between the two bias levels will cause a meter deflection. The top scale of the meter is calibrated so that the true small signal ac current gain (H_{fe}) may be read directly.

4.2 Saturation and Forward Voltage Measurements (Refer to Fig. 4-3)

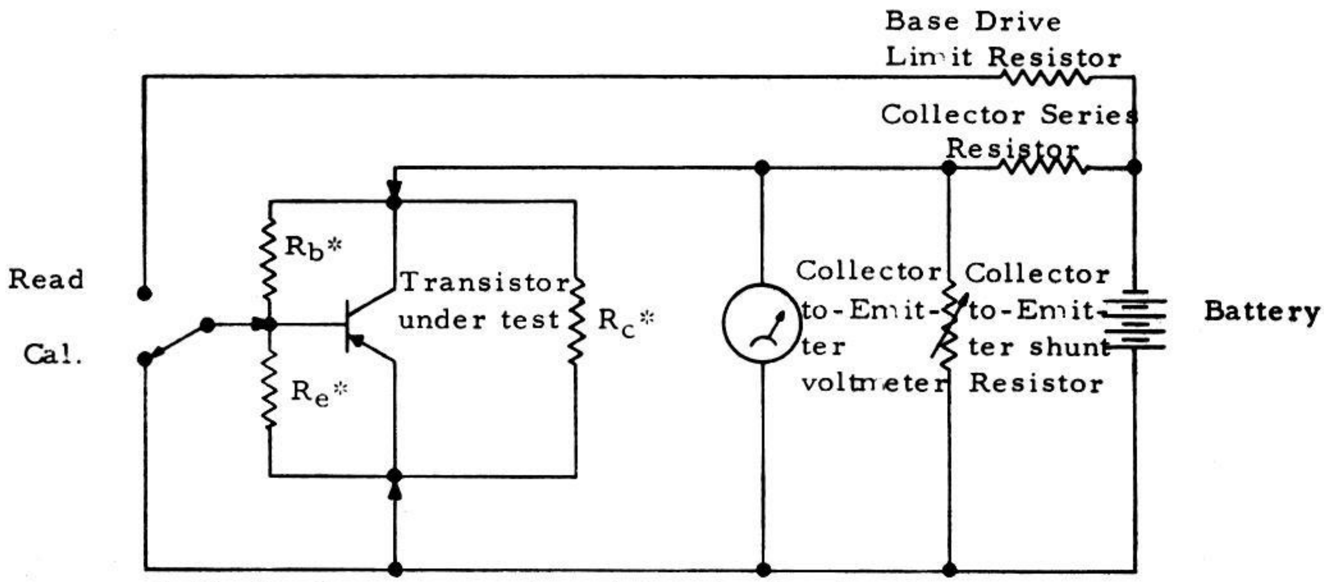
The Model 3 measures the saturation voltage of transistors ($V_{CE(SAT)}$) and the forward drop (V_F) of diodes and silicon controlled rectifiers in-circuit or out-of-circuit. The saturation voltage measuring circuit consists of a battery, collector-to-emitter series and shunt resistors, and a collector-to-emitter voltmeter.

When measuring the saturation or forward voltage of a device under test, the FUNCTION switch is set to V_{SAT}, and the DEVICE switch is set to NPN, PNP, or DIODE according to the type of device under test. The saturation current is selected by setting the TEST CURRENT switch to 5 ma, 50 ma, or 500 ma.

After the FUNCTION, DEVICE, and TEST CURRENT switches have been set, the instrument is calibrated to compensate for the circuit resistance of the device under test. This is accomplished by depressing the ON switch and adjusting the BIAS thumbwheel until the meter reads CAL (full scale). When the ON switch is depressed, a voltage is applied to the device from Battery A. The thumbwheel varies the shunt resistor until the parallel combination of the shunt resistor and the circuit resistance is equal to the series resistor in the collector circuit. When the thumbwheel is properly adjusted to this condition, the equivalent source voltage is one-half the battery supply, and the source resistance is one-half the collector series resistor. While adjusting the thumbwheel, the transistor is non-conducting with the base and emitter shorted together. For diodes and rectifiers, the device is reverse biased and non-conducting while the thumbwheel is adjusted. In the case of controlled rectifiers, the gate terminal is shorted to the cathode with the device non-conducting.

After the instrument has been calibrated for the circuit resistance about the device, the READ switch is moved to the READ position and the saturation or forward voltage of the device is read directly on the bottom scale of the meter. As the READ switch is moved to the READ position, the base of the transistor under test is driven with the saturation base current. The meter reads the saturation voltage from collector to emitter. The base is driven adequately to saturate a transistor with a minimum gain of 2 and a minimum circuit resistance of 20 ohms between the base and emitter.

Diodes and rectifiers are forward biased when the READ switch is placed in the READ position. The forward voltage drop at the selected test current is then read on the bottom meter scale. In the case of controlled rectifiers, a gate signal is supplied to the device to cause it to switch into the conducting state. The forward voltage drop from anode to cathode at the selected test current can then be read directly on the meter. The forward drop of silicon controlled rectifiers can be measured at forward currents up to one-half ampere and gate currents of 100 ma at 2 volts in-circuit with a minimum of 20 ohms resistance. Gate voltages up to 6 volts may be obtained where circuit resistance of the gate circuit is high and the required gate current is low. The source resistance for the gate circuit is 20 ohms from 6 volts on the 500 ma current range.



* R_b, R_c, R_e, represent resistors in the circuit

4.3 Leakage Current Measurements

Measurements are made by setting the FUNCTION switch to the desired test, setting the DEVICE switch to the appropriate position, and depressing the ON switch. When the ON switch is depressed, a dc voltage of 6 volts is applied to the appropriate terminals of the device. The leakage current range may be set to 30, 3, 0.3, or 0.03 ma full-scale with the TEST CURRENT switch.

The collector-to-emitter leakage current (I_{CES}) is measured with the base shorted to the emitter. The collector-to-base leakage (I_{CBO}) is measured with the emitter open. The emitter-to-base leakage (I_{EBO}) is measured with the collector open.

NOTE: Battery Voltage in I_{EBO} is 3.0 volts.

5.1 Preventive Maintenance

The entire instrument should be inspected every few months for possible circuit defects. These defects may include such things as loose or broken connections and scorched wires or resistors. For most troubles detected by visual inspection, the remedy is apparent; however, particular attention must be given to heat-damaged components. Overheating of parts is often the result of other, less apparent, defects in the circuit. It is essential that you determine the cause of overheating before replacing heat-damaged parts in order to prevent further damage.

When the Model 3 is not in use, set the TEST CURRENT switch to STORAGE, and store the instrument in a dry place. Avoid temperature extremes.

5.2 Removal and Replacement of Parts

The chassis of the Model 3 may be lifted from its case by removing two retaining screws from the bottom of the case. The chassis may then be disassembled by removing four additional screws and disconnecting two cable connectors.

Procedures required for replacemtnt of most parts in the Model 3 are obvious. Care should be exercised in removing and replacing soldered components. Excessive heat can damage transistors and diodes.

Most of the components contained in the Model 3 may be obtained locally. Refer to Section 6 for the parts list and component identification. Replacement parts may be ordered from the factory or the instrument may be returned to the factory for repair.

5.3 Battery Test

Means have been provided on the front panel to check the condition of the batteries. Refer to Section 3.1.3 for this procedure. The instrument will not function properly if the batteries are weak.

5.4 Troubleshooting

Before attempting any troubleshooting work, you should check all controls for proper settings. If you are in doubt about control settings, review the Operating Information section of this manual. When you have ascertained that trouble does exist in the instrument, you may proceed to isolate the defective circuit.

The schematic diagrams included in Section 6 of this manual will be beneficial in isolating the t rouble. The reference designation of each electronic component of the instrument is shown on the circuit diagrams. Wiring used in the Model 3 is color coded to facilitate circuit tracing. Wire colors are designated on the schematic diagrams. The wafers of selector switches shown on the schematic diagrams are lettered to indicate the position of the wafer on the switch. The "A" wafer is the wafer nearest the observer when the switch is viewed from the rear of the panel. The terminals of each wafer are numbered clockwise when viewed from the rear of the panel. Position 1 is in the "one o'clock" position, when the panel is in an upright position.

When a trouble has been isolated to a definite circuit, perform a complete visual check of that circuit. Many troubles can be found easily be visual means. If a visual check fails to detect the cause of the trouble, check all transistors in the circuit. Transistor failure is the most frequent cause of circuit failure.

SECTION 6

PARTS LISTS AND SCHEMATICS

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

TAD-60-C	
NEXT ASSEMBLY	USED ON
APPLICATION	

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58		
SHEET	REV																																
INDEX	SHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26						

ORIGINAL DATE OF DWG.		INTERNATIONAL DATA SYSTEMS, INC.
DRAFTSMAN 8-24-67 Dal Smith	CHECKER	
TRACER	CHECKER	LIST OF MATERIAL P.C.BOARD 2 MODEL 3B
ENG.	PROJ. ENG.	
SUBMITTED		
APPROVED		

CODE IDENT NO	SIZE		
	A	TAD-60-A	
SCALE		SHEET	1 of 4

1	2				3	4	5	6	7	8
ITEM	UNIT QTY				DESCRIPTION	REF. DESIG.	PART NUMBER (DWG. NO.)	MANUFACTURER OR MIL. SPEC	MANUFACTUER P/N OR MIL. NO.	REMARKS
	-1	-2	-3	-4						
1	1				Printed Circuit Board	TAD-61-D	—			
2	1				Transistor	Q1	—	RCA or Equiv.	40319	
3	1				Element	Z1	—	MOTOROLA or Equiv.	MC1430	
4	1				Coil	K1	—	COTO	#258	
5	1				Reed		—	GORDOS	MR200-1	
6	1				Capacitor, 1000 µf, 15 V	C26	—	CORNELL DOUBLIER	BR 1000-15	
7	2				Capacitor, .01 µf, 200V	C27,30	—	MIDWEC		
8	1				Resistor, 3W, 1%, 3Ω	R3	—	TEPRO or Equiv.		
9	1				Resistor, 3W, 1%, .3Ω	R4	—	"		
10	1				Resistor, 3W, 1%, .033Ω	R5	—	"		
11	1				Resistor, 3W, 1%, 1Ω	R17	—	"		
12	1				Resistor, 3W, 1%, 9Ω	R18	—	"		
13	1				Resistor, 3W, 1%, 90Ω	R19	—	"		
14	1				Resistor, 3W, 1%, 10Ω	R22	—			

NOTES:

REV.	LIST OF MATERIAL FOR: SWITCHING CIRCUIT	SIZE ASSY. DWG. LM TAD-60-A
DATE		
APPR.		SHEET 2 OF 4

1	2				3	4	5	6	7	8
ITEM	UNIT QTY -1	-2	-3	-4	DESCRIPTION	REF. DESIG.	PART NUMBER (DWG. NO.)	MANUFACTURER OR MIL. SPEC	MANUFACTUER P/N OR MIL. NO.	REMARKS
15	1				Resistor, 3W, 1%, 11.1 Ω	R28		TEPRO or Equiv.		
16	1				Resistor, 3W, 5%, 20 Ω	R15		"		
17	1				Resistor, 3W, 5%, 7.5 Ω	R1				
18	1				Resistor, 1/2W, 1%, 1.1K	R6		IRC or Equiv.		
19	1				Resistor, 1/2W, 1%, 1K	R7		"		
20	1				Resistor, 1/2W, 1%, 110K	R9		"		*
21	1				Resistor, 1/2W, 1%, 6.04K	R20		"		*
22	1				Resistor, 1/2W, 1%, 23.2K	R21		"		
23								"		*
24	1				Resistor, 1/2W, 1%, 243K	R24		"		*
25	1				Resistor, 1/2W, 1%, 205K	R25		"		*
26										
27	1				Resistor, 1/2W, 10%, 100Ω	R8		ALLEN BRADLEY or Equiv.		
28	1				Resistor, 1/2W, 10%, 2.2K	R32		" "		*

NOTES:

* INDICATES FACTORY ADJUSTMENT, AND INDICATED VALUES GIVEN ARE NORMAL.

REV.									
DATE									
APPR.									

LIST OF MATERIAL FOR:

SWITCHING CIRCUIT

SIZE ASSY. DWG. LM TAD-60-A

1	2				3	4	5	6	7	8
ITEM	UNIT QTY				DESCRIPTION	REF. DESIG.	PART NUMBER (DWG. NO.)	MANUFACTURER OR MIL. SPEC	MANUFACTUER P/N OR MIL. NO.	REMARKS
	-1	-2	-3	-4						
29	1				Resistor, 1/2W, 10%, 30K	R33	—	ALLEN BRADLEY or Equiv.		
30	1				Resistor, 1/2W, 10%, 20 Ω	R30	—	" "		
31	1				Resistor, 1/2W, 10%, 200 Ω	R14	—	" "		
32	1				Resistor, 1/2W, 10%, 820 Ω	R16	—	" "		
33	1				Resistor, 1/2W, 10%, 2K	R13	—	" "		
34	1				Resistor, 1/2W, 10%, 100K	R31	—	" "		
35	1				Resistor, 1/2W, 10%, 82 Ω	R2	—	" "		
36	1				Resisto, 3W, 1%, 200 Ω	R10	—	TEPRO or EQUIV.		
37	1				Resistor, 3W, 7%, 20 Ω	R11	—	" "		
38	1				Resistor, 3W, 1%, 2Ω	R12	—	" "		
39	1				Resistor, 1/2 W 10% 47K	R34	—	Allen Bradley or Equiv.		
40	1				Transistor, 40319	Q2	—	RCA		
41	1				Transistor, 2N2270	Q3	—	RCA		
42	1				Resistor, 1/2 W 10% 240K	R35	—	Allen Bradley or Equiv.		

NOTES:

REV.									LIST OF MATERIAL FOR:	SIZE ASSY. DWG.	LM TAD-60-A
DATE									SWITCHING CIRCUIT		
APPR.											SHEET 4 OF 4

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

NOTES:

1. This L/M applies only to production models assembled after 3-1-69.

NEXT ASSEMBLY	USED ON	QTY -NO.
APPLICATION		

SHEET REV																															
SHT	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
SHEET INDEX REV																																
SHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26						

SIGNATURE	DATE
DR Barbara Caldwell	5-12-69
CKD	
ENG	
RELEASED BY PROJ. ENG [signature]	5-13-69
MATERIAL	
FINAL PROTECTIVE FINISH	

TEC

TEST EQUIPMENT CORPORATION
DALLAS, TEXAS

LIST OF MATERIAL
P.C. BOARD 1
MODEL 3 B

CODE IDENT NO.	SIZE		REV
	A	TAD-54-D-1	
SCALE		SHEET 1 of 5	

1	2				3	4	5	6	7	8
ITEM	UNIT QTY				DESCRIPTION	REF. DESIG.	PART NUMBER (DWG. NO.)	MANUFACTURER OR MIL. SPEC.	MANUFACTUER P/N OR MIL. NO.	REMARKS
	-1	-2	-3	-4						
1	1				Printed Circuit Board		TAD-55-D			
2	4				Clocked Flip Flop	Z1, 3, 4, & 7		MOTOROLA	MC 845P	
3	1				Quad 2 - Input Gate	Z2		MOTOROLA	MC 846P	
4	1				Dual 4 - Input Power Gate	Z6		MOTOROLA	MC 832P	
5	1				Monolithic Operational Ampl.	Z8		MOTOROLA	MC 1430G	
11	1				Transistor	Q8		RCA	2N1305	
7	5				Transistor	Q1, 2, 7, 9, 10		RCA	2N2270	
8	3				Transistor	Q3, 4		MOTOROLA	2N3251	
9	1				Transistor	Q5		RCA	2N2270	
10	1				Transistor	Q6		RCA	40319	
					Deleted					
12	1				Transformer	T1		Test Equip. Corp.	TX 240	
13	1				Transformer	T2		TRIAD	SP 66	p 327
14	2				Resistor, 1/4W, 5%, 9.1K	R3, 6		Allen Bradley		

NOTES:

REV.									LIST OF MATERIAL FOR: P. C. Board 1 Model 3B	SIZE ASSY. DWG.	LM TAD-54-D-1
DATE											
APPR											SHEET 2 OF 5

IDS FORM 8-119

1	2				3	4	5	6	7	8
ITEM	UNIT QTY -1	-2	-3	-4	DESCRIPTION	REF. DESIG.	PART NUMBER (DWG. NO.)	MANUFACTURER OR MIL. SPEC.	MANUFACTUER P/N OR MIL. NO.	REMARKS
15	2				Resistor, 1/2W, 10%, 560Ω	R1, 10		ALLEN BRADLEY	EB	
16					Resistor, 1/2W, 10%, 20K	R13		" "	"	
17	1				Resistor, 1/2W, 10%, 3K	R42		" "	"	
18	3				Resistor, 1/2W, 10%, 10K	R30, 33, 29		" "	"	
19	2				Resistor, 1/2W, 10%, 2.2K	R4, 8		" "	"	
20	4				Resistor, 1/2W, 10%, 1K	R43, 14, 20, 21, 28		" "	"	
21	1				Resistor, 1/2W, 10%, 2K	R12		" "	"	
22					Deleted					
23	1				Resistor, 1/2W, 10%, 47Ω	R22		" "	"	
24	1				Resistor, 1W, 5%, 300Ω	R23		" "	"	
25	1				Resistor, 1/2W, 10%, 15K	R24		" "	"	
26	2				Resistor, 1/2W, 10%, 1.8K	R25, 26		" "	"	
27	1				Resistor, 1/2W, 10%, 22K	R31		" "	"	
28	2				Resistor, 1/2W, 10%, 3.3K	R32, 19		" "	"	

NOTES:

REV.	
DATE	
APPR.	

LIST OF MATERIAL FOR:
P.C. Board 1
MODEL 3 B

SIZE ASSY. DWG. LM TAD-54-D-1

SHEET 3 OF 5

IDS FORM 3-119

1	2				3	4	5	6	7	8
ITEM	UNIT QTY -1	-2	-3	-4	DESCRIPTION	REF. DESIG.	PART NUMBER (DWG. NO.)	MANUFACTURER OR MIL. SPEC.	MANUFACTUER P/N OR MIL. NO.	REMARKS
29	1				Resistor, 1/2W, 10%, 150Ω	R34		ALLEN BRADLEY	"	
30					Deleted					
31	1				Resistor, 1/2W, 10%, 390K	R27		" "	"	
32					Var. Resistor	R36		Helitrim	77PR5K	
33	2				Resistor, 1/4W, 10%, 33K	R39, R40		" "	"	
34					Deleted					
35	2				Capacitor, .1μf, $\pm$ 20%, 100V	C1, C4		MIDWEC	TYPE 3	
36	1				Capacitor, 500pf, $\pm$ 20%, 100V	C19		Sprague	TG-D50	
37	5				Capacitor, .47μf, $\pm$5%, 100V	C6, 8, 10, 12 & 13		"	"	
38	1				Capacitor, .02μf, $\pm$ 5%, 100V	C9		"	"	
39	1				Capacitor, 10μf, $\pm$ 20%, 20V	C11		Sprague	TYPE 1500 106X0020B2	
40					Deleted					
41	1				Capacitor, 25μf, 6V $^{-10}_{+75\%}$	C15		"	TE 1091	
42	2				Capacitor, 33pf, $\pm$ 5%, 500V	C2, 3		CDE	CD 15E330J	

NOTES:

REV.								
DATE								
APPR.								

LIST OF MATERIAL FOR:
P.C. Board 1
MODEL 3B

SIZE ASSY. DWG.

LM TAD-54-D-1

SHEET 4 OF 5

IDS FORM 8-119

1 ITEM	2 UNIT QTY -1	-2	-3	-4	3 DESCRIPTION	4 REF. DESIG.	5 PART NUMBER (DWG. NO.)	6 MANUFACTURER OR MIL. SPEC.	7 MANUFACTUER P/N OR MIL. NO.	8 REMARKS
43	1				Capacitor, .01µf, ± 5%, 100V	C14	-	MIDWEC	TYPE 3	
44	1				Test Jack Red	TP2	-	H. H. S.	430-102	
45	1				" " Orange	TP3	-	"	430-106	
46	1				" " Yellow	TP4	-	"	430-107	
47	1				" " Green	TP5	-	"	430-104	
48	1				" " Blue	TP6	-	"	430-105	
49	1				" " Purple	TP7	-	"	430-112	
50	1				" " Gray	TP8	-	"	430-113	
51	1				" " White	TP9	-	"	430-101	
52	1				" " Black	TP10	-	"	430-103	
53	1				Transipad		-	THERMALLOY	7717-20N	
54	8				Transipad		-	MILTON ROSS or Equiv.	10098	
55	1				Test Jack, Brown	TP1	-	H. H. S.	430-108	
56	10 inches				#22 Awg. Tinned Buss wire		-			

NOTES:

REV.									LIST OF MATERIAL FOR: P.C. Board 1 MODEL 3 B	SIZE ASSY. DWG.	LM TAD-54-D-1
DATE											
APPR.											SHEET 5 OF 5

IDS FORM 8-119

CALIBRATION

7.1 Calibration Procedure

7.1.1 This procedure verifies the correct performance of the Test Equipment Model 3, Transistor and Diode Tester, hereafter referred to as the Test Instrument, within the required tolerances.

7.1.2 Perform this procedure in the order in which it is written. If necessary to perform one section alone, review the preceding sections in order to establish the correct connections and equipment control settings.

7.1.3 Complete a Data Sheet. A master form is included at the conclusion of this procedure.

7.1.4 All standards used for this calibration must bear current calibration stickers.

7.1.5 This instrument shall be calibrated at least once each 180 days.

7.1.6 Refer to Manufacturer's Manual for adjustment procedures.

7.2 Test Equipment Required:

ITEM		SPECIFICATIONS	RECOMMENDED EQUIPMENT
7.2.1	Decade Resistor	Resistance: 100 Kilohm to 1 megohm. Resolution: 1 kilohm Accuracy: ±0.2%.	1432P, General Radio
7.2.2	Decade Resistor	Resistance: 1 ohm to 50 kilohm. Resolution: 0.1 ohm. Accuracy: ±0.2%.	1432M, General Radio
7.2.3	DC Differential Voltmeter	Range: 0 to 7 volts. Resolution: 1 millivolt Accuracy: ±0.1% Range: 0 to 150 millivolts Resolution: 0.1 millivolt Accuracy: ±0.1%	832A, John Fluke Co.
7.2.4	Shunt	1.5 amperes, 0.1 ohm, ±0.1%	4385, Leeds and Northrup Co.
7.2.5	Oscillo-scope	0.5 MS centimeter and 5 MS centimeter sweep times Accuracy: ±3%.	545A, With CA Plug-In, Tektronix, Inc.

7.3 **Preliminary Operations:**

7.3.1 Check for completeness.

7.3.2 Clean Test Instrument.

7.3.3 Check for loose, burned, or broken parts.

7.3.4 Install new batteries.

7.3.5 Allow 30 minutes for test equipment warm-up.

7.4 Calibration Procedure:

7.4.1 Battery Test

7.4.1.1 Set TEST CURRENT switch to 0.03MA, FUNCTION switch to V sat, and the device switch to BATT A. Depress ON switch. Meter indication must be above lower dot on battery scale. With new batteries an off-scale reading is permissible.

7.4.1.2 Set DEVICE switch to BATT B. Depress ON switch. Meter indication must be above lower dot on battery scale.

7.4.2 Meter Movement

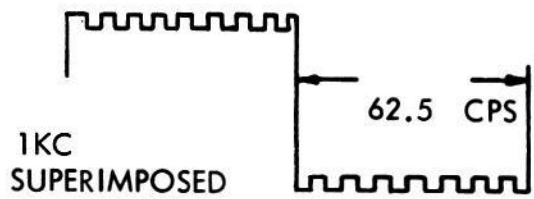
7.4.2.1 Set FUNCTION switch to I REV-CES position, TEST CURRENT switch to 0.03, DEVICE switch to any position, connect 100 kilohm to 1 megohm resistor decade box set for maximum resistance between the collector (black) and emitter (yellow) leads of Test Instrument test lead cable. Monitor emitter-collector voltage with DC differential voltmeter. Depress the ON switch and adjust resistor decade box for a reading of 0.03MA on Test Instrument meter. Use Ohm's Law, $I=\frac{E}{R}$, to determine current through resistor decade box. Repeat procedure for other panel meter readings listed. Computed currents must be within listed limits at each test point. At completion of step disconnect all test equipment.

7.4.3 Leakage

7.4.3.1 Connect 1 ohm to 50 kilohm resistor decade box set for maximum resistance, in parallel with DC differential voltmeter, between the collector (black) and emitter (yellow) leads of Test Instrument test lead cable. Set TEST CURRENT switch to 0.3 MA on Test Instrument panel meter. Use Ohm's Law, $I=\frac{E}{R}$, to compute current through resistor decade box. Repeat for each leakage current range listed. Computed currents must be within listed limits for each range.

7.4.4 Test Frequency

7.4.4.1 Set FUNCTION switch to Hfe, DEVICE switch to PNP, TEST CURRENT switch to 10MA., Hfe multiplier switch to Hfe X 10, OPERATE-COLLECTOR DC CURRENT switch to COLLECTOR DC CURRENT, and BIAS and 1 KC calibrate thumbwheels to a minimum setting. Connect Oscilloscope, between Test Instrument test cable base (green) and emitter (yellow) leads. Advance BIAS and 1 KC thumbwheels as required to measure frequencies listed. Wave form should be as shown:



7.4.5 DC Collector Current

7.4.5.1 Using a transistor of sufficient collector current rating for range being tested, insert .1 ohm shunt, or 1 ohm to 50 K decade resistor in series with collector lead. Set OPERATE/DC Collector Current Switch in to DC Collector Current. Set 1 KC Thumbwheel to minimum setting. Set BIAS thumbwheel to full scale DC Current for range selected. With resistance values as shown below, monitor voltage across shunt or decade resistor, with a DC Differential voltmeter. Using ohm's Law, calculate Current thru shunt, and multiply by 2 to obtain current meter reading on Model 3 DC Collector Current range. (It is necessary to multiply by two, due to this current being a 62.5cps square wave).

Range	Resistance	Voltage		DC Current
10 MA	10 ohm	50 MV	$2x\frac{.050}{10}$	= 10MA
100 MA	1 ohm	50 MV	$2x\frac{.050}{1}$	= 100MA
1000MA	.1 ohm (shunt)	50 MV	$2x\frac{.050}{1}$	= 1000MA

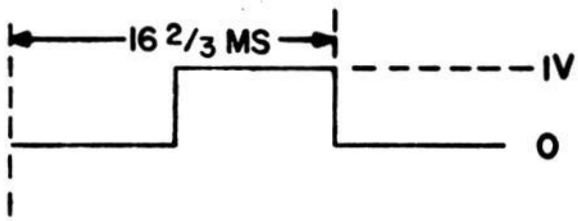
(Note: Intermediate values may be verified in the same manner)

7.4.6 Functional Check

7.4.6.1 Check a variety of known good transistors using Manufacturers Manual test procedure.

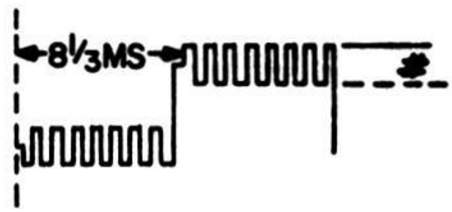
7.5.0 **Maintenance**

The following diagrams are to show the circuit components associated with the various test performed by the Tequipco Model 3B. Appropriate wave shapes as observed on an oscilloscope are shown in Table 5. 1 to assist in maintaining the Instrument. All measurements taken to chassis grounds.



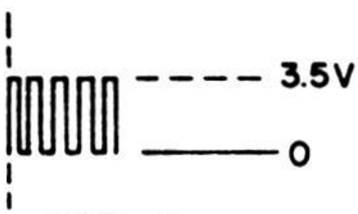
TP1

* Variable with Bias Adjust.



TP1

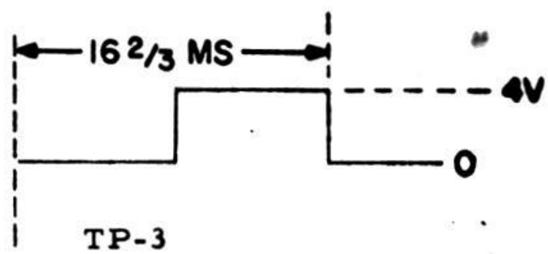
Variable with 1KHZ adjust



TP2

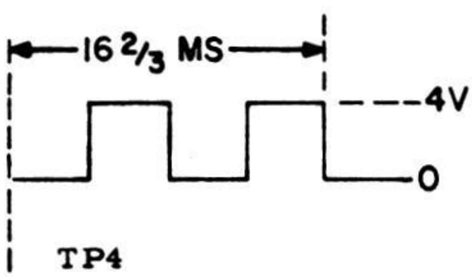
1 KHZ

16 Pulses 16 2/3 MS



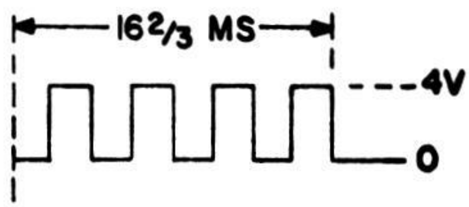
TP-3

62.5 HZ



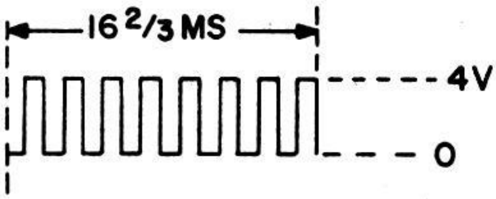
TP4

125 HZ



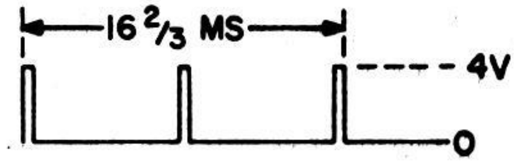
TP5

250 HZ



TP-6

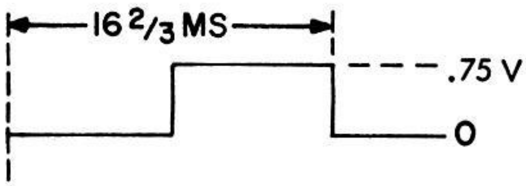
500 Hz



TP-7

1 MS Blanking Pulse

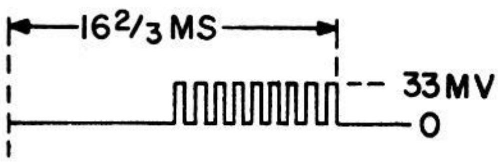
Every 8 1/3 MS



TP-8

Feed Back Signal Variable

with Current Range and Bias



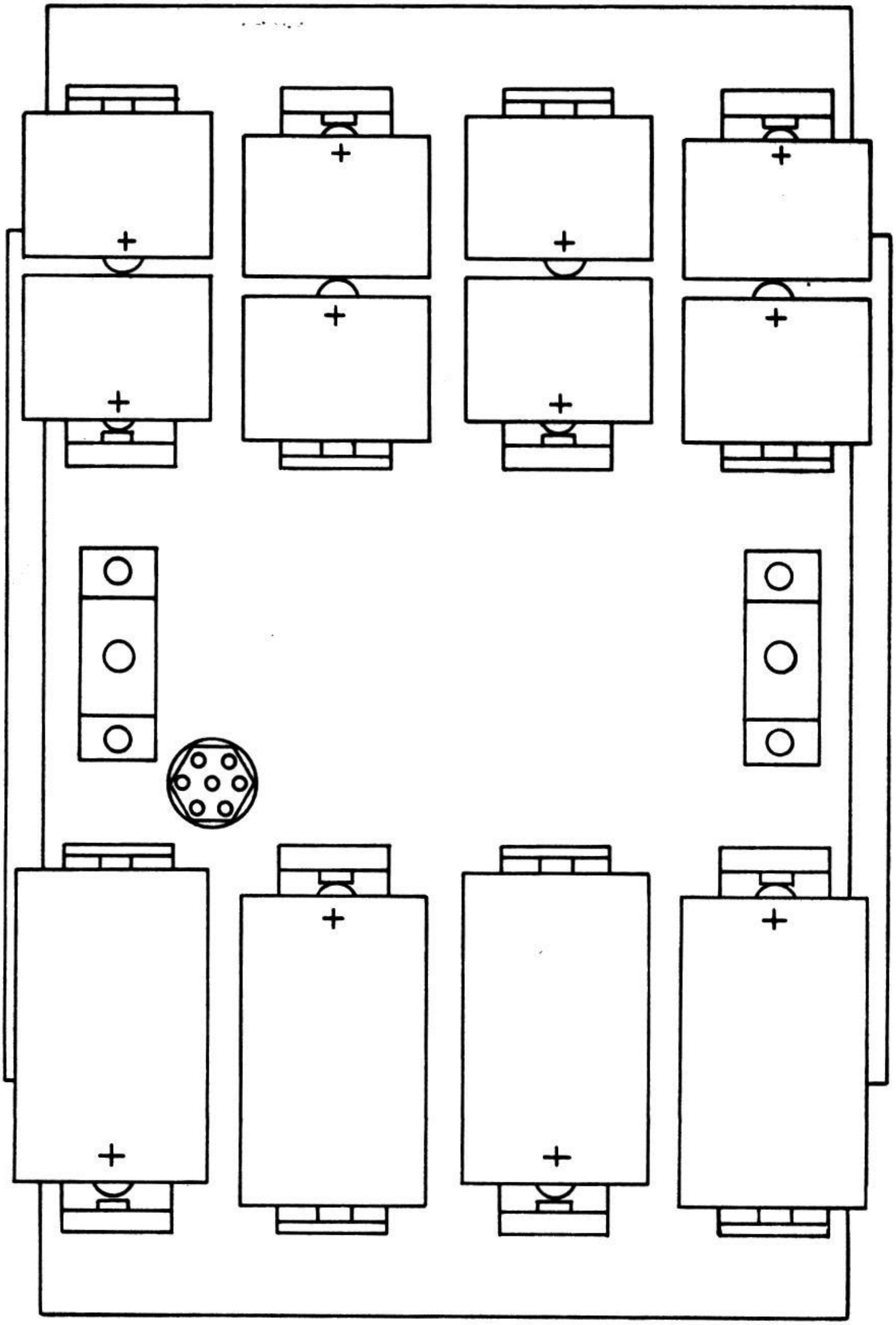
TP-9

Variable with gain of device

being measured

TP-10 Same as TP-9

Variable to 2.5 V.



Battery Placement Chart