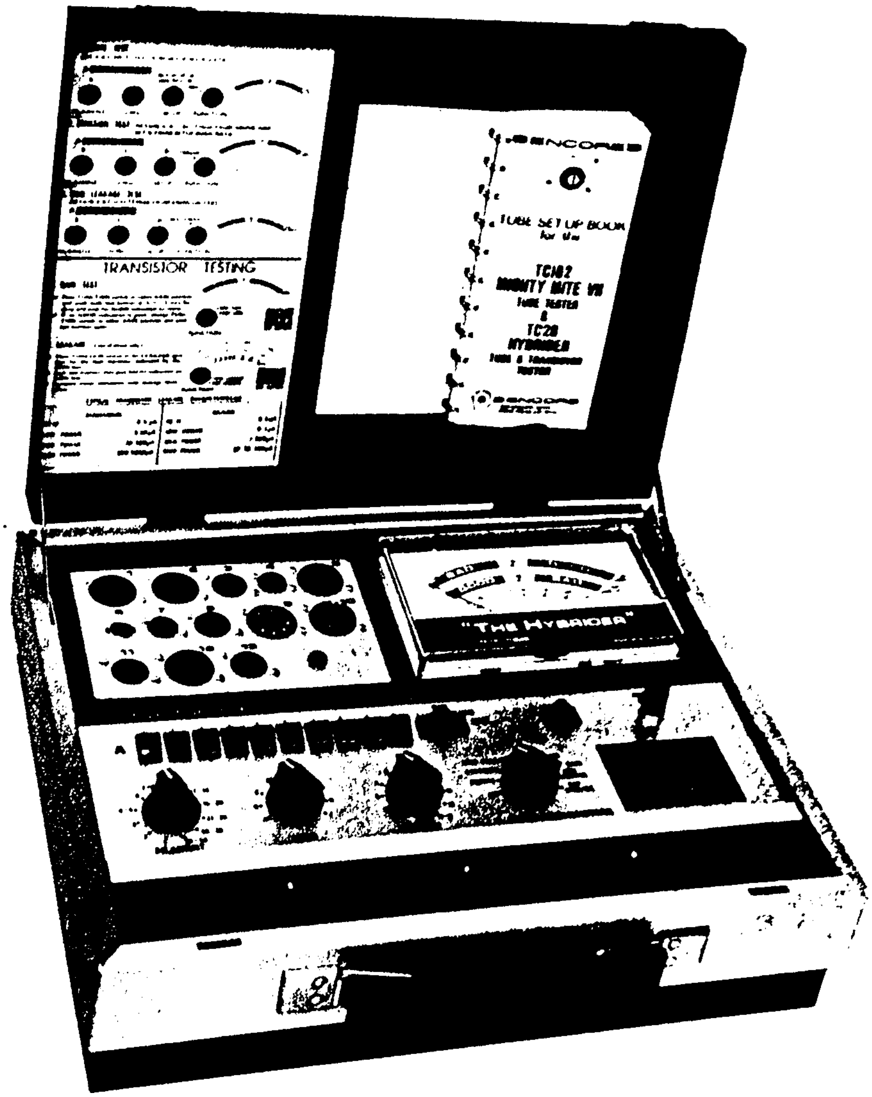
TC28

"THE HYBRIDER"

SERVICE MANUAL



SENCORE
"the all american line"

SAFETY REMINDERS

When testing electronic equipment, there is always a danger present. Unexpected high voltages can be present at unusual locations in defective equipment. The technician should become familiar with the device that he is working on and observe the following precautions.

1. When making test lead connections to high voltage points, remove the power. If this cannot be done, be sure to avoid contact with other equipment or metal objects. Place one hand in your pocket as a safety precaution and stand on an insulated floor to reduce the possibility of shock.

2. Discharge filter capacitors before connecting test leads to them. Capacitors can store a charge that could be dangerous to the technician.

3. Be sure your equipment is in good order. Broken or frayed test leads can be extremely dangerous and can expose the technician to dangerous potentials.

4. Remove the test leads immediately after the test has been completed to reduce the possibility of shock.

5. Do not work alone when working on hazardous circuits. Always have another person close by in case of accident. Remember, even a minor shock can be the cause of a more serious accident, **such as** falling against the equipment, or coming in contact with **high** voltages.

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INTRODUCTION

DESCRIPTION

Numerous solid-state devices are finding increasing application in television and other home entertainment equipment. These devices are also being used in conjunction with a multitude of tube types to produce the hybrid sets.

To be effective in the field service of these units, the service technician is faced with transporting a rather cumbersome and costly array of test equipment. The Sencore engineering staff is aware of the problems and needs encountered in the service industry. In response to these needs, the ever popular Mighty Mite Tube tester has been expanded to incorporate the features of Sencore's latest solid state device tester, the **TOUCH** TONE CRICKET. Now, in one compact, rugged, easy-to-use unit, exists the ability to completely and reliably test the tubes, transistors, FET's and diode devices found in modern home entertainment equipment.

FEATURES

* A single instrument for fast, accurate testing of tubes, transistors and FET's without complicated set ups.

* Pin elimination switches for greater capability in tube tests as **new** types are announced.

* Full cathode current emission test of tubes.

* Sensitive 100 megohm grid leakage test in addition to regular shorts test, all on a large easy-to-read meter.

* Complete test for transistors and FET's including in-circuit gain **and** out-of-circuit gain and leakage with NO set-up or basing data required.

* Rugged construction throughout, including protection against overload for sensitive meter and circuitry.

SPECIFICATIONS

DEVICES TESTED

Devices tested	Tubes, transistors, diodes, single-gate FET's

TUBE TESTS:

Emission	Load currents to 120mA and maximum applied voltage of 40 VAC RMS

Grid-Leakage	100 Megohm or less reads BAD. 100 Megohms to 200 Megohms reads in questionable area.
Shorts	200,000 ohms or less (40 VAC RMS applied voltage) indicates short on meter.

TRANSISTOR TESTS:

Gain (IN or OUT of Circuit)	VCE = 5 volts; VBE = 3 volts peak-to-peak, zero reference, 2KHz frequency. GOOD/BAD meter indication plus audible "chirp" for good test indication.
Leakage (OUT of circuit only)	5VDC applied voltage, meter indicates 0 - 3000 microamps leakage current.
SIZE:	14¾ X 12 X 4½
POWER REQUIREMENTS	105 - 125 VAC, 50/60Hz

CONTROLS

GENERAL OPERATION

TUBES/TRANSISTORS FUNCTION SWITCH: This rotary switch applies power to the TC28, selects tube or transistor tests and the type test to be made.

METER ZERO: This control is used to set meter to zero previous to making any test.

CONTROLS RELATED TO TUBE TEST:

"A" SWITCHES: These slide switches switched to the down position serve to isolate extra connections to the tube which would falsely indicate a shorted condition. The slide switch labeled RESET instantly clears all pin elimination switches.

FILAMENT or "B" SWITCH: This rotary switch sets the proper filament voltage for the tube being tested.

LOAD or "C" SWITCH: This rotary switch determines the range of load current to be carried by the tube during the emission test.

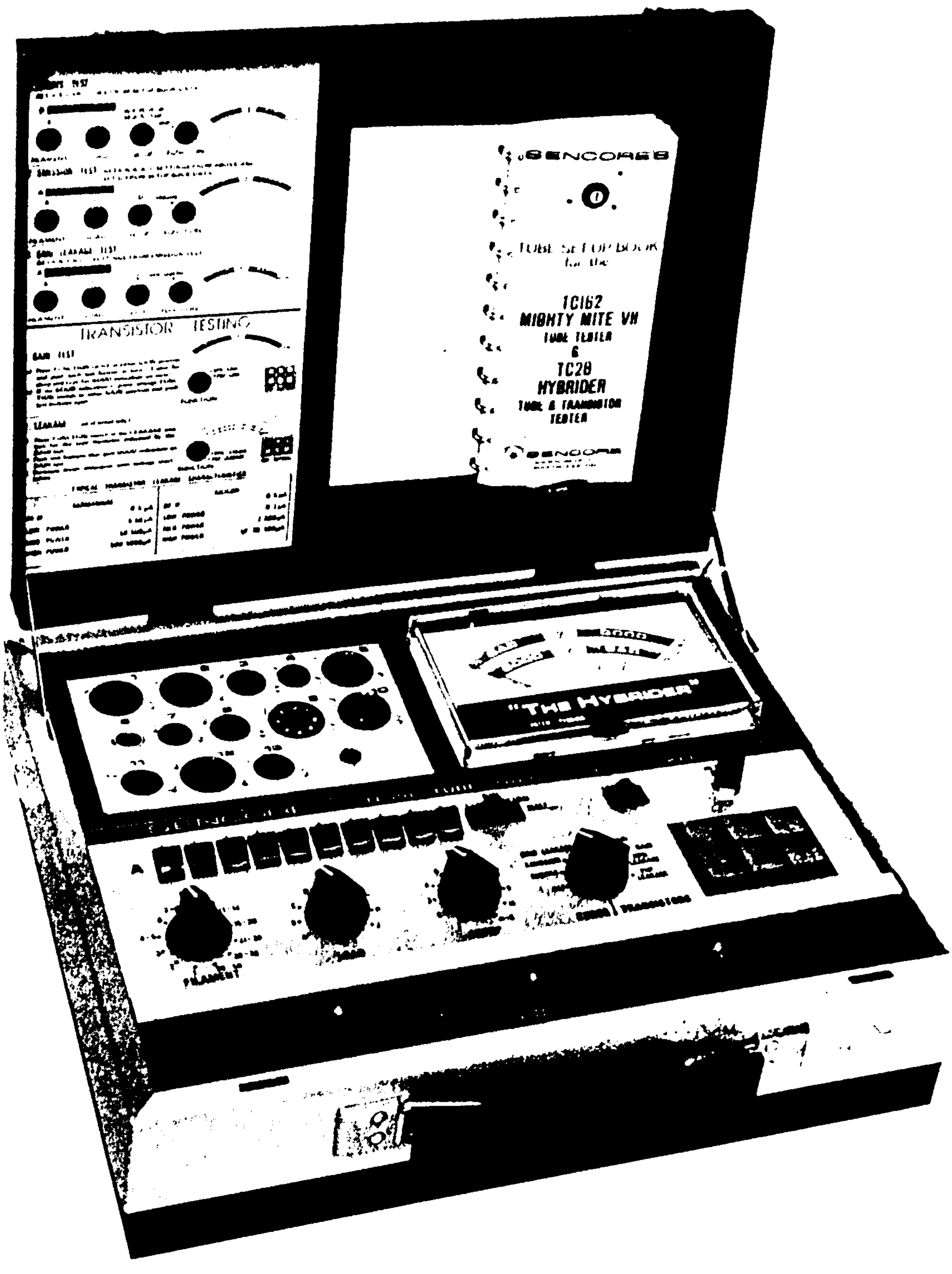


Fig. 1 TC28 "The Hybrider"

SETUP or "D" SWITCH: This rotary switch selects the control grid pin for the emission test. It also serves as the shorts test switch, for any inter-electrode shorts, by rotating the switch through its positions.

LIFE TEST: This slide switch provides a test of the useable life of a tube by measuring how well the tube performs with a reduced filament voltage.

CONTROLS RELATED TO TRANSISTOR TEST:

TEST SWITCHES: These six pushbutton switches apply the test voltage to the elements of the device under test, and mechanically rotate lead connection to all possible basing configurations, thus eliminating requirements for basing or circuit information.

CONNECTIONS: A socket panel provides a total of 13 tube sockets plus 1 transistor socket for all test conditions. A test lead cable terminated in **3** EZ Hook connectors facilitates in-circuit transistor or FET gain and leakage tests.

OPERATION

TUBE TEST SET UP

Operation of the TC28 Hybrider has been designed for simplicity, speed and accuracy. All that is necessary to completely check a tube is to follow the basic test procedure outlined below.

1. Connect the TC28 Hybrider to a grounded source of 105 to 125 volts, 50 to 60 Hz, AC power.
2. Locate the tube type to be tested in the setup chart. Looking to the right of the tube number, observe the setup information for the controls labeled A,B,C,D and socket. Some tubes have more than one listing indicating that the tube has more than one section to be tested. Each section of the multiple tube is tested separately.
3. Push the PIN ELIMINATION switches listed under A down to eliminate those pins. If none are listed, leave all switches in the up position.
4. Set the B,C, and D switches to the positions indicated and insert the tube into the socket listed. Where more than one setting is listed, make the emission and grid leakage test on each section. The shorts test need be made only once.

SHORTS TEST

Set the TUBES/TRANSISTOR Function Switch to SHORTS and check the front panel METER ZERO adjust to ensure a "0" indication on the meter. Allow a period of time for the tube filament to warm up, then rotate the "D" switch slowly through all of its positions while observing the meter. If no short exists or the resistance of the short is greater than 200,000 ohms, the meter will remain in the GOOD area of the GOOD/ BAD SHORTS scale. Shorts of 200,000 ohms or less will be indicated to a relative degree on the SHORTS scale. Tubes having a directly heated cathode (those in which the filament serves as the cathode) will show a direct short between heater and cathode on the H-K position of the "D" Switch. This is a normal condition and these tubes are indicated in the setup book by an asterisk (*) .

EMISSION TEST

If the tube passes the SHORTS test, rotate the Function switch to the EMISSION position and read the emission quality of the tube on the top scale of the meter. A tube indicating in the questionable area (?), has an emission level much lower than normal. It's replacement would be determined by you and your customer, based on the nature of the circuit in which the tube is to operate.

GRID-LEAKAGE TEST

If the tube reads in the GOOD area of the meter and passes the EMISSION test, switch to GRID LEAKAGE and read the grid leakage of the tube on the GRID LEAKAGE scale of the meter. This is a very important check and will pinpoint troublesome tubes that may otherwise check good. If the meter is indicating in the GOOD area of the scale but slowly rising, wait a minute or so to allow the meter to stabilize before judging test results. On large power tubes, such as a horizontal output tube, do not make a grid leakage check after an extended emission check. If the tube is left in the emission check position for several minutes, the grid will heat up and, when switched to grid leakage, will read higher than normal. Allow the tube to cool slightly before the grid leakage check. You can expedite the grid leakage check by raising the filament voltage for a few seconds. This is not the same overheating as was caused in the emission check, but will show up grid leakage. If the grid leakage indication climbs into the BAD area on the meter, reduce the filament voltage and see if the meter remains in the bad area. If it does so, then the tube will give trouble in the circuit and should be replaced. If the meter drops off rapidly back into the GOOD area, then the tube is good.

If the tube passes all of the above tests, it can be considered good and need not be replaced. If the tube is in the questionable area on any test, it becomes a value judgement based upon circumstances as to whether or not it should be replaced.

LIFE TEST

If the meter needle climbs very slowly into the GOOD area or Questionable area of the meter on the Emission test, the life expectancy of the tube can be considered much less than if the meter indicated **GOOD** in **a** shorter period of time. Also, if the needle should climb into the GOOD area and then "fall off," life expectancy can be considered much less. A general measure of the usable life remaining in a tube can be obtained by using the "Life test" position of the TC28 "Hybrider." Simply slide the LIFE TEST switch to the right and hold it for a few moments. Observe the emission level of the tube during this time. If the emission remains the same or drops only slightly the tube can be considered good. If the emission falls off quickly into the questionable or bad areas, it may be wise to replace the tube. (The rapid drop in emission generally indicates a short life expectancy).

FILAMENT WARM UP TIME

When replacing a costly horizontal output tube in a television receiver, it is a good idea to not only check the horizontal oscillator for emission and other standard tests, but to also check the length of time it takes to warm up. If the horizontal oscillator tube is slower in warming up than the output tube, the output tube will draw heavy current and its life will be shortened considerably. Checking the warm up time of the oscillator tube and making sure that it is as fast or faster than the output tube can reduce the chance of a call back later for the same trouble and keep your customer's confidence high in your service ability.

FILAMENT VOLTAGE SENSITIVITY

Some tubes may check good on the emission test and pass the other tests in the Hybrider, but still not operate properly in the receiver. These tubes may have a filament sensitive cathode. This means that the emission from the tube will change with a change in the applied filament voltage to the tube. This is caused from a low power line or defective power transformer in the receiver. This type of tube can be most troublesome in series string receivers. To test for this trouble, simply push the LIFE TEST switch while monitoring the emission of the tube on the meter. A good tube will not change its reading at all while a filament sensitive tube will drop in emission. If the tube falls into the questionable area (?) on the meter, it will give trouble in the circuit and should be replaced.

REJUVENATION

If you wish to rejuvenate a small tube, merely increase the filament voltage by setting switch "B" one setting higher for ten to fifteen seconds. This will super heat the cathode and boil out more emitting material from under the oxide coating. This is only a temporary measure as rejuvenation of a receiving tube will not last very long.

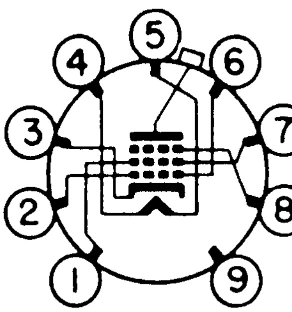
SET UP FOR NEW TUBES

New tubes can sometimes be a problem as they **may not be listed in the** set-up chart. This can be especially true on new receivers just introduced by the set manufacturers. Though new tubes are seldom **being added at** the present time, new tubes will undoubtedly **appear in the future. With an** understanding of the setup controls and what **each does, you can set** the Hybrider from a tube manual or even the schematic **of the receiver** itself.

"A" PIN ELIMINATION

The "A" PIN ELIMINATION switch is used to isolate internal connections of two pins to the same element of the tube so that a test **may be made.** For example, the tube basing shown in Figure 2 is a **9QL basing. The con-**trol grid is tied to pins 2 and 6, the screen grid to pins 1 and 7 and pin 9 is an internal connection that could be **connected to any pin inside of the** tube. To eliminate any shorts indication other than that which **are true** shorts in the tube, the PIN ELIMINATION switches 6, 7, and **9 would be** set in the down position to open these pins before the test is made. All the numbers correspond to the tube base pin number except for socket number 10, the compactron, where pin 11 is connected to PIN ELIMINATION switch number 1. If no isolation is **needed, all switches** should be in the uppermost position. After **each** tube **is tested, push the** RESET switch to the right to place all switches in the **up position. Each** can be moved independently of each other, either up **or down or set with** RESET switch.

BASING 9QL



BOTTOM VIEW

TERMINAL CONNECTIONS

Pin 1 – Grid #2
Pin 2 – Grid #1
Pin 3 – Cathode
Pin 4 – Heater
Pin 5 – Heater
Pin 6 – Grid #1
Pin 7 – Grid #2
Pin 8 – Grid #3
Pin 9 – Internal connection – do not use
Cap – Plate

Fig. 2 9QL Basing for 6JE6 Tube

"B" FILAMENT

This switch selects the filament voltage applied to the **tube under test** from 1 volt to over 50 volts. The twelve position switch selects **a** voltage range and, with the unique design of the **filament transformer,** the tube under test will load the transformer to obtain the correct voltage for testing. When setting up a new tube, simply set the "B" FILAMENT switch to the correct voltage or voltage range.

"C" LOAD

This switch selects the proper AC voltage to be applied to the plate of the tube as well as the correct load resistor so that the tube's designed current can be set and the tube checked under full load. The current ranges for the settings of the "C" LOAD switch are as follows:

LOAD switch	Cathode Current	LOAD switch	Cathode Current
A	50mA plus	F	2 - 7mA
B	20 - 50mA	G	.7 - 2mA
C	15 - 30mA	H	.5 - .8m A
D	10 -16mA	J	.5mA or less
E	6 - 12mA		

The current that the "C" LOAD switch is set to is the normal cathode current under normal bias conditions as listed in the tube manual. If a tube manual is not handy, compute the cathode current by the voltage drop across the cathode or plate load resistor in the circuit or from the schematic by using Ohm's Law.

"D" SET UP

The "D" switch is used to pick up the control grid for the test on the tube. It was discovered many years ago that approximately 97% of the electrons would go to the control grid when checking cathode emission. This is now used as the pick-up element. In the example of Figure 2, the "D" switch would be set to one of the control grids that is not isolated. If pin 6 were to be isolated, the "D" switch would be set to pick up pin 2.

The only exception to the above is on socket number 10 where pin 11 on the tube base is picked up with the first position of the "D" switch.

Sockets number 3 and 8 are wired identically except that socket number 8 has three pins not connected. This socket is used to isolate extra connections where more than two base pins are connected to the same element such as in the 1X2 high voltage rectifier. The seven-pin sockets 4 and 7 are alike except that the filament pins on socket 4 are 3 and 4 while on socket 7 they are 1 and 7.

SOCKET SET UP

The sockets on the TC28 have the filament pins prewired to eliminate the extra setup that is involved. The actual pin connections can be seen on the schematic diagram of the unit. Note that the two octal sockets **have** different filament connections. Socket number 1 is for filaments on pins 2 and 7 while socket number 2 is for filaments on pins 7 and 8. Sockets 3 and 8 have filaments on pins 4 and 5 while socket number 13 is for special Hi-Fi tubes with filaments on pins 1 and 2.

There are two novar sockets that are wired identically. Socket number **5** is for the standard novar based tubes while socket number 12 is for the magnoval based tubes. The pins on the magnoval based tubes are larger in diameter than the standard novar base and can damage the novar socket. All magnoval tubes are checked in socket number 12 to prevent damage to the regular novar socket number 5. When selecting the socket for **a** new tube, select the socket for the filament wiring as well as the socket the tube should fit into.

4

EXAMPLE OF **SETTING** UP THE TC28 **FOR NEW TUBES**

Let's use for our example, the 6JE6 shown in Figure 2. This tube is a standard novar based tube with the control grid tied to two pins on the tube base.

FIRST: Determine the socket to use. In this case, the tube is a standard novar base tube so that socket number 5 will be used.

SECOND: All the pins that must be isolated for testing must be noted. In this example, we have the control grid on pins 2 and 6 and the screen grid on pins 1 and 7 with pin 9 possibly connected to some pin internally. With the "A" PIN ELIMINATION switch,we will isolate the extra pins. For our example, we will push switches 6 and 7 down to the isolation position along with switch 9 to eliminate any possibility of this pin causing a false indication.

THIRD: Determine the filament voltage. In this case, it is the 6JE6 so that the filament switch "B" will be set to 6. The first set of numbers on the tube generally indicate the filament voltage of the tube. On foreign tubes, consult a substitution guide to find the filament voltage and characteristics that can be used to check the tube.

FOURTH: Select the current range that the tube is to be checked at using the information under "C" LOAD switch section of "SETUP FOR NEW TUBES. For our example, the A position would be used as the 6JE6 draws a very heavy plate current under normal use. Then perform the tests as previously described.

TRANSISTOR TESTS

GAIN TEST

The gain test on a transistor or FET with the TC28 is actually simpler than testing a tube. There is no need to know the transistor basing, polarity, or even if it is a transistor or an FET. Merely connect the leads in any combination and press the test buttons. Follow the procedure below to make a gain test on a transistor or FET.

1. Remove power from the equipment *containing* the device to be tested and discharge all power supply filter capacitors.

2. Connect the TC28 to a source of 105 - 125 volts, 50 to 60Hz, AC power.

3. The test cable is located in the lead storage compartment. Connect the test leads to the leads of the device to be tested. If the device to he tested is a plug-in type and can be removed easily, you may use the transistor socket located on the socket panel in place of the test cable. It is not necessary to determine basing of the device, the automatic test circuit will accomplish this.

4. Press each of the six test buttons in turn. If no audible chirp is heard and meter does not indicate in the GOOD area of GAIN / EMISSION meter scale, select the opposite polarity on the TUBES/TRANSISTORS Function switch and press the six test buttons again. If audible chirp is still not heard, the device being tested is bad. If the device tests bad in circuit it should be removed from the circuit and retested before a replacement is installed. A good FET and most good transistors will give a GOOD indication on two of the test buttons. If the exact basing of the device under test is desired, refer to the section of this manual on "Determining transistor basing." Some special devices such as Darlington amplifiers or diode protected transistors will test good on only one test button. Refer to the table in Figure 3 to determine the basing of these devices.

There are some rare cases where a good transistor may test BAD by the Hybrider when testing in-circuit. This will occur for a circuit whose base to collector resistance is less than 100 ohms, or when large electrolytic capacitors of 50uf or more are connected directly between the base or collector leads of the transistor and ground. These situations are not usually found in typical circuit applications.

Therefore, it is recommended that if the in-circuit test of a transistor indicates BAD, it should be removed and retested for gain before a replacement is installed. This retest should also include the out-of-circuit leakage test.

If a transistor tests BAD in-circuit and GOOD out-of-circuit, this may indicate other problems in the circuit. First check the schematic for resistors of less than 100 ohms between base and collector or electrolytic capacitors of 50uf or more connected to the transistor base or collector. If these are not found, check the circuit board for the possibilities of:

1. Shorted foils on the board.

2. Large resistors, connected to the transistor, which may have changed value or become shorted.

LEAKAGE TEST

It is possible for a transistor or FET to have good gain, and still **not work** in the circuit because the leakage upsets the DC circuit values. The leakage test on a transistor is nearly the same as the grid **leakage test of** a tube. To make the leakage test, proceed as follows:

1. Remove the transistor from the circuit and plug it into the transistor socket on the test panel or connect the test leads to the **leads of the** device. Make the gain test and note which two test buttons result in a good indication.

2. Switch to the LEAKAGE test, and press the two buttons that **gave** a good gain test. This test checks the ICBO and ICEO leakage values of transistors and the IGDO and IGSO leakage of FET's. These leakages should measure zero for FET's and small silicon transistors. High power silicon and small germanium transistors may indicate up to 100uA leakage, while germanium power transistors may indicate up to **3000uA and** still be acceptable.

3. Press the remaining four buttons. Two of these will result in **a** full scale leakage reading and the other two may or may not **indicate leakage** depending on the transistor. A junction FET will indicate full scale on all four remaining buttons, while a MOS FET should **indicate leakage on** only two buttons. If you desire to determine the **exact type leakage for** a particular transistor, refer to the **Locating Leakage section of this manual.**

DETERMINING BASING

If the device being tested checks good on two of the test buttons, it is either a standard transistor or an FET. To determine if the device is a transistor or FET, and the basing diagram, if it is a transistor, it is necessary to insert a resistor in series with the base/gate **lead. The value** of this resistor will depend on the transistor being tested, but the minimum value to use is 10K. If the device still tests good on two buttons, the value of the resistor will have to be increased in 10% steps (10K, 12K, 15K, etc.) until it tests good on only one button. If the device is still testing good on two buttons with a 100K resistor in series with the base, it is an FET. Since the source and drain are interchangeable on an FET, it is not possible to determine the exact basing. To determine the **basing on a transistor,** proceed as follows:

1. With the transistor out of circuit, connect the TC28, and determine which two test buttons produce a good indication.

2. Refer to the table in Figure 3, to determine the base lead, and connect a 10K resistor in series with it.

3. Retest the transistor and note which test button produces a good indication. Increase the value of the base resistor as necessary until the transistor tests good on only one button. Note the button that produces a good indication.

4. Refer to the table in Figure 3, to determine the basing of the transistor.

TEST SWITCHES

1	2	3
4	5	6

	TEST SWITCHES											
	I_{CBO}		I_{ECO}		I_{BEO} (full scale)		I_{EBO}		I_{CEO}		I_{BCO} (full scale)	
LEAD COLOR	1		2		3		4		5		6	
GREEN	E	S	B	G	C	D	C	D	B	G	E	S
YELLOW	B	G	C	D	E	S	B	G	E	S	C	D
RED	C	D	E	S	B	G	E	S	C	D	B	G
	TRANSISTOR OR FET BASING COMBINATIONS											

Fig. 3 Lead Basing

LOCATING LEAKAGE

In some cases it may be desirable to determine the exact nature of leakage in a transistor. With the test switches on the TC28 there is no need to connect to the transistor four different ways, the test switches do it for you. To locate the exact nature of the leakage, proceed as follows:

1. Determine the basing of the transistor or FET. Connect the green test lead to the emitter, the yellow test lead to the base and the red lead to the collector. If the device is an FET, connect the yellow test lead to the gate and the red lead to either the source or the drain. Connect the green lead to the remaining element of the FET.

2. Refer to Figure 4, and press the test button corresponding to the desired leakage test. Note that for regular transistors, buttons number 2 and 6 will produce a full scale leakage indication, corresponding to the conduction of the forward biased base-emitter and base-collector junctions respectively, junction FET's will produce a full scale reading on buttons 2 and 6 corresponding to the forward conduction of the gate diode: and on buttons 3 and 5 corresponding to the current flow through the low resistance source-drain channel. MOS or IG FET's should only produce a full scale reading on buttons 3 and 5; corresponding to the current flow through the channel.

TEST SWITCHES

1	2	3
4	5	6

LEAD COLOR	TEST SWITCHES 1	2	3	4	5	6
GREEN E/S YELLOW B/G RED C/D	I_{CBO} / I_{GDO}	I_{BEO} / I_{SGO}	I_{ECO} / I_{DSO}	I_{EBO} / I_{GSO}	I_{CEO} / I_{SDO}	I_{BCO} / I_{DGO}

Fig. 4 Leakage Chart

3. The following is an explanation of which **leakage is measured with each** test button, and its importance to the operation of the transistor or FET. This information is summarized in Figure 5.

ICBO

Button 1: ICBO is the leakage current that flows in a transistor **when** a voltage is applied between the collector and base, with the emitter open and the collector-base junction reverse biased. (Collector positive with respect to base for NPN transistor). Its effect **is similar to grid leakage in** a tube in that even a small amount will upset the DC bias in the circuit. In an FET, this leakage is called IGDO, and its effect on the DC **bias of** the circuit is even greater than for transistor ICBO. When making this leakage measurement, press the button carefully and note any up scale deflection of the meter. Even a very small up scale deflection should be cause to reject a small silicon transistor or FET. Larger silicon and small germanium transistors may safely indicate up to 50uA leakage, while some special high power germanium transistors may indicate up to 3,000uA and still be within manufacturers specifications.

IBEO

Button 2: IBEO in transistors is the current that flows through the forward biased base-emitter junction. (Base positive with respect to the emitter for an NPN transistor). This button should produce a full scale indication for transistors. For FET's this leakage would be called ISGO and indicate full scale for junction FET's and zero for MOS or IG FET's.

IECO

Button 3: IECO is the leakage current that flows in a transistor when a voltage is applied between emitter and collector with the base open. (Emitter positive with respect to collector for an NPN transistor). IECO is a measurement of the transistors ability to block reverse voltages, such as would be encountered in circuits with an inductive load in the collector. In FET's, this current would be called 1DSO and should indicate full scale because of the normal conduction of the low resistance drain source channel.

IEBO

Button 4: IEBO is the leakage current that flows in transistors when a voltage is applied between emitter and base, with the collector open and the emitter-base junction reverse biased. (Emitter positive with respect to base for NPN transistor). IEBO is most important in pulse circuits, where the base is driven deep into reverse bias and the leakage current could influence the pulse shaping circuits. In an FET, this leakage is called IGSO, and is a measurement of leakage current that flows from gate to source, with the gate source junction reverse biased for junction FET's. Even a small up scale deflection should be cause to reject a small silicon transistor or any FET. Larger silicon and small germanium transistors may safely indicate up to 50uA of leakage, while some special high power germanium transistors may indicate up to 3,000uA and still be within manufacturers specifications.

ICEO

Button 5: ICEO is the leakage current that flows in a transistor when a voltage is applied between the collector and the emitter, with the base open. (Collector positive with respect to emitter for an NPN transistor). Excessive ICEO will cause a transistor to operate unreliably **in any** circuit, however, the transistors most prone to this type leakage are high power types such as those used in audio output circuits and power supply regulators. In FET's this current would be called ISDO and should indicate full scale because of the normal conduction of the low resistance source-drain channel.

IBCO

Button 6: IBCO in transistors (Base positive with respect to the collector for an NPN transistor) is the current that flows through the forward biased base-collector junction. This button should produce a full scale indication for transistors. For FET's this leakage would be called IDGO, and indicate full scale for junction FET's and zero for MOS or IG FET's.

TYPE OF DEVICE	BUTTON 1 I_{CBO} (GDO)	BUTTON 2 I_{BEO} (SGO)	BUTTON 3 I_{ECO} (DSO)
Small Si. Transistor	0-.1uA	3000uA	0-.1uA
Large Si. & Small Ge. Transistor	1-50uA	3000uA	1-50uA
Large Ge. Transistor	10-3000uA	3000uA	10-3000uA
JFET	0uA	3000uA	3000uA
MOSFET	0uA	0uA	3000uA

TYPE OF DEVICE	BUTTON 4 I_{EBO} (GSO)	BUTTON 5 I_{CEO} (SDO)	BUTTON 6 I_{BCO} (DGO)
Small Si. Transistor	0-.1uA	0-1uA	3000uA
Large Si. & Small Ge. Transistor	1-50uA	10-500uA	3000uA
Large Ge. Transistor	10-3000uA	100-3000uA	3000uA
JFET	0uA	3000uA	3000uA
MOSFET	0uA	3000uA	0uA

Fig. 5 Maximum Leakages for Good Transistors and FET's

CHECKING DIODES

The leakage test on the TC28 provides a simple, accurate method of determining the front to back ratio of a diode or rectifier. The test switches allow measurement of both forward and reverse currents with no need to reconnect the diode.

1. Set the TUBES/TRANSISTORS Function Switch to the NPN LEAKAGE position.

2. Connect the red test lead to the anode of the diode and the yellow lead to the cathode.

3. Press button number 1 to measure the forward current. The forward current should indicate at or near full scale.

4. Press button number 6 to measure the reverse current. The leakage current should indicate at or near zero on the leakage scale.

CIRCUIT DESCRIPTION

THEORY OF OPERATION - TUBE TEST

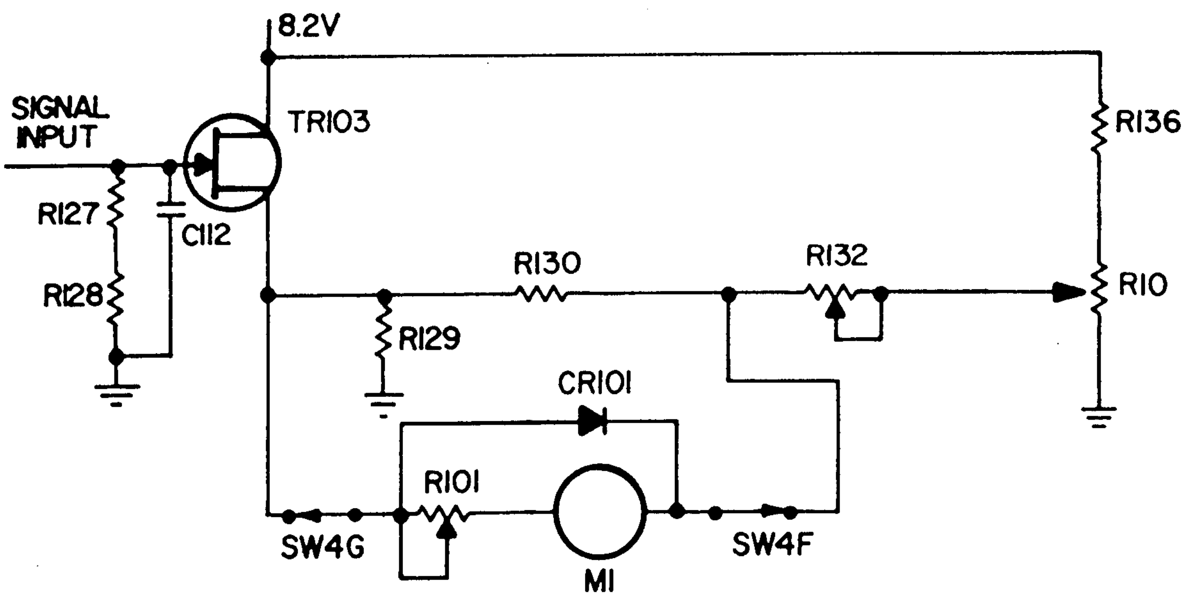


Fig. 6 Tube-test Bridge Circuit

The basic circuit of the tube-test section of the TC28 Hybrider, shown in Figure 6, is a balanced bridge meter amplifier circuit consisting of FET TR103 and the combination of R136 and R10. These resistors represent an adjustable voltage that takes the place of the second FET normally needed for the bridge circuit. The METER ZERO control, R10, on the front panel is just like the zero controls of a VTVM and balances the circuit so that with no signal input, the meter reads zero. When a voltage is impressed on the gate of the FET TR103, the bridge is unbalanced and the meter will read in proportion to the applied signal.

EMISSION TEST

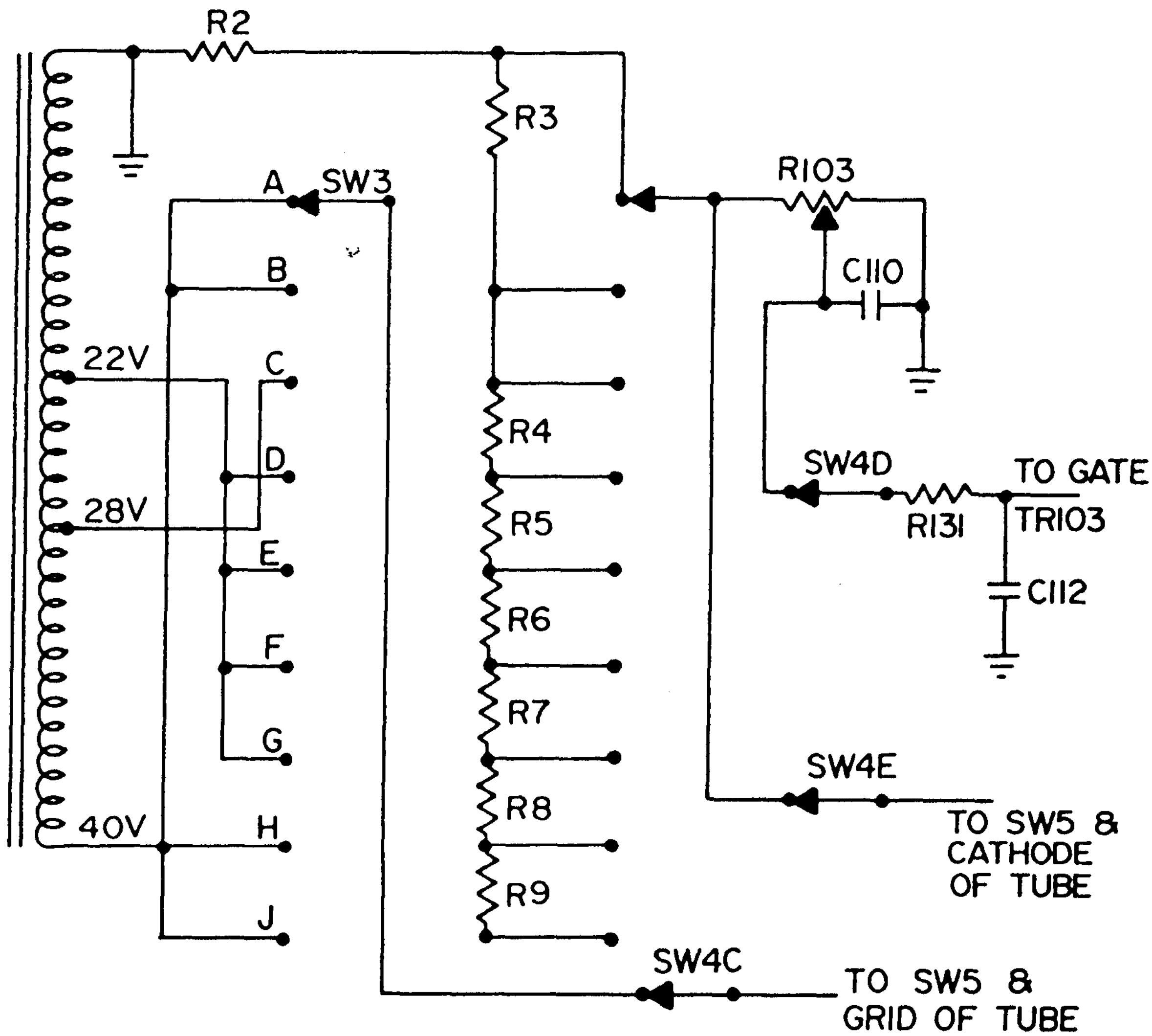


Fig. 7 Emission Test Circuit

The cathode emission test puts AC voltage between the control grid of the tube under test and the cathode, with a load resistor in series with the cathode to develop a pulsating DC voltage. The "C" LOAD switch selects the different size load resistors and applied voltage so that a full range of current is available from less than .5mA to 120mA. The tube under test rectifies the applied AC voltage and develops a voltage drop across the load resistors R3 through R9. The pulsating DC voltage is coupled through the filter network of R103 and C110 to smooth it to a pure DC voltage. This voltage is applied to the gate of TR103 through an additional isolation and filtering network of R127, R128, R131, and C112, shown in Figure 6. The resultant DC voltage is coupled through SW4D and upsets the balance of the circuit causing the meter to read up-scale in proportion to the emission quality of the tube.

GRID-LEAKAGE TEST

In the grid leakage test, the control grid of the tube under test is made negative to all other elements in the tube by connecting the grid to ground through the 30 megohm gate resistor consisting of R127 and R128 of Figure 6, and applying +8 volts to all other tube elements. If the tube has any grid leakage or contamination causing the grid to emit electrons, the flow of electrons will be through the gate resistor. Any current flow through the resistor will cause a voltage drop across the resistor resulting in an unbalance in the bridge circuit. The meter will read upscale in proportion to the amount of grid current in the tube under test. A leakage of 100 megohms or less will cause the meter to read into the BAD area. A leakage of 100 to 200 megohms will cause a meter reading in the questionable area and a leakage of 200 megohms or more will read in the GOOD area on the meter. A leakage of 100 megohms represents a grid current in the tube under test of .5 microamps.

SHORTS TEST

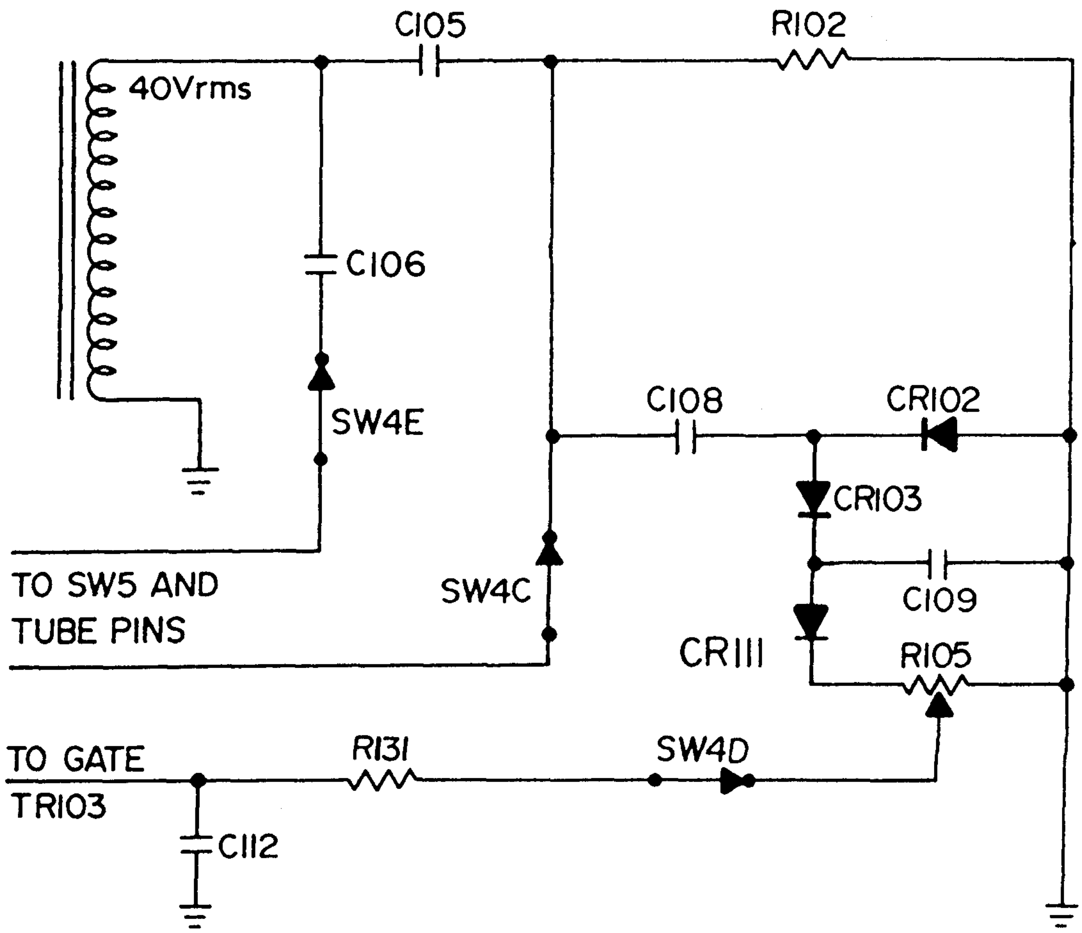


Fig. 8 Shorts Test Circuit

The shorts test utilizes the Sencore stethoscopic approach **where each and** every element in the tube is checked against all other elements. **A voltage** divider consisting of C105 and R102 in figure 8 is placed **across the 40** volt secondary of the transformer. The 40 volts AC RMS is divided down to approximately 34 volts RMS. The **lower voltage is necessary to prevent** arc over and breakdown in nuvistors and frame-grid tubes. C106 **is a** coupling capacitor which prevents any DC action of the tube from upsetting the shorts test. Any shorting resistance present between the tube elements will upset the action of the voltage divider which will in turn increase the AC voltage at the input of the peak-to-peak detector comprised of CR102 and CR103. The output of the peak-to-peak detector is filtered by C108 and C109 and presented across CR111 and R105. CR111 prevents an upscale meter indication with no short present at the tube elements by blocking DC voltages of **less than 0.6 volts.** The output of the detector greater than 0.6 volts DC is applied to the **gate** of TR103 through SW4D. The increased DC **level at the source of TR103** causes the meter to indicate up scale in proportion to the **severity of the** short. R105 at the detector output is a calibration control that establishes the sensitivity of the test such that a shorting resistance of less than 200,000 ohms will indicate BAD on the meter.

THEORY OF OPERATION - TRANSISTOR TEST

GAIN TEST

The operation of the TC28 transistor gain test represents **a** unique approach to the testing of transistors and FET's. The test depends on a good transistor or FET providing a signal polarity reversal from input to output when operating with the emitter or source common. Refer to the TC28 Schematic and Parts List insert for this brief description of overall test circuit operation.

A 2KHz square wave is generated by IC1B, and through an emitter follower TR101 and TR104, is coupled to the base or gate of the device under test by the test switches. The test switches ground the emitter or source and also connect a positive 5 volts from the power supply to the collector or drain. If the device under test is good, the collector signal voltage developed at the junction of R111 and R112 will be 180 **degrees** out of phase with the base signal.

The base signal from the 2KHz oscillator is amplified by **IC1C,and the** collector signal is amplified by IC1D. The outputs of IC1C **and** coupled to the logic circuit of IC2, that provides an output to the meter and speaker only when the two input signals are 180 degrees out of **phase.** This provides both audio and visual indication of a good transistor.

POWER SUPPLY

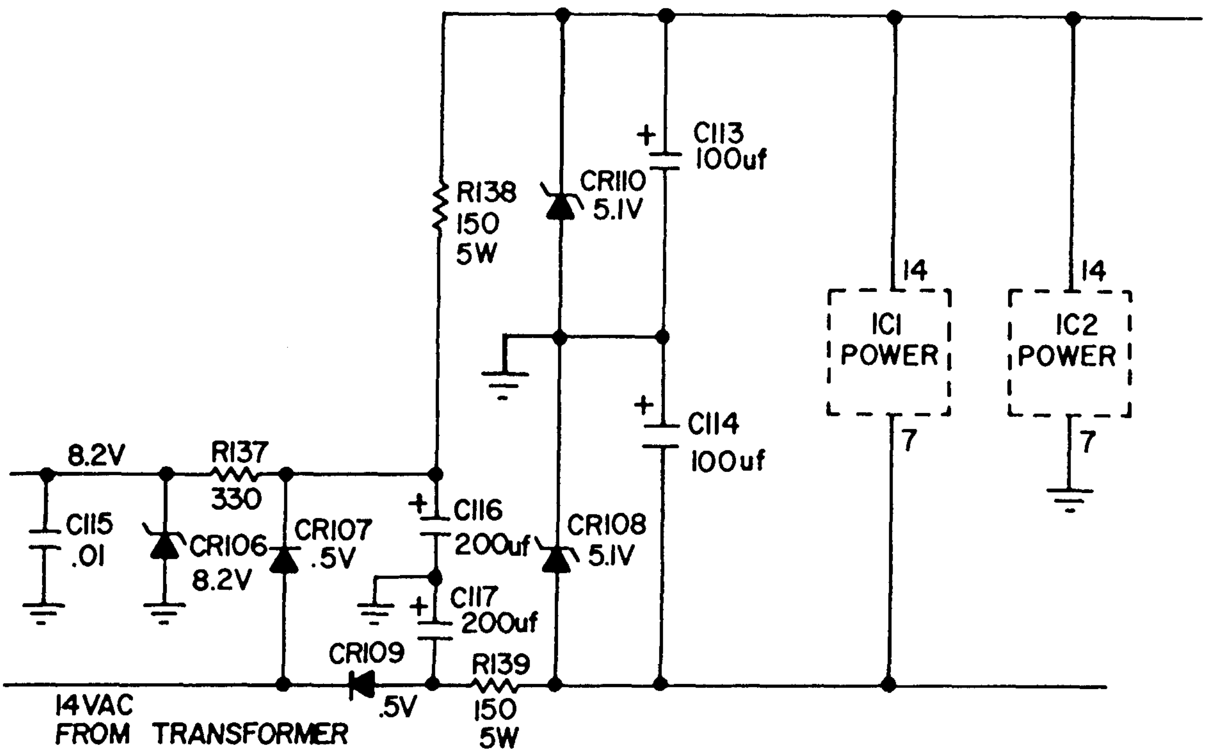


Fig. 9 Power Supply Schematic

The 14VAC from the transformer is rectified by CR107 and CR109, shown in Figure 9, and filtered by C116 and C117 to produce 16 volts DC. This voltage is regulated by R137 and CR106 to produce 8.2 volts DC for the bridge circuit. Positive and negative 5 volts DC for transistor test voltages are obtained from CR110, CR108, and R138. The plus 5 volt supply is filtered by C113, and the minus 5 volt supply is filtered by C114.

2KHz OSCILLATOR AND SIGNAL AMPLIFIERS

IC1B is connected as a square wave oscillator operating at approximately 2KHz as shown in figure 10. The frequency of operation is determined by R108 and C101. The amplitude of the output signal is set by the ratio of R106 and R107. TR101 and TR104 operate as dual emitter followers providing a low impedance source for the 2KHz signal. TR101 and TR104 are both biased off and have a common emitter load resistor R118. TR101 passes the positive portion of the square wave and TR104 passes the negative portion. The total square wave signal then appears across R118.

The 2KHz signal is coupled by R119, SW4H, and the test switches to the base of the transistor under test. It is also coupled to the non-inverting input of IC1C by C104 and R120.

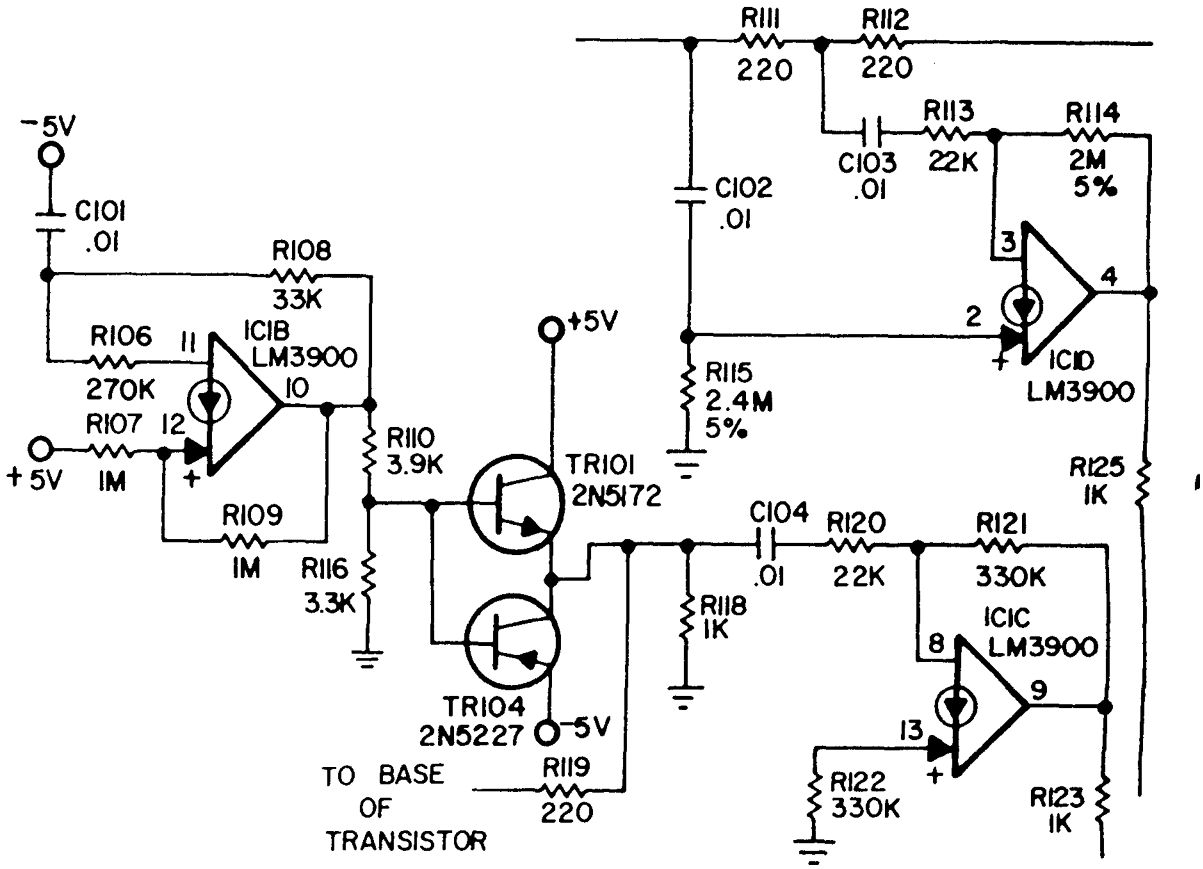


Fig. 10 2KHz Oscillator and Amplifiers Schematic

IC1C amplifies the signal applied to the base of the transistor under test. The amplified signal from the output of IC1C is coupled by R123 to input 2 of IC2. IC1D amplifies the signal from the collector of the transistor under test. The amplified signal from the output of IC1D is coupled by R125 to input 4 of IC2.

LOGIC CIRCUIT AND INDICATOR DRIVE

The logic circuitry of IC2 is the heart of the TC28. It is here that the base and collector signals from the transistor under test are compared, and the differentiation made between a good and a bad transistor. IC2 is actually a quad, two-input "NAND" gate. The truth table for the "NAND" gate shows that the only time that the output of the gate is zero is when both inputs are positive. The input and output signals in Figure 11 show operation of the circuit for a good transistor.

With a good transistor connected to the TC28, the base signal coupled into pin 2 of IC2A will be out of phase with the collector signal coupled into pin 4 of IC2B. IC2A is simply connected as an inverter so that it's output from pin 3 is in phase with the collector signal. IC2B is then used as a NAND gate, that is it will produce a zero output only when the two

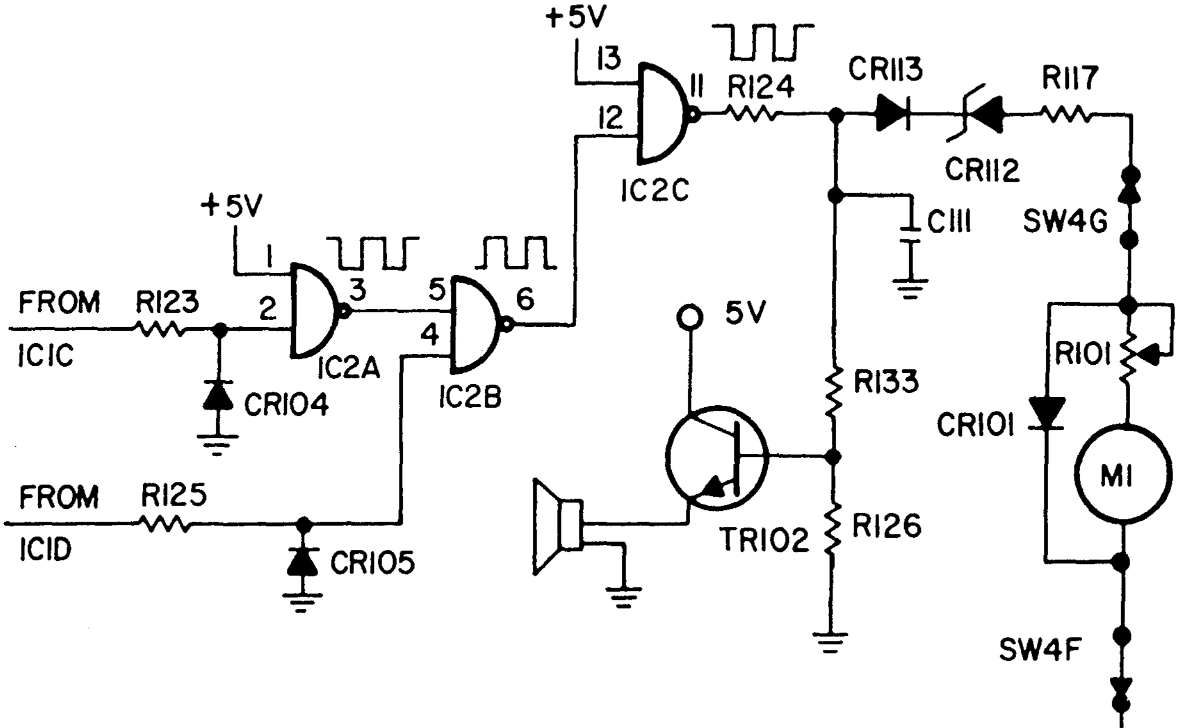


Fig. 11 Logic Circuit and Indicator Drive Schematic

inputs are positive. Finally, IC2C is used as an inverter so that it's output is positive only when the input pin 12 is zero. This pulsating positive output from IC2C is used to drive the meter and the speaker transistor TR102.

A bad transistor will not yield an out-of-phase collector signal for pin 4 input of IC2B. IC1D is biased such that it's output is zero when there is no input signal from the collector of the transistor under test. This zero level is coupled to pin 4 of IC2B and makes the output at pin 6 positive. The output of IC2C is then zero which indicates BAD on the meter.

LEAKAGE TEST

The collector lead of the transistor under test is connected through R111 and R112 to plus or minus 5 volts by one section of SW4B, as shown in Figure 12. The base lead of the transistor under test is connected to ground through Ml by SW4F or SW4G and indicates the leakage current through the transistor. CR101 provides meter compression and R101 is a calibration adjustment to set the full scale leakage sensitivity at 3000uA. The emitter lead is disconnected from the circuit by one section of SW4J.

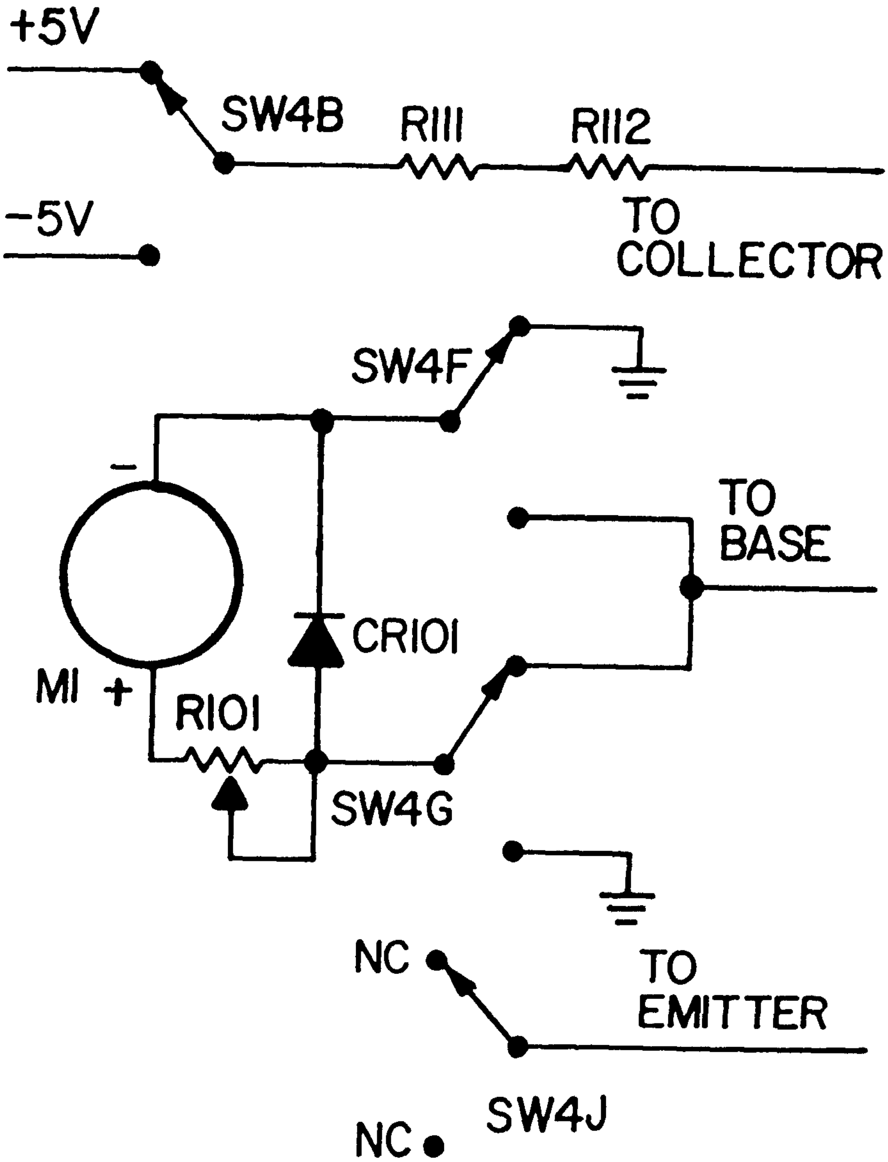


Fig. 12 Leakage Test Circuit

SERVICING THE TC28

DISSASSEMBLY INSTRUCTIONS

To remove the TC28 from its case for adjustment of the internal calibration controls, or to facilitate service, merely remove the four screws from the back of the instrument case. The front panel may now be lifted from the case, exposing all circuitry for calibration or service. All of the circuitry, except for the point-to-point wired switches and **sockets, has** been contained on the one printed circuit board. The board **may be** easily removed by simply unplugging the keyed molex connectors and removing the two screws that hold the board in place. To re-assemble the TC28 merely reverse the above procedure.

CALIBRATION

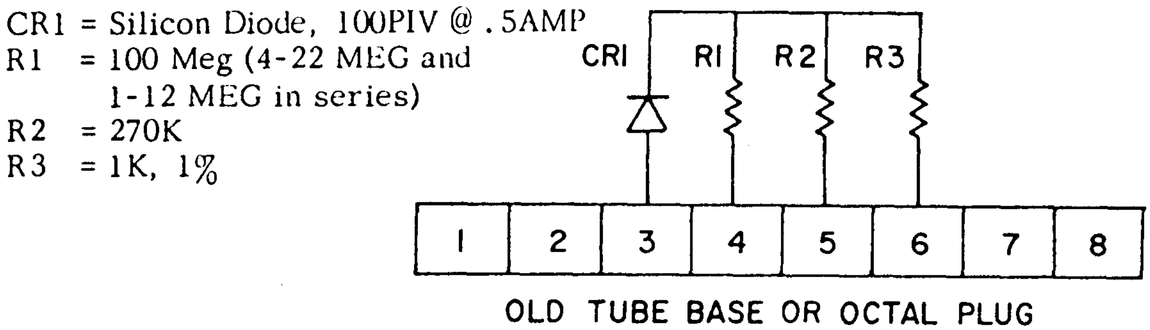


Fig. 13 Calibration Module

The TC28 Hybrider should seldom need calibration. However, should you desire to periodically check the TC28 calibration accuracy, thereby insuring its top performance, the calibration module described above in Figure 13, is recommended. The module can be constructed on an octal plug or discarded octal tube base and is to be inserted into the socket 1 on the TC28 socket panel.

Some of the calibration adjustments for the TC28 interact and for this reason the following adjustment procedure must be followed:

There are six calibration controls located on the printed-circuit board in the TC28. Refer to Figure 14 for the location of these controls. The first three adjustments have to do only with the tube test functions of the TC28. The remaining three adjustments pertain to the transistor test portion of the TC28.

1. To begin the calibration procedure, remove the TC28 from its cabinet and, with the unit in its normal operating position, adjust the mechanical-zero adjust on the meter of the TC28 for a "0" indication.

2. Apply 105 - 125 VAC power to the unit and turn the TUBES/ TRANSISTORS Function Switch to the NPN LEAKAGE position. Connect the positive terminal of a DC milliameter to the red test lead. Connect a 2000 ohm variable resistor between the negative terminal of the meter and the yellow test lead. Press TEST button No. 1 and adjust the external resistor until the external meter indicates 3.0mA. Adjust R101, the Leakage Cal. Control, for a full scale indication on the TC28 meter.

3. Insert the calibration module into socket 1 and make the following setup on the front panel selectors:

A	B	C	D	SKT
ALL UP	1	D	4	1

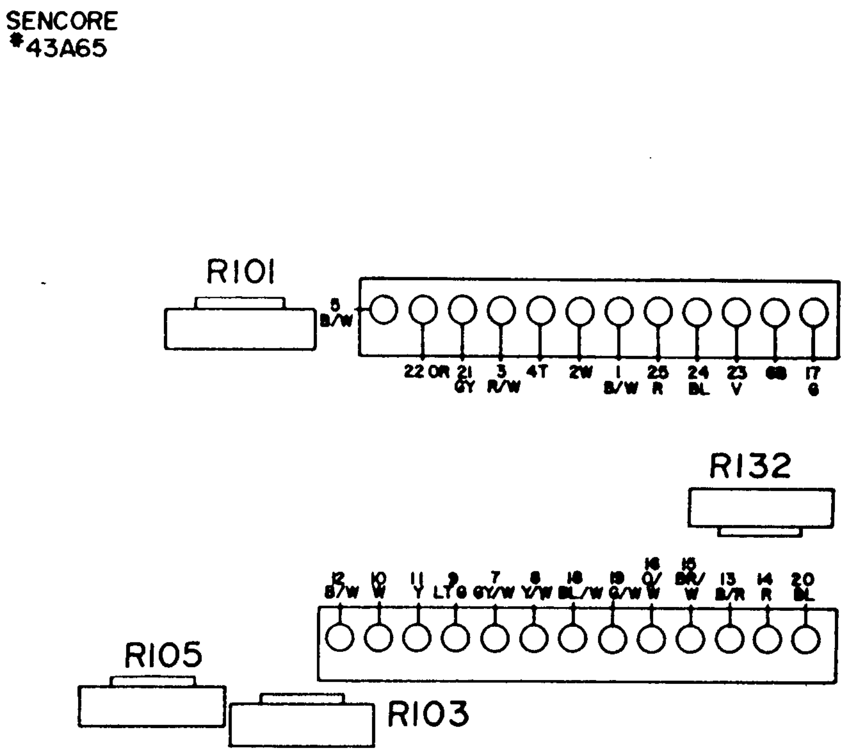


Fig. 14 Circuit Board Layout

4. Set the TUBES/TRANSISTORS Function Switch to SHORTS and adjust the meter to zero with the front panel METER ZERO control.

5. Switch to the GRID—LEAKAGE position on the Function switch and adjust R132, the Grid Leakage Cal. Control until the meter reads between the "?" and BAD on the GRID LEAKAGE scale on the meter.

6. Switch back to SHORTS and recheck the meter zero. Adjust front panel METER ZERO control if necessary.

7. Repeat steps 4 and 5 as required to achieve continuity.

8. Change the setting of the SETUP or "D" switch from position 4 to position 3.

9. Set the TUBES/TRANSISTORS Function Switch to EMISSION and adjust R103, the Emission Cal. Control until the meter indicates "?"on the EMISSION/GAIN scale of the meter.

10. Switch back to the SHORTS position and recheck the meter zero. Adjust front panel METER ZERO control if necessary.

11. Repeat steps 9 and 10 as required.

12. Change the setting of the SETUP or "D" switch from position 3 to position 5.

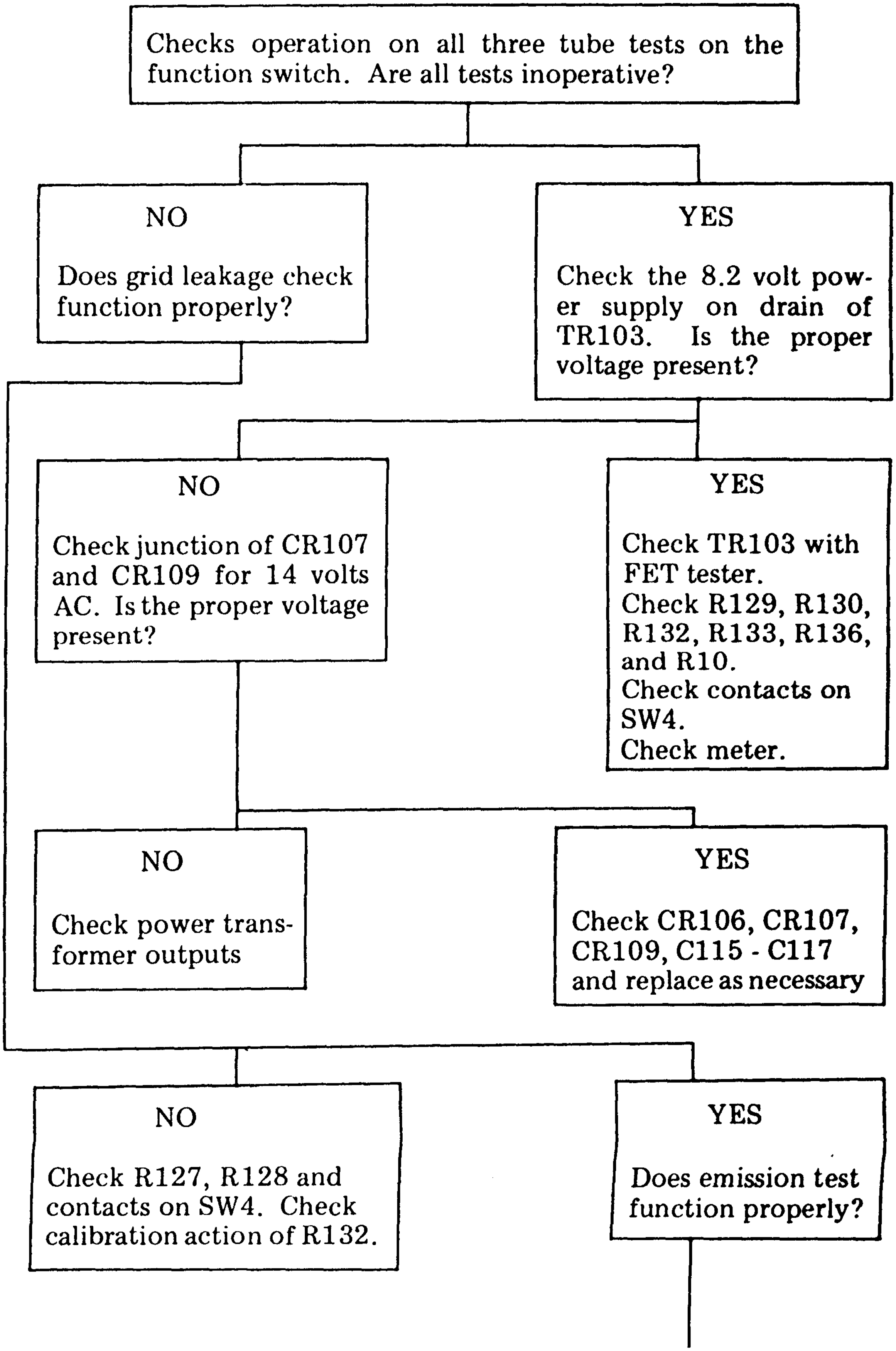
13. With the TUBES/TRANSISTORS Function Switch in the SHORTS position, adjust R105, the Short Cal. Control, so that the meter indicates on the line between GOOD and "?"on the GRID LEAKAGE - SHORTS scale of the meter.

14. Change the setting of the SETUP or "D" switch from position 5 to position 7 and observe that the meter indicates zero. Adjust the front panel METER ZERO if required.

15. Repeat steps 11 through 13 as required.

TROUBLE CHARTS

TUBE TESTS INOPERATIVE



continued on next page

NO

Check power transformer voltages.
Check R2 - R9 and replace as necessary.
Check C110 and R103 and replace as necessary.

YES

Does shorts test function properly?

NO

Check C105 - C109, CR102, CR103, R104, R105 and replace as necessary.

YES

Complete the calibration procedure.

TRANSISTOR GAIN TEST INOPERATIVE

Check test leads by shorting all three leads, switching to leakage and pressing all 6 buttons in sequence. Do all buttons indicate full scale?

NO

CONCLUSION:
Check and replace as necessary: wiring and test leads.

YES

Connect a known good transistor to the TC28: green lead to emitter, yellow lead to base, and red lead to collector. Select the correct polarity, and press button 1. Are both meter and speaker indications inoperative?

continued on next page

NO

CONCLUSION:
Check for plus 4 volts at pin 11 of IC2 and 4 volt 2KHz pulses at pin 12 with button 1 pushed. If both signals are present, troubleshoot defective indicator circuit. If one signal is missing, replace IC2.

YES

Remove transistor and connect scope ground lead to green test lead, press button 1, and measure signal on yellow and red leads. Does yellow lead measure 3 vp-p and red lead measure ± 5 volts?

NO

CONCLUSION:
Start at base of TR101, locate where 2KHz signal is lost.

YES

Connect known good transistor to the TC28: green lead to emitter, yellow lead to base, and red lead to collector. Select the correct polarity, press button 1, and using a dual trace scope, check for out of phase signals on inputs 3 and 8 of IC1. Are proper signals present?

NO

CONCLUSION:
Use scope to locate where 2KHz signal is lost.

YES

Check for out of phase signals at inputs 2 and 4 of IC2. Do signals swing from -.5 volts to 4 volts DC?

NO

CONCLUSION:
Trace signal back to output pins 9 and 4 of IC1. If no output at pins 9 and 4, and power supply connections are good, replace IC1.

YES

CONCLUSION:
If power supply voltages are normal, replace IC2.

SERVICE AND WARRANTY

You have just purchased the finest amplifier tester on the market today. The Sencore TC28 has been inspected and tested twice at the factory and has passed a rugged use test by our Quality Assurance Department to insure the best quality instrument to you. If something should happen, the TC28 is covered by a standard 90 day warranty as explained on the warranty policy enclosed with your instrument.

Sencore has six regional offices to serve you. Instruments to be serviced should be returned to the nearest regional office by UPS if possible. Parcel post should only be used as a last resort. Instruments should be packed with the original packing materials or equivalent, and double boxed to insure safe arrival at the regional office. The display carton IS NOT an acceptable shipping container. When returning an instrument for service, be sure to state the nature of the problem to insure faster service.

If you wish to repair your own TC28 Hybrider, we have included a schematic, trouble charts, and parts list. Any of these parts may be ordered directly from the regional office nearest you.

We reserve the right to examine defective components before an in warranty replacement is issued.

SENCORE REGIONAL OFFICES:

East Central Sales & Service
4105 Duke Street
Alexandria, VA 22304
A/C **703-751-3556**
TWX 710-832-0618

Central Sales & Service
2711 B. Curtis Street
Downers Grove, IL 60515
A/C 312-852-6800
TWX 910-695-3226

Western Sales & Service
833 Mahler Rd.
Burlingame, CA 94010
A/C 415-697-5854
TWX 910-375-3307

Central West Sales & Service
3200 Sencore Drive
Sioux Falls, SD 57107
A/C 605-339-0100
TWX 910-660-0300

Southeastern Sales & Service
2459 Roosevelt Hwy., Suite B9
College Park, GA 30337
A/C 404-768-0606
TWX 810-751-3546

Northeastern Sales Office
1593 H Central Avenue
Albany, NY 12205
A/C 518-869-0996
TWX 710-444-4969

Page 32: "Sencore Regional Offices"

The Northeastern Sales Office address has been changed to:

1237 Central Avenue
Albany, New York 12205
(518) 459-6040

The Southeastern Sales Office address has been changed to:

2459 Roosevelt Hwy., Suite B3
College Park, Georgia 30337
(404) 768-0606

ADDITIONAL APPLICATION NOTES

IN-CIRCUIT TESTING

There are some rare cases where a good transistor may test BAD by the Hybrider when testing in-circuit. This will occur for a circuit where the base to collector resistance is less than 100 ohms, or when large electrolytic capacitors of 50mF or more are connected directly between the base or collector leads of the transistor and ground.

Therefore, it is recommended that if the in-circuit test of a transistor indicates BAD, it should be removed and retested for gain before a replacement is installed. This retest should also include the out-of-circuit leakage test.

If a transistor tests BAD in-circuit and GOOD out-of-circuit, this may indicate other problems in the circuit. First, check the schematic for resistors of less than 100 ohms or electrolytic capacitors of 50mF or more, connected between the transistor base and collector. If these are not found, check the circuit board for the possibilities of: Shorted foils on the board, or resistors or capacitors connected to the transistor which may have changed value or become shorted.

"GOOD" READING ON **ONLY** ONE **BUTTON**

All good FET's and most good transistors will show a **GOOD** gain reading when either of two buttons is depressed. However, there are a few transistors, such as Darlington pairs, or devices with protective diodes between emitter and collector, that will read good on only one button.

If an in-circuit transistor shows GOOD gain on only one button, it may indicate a leakage condition. Therefore, it is recommended that such a transistor be removed from the circuit and tested again, both for gain and leakage. If the transistor gives a **GOOD** reading on only one button and does not show excessive leakage when tested out of circuit, the transistor is good and is probably one of these special types.

TC28 MANUAL ADDENDUM

Please note these changes to the TC28 Hybrider manual (Form 959). Mark the following sections in the manual "Revised — Refer to Addendum," and use these instructions.

Page 13: "Determining Basing"

If the device being tested checks good on two of the test buttons, it is either a standard transistor or an FET. To determine if the device is a transistor or FET, and the basing diagram, it is necessary to insert a 100K ohm variable resistor in series with the base/gate lead. Perform the Gain Test with the control at zero ohms and increase the resistance in 10% steps. Retest both buttons at each step until the device tests good on only one button. This indicates the device is a transistor. If the device still tests good on two buttons with the total 100K resistance in series with the base/gate lead, it is an FET. Since the source and drain are interchangeable on an FET, it is not possible to determine the exact basing. To determine the basing on a transistor, proceed as follows:

1. With the transistor out of circuit, connect the TC28, and determine which two test buttons produce a good indication.
2. Refer to the table in Figure 3 to determine the base lead, and connect a 100K ohm control in series with it.
3. Retest the transistor and note which test button produces a good indication. Increase the resistance of the control as necessary until the transistor tests good on only one button. Note the button that produces the good indication.
4. Refer to the table in Figure 3 to determine the basing of the transistor.

TEST SWITCHES

1	2	3
4	5	6

	TEST SWITCHES											
	I_{CBO}		I_{BEO} (full scale)		I_{ECO}		I_{EBO}		I_{CEO}		I_{BCO} (full scale)	
LEAD COLOR	1		2		3		4		5		6	
GREEN	E	S	B	G	C	D	C	D	B	G	E	S
YELLOW	B	G	C	D	E	S	B	G	E	S	C	D
RED	C	D	E	S	B	G	E	S	C	D	B	G
	TRANSISTOR OR FET BASING COMBINATIONS											

Fig. 3 Lead Basing

THE IDEA PEOPLE

SENCORE

3200 SENCORE DRIVE, SIOUX FALLS, SOUTH DAKOTA 57107

TC28

TUBE & TRANSISTOR TESTER

SCHEMATIC AND PARTS LIST

SENCORE

THE ALL AMERICAN LINE OF HIGH QUALITY TEST EQUIPMENT

TC28 PARTS LIST

SCHEMATIC REFERENCE	PART NUMBER	DESCRIPTION	PRICE
P.C. BOARD MOUNTED COMPONENTS			
IC101	69G9	IC, Quad Op Amp, LM3900	2.50
IC102	69G10	IC,Quad Nand Gate, SN7400	1.25
TR101, 102	19A28	Transistor, NPN, 2N5172	.50
TR103	19C11-1	FET, N-channel, 2N5457	1.75
TR104	19A16-1	Transistor, PNP, 2N5227	.75
CR101, 104, 105 111—114	5005-2	Diode, 1N4148	.25
CR102, 103	50C3-1	Diode, 1N34A	.25
CR106	50C4-2	Diode, Zener, 8.2V	.75
CR107, 109	16S10	Rectifier, 0.5A, 400 PIV	.50
CR108, 110	50C4-13	Diode, Zener, 5.1V	1.00
R101	15C7-2	Control, 10K, Leakage Cal	.75
R103	15C7-8	Control, 1.2M, Emission Cal	.75
R105	15C7-6	Control, 500K, Shorts Cal	.75
R132	15C7-2	Control, 10K, Grid Leak Cal	.75
R138, 139	14B49-9	Resistor, 150 Ohm, 5W, 10%	.25
C101-104, 110, 112, 115	24G126	Capacitor, 0.01 mF	.50
C106, 108, 111	24G293	Capacitor, 0.lmF, Mylar	.50
C109	24G289	Capacitor, 0.47 mF, Mylar	.75
C113, 114	24G118	Capacitor, 100mF, Lytic	.50
C116, 117	24G181	Capacitor, 200mF, Lytic	1.00
CHASSIS MOUNTED COMPONENTS			
R10	15C1-38	Control, 200 Ohm, Meter Zero	1.25
R2, 3	14B49-9	Resistor, 150 Ohm, 5W, 10%	.25
Cl	24G120	Capacitor, 10mF, Lytic	.25
C2	24G140	Capacitor, .002mF	.25
C3	24G25	Capacitor, 220pF, Disc	.25
T1	28B58D	Transformer, Power & Filament	15.25
SW1	25G197	Switch, Slide, LIFE TEST	1.00
SW2	25A154	Switch, Rotary, FILAMENT	4.50
SW3	25A157	Switch, Rotary, LOAD	3.25
SW4	25A196	Switch, Rotary, FUNCTION	7.25
SW5	25A158	Switch, Rotary, SELECTOR	3.50
SW6—15	25A155	Switch, Slide, PIN ELIMINATION	2.75
SW16	25A156	Switch, Slide, RESET	.75
SW17, 18, 19 20, 21, 22	25A186	Switch, PUSH Push	3.50
Ml	23C51	Meter, 6", 100uA	22.75

SCHEMATIC REFERENCE	PART NUMBER	DESCRIPTION	PRICE
I1	20G12	Neon Bulb, No. NE-2	.25
LS1	48A2-2	Speaker, 2", 8 ohm	2.75

ASSEMBLIES

	108B107	Socket Panel Assembly	24.50
	143A65	Printed Circuit Assembly	42.25
	143A58-.1	Push Switch Assembly	7.25
	143A58-2	Push Switch Assembly	7.25
	168G12	Hook and Cable Assembly	10.00
	110C311	Case Assembly	25.00
	110C313	Cover Assembly	15.25

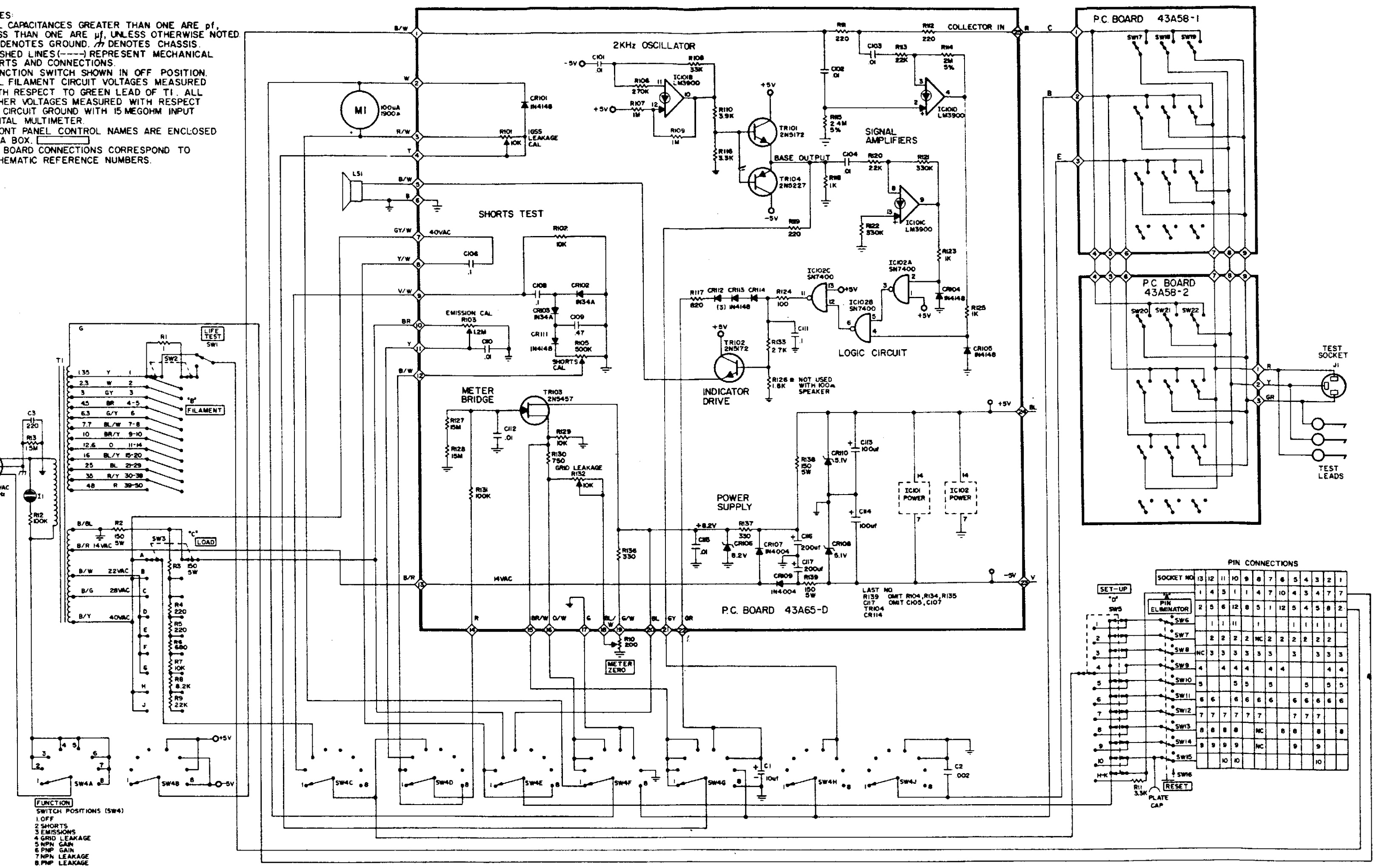
MISCELLANEOUS

	26G4	Socket, Octal, 1&2	.50
	26G65	Socket, 10 Pin min., 3	.50
	26G63	Socket, 7 Pin min., 4	.25
	26G56	Socket, Novar, 5&12	.50
	26G23	Socket, Nuvistor, 6	.50
	26G2	Socket, 7 Pin min., 7	.25
	26G3	Socket, 9 Pin min., 8&13	.25
	26G15	Socket, Loctal, 9	3.25
	26G21	Socket, Compactron, 10	.50
	26G54	Socket, 10 Pin min., 11	.50
	26G183	Socket, Transistor	1.25
	26G105	Clip, Plate Cap	.75
	21A32	Knob, Bar Pointer	.75
	21A33	Knob, Meter Zero	.75
	21A44B	Glamour Cap, Black	.25
	21A44R	Glamour Cap, Red	.25
	21A59R	Glamour Cap, Large, Red	.25
	21A58	Pushbutton	.25
	27G14	Line Cord	2.25
	37A16	Rubber Foot, Bottom	.25
	37A26	Rubber Foot, Back	.25
	8B109B	Escutcheon	3.25

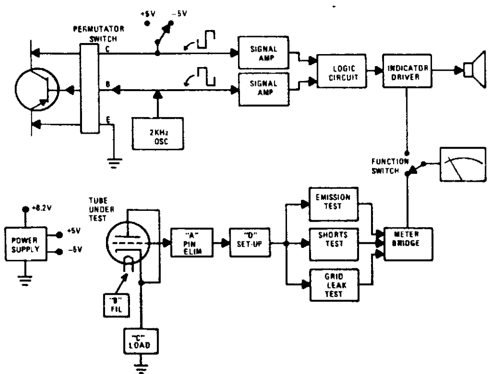
Components not listed are standard replacement parts and may be purchased locally. When ordering parts, please specify instrument model number, schematic reference, part number and description. Please include remittance (check or money order) with your order, otherwise invoices will be shipped C.O.D. Minimum billing is $3.00. Prices and specifications in effect at date of printing and are subject to change without notice.

P.C BOARD LAYOUT

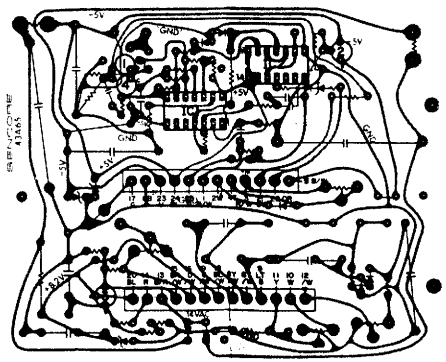
NOTES:
1. ALL CAPACITANCES GREATER THAN ONE ARE pf, LESS THAN ONE ARE µf, UNLESS OTHERWISE NOTED
2. ⏚ DENOTES GROUND, /// DENOTES CHASSIS.
3. DASHED LINES (----) REPRESENT MECHANICAL PARTS AND CONNECTIONS.
4. FUNCTION SWITCH SHOWN IN OFF POSITION.
5. ALL FILAMENT CIRCUIT VOLTAGES MEASURED WITH RESPECT TO GREEN LEAD OF T1. ALL OTHER VOLTAGES MEASURED WITH RESPECT TO CIRCUIT GROUND WITH 15 MEGOHM INPUT DIGITAL MULTIMETER.
6. FRONT PANEL CONTROL NAMES ARE ENCLOSED IN A BOX. ▭
7. PC BOARD CONNECTIONS CORRESPOND TO SCHEMATIC REFERENCE NUMBERS.



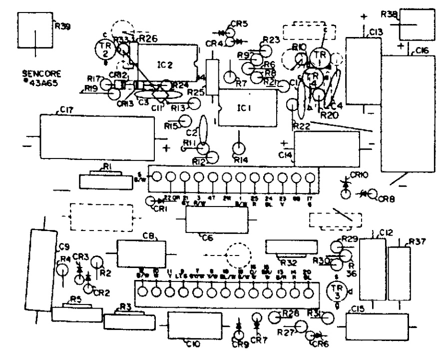
SCHEMATIC DIAGRAM
THE TC28 HYBRIDER



BLOCK DIAGRAM



FOIL SIDE



COMPONENT SIDE