PRICE $2.00

# Assembling and Using your

# CONAR

# Transistor Tester

## Model 214

QUALITY EQUIPMENT BUILT ON A HALF CENTURY OF SERVICE IN ELECTRONICS

# *Dear Customer*

No matter what your experience has been with equipment, there's a new and even greater satisfaction awaiting you in this CONAR product.

CONAR is a division of the National Radio Institute - a pioneer of more than 50 years in the Electronics field. True, age alone is seldom a compliment. Yet there is no substitute for the priceless ingredient of experience. Intelligent design and engineering, clear-cut instructions written for the user, top-grade components are your assurance you have made a wise choice - a sound dollar investment.

The purpose of this book is to tell you how to get maximum value from this CONAR product. Please read these instructions carefully and follow them faithfully. Then you can rely on the dependable service of CONAR quality.

We reserve the right to make changes in design or improvement when such changes or improvements represent an equal or greater value to our customers.

WARRANTY

All CONAR products carry a 90-day Electronics Industries Association warranty. CONAR will replace at no charge any parts or components which are found defective during the warranty period, provided such defects are not the result of misuse or accident.

There are four conditions under which you may have to write us about this CONAR product:

(1) It arrives damaged. We ship some items by parcel post, others by express. In a parcel post shipment, if any part is broken on arrival, we will replace it without charge, if you return it to us. However, for damage in express shipments, the Railway Express Agency is responsible. If you find any damage in an express shipment, contact the Express Agency and ask for an Inspection Report. They will fill out the report and give you a copy, which you are to send to us. We cannot replace damaged parts until we receive this report.

(2) Parts are missing. If anything is missing, and you find no substitute or other instructions after carefully examining the packing for small items, write us a letter explaining.

(3) A part has a defect. DEFECTIVE MATERIAL MUST BE RETURNED BEFORE A REPLACEMENT CAN BE MADE. TWO THINGS MUST BE WITH EVERY PACKAGE YOU RETURN TO US: (1) Your name and address, (2) Your reason for returning it. You may enclose a letter in the package, if you mark the package "first class letter enclosed". Such a package requires a stamp in addition to the regular parcel post charge. Unless examination shows an obvious defect, write first, and tell us why you think the part is defective. Some other part may be causing the trouble.

(4) You lose or damage parts. Parts listed in this manual may be ordered direcuy from CONAR, 3939 Wisconsin Ave., Washington, D.C., 20016. When ordering parts, please be sure to give the following information:

1. The part number.
2. The part name.
3. The type and model number of the product in which the part is used.

**CONAR INSTRUMENTS** DIVISION OF NATIONAL RADIO INSTITUTE, WASHINGTON, D.C. 20016



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# THE CONAR MODEL 214 TRANSISTOR TESTER

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# THE CONAR MODEL 214 TRANSISTOR TESTER


## CONAR MODEL 214 TRANSISTOR TESTER SPECIFICATIONS

**TESTS:**

| | | |
|---|---|---|
| Bipolar Transistors | — | Leakage ($I_{CBO}$) 0 - 200 μa |
| | — | DC Beta 0 - 50, 0 - 500 |
| Field-Effect Transistors | — | Leakage ($I_{DGO}$) 0 - 200 μa |
| | — | Drain Current ($I_{DSS}$) 0 - 20 ma |
| | — | Gain (Gm) 0 - 50,000 μmhos |
| | — | Gate Control (Relative) |

**TESTING MODE:** DC Beta Test "IN" or "OUT" of circuit – all other tests "OUT" of circuit only.

**ACCURACY:** ±10% of full scale, or better.

**POWER REQUIREMENTS:** Built-in battery supply – two 9-volt transistor batteries (furnished).

**METER MOVEMENT:** 200 μa D'Arsonval diode protected against overload – burnout proof.

**SIZE:** 5-3/4"H X 10-3/4"W X 2-3/4"D.

**WEIGHT:** 3 lb. actual, 5 lb. shipping.

Whether you are a newcomer to the field of electronics or an experienced technician, you will find the CONAR Model 214 Transistor Tester one of the handiest instruments on your bench. With it you can find out everything you need to know about the condition of any diode, conventional transistor or field-effect transistor you are likely to encounter. The functional design of the front panel makes for easy operation, and the long test leads aid in making in-circuit checks.

Like any other fine instrument, the Model 214 must be properly used and cared for if it is to deliver the topnotch performance and long service life designed into it. If you purchased your tester assembled, read the operating instructions carefully before you begin using your new instrument.

# Operating the Transistor Tester

The CONAR Model 214 Transistor Tester checks bipolar transistors for Beta (current gain) and leakage. Beta measurements can be made either in-circuit or out-of-circuit. This means that it is no longer necessary to remove a transistor from a piece of equipment before you can test it. Leakage tests, because of their very nature, must always be made out-of-circuit. However, in many cases a Beta check will suffice to tell you whether or not the transistor is capable of working in a circuit. This means that much of your testing can now be done without the bother of unsoldering transistors from the circuit.

In addition to bipolar transistors, the Model 214 tests FETs in four ways: for gate leakage, for drain saturation current ($I_{DSS}$), for mutual conductance (Gm), and for the ability of the gate to control drain current.

All readings are made on an easy-to-read 6" meter. The scale on the meter that indicates the correct reading depends on the function selected. A detailed discussion of the use of the scales is included in these operating instructions. A few minutes spent in studying these instructions will be repaid in easier and more pleasant use of this fine instrument.

## OPERATING CONTROLS

The four controls of the front panel of the Model 214 can be described as follows:

The Function switch selects the operating mode of the transistor tester. Although you will note that there are only seven positions marked on the switch, there are actually eight operating positions, since one is used for testing both FETs and bipolar transistors. The first five positions of the switch are used for testing field effect transistors (FETs); the fifth position, for leakage, is used along with the last two positions for testing bipolar transistors.

The Polarity Reversal switch connects the batteries and meter movement to the rest of the tester so that both NPN and PNP or N-channel and P-channel can be tested without the need for changing any connections. The center position of the polarity reversal switch is the "off" position. The switch should *always* be returned to this position when the transistor tester is not in use.

The Gm Zero and Beta Cal controls are used to calibrate the meter for proper reading of dc Beta and transconductance. The use of these controls will be explained later.

## READING THE METER SCALES

There are four different scales printed on the meter face. Each of these scales has a distinct purpose. The top scale is used for measuring Beta of bipolar transistors and is calibrated from 1 to 50. Since there are two Beta ranges, the meter can be read either directly, or the readings can be multiplied by 10 for testing transistors that have a high Beta.

The second scale from the top is used for measuring mutual conductance (Gm) of field-effect transistors. The Gm scale is calibrated in thousands of micromhos. Note that both this scale and the Beta scale are backward-reading; that is, the lowest values will be found at the right of the scales, and the highest at the left.

The bottom scale is really two scales in one. The scale divisions are identical, but a separate set of calibration markings is used for each. The top half of the bottom scale is calibrated in microamps from 0 to 200, and is used for measuring leakage currents. The lower half of the bottom scale is calibrated in milliamps from 0 to 20, and is used for measuring the $I_{DSS}$ of FETs.

There is a definite reason why some of the panel and meter scale markings are black, and others are red: Markings that pertain only to field-effect transistor testing are marked in red; markings for bipolar transistors are in black.

## BIPOLAR TRANSISTOR TESTING

Now that you know what the various controls on your Model 214 are, you are ready to put your instrument to use. Locate one or more bipolar transistors (NPN or PNP) that you know to be in good condition. A few minutes using these transistors to practice operating the Model 214 will be of great help in building up your confidence in the use of this piece of test equipment.

The test procedure to be described in this section can be used for testing bipolar transistors either in-circuit or out-of-circuit. However, any leakage can be measured *only* out-of-circuit. For in-circuit testing, disregard any leakage reading you get, and proceed to measure the Beta of the transistor. If the transistor shows a Beta greater than 1, it is generally safe to assume that it is good. If you are really in doubt about the condition of a particular transistor, you can always remove it from the circuit and test it out-of-circuit, with assurance of greater accuracy. You would then, of course, also be able to accurately measure any leakage present.

**NOTICE**

ALL IN-CIRCUIT TESTING MUST BE DONE WITH ALL POWER REMOVED FROM THE EQUIPMENT UNDER TEST. FAILURE TO HEED THIS WARNING WILL DAMAGE YOUR INSTRUMENT AND VOID OUR WARRANTY.

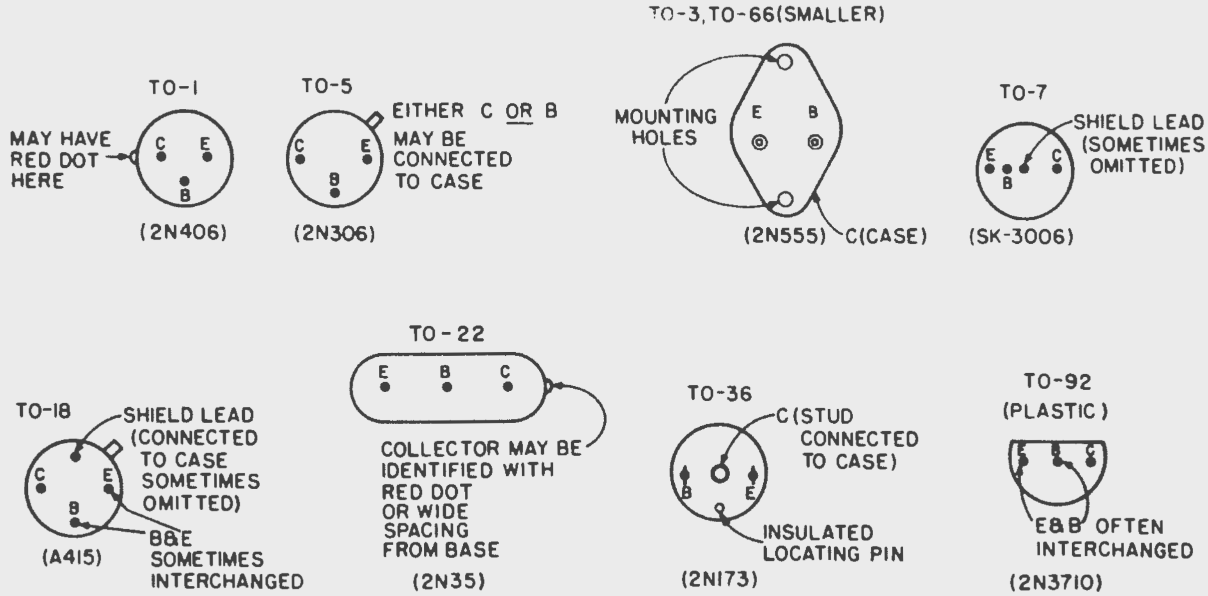



**Fig. 1. Transistor lead identification.**

The first step that you must take in testing any transistor is to identify the transistor leads. As you probably know if you have serviced much electronic equipment, transistors come in a wide variety of sizes and shapes, and with even a greater variety of lead arrangements. Fortunately, only a few transistor basing arrangements have come into wide use. The most often seen ones are shown in Fig. 1. For further information regarding transistor basing, we suggest that you obtain a good, up-to-date transistor manual, such as the "Transistor Specifications Manual", published by Howard W. Sams & Company. When you are sure which transistor lead is which, connect the three device leads to the transistor tester clips. If a fourth lead connected to the transistor case for shielding is present, it should be left unconnected, and not allowed to touch any of the other leads or test clips.

The transistor tester leads are color-coded as follows: black for emitter, green for base, and red for collector. This information is provided in condensed form on the front panel of the instrument.

Always start your tests with the polarity switch set to the center "off" position, and with the function switch set to the "leakage" position. The positions of the Beta Cal and Gm Zero knobs are of no concern at this time.

The first step to take is to turn the instrument *on.* If you know the polarity of the transistor you are testing, set the polarity switch to that polarity. If the switch is accidentally set to the wrong position, either through an operating mistake or because you don't know what type of transistor you are testing, no damage will be done to the meter or to the transistor being tested. However, high leakage will be indicated, since the normally reverse-biased base-collector junction becomes forward-biased. You can use this indication to tell whether an unknown transistor is NPN or PNP. Remember, a good transistor will show very little leakage when it is properly biased by the correct setting of the polarity reversal switch.

After you have observed the leakage reading, and are sure that the polarity switch is correctly set, turn the function switch one more position clockwise to "Beta Cal". Adjust the Beta Cal potentiometer to one of the two calibration markings on the meter scale. One of these markings is labeled "Cal X 1", and coincides with the "10" calibration on the Beta scale. The other is at full scale, and is marked "Cal X 10". If the transistor is suspected to be a low Beta device, or if you are marking an in-circuit measurement, set the meter to the "Cal X 1" mark. If the transistor is expected to have a high Beta, use the "Cal X 10" mark. Of course, if you don't get the desired results on the first try, you can repeat this step later, using the other calibration mark.

The transistor tester is designed to be able to measure Beta over a wide range, so the Beta Cal control of necessity is not a vernier adjustment. This means that it may at times be necessary to very carefully set the knob for the desired amount of meter deflection. This does not indicate that the control is defective; it simply indicates that the instrument is very responsive to small changes in transistor conduction.

After you have accurately set the Beta Cal control to the desired calibration mark, move the function switch one more position clockwise, to the "Beta" position. The meter will now display the dc Beta of the transistor under test. If you have set the Beta Cal control to the "Cal X 1" mark, you may now read the Beta directly from the top scale of the meter. If you used the "Cal X 10" mark, multiply the indicated value by 10 to get the actual Beta of the transistor.

**NOTE:** You may find that you cannot properly set the Beta Cal control when testing certain high Beta germanium transistors. This may be particularly true of germanium power transistors. If the meter deflects past full scale in the "Beta Cal" position, even with the Beta Cal control fully counterclockwise, turn off the tester, interchange the emitter and collector leads (red and black clips), and test the transistor again. If it is good, it will show little leakage, but low Beta.

## TESTING FIELD-EFFECT TRANSISTORS

As in the case of bipolar transistors, the first step to take is to identify the leads of the device. In almost all cases, this information will be provided by the manufacturer of the device or of the equipment in which the device is used. This is fortunate, since there is little standardization of FET basing arrangements.

As in the case of testing bipolar transistors, make sure that the polarity switch is set to the center "off" position, and that the function switch is in the "leakage" position. Now connect the leads of the device to the transistor tester leads, using the following color code: Black for source, Green for gate, and Red for drain. This information is provided in condensed form on the front panel of the instrument. If you should encounter a FET for which the basing arrangement is not known, connect the transistor to the tester in every possible way, each time checking to see if a normal reading is obtained. In nearly all cases the source and drain leads will be interchangeable, so it is only the location of the gate lead that is of any consequence.

In general, we recommend that you do not attempt to use the Model 214 to test MOSFETs (metal-oxide-semiconductor FETs, also known as IGFETs). Those MOSFETs that do not have internal protective diodes are easily damaged by handling, and those that do have internal protection may give false indications of excessive leakage, due to the undesired conduction of the built-in protection diodes. However, it is likely that almost all the FETs that you encounter in your work will be of the junction type (JFETs), and these the Model 214 will test with ease.

After you have connected the FET to the tester clip leads, turn the polarity switch to the right or left of center, depending upon the polarity of the transistor under test. If you don't know whether the FET is an N-channel or a P-channel, throw the switch both ways and see which setting produces no leakage indication. This is the correct setting, and this test can be used to determine the polarity of unknown FETs. All field-effect transistors in commercial use are made of silicon, so no leakage current at all should be seen on the meter. Even the slightest movement of the pointer says that the transistor is faulty.

After the FET passes the leakage test, turn the function selector switch one position counterclockwise, to the "$I_{DSS}$" position. You can now read the $I_{DSS}$ of the transistor directly from the bottom scale of the meter. If no reading is noted, the channel (the conductive path between source and drain) is open, and the transistor is defective. Or it could be that the transistor you are trying to test is a bipolar device, which should give little or no indication on this position of the function switch. Try testing the transistor as a bipolar to see if it has any Beta. If it does, you know for sure that is is not an FET.

After you have noted the $I_{DSS}$ of the FET, again turn the function switch one position counterclockwise, to the Gm Zero position. In this position of the switch, you are to adjust the Gm Zero potentiometer for a reading of "0" on the Gm scale. In other words, you are to adjust the meter for full-scale deflection. After doing this turn the function switch one position more counterclockwise, to the "Gm" position, and read the Gm of the transistor directly (in thousands of micromhos) from the red Gm scale.

Up to this point, you have tested the FET for gate leakage and channel conduction. However, you don't yet know if the gate is really doing its job; the gate lead could be open and yet the transistor would easily pass the previous tests. The "Gate" position of the function switch is provided to make sure that the gate terminal is not open. After you note the Gm reading, rotate the function switch one more position counterclockwise to the "gate" position. When you do this, if the gate is working, the Gm reading should decrease. That is, the *meter pointer should move toward the right* (toward zero). If there is no movement at all, the gate is open. If the needle actually moves to the left, the transistor may be faulty, or the polarity switch could be set to the wrong position. Recheck the position of this switch on the leakage position of the function switch, as described previously.

## TESTING DIODES WITH THE MODEL 214

There are several possible ways to use the Model 214 to test the front-to-back ratio of semiconductor diodes, but we recommend the following: Connect the green lead to the cathode of the diode (the marked end of any diode is the cathode, regardless of the type of marking), and the red lead to the anode. The black lead should be left free, and should not touch the other leads or test clips.

As in the case of all other tests with the Model 214, start with the polarity switch in the "off" position, and with the function switch in the "leakage" position. Now turn the polarity switch to the "NPN" position. The meter should deflect full scale. If no movement is noted, the diode is open. Next, turn the polarity switch to the "PNP" position. The meter should then indicate zero leakage, or very close to it. If the meter deflects full scale, the diode is shorted.

If you need to test an unmarked diode, simply connect it to the red and green leads in either way. Then, when you turn the polarity switch from one position to the other, you should see that the diode conducts in one direction, but not in the other. If it conducts in both directions, it is shorted; if it conducts in neither direction, it is open. You should notice conduction with the switch in the "NPN" position, with the cathode of the diode connected to the green test lead. If you wish, you can mark this end of the diode for later reference.

# Theory of Operation

The Model 214 checks bipolar transistors for Beta (current gain) and leakage. Beta measurements can be make either in-circuit or out-of-circuit. This means that it is not necessary to remove a transistor from a piece of equipment before you can test it. Leakage tests, because of their very nature, must always be made out-of-circuit. However, in many cases a Beta check will suffice to tell you whether or not the transistor is capable of working in a circuit. This means that much of your testing can now be done without unsoldering transistors from the circuit.

The Model 214 checks FETs in four ways: for gate leakage, for drain saturation current, for mutual conductance (gain), and for the ability of the gate to control drain current.

In a good field-effect transistor, no current ever flows between the gate and the channel (source or drain). The leakage test measures the current that flows between the drain and gate terminals in the device under test. If any current is indicated, the transistor is faulty. All good FETs will show a zero indication on this test.

The test for channel saturation current ($I_{DSS}$) is an important one, since it is this characteristic of FETs that affects their performance in a circuit more than any other variable. Because of this, the $I_{DSS}$ test is very useful in selecting matched pairs of FETs.

The mutual conductance of a field-effect transistor is an indication of how much voltage gain it can provide. The Model 214 reads Gm directly, in thousands of micromhos.

The fourth test, for gate effectiveness, applies a small reverse voltage to the gate. If the transistor is good, the Gm reading will decrease. (The meter pointer will move to the right.) A transistor with an open gate will cause no difference in the reading when this reverse voltage is applied, so you will instantly know that the transistor is defective.

## BETA TESTING

A simplified diagram of the Beta measuring circuit is shown in Fig. 2. The transistor shown is the transistor being tested. There are no transistors or other amplifying devices inside the Model 214. The switch shown is a portion of the 7-position function switch. Only that position of the function switch that involves Beta testing is shown in Fig. 2.

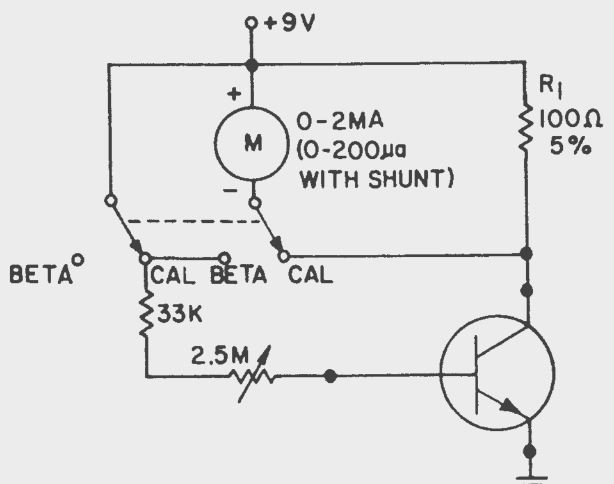



**Fig. 2. Simplified diagram of Beta measuring circuit.**

Note that this switch has two positions: "Cal" and "Beta". In the "Cal" position, the meter is used to measure the collector current of the transistor under test. The meter movement itself has a basic sensitivity of 200 microamps for full scale deflection, but in the "Cal" position of the function switch, a shunt resistor ($R_1$) is used to decrease the sensitivity of the meter. With the 100-ohm shunt, the sensitivity becomes 2 milliamps for full-scale deflection.

While the collector current is being monitored by the meter, the base current is adjusted with the 2.5 megohm variable resistor (the Beta Cal Control) to bring the meter pointer to full scale. In other words, the variable resistor adjusts the base current to the value needed to produce 2 milliamperes of collector current. Since Beta is defined as the ratio of collector current to base current, all we need to do to calculate Beta is to measure the base current. This is what happens when the function switch is changed from "Cal" to "Beta". The 100-ohm resistor allows the same collector current to flow, but the base current must now pass through the meter, so it can be read.

However, the scale is not calibrated to read the base current directly in microamperes. Instead, since the collector current is known and the base current is being measured, the scale is calibrated directly in terms of Beta, so no complicated calculations are necessary.

If a low-Beta transistor is being measured, or, as sometimes happens in in-circuit testing, the circuit resistances are very low, the Beta Cal control is adjusted to produce only 1/10 full scale deflection and the switch is turned to read the Beta. In this case, the Beta scale is read just as it is calibrated.

Notice in Fig. 2 that the transistor is an NPN device, and that the supply voltage and meter polarities are selected to match this type of polarity. For PNP transistor testing, the supply voltage and meter polarities are reversed by the switch.

## LEAKAGE

The simplest test performed by the Model 214 is the leakage test, shown in simplified form in Fig. 3. As you can see, a reverse bias in applied to the base-collector junction of the transistor under test, and any current that flows is measured on the sensitive meter. Germanium transistors will show a slight indication, but all silicon transistors (good ones, that is) should show zero current when tested in this mode.

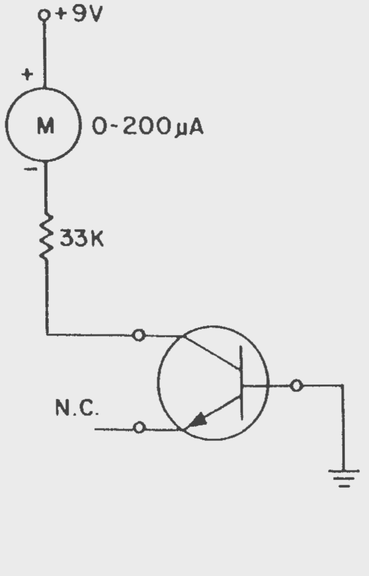



**Fig. 3. Simplified diagram of leakage ($I_{CBO}$) measuring circuit.**

For testing gate leakage of FETs, exactly the same circuit configuration is used, but the leakage is measured from drain to gate. The connections and indications remain exactly the same, and even the same setting of the function switch is used. Since all FETs are silicon devices, all good ones will show zero leakage.

## CHANNEL SATURATION CURRENT ($I_{DSS}$)

Fig. 4 shows the circuit used for measuring FET saturation current. Channel saturation current, called $I_{DSS}$, is defined as the current that flows through the channel when the bias between gate and source is zero volts. In other words, we measure the current through the channel with the gate and source shorted together.

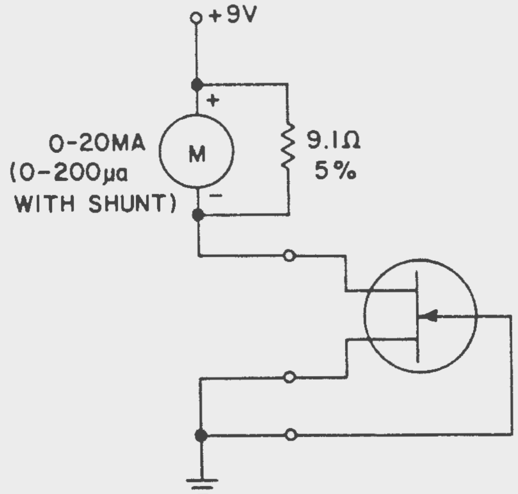



**Fig. 4. Simplified diagram of $I_{DSS}$ measuring circuit.**

The $I_{DSS}$ of most FETs is on the order of 1 to 10 milliamps, with some types being slightly higher. A 9.1-ohm resistor is used as shunt from the 200 microamp meter movement, allowing the meter to measure $I_{DSS}$ from 0 to 20 milliamps, so that practically all available types can be tested in regard to this critical parameter. If a circuit application arises that calls for matched pairs of FETs, simply measure the ones that you have on hand until you find two with very close $I_{DSS}$ readings. As long as these devices are both of the same type, the closeness of the $I_{DSS}$ readings practically guarantees their success in a circuit requiring matched transistors.

## MUTUAL CONDUCTANCE

The remaining two field-effect transistor tests are performed by the circuit shown in Fig. 5. Basically, this circuit is used to measure the mutual conductance (Gm) by measuring the resistance of the channel (resistance from source to drain, with no bias voltage applied) at a very low drain voltage. Basically, what we have here is a simple ohmmeter circuit. With the switch set to the "Gm Zero" position, only the meter, series resistor, and 25k-ohm control (Gm Zero) are connected to the battery supply. The control is then adjusted for full-scale deflection of the meter. When the switch is set to its center position to read mutual conductance, the channel is connected in parallel with the meter movement, and the resistance of the channel will cause the meter reading to decrease. The lower the resistance of the channel, the more the reading will decrease.

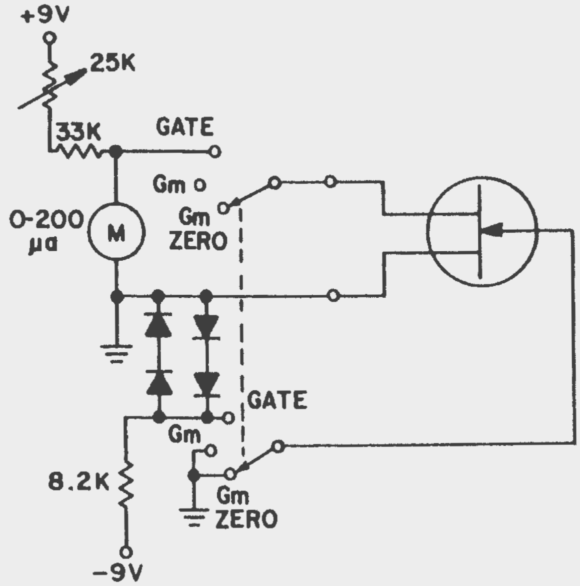



**Fig. 5. Simplified diagram of Gm measuring circuit.**

At this point you may be asking, "What does the channel resistance have to do with the mutual conductance?" It can be shown mathematically that Gm is the reciprocal of channel resistance. That is, $Gm = \frac{1}{R_{DS}}$, where $R_{DS}$ is the resistance from drain to source. As with the Beta scale, no calculations are necessary here. The meter scale is calibrated directly in thousands of micromhos.

## GATE TEST

So far in this discussion of FET testing, we have checked for leakage between channel and gate, channel saturation current, and mutual conductance. However, a transistor with an open gate but otherwise in good condition could easily pass these three tests. For this reason, a fourth test is included, so that you can tell for sure that the gate is doing its job.

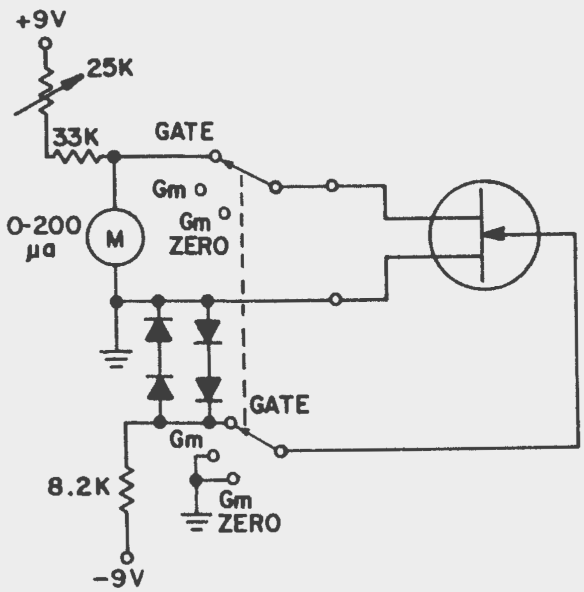



**Fig. 6. Circuit of Fig. 5 with the switch shown in the "GATE" position.**

This fourth test is accomplished by setting the switch shown in Fig. 6 to the GATE position. Here, the channel is still connected to the ohmmeter circuit, but a small reverse-bias voltage is applied to the gate. If the gate is in good condition, this will cause the channel resistance to increase, so the Gm reading should decrease. If setting the switch to this position makes no difference, the gate is open.

## POLARITY SWITCH

As mentioned before, all the checks described, for bipolar as well as field-effect transistors, can be made on PNP and P-channel as well as NPN and N-channel transistors. In addition, the front-to-back ratio of diodes can readily be determined.

# Maintenance

The CONAR Model 214 Transistor Tester has been designed to give many years of service with minimum care. Occasional replacement of the internal batteries is about all that's necessary to keep the instrument in top operating condition. Two batteries are used in your transistor tester. To test them, set the function selector switch to the "Gm Zero" position, and then try to adjust the Gm Zero potentiometer for full-scale deflection in the "NPN" and "PNP" positions of the polarity switch. Failure to get full scale reading in the "NPN" position indicates a dead or weak 9-volt battery $B_1$, while a low reading in the "PNP" position indicates a faulty $B_2$.

To replace a battery, remove the four screws from the back of the cabinet. The instrument may then be separated from the cabinet, allowing easy access to the battery compartment. Now place the tester face down on a soft cloth to avoid scratching the plastic meter face. Spring the battery retaining shelf slightly to release its grip on the battery to be replaced. You can use a screwdriver as a lever to spring the shelf away from the battery. The battery may then be pulled from its mounting position, using the leads attached to the battery clip. Once the battery is removed, unsnap the battery clip and reconnect it to the new battery. Insert the new battery into its mounting position by reversing the procedure used for removal.

The complete internal schematic diagram for the Model 214 is shown in Fig. 7. Most of the complexity of this diagram is due to the many contacts on the function switch. To more easily see how the individual circuits and parts are related to one another, refer to the partial schematics given in the theory of operation section of this manual.

If your instrument develops a defect which you cannot locate, you may use our free CONAR consultation service for assistance. Write us a letter explaining how the instrument behaves and what you have done in an effort to correct the problem. Since the amount of help we are able to give you will depend on how much information you give us, try to be as specific as possible in explaining the nature of your trouble. Include the results of any tests which you may have made.

If you prefer, you may send the completed instrument back to us for repairs. On units returned after the warranty period has elapsed, a minimum charge of $5 will be made, plus the cost of any parts which must be replaced. Send a separate letter telling us that the instrument is on its way, enclosing the $5 minimum charge (in the form of a check or money order) in the letter. *Do not send cash.* Pack the instrument in a sturdy container surrounded with suitable packing material such as shredded newspaper. Ship by insured parcel post.

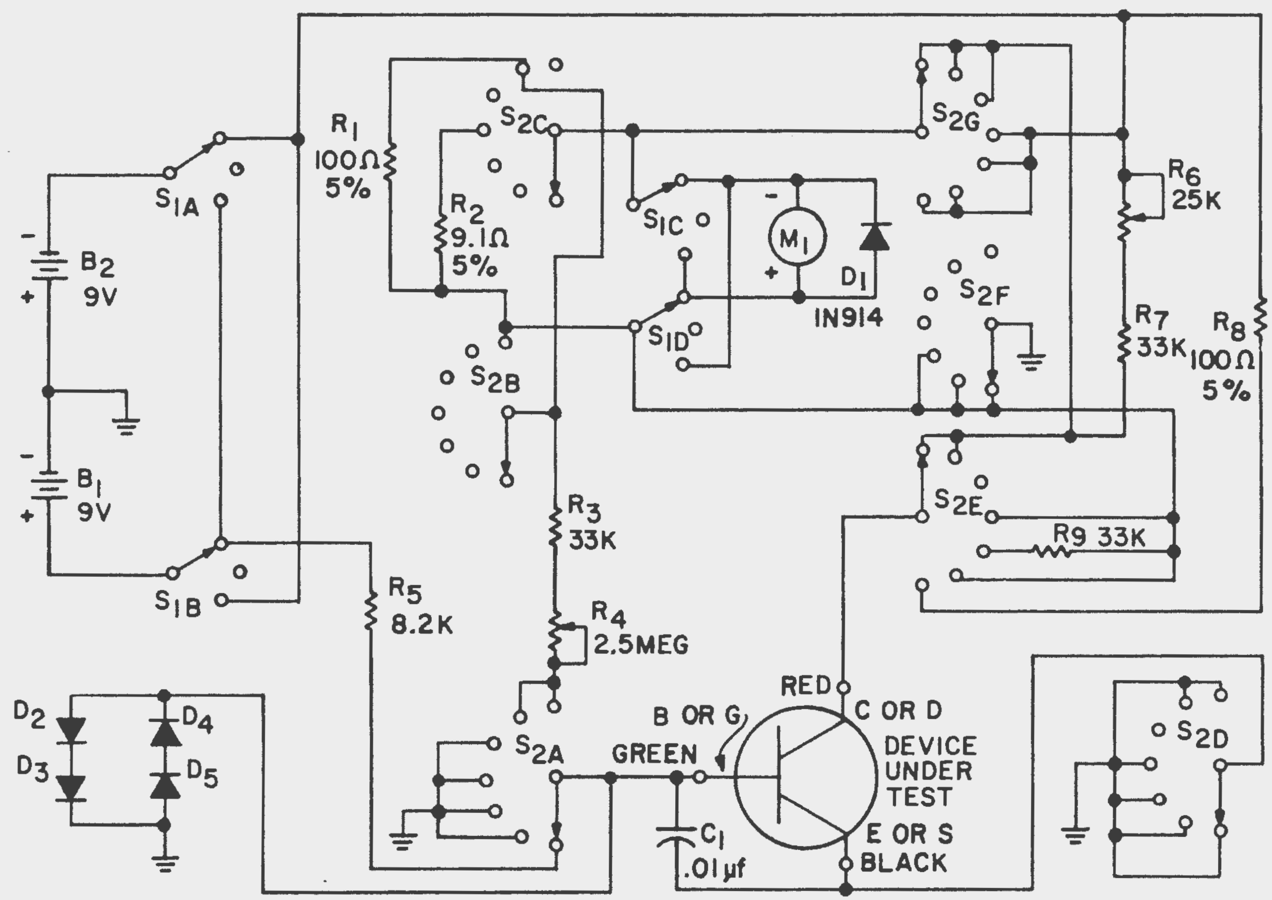



Fig. 7. The complete internal schematic diagram for the Model 214.

# Preparing for the Assembly

Check the parts that you have received against the parts list. Use the parts photo, Fig. 8, to help identify each component. Sometimes a part supplied with a kit will not look exactly like the one shown in the photograph even though it is electrically identical. So check carefully before you decide that a part is missing. If you do find that a part is missing or has been damaged in shipment, follow the instructions printed on the inside front cover to obtain a replacement part.

## RESISTORS

The resistors supplied in your kit have either a 5% or 10% tolerance. It is very important that you use the correct resistor in a circuit. While we might possibly substitute a 5% (gold) tolerance resistor for a 10% (silver) tolerance resistor, *do not* use a 10% tolerance resistor where a 5% tolerance is called for. Some of the resistors supplied in your kit may have more than the usual four color bands. A fifth band is sometimes added to denote the reliability grade for military specifications. Disregard this fifth band when you identify your resistors.

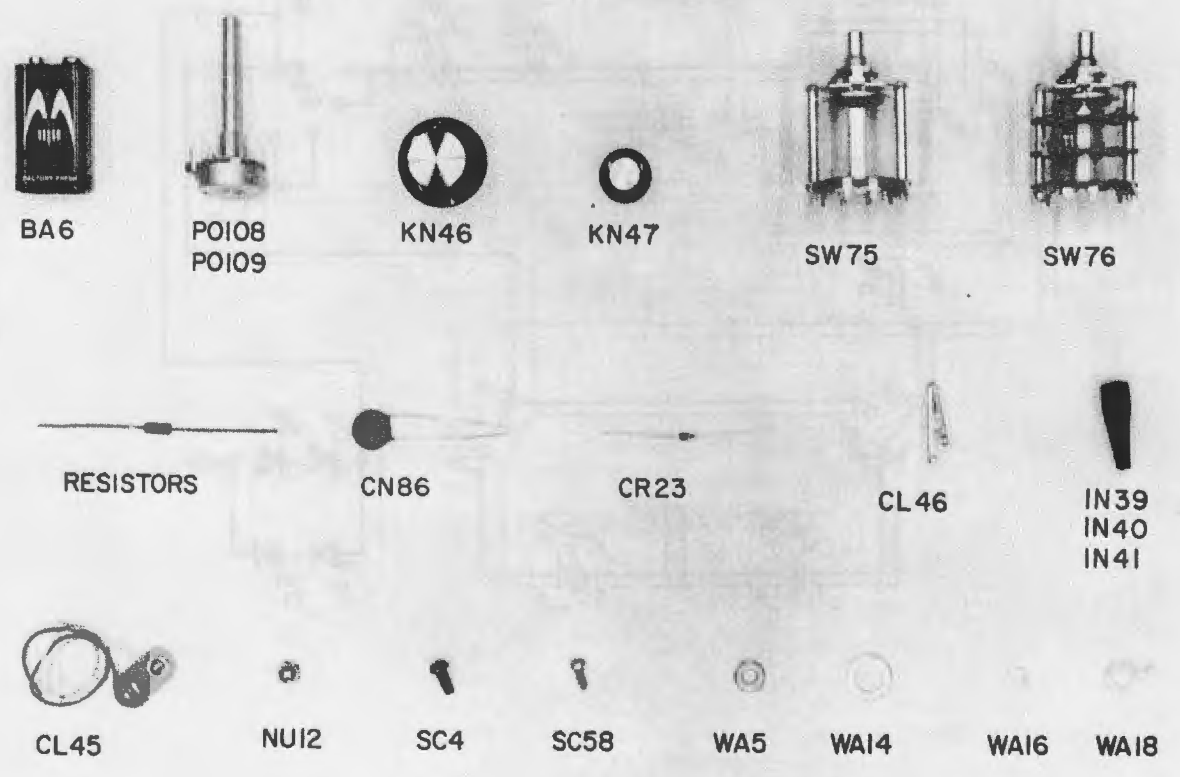



**Fig. 8. Some of the parts used in the Model 214 Transistor Tester.**

| Quan. | Part No. | Description | Price Each |
|---|---|---|---|
| 2 | BA6 | 9-volt transistor battery (NEDA 1604) | .68 |
| 1 | CB23 | Cabinet | 2.95 |
| 2 | CL45 | Battery connector clip | .26 |
| 3 | CL46 | Alligator clip | .14 |
| 1 | CN86 | .01 mfd ceramic disc capacitor | .15 |
| 5 | CR23 | 1N914 silicon diode | .40 |
| 1 | EC41 | Etched circuit board | 2.75 |
| 1 | HA8 | Rosin-core solder | .08 |
| 1 | HA79 | Handle | 2.18 |
| 1 | IN39 | Red clip insulator | .10 |
| 1 | IN40 | Black clip insulator | .10 |
| 1 | IN41 | Green clip insulator | .10 |
| 2 | KN46 | Large knob | .40 |
| 2 | KN47 | Small knob | .32 |
| 1 | ME24 | 6″ d'Arsonval meter, 200$\mu$A | 12.25 |
| 2 | NU12 | 8-32 cap nut | 12/.25 |
| 1 | PA39 | Front panel | 3.50 |
| 1 | PO108 | 25k-ohm potentiometer w/control nut | .70 |
| 1 | PO109 | 2.5 megohm potentiometer w/control nut | .70 |
| 2 | RE3 | 100-ohm, 5%, 1/2-watt resistor | .25 |
| 1 | RE51 | 8.2k-ohm, 10%, 1/2-watt resistor | .15 |
| 3 | RE64 | 33k-ohm, 10%, 1/2-watt resistor | .15 |
| 1 | RE168 | 9.1-ohm, 5%, 1/2-watt resistor | .24 |
| 2 | SC4 | 8-32 × 3/8″ machine screw | 12/.15 |
| 4 | SC58 | 6-32 × 3/8″ self-threading screw | 12/.25 |
| 1 | SW75 | Single-wafer rotary switch w/nut | 1.50 |
| 1 | SW76 | Triple-wafer rotary switch w/nut | 2.15 |
| 2 | WA5 | No. 8 flat washer | 12/.15 |
| 2 | WA14 | Control flat washer | 12/.15 |
| 2 | WA16 | No. 8 lockwasher | 12/.15 |
| 4 | WA18 | No. 10 flat washer | 12/.15 |
| 1 | WR62 | 3′ white hookup wire | 12′/.25 |
| 1 | WR298 | Red test lead wire | .10 |
| 1 | WR299 | Black test lead wire | .10 |
| 1 | WR300 | Green test lead wire | .10 |

Some of the parts listed here are not shown in the parts photo.

## OTHER PARTS

The other parts you received in this kit should be fairly easy to identify. The two rotary switches, SW75 and SW76, are easily distinguished. SW75, the polarity switch, has only a single deck (wafer), while SW76, the function switch, has three decks. In addition, the part number is stamped on the metal frame of each switch.

The two potentiometers are very similar in appearance, but differ greatly in resistance. It is extremely important that you install each in its correct place. Again, the potentiometer part numbers are stamped on the metal cases of these components.

Only a single capacitor is supplied in this kit, and it is a .01 mfd ceramic disc unit.

The five diodes are Type 1N914 silicon switching diodes. Be sure to install each of them as shown, with the banded end (the cathode) in the right position.

## TOOLS

Ordinary hand tools are all you need to assemble this kit. You'll need a small screwdriver with about a 1/8" blade, longnose pliers, diagonal cutters, and a small soldering iron. We recommend a pencil iron rated at 30 to 65 watts. A set of hex nut drivers and a wire-stripping tool are helpful, but not absolutely necessary. CONAR stocks a complete line of high quality tools, which are available at nominal cost.

## ASSEMBLY HINTS

It's a good idea to read over the entire assembly manual before beginning actual construction. This way you will get an overall picture of what is to be done and see how each stage of the assembly relates to others. When you are ready to begin construction, read each step through and make sure you understand what must be done. After performing the step, check it off in the space provided and then proceed to the next step.

**Follow the instructions.** Perform each step in the exact order given. Don't try any shortcuts such as omitting steps or assembling the kit from the schematic diagram. Our experience has shown that even veteran kit builders are likely to make wiring errors when using such practices. Tracking down and correcting wiring errors in completed kits can be a tedious and time-consuming process. By far, the quickest shortcut to a completed and working instrument is to follow the assembly instructions to the letter.

**Do a good soldering job.** Poor soldering is the greatest single cause of problems in completed kits. A leaflet packed with your kit explains how to prepare your soldering iron and also gives general soldering procedures. If you haven't had previous soldering experience, take a little time now, *before* you begin construction of your kit, to read the leaflet and practice soldering on scrap metal.

Most of the soldering in this kit will be done on the printed circuit board. This makes it easy to do a professional looking construction job with a nimimum of effort. To mount components on the board, first bend the leads to fit the holes in the board, using your longnose pliers.

Next, pass the leads through the holes and press the component down until it rests squarely on the surface of the board. The leads on the other side of the board may then be bent outward slightly so that the component will stay put when the board is turned over for soldering. All parts in this kit must be mounted flush against the circuit board.

To solder the component leads to the foil pads, apply the tip of your iron so that it touches both the lead and the foil. At the same time, feed the end of the solder to the lead and the foil until a small mound of molten solder surrounds the lead and covers the pad. When this happens, withdraw the solder, then the iron.

After the solder has solidified, clip off the lead close to the solder mound with your diagonal cutters. One thing to watch out for when soldering components on the board is short circuits caused by solder bridges. Each time a connection is soldered, make sure that the solder mound covers only that one connection and does not run over onto a nearby pad or foil path.

**Use the figures.** Pictorial diagrams and photographs throughout this manual show the placement of parts and details of construction steps. In some cases a part may fit into position in more than one way, only one of which is correct. Study the figures carefully and make sure that you know exactly how a part is to be mounted before proceeding with the step.

# Assembling the Transistor Tester

The assembly of your transistor tester is divided into several stages. At each stage you will perform only a few simple steps. In this way you can stop at frequent intervals and check to make certain that you have done what was expected for each stage. Or, if you are interrupted for any reason, there are very convenient stopping points. Just note where you stopped so that you can pick up your work conveniently.

Before you begin the assembly of any stage, read over the entire list of instructions and make sure you know exactly which parts you will need. Then select the required parts and perform the assembly steps indicated. When you install parts on the etched circuit board, the assembly steps are given as numbered blocks around a picture of the board with arrows going from the block to the location on the board where the part is to be placed.

After you have assembled the etched circuit board you will install the meter and other parts on the panel. You will then make up the test leads and attach them to the circuit board. Finally you will fasten the circuit board to the panel and meter and make a few simple checks before joining the cabinet and panel.

### CIRCUIT BOARD ASSEMBLY (STAGE I)

Before you begin assembly, check to make certain that your soldering iron is clean and well-tinned. If it is not in good condition, plug it in, clean it, and retin it. Clear a space on your work table and put a clean, soft cloth down on which to place the circuit board as you work on it. This will protect both the circuit board and the table top. Identify and gather the following parts:

**1 Etched circuit board**
**2 100-ohm, 5%, 1/2-watt resistors (RE3, brown-black-brown-gold)**
**1 8.2k-ohm, 10%, 1/2-watt resistor (RE51, gray-red-red-silver)**
**3 33k-ohm, 10%, 1/2-watt resistors (RE64, orange-orange-orange-silver)**
**1 9.1-ohm, 5%, 1/2-watt resistor (RE168, white-brown-gold-gold)**
**5 1N914 silicon diodes (CR23)**
**1 .01-mfd ceramic disc capacitor (CN86)**
**Solder**

Stage I assembly instructions are given in Fig. 9. Be sure to mount all components flush with the circuit board, on the phenolic side of the board (the side with no copper foil). Take special care when you install the five silicon diodes. Make sure that each diode is installed with its cathode (the banded end) pointing away from the two potentiometer mounting holes.

When you are certain that you understand all of the steps, proceed to install the parts. As you complete each step, cut off excess leads and place the check marks in the space ( ) provided.

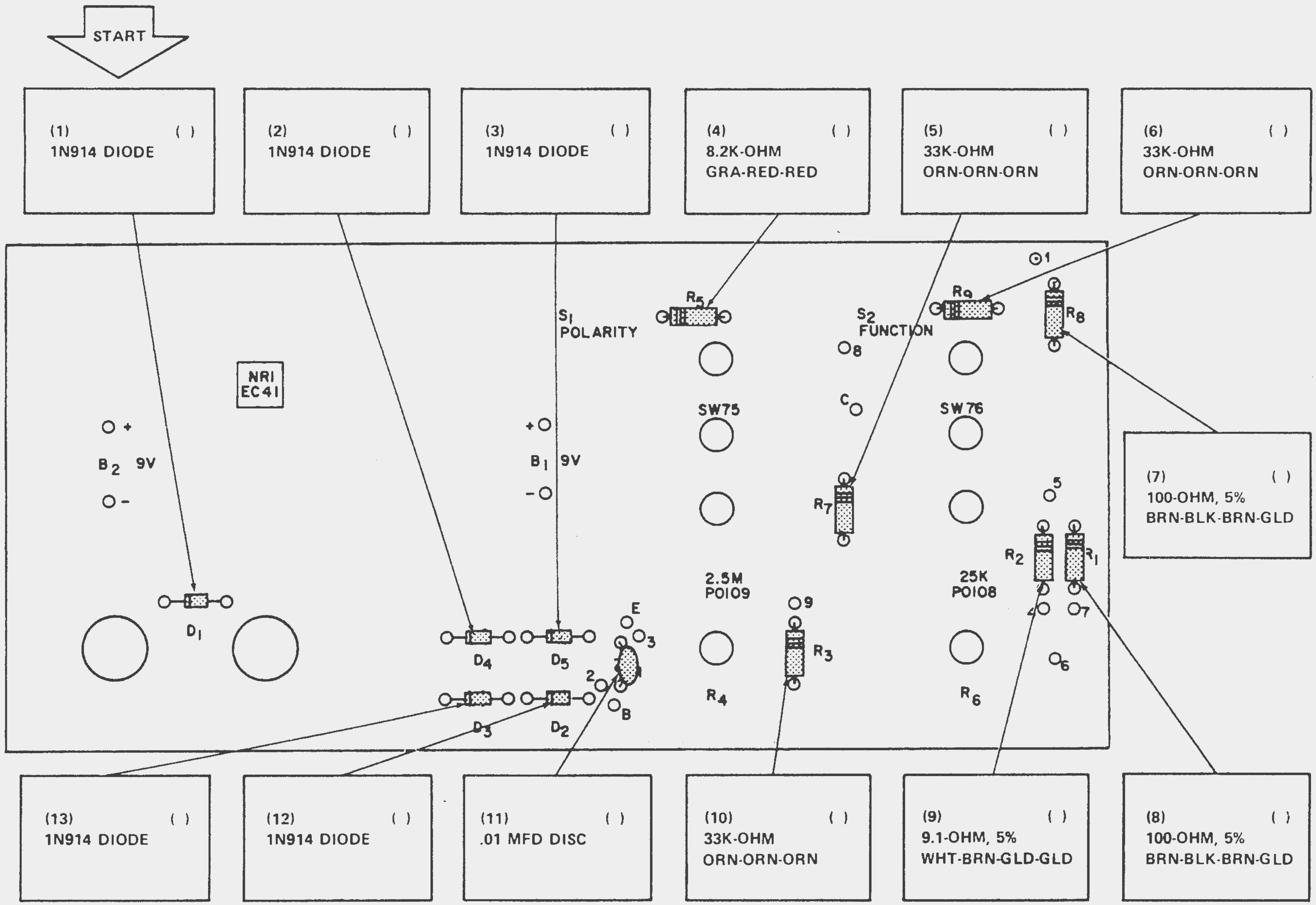



Fig. 9. Stage I assembly instructions.

## CIRCUIT BOARD ASSEMBLY (STAGE II)

In this stage of assembly, you will install the two rotary switches, several jumper wires, the two potentiometers, and the two battery connector clips. Gather the following parts:

1 **Function switch (SW76, three sections)**
1 **Polarity switch (SW75, single section)**
1 **25k-ohm potentiometer with control nut (PO108)**
1 **2.5-megohm potentiometer with control nut (PO109)**
2 **Battery connector clips (CL45)**
1 **3′ length hookup wire (WR62)**

Stage II circuit board assembly steps are shown in Fig. 10. Note that some of the steps are numbered, and some are lettered. Perform these steps in the order indicated, starting with Step A and working clockwise around the diagram.

The first part to be installed in the three-section function switch, SW76. Note that this switch can be installed in only one direction. Carefully line up all the solder lugs on the rear of the switch with the holes in the etched circuit board, and solder the switch into place.

The easiest way to do this is to first solder only two connections (at opposite ends of the switch), recheck the positioning of the switch, then solder the remaining lugs to the circuit board foil. Be careful to avoid using too much solder, as excess solder could be drawn into the switch contacts, thus rendering the switch useless.

After the function switch is soldered into place on the circuit board, examine the switch carefully to locate the vertical row of three terminals, near hole 8 on the circuit board. Each of these terminals is on one of the three switch wafers, and the three terminals line up to form a single vertical row.

Cut a 1-1/4″ piece of hookup wire, strip all the insulation from it, and pass the bare wire through the top two terminals, and connect the wire to the bottom terminal. Now wrap the bare wire around the top terminal, and solder all three terminals.

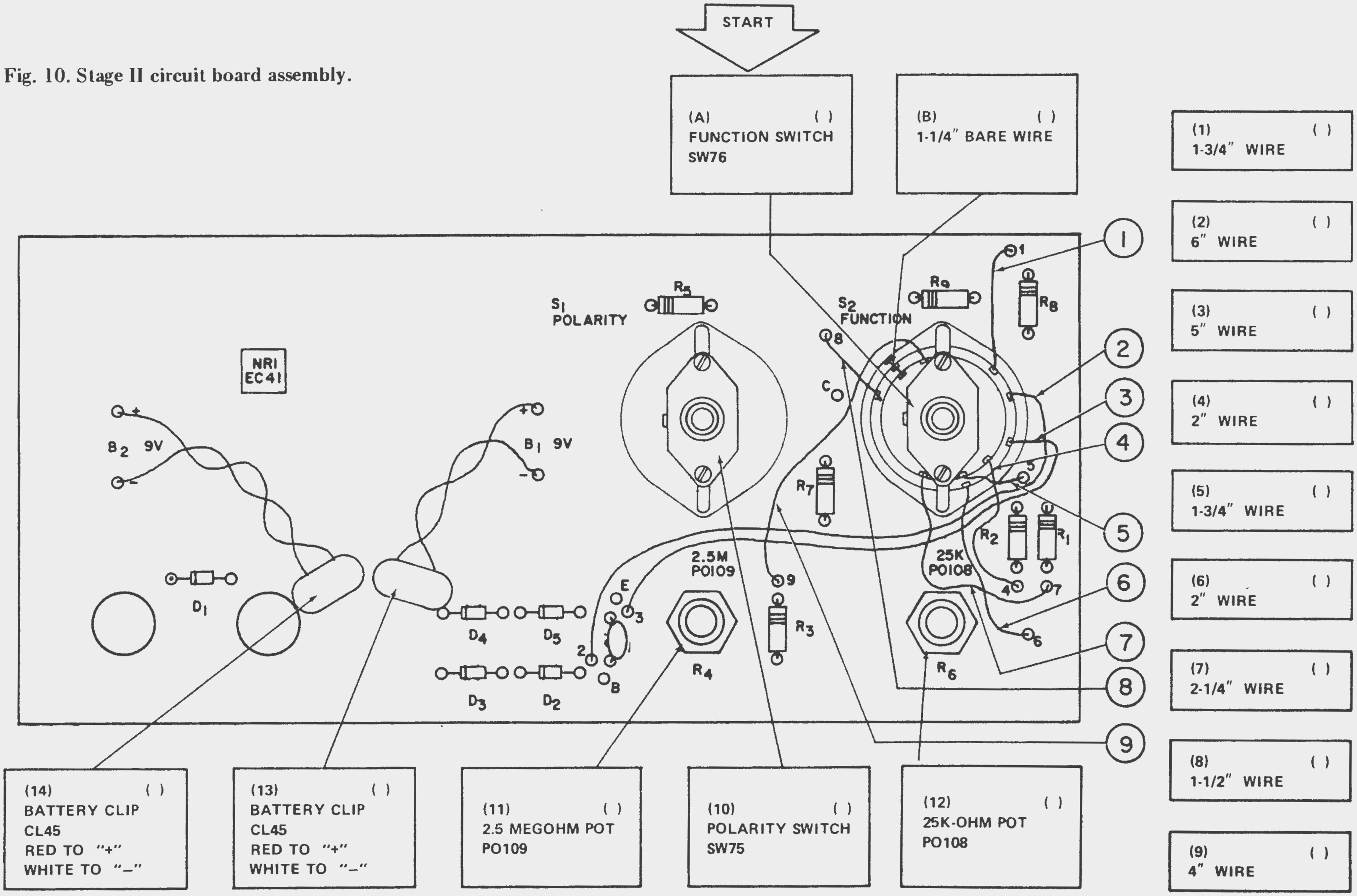
In the next nine steps, you are to connect insulated hookup wires between various points on the function switch to numbered holes on the circuit board. Refer to Fig. 10 for wire lengths and placement.

After all jumper wires are installed, proceed with the remaining steps of Fig. 10. Be very careful in installing the polarity switch, SW75, as it can go on the circuit board in either of two ways. However, this switch must be mounted so that its locating lug (on the front of the switch frame) is away from the function switch.

Before you mount the potentiometers, carefully tin the circuit board foils to which these controls will be attached. This will aid greatly in making good solder connections at these points. When you mount the controls, be sure to install each in its proper place, and before you solder them into place, secure each to the circuit board with a control nut. Note that these two controls are the only components mounted from the foil side.

When you connect the battery clips to the circuit board, connect the white wires to the "minus" terminals and the red wires to the "plus" terminals. When you have completed these assembly steps, you are ready to proceed with the mechanical assembly.

Fig. 10. Stage II circuit board assembly.



## MECHANICAL ASSEMBLY

Set the etched circuit board aside for the time being and locate the meter movement and front panel.

Gather the following parts:

1 **Front Panel (PA39)**
1 **Meter movement (ME24) with hardware**
3 **Alligator clips (CL46)**
3 **Colored clip insulators**
3 **Colored test leads**
4 **No. 10 flat washers (WA18)**
2 **Flat control washers (WA14)**
2 **Control nuts**
2 **9-volt transistor batteries (BA6)**
2 **Large knobs (KN46)**
2 **Small knobs (KN47)**

Position the meter movement, ME24, over the large cutout in the panel. The four mounting screws should line up with four of the mounting holes in the panel, with the barrel of the meter passing through the large cutout in the panel. With the meter firmly up against the panel, install a small lockwasher and nut (furnished with the meter) on each of the four mounting screws. Save the four large nuts, as they will be used later. *Remove the shorting wire from the meter terminals.*

**CAUTION:** With the meter now installed on the panel, be especially careful not to scratch or otherwise damage the meter face. Always place a clean, soft cloth on your work area to protect the meter as you work behind the panel.

Now locate the three colored test leads, the three colored clip insulators, and the three miniature alligator clips. Strip 1/4" of insulation from both ends of each of the test leads. Tin all six ends to make later connections easier. Before you attach the colored wires to the alligator clips, push one of the colored insulators onto each of the colored wires (red on red, black on black, and green on green) and push the insulators back an inch or two from the end of the wire. The large end of the insulator must be toward the end of the wire. Now carefully solder an alligator clip to each of the test leads. After the solder cools, push the insulator down over the clip so that the solder connection and the clip are covered by insulating material . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . ( )

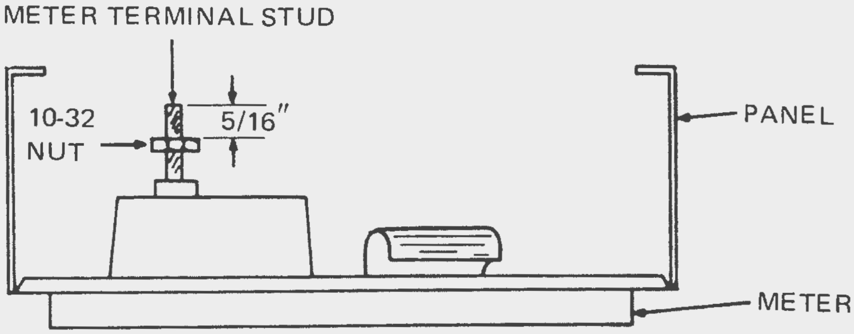



**Fig. 11. Put 10-32 nuts on meter terminal studs 5/16″ from end.**

Push the test leads through the small hole at the bottom of the front panel. To do this, first push one of the leads through, then the second. This will be very easy. However, when you try to get the third lead through the panel, you will meet with some resistance. You will have to push very hard on the third wire to get it through the panel. However, it will go through and there is no danger of damaging the wires. After all three wires are through the hole, adjust them so that the portions of the wires outside the front panel are of equal length. There should be about 12″ of wire outside, and about 6″ of each wire inside . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .( )

Take two of the 10-32 nuts supplied with the meter and run one down on each meter terminal stud so the top of each nut is 5/16″ from the end of the stud, as shown in Fig. 11 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .( )

Place one No. 10 flat washer on each meter stud . . . . . . . . . . . . . . . . . . . . . . . .( )

Connect the red, green, and black test leads to the circuit board as shown in Fig. 12.( )

Now carefully rotate the etched circuit board into position so that the two switch shafts will come through the upper holes in the panel and the two potentiometer shafts will come through the lower holes in the panel. The two meter studs should pass through the two large holes of the etched circuit board. Make certain that the test leads are free and not pinched between the switch bushings and the panel. Also make sure that the battery clip leads are not caught on the meter studs. The locating lugs of the two switches should pass through the small slots in the panel . . . . . . . . . . . . . . . . . . . . . . . . . .( )

When you are sure that the switches are correctly seated, place a large flat washer over each of the switch bushings and lightly fasten the switches with the two large control nuts. Tighten these nuts only "finger-tight" for now . . . . . . . . . . . . . . . . . . . . . . .( )

Now sight along the etched circuit board from the end near the meter. The board should be straight and resting on the two washers on the meter studs. If the board is "bowed" out or must be pushed in to rest on the washers, adjust the position of the 10-32 nuts on the meter studs so that the board rests on the washers without bowing .( )

Place the two remaining No. 10 flat washers over the meter studs and fasten lightly (finger-tight) with the remaining 10-32 nuts . . . . . . . . . . . . . . . . . . . . . . . . . . .( )

Now look at the two potentiometer shafts coming from the front of the panel. They should be fairly well centered in the panel holes. If they are not, slightly loosen the two control nuts which secure the two rotary switches, and the two meter stud nuts. With these four nuts loosened, you can move the etched circuit board around enough to center the potentiometer shafts. With the shafts centered, hold the circuit board in place as you tighten securely the two control nuts of the rotary switches . . . . . . . . . . . . . . . . .( )

Now tighten securely the two nuts that fasten the circuit board to the meter studs .( )

Take one of the large knobs, and check to see that the setscrew does not protrude into the shaft opening. Place this knob on the shaft of the polarity switch so that the setscrew will bear on the flat part of the shaft. Tighten the setscrew. Rotate the switch to the center (off) position . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .( )

In a similar manner install the other large knob on the function switch . . . . . . . . .( )

There are no flats on the potentiometer shafts, so you may install the two small round knobs on these shafts in any position. Tighten their setscrews securely . . . . . . . . . .( )

Locate the two 9-volt batteries and connect each of them to one of the battery connect clips which are soldered to the circuit board. Now insert the two batteries into the cabinet, where they are to be held in place by the small metal shelf directly below the barrel of the meter. To install the batteries, lift up the shelf very slightly, and slide the

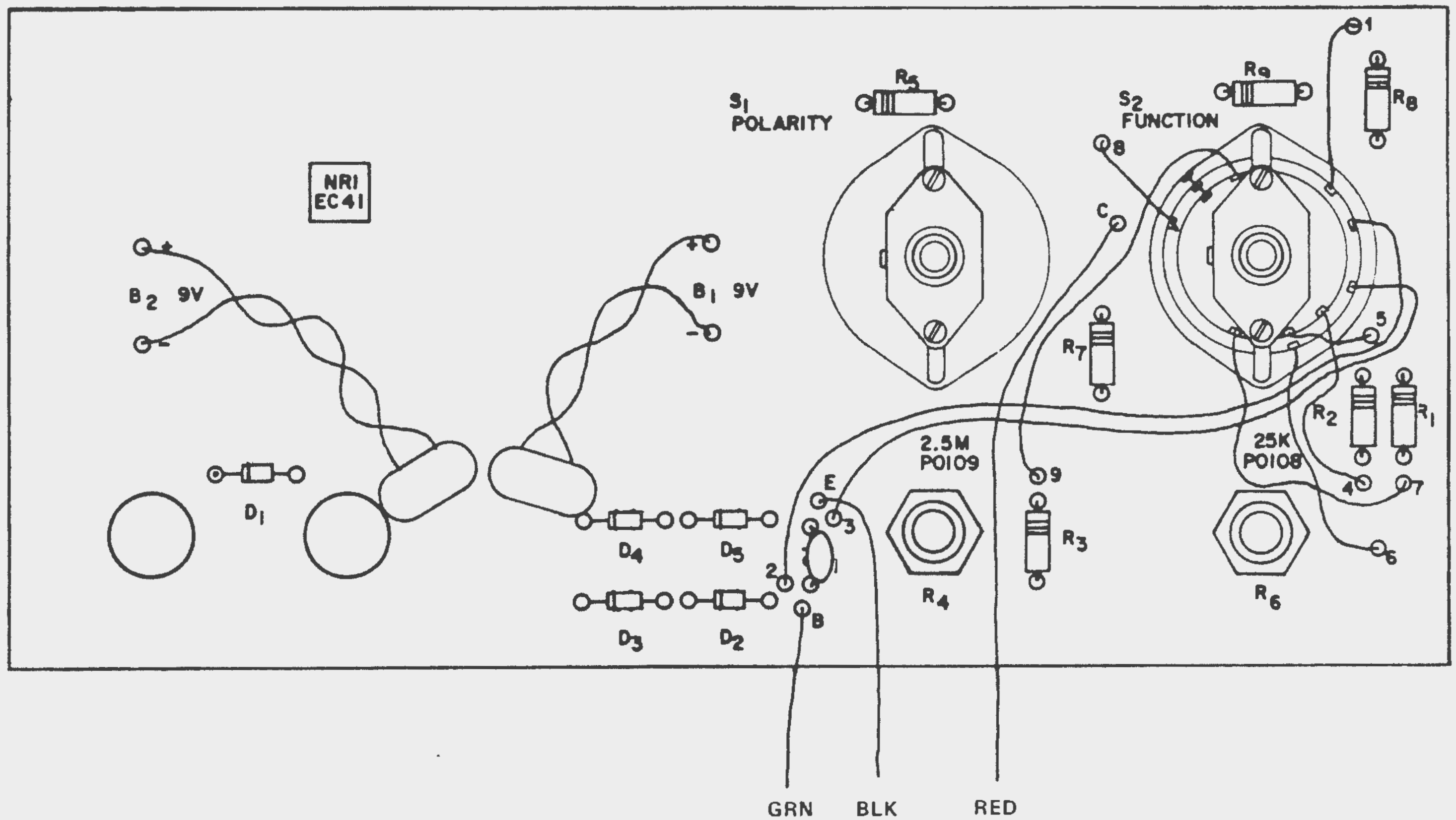



Fig. 12. Red, green, and black test lead connections.

batteries under the shelf so that they rest on one side, compressed between the shelf and the inside wall of the panel. Place the batteries bottom-to-bottom, with their wires coming from opposite ends. Be sure that the wires from the clips are so placed that they are not pinched against the panel . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .( )

This completes the electrical assembly of your transistor tester. You are now ready to check its operation.

## INITIAL CHECKS

**Presetting the controls.** Place the transistor tester face up on your work table and preset the front panel controls as follows:

**Function switch: Leakage**
**Polarity switch: Off**
**Beta Cal: Fully counterclockwise**
**Gm Zero: Fully counterclockwise**

**Mechanical Zero Adjustment.** With the instrument lying face up on your work table, check to see that the meter pointer rests squarely over the zero marks at the extreme left-hand of the lowest scale. If it does, the mechanical zero is correctly set and does not require further adjustment. If the pointer reads a little above or a little below the zero mark, proceed as follows:

Select a screwdriver with a blade that fits the plastic screw located in the lower center of the meter face. Using this screwdriver, turn the screw one complete revolution in a clockwise direction. Notice as you turn the screw that the meter pointer at first moves a short distance in one direction, then stops and moves a short distance in the other direction.

Now turn the screw clockwise until the pointer goes below the zero mark. Continue turning the screw slowly clockwise until the pointer is exactly over the zero mark. If you overshoot the zero mark, continue turning the screw clockwise through another complete cycle of pointer movement. The idea is to approach zero with an upward (towards center scale) motion of the pointer.

**Battery Test.** Move the polarity switch to the "NPN/N-CH" position, and the function switch to the "Gm Zero" position. The meter should deflect upscale, between midscale and full scale. Now adjust the Gm Zero control so that the meter reads full scale (0 on the Gm scale). This shows that $B_1$, one of the 9-volt batteries, is in good condition. Next place the polarity switch in the "PNP/P-CH" position, and repeat the test. If you can reach full-scale deflection by adjusting the Gm Zero control, battery $B_2$ is also good.

**Wiring Check.** To check the performance of your transistor tester, first make sure that none of the three clip leads is connected to anything, then set the polarity switch to the NPN/N-CH position, and rotate the function switch through each of its positions.

In the first three positions of the function switch (Gate, Gm, and Gm Zero) the meter should deflect an equal amount depending upon the setting of the Gm Zero control. In the next three positions of the function switch ($I_{DSS}$, leakage, and Beta Cal) the meter should remain at zero, with no noticeable deflection. However, when you switch to the seventh position (Beta), you should notice some deflection, depending upon the setting of the Beta Cal control. You should be able to make the meter reach full scale by turning the control fully clockwise. This shows that your transistor tester is working properly. Now repeat each of these checks, this time with the polarity switch in the PNP/P-CH position. All results should be exactly the same. Of course, you should observe no deflection at all when the polarity switch is set to its off position.

**In Case of Difficulty.** If you are not able to get the results described above, there may be an error in the wiring of the instrument, you may have a poor solder connection, or one or more of the parts may be faulty.

If you get no meter reading whatever, check to be sure that the two meter terminal nuts are tight. If you get readings on only one position of the polarity switch, interchange the two 9-volt batteries to see if the symptoms change. If so, one of the batteries is faulty, and must be replaced.

Since most problems with completed kits are caused by marginal soldering, check all your soldered connections, and, while you are at it, check to make sure that all resistors, diodes, and the capacitor are properly installed. Double-check the placement of the jumper wires, since an accidental reversal of two wires could produce very puzzling results.

After you check your work, try the previous testing procedure again. If you still don't get the proper results, go through all of the assembly steps again, and check each step against the instructions and the pictorial and schematic diagrams.

If you still cannot get your meter to operate satisfactorily, write to us, giving full details of how the transistor tester behaves, and results you obtained when you attempted to operate the instrument, and the results of any tests you may have made (resistance readings, etc.). Be sure to give us complete and detailed information so that we will have a clear picture of your problem. We'll make every effort to help you get your tester into operating condition.

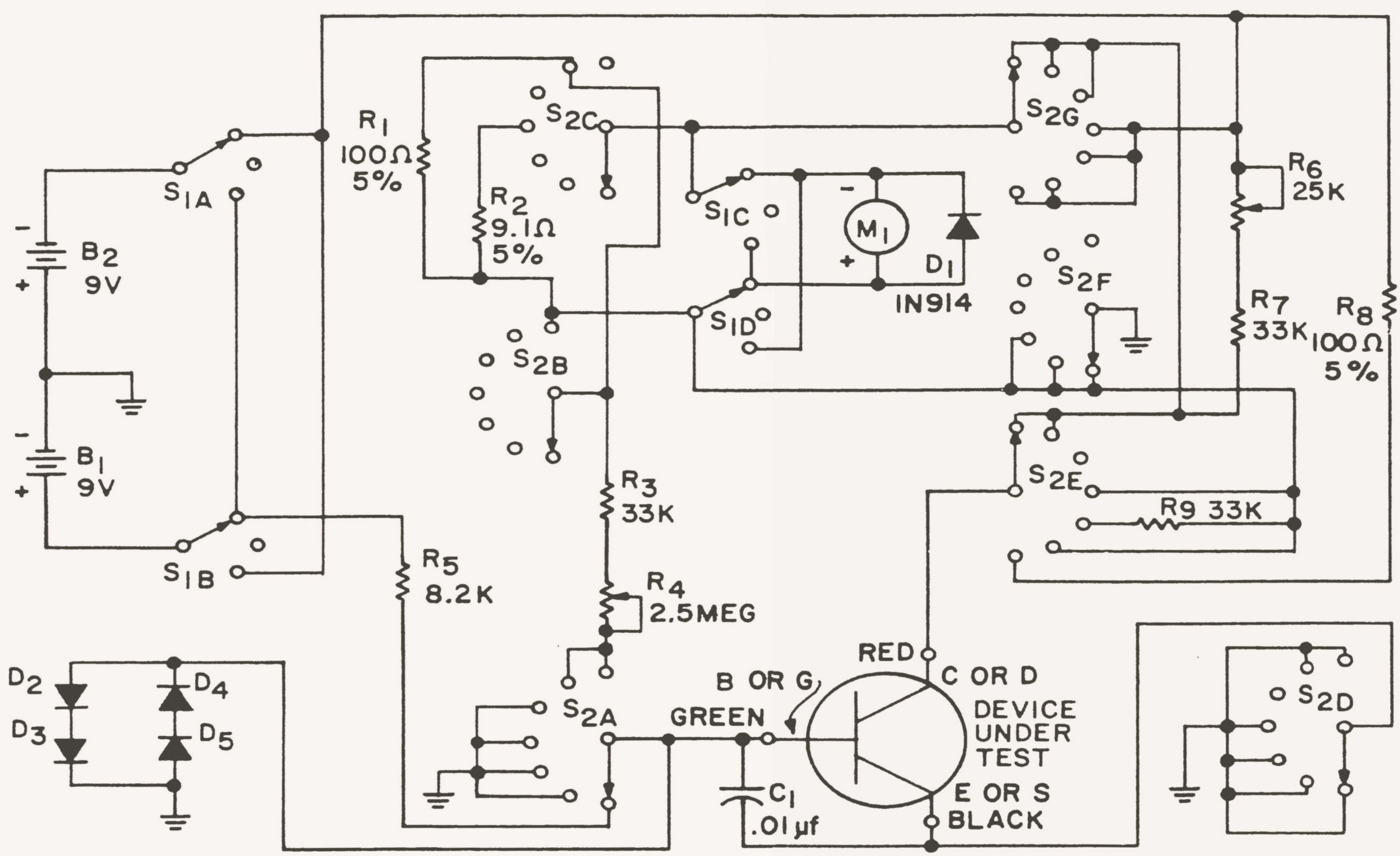
## ASSEMBLING THE CABINET AND HANDLE

You will need the following parts to assemble the cabinet and handle:

**1 Cabinet (CB23)**
**1 Handle (HA79)**
**2 8-32 cap nuts (NU12)**
**2 8-32 × 3/8″ machine screws (SC4)**
**4 6-32 × 3/8″ self-threading machine screws**
**2 No. 8 flatwashers (WA5)**
**2 No. 8 lockwashers (WA16)**

To assemble the handle to the cabinet, first place a No. 8 lockwasher over one of the 8-32 × 3/8″ screws. Pass the screw through one of the holes in the center of one end of the cabinet from the *inside* to the *outside.* While holding the screw head and lockwasher against the inside of the cabinet, place a No. 8 flat metal washer over the screw, then position the handle so that the screw can also pass through one of the holes in the handle. Secure this assembly temporarily with one of the cap nuts. Tighten only finger-tight for now.

Following exactly the same procedure just described, secure the other end of the handle to the cabinet with a 8-32 X 3/8" screw, No. 8 lockwasher, No. 8 flat washer, and a cap nut. With both ends of the handle fastened, tighten both screws as much as possible. This will secure the handle and yet allow you to move it around to serve as a stand for the completed transistor tester. To fasten the cabinet and meter together, lay the instrument face down on a clean, soft surface such as a tablecloth or bedspread. Put the cabinet into place, being sure that the four small holes in the back of the panel line up with the holes in the cabinet. Now fasten the cabinet to the panel with the four 6-32 X 3/8" thread-cutting screws. *Do not overtighten the screws.* The panel is aluminum, and if you overtighten the screws they will probably pull out of the aluminum. This completes the assembly of your transistor tester.




The complete internal schematic diagram for the Model 214.

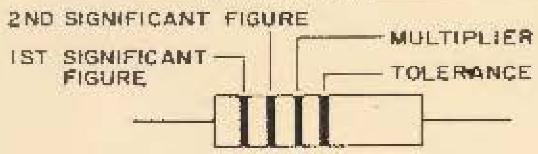

USE THIS HANDY RULER FOR MEASURING LENGTHS OF WIRE

## RESISTOR AND CAPACITOR COLOR CODES

JAN and EIA stand for the two common color codes (Joint Army-Navy and Electronics Industries Association). The two codes are the same except as indicated. We have not indicated temperature coefficients or characteristics of capacitors, because they are not necessary for identifying your parts.

| COLOR | SIG. FIG. | MULTIPLIER | RESIS. | TOLERANCE: CERAMIC CAPACITORS 10 MMF OR LESS | TOLERANCE: CERAMIC CAPACITORS OVER 10 MMF | TOLERANCE: MICA CAPACITORS (As below, or ± 1 mmf, whichever is larger) | TOLERANCE: PAPER CAP |
|---|---|---|---|---|---|---|---|
| Black | 0 | 1 | | ± 2.0 MMF | ± 20% | ± 20% | 20% |
| Brown | 1 | 10 | | ± 1.0 MMF | ± 1% | ± 1% | |
| Red | 2 | 100 | | | ± 2% | ± 2% | |
| Orange | 3 | 1000 | | | ± 2.5% | ± 2.5% | |
| Yellow | 4 | 10,000 | | | | | |
| Green | 5 | 100,000 | | ± 0.5 MMF | ± 5% | ± 5% (EIA) | 5% |
| Blue | 6 | 1,000,000 | | | | | |
| Violet | 7 | 10,000,000 | | | | | |
| Gray | 8 | | | ± 0.25 MMF | | | |
| White | 9 | | | ± 1.0 MMF | ± 10% | | 10% |
| Gold | | .1 | ± 5% | | | 5% (JAN) | 5% |
| Silver | | .01 | ± 10% | | | 10% | 10% |
| No color | | | ± 20% | | | | 20% |

RESISTORS — RESISTANCE GIVEN IN OHMS




Black body = composition, non-insulated.
Colored body = composition, insulated.
Double width band for 1st sig. figure indicates wire-wound.

CAPACITORS — CAPACITY GIVEN IN MMF