Crystal rectifier test set, model TS-268/U

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/21272574
Report (National Research Council of Canada. Electrical Engineering and Radio Branch : ERB); no. ERB-179, 1947-12

REPORT NO. ERB-179

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LABORATORIES

OF

THE NATIONAL RESEARCH COUNCIL OF CANADA

ELECTRICAL ENGINEERING AND RADIO BRANCH

CRYSTAL RECTIFIER TEST SET MODEL TS-268/U

OTTAWA

DECEMBER, 1947

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CRYSTAL RECTIFIER TEST SET

MODEL TS - 268/U

BY

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Ottawa, December, 1947

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CRYSTAL RECTIFIER TEST SET

MODEL TS-268/U

1.0 Summary

1.1 Types of Crystals that may be tested

Frequency Band	Lowest Sensitivity	Medium Sensitivity	Highest Sensitivity	High Burnout
L-Band	1N21			1N25
S-Band	1N21	1N21A	1N21B	
X-Band	1N23	1N23A	1N23B	

Crystal Rectifiers having a polarity opposite to those listed above may be tested as outlined in paragraph 3.1.4. Detailed test information on later types and K-band crystals was not available at the time of printing. Any type of crystal may be checked for back-to-front ratio and back current, however.

1.2 Types of test possible

(a) Forward Resistance
(b) Backward Resistance
(c) Back Current

1.3 Power Supply

Self-contained 1 1/2-volt, dry cell, type C.

2.0 General

The information in this report is taken from the "Instruction Book" published by Radio Frequency Laboratories, Inc., Boonton, N.J., manufacturers of the equipment.

The instrument is designed to provide a means of rapidly checking crystal rectifiers to determine the ratio of back-to-front resistance and the back current. The unit is completely self-conatined in a waterproof, portable aluminum case. A switch, operated by the case cover, is provided so that the battery circuit cannot be left closed when not in use.

The equipment operates from a 1 1/2-volt, dry cell power source, the battery supplying this power being mounted in the unit behind the front panel. The panel incorporates a meter calibrated in kilohms for resistance measurements, and in milliamperes for back current readings. The current scale is provided with coloured sections which facilitate acceptance or rejection of crystals, according to the type being tested.

3.0 Method of Operation

Warning

Keep crystal rectifiers in metal box or wrapped in metal foil except when in use or being tested. When inserting crystal rectifier in test set holder, hold crystal rectifier by body and touch finger to grounding spring to discharge electrostatic charges before insertion.

3.1 Testing Crystals

3.1.1 Preparation for testing

1. Turn selector switch to off position.
2. Hold crystal rectifier by body and touch finger to grounding spring.
3. Insert crystal rectifier in holder.

3.1.2. Testing

The following step-by-step procedure should be performed by rotating the selector switch in a clockwise direction in the order outlined.

1. Adjust meter - Turn selector switch to MTR ADJ and adjust MTR ADJ control to give full scale deflection on meter.
2. Forward resistance - Turn selector switch to FWD RES and read forward resistance in kilohms on upper scale of meter. Discard crystal rectifier if the forward resistance is greater than .5 kilohms (500 ohms).
3. Backward resistance - Turn selector switch to BKWD RES and read backward resistance in kilohms on upper scale of meter. Discard crystal rectifier if ratio of backward resistance to forward resistance is less than 10 to 1.
4. Adjust meter - Turn selector switch to MTR ADJ and adjust MTR ADJ control to give full scale deflection on meter.
5. Back current - Turn selector switch to BACK CUR and read back current in milliamperes on the lower scale of the meter. Discard the crystal rectifier if the meter indicates

in poor (red) portion of scale corresponding to type of crystal rectifier being tested.

3.1.3 Inserting Crystal Rectifier in mixer after test.

1. Hold crystal rectifier by body.
2. Touch finger to mixer chassis to discharge electrostatic charges.
3. Insert crystal rectifier in holder.

3.1.4 Testing Crystal Rectifier of opposite polarity.

Crystal rectifiers of opposite polarity (British Types) may be tested on the TS-268/U Test Set in the following manner.

1. Forward and Backward Resistance- Follow steps (1), (2) and (3) in paragraph 3.1.2 above, except that the reading obtained in step (2) represents the Backward resistance and the reading obtained in step (3) represents the Forward resistance. Basis for rejection of crystal rectifier is, however, the same as expressed above.
2. Back Current - It is not practical to measure the back current of crystal rectifiers of opposite polarity under the normal circuit conditions of this equipment. However, in an emergency, back current measurements may be accomplished by devising an adapter by which the position of the crystal rectifier can be reversed with respect to the present holder. When this is done, the test procedure for both resistance and current measurements is the same as described in steps (1) through (5) of paragraph 3.1.2 above. If a large number of crystal rectifiers of this type are to be tested it may be more advantageous to reverse temporarily the connections to the present holder, on the under side of the panel. Definite limits have not been established for British type crystal rectifier. However, good results may be obtained by comparison with the equivalent limits of the American types.

4.0 Detailed Description.

4.1 Crystal Rectifier Test Set.

4.1.1 General - The Crystal Rectifier Test Set **permits testing crystal rectifiers quickly** and with sufficient accuracy to determine whether or not they are satisfactory for use. This is accomplished by measurement of the forward and backward resistance, and the back current at 1 volt. Crystal rectifier may be accepted or rejected on the basis of the values obtained in accordance with the allowable limits, as stated in paragraph 3.1.2.

4.1.2 Circuit Details - The circuit of the Crystal Rectifier Test Set actually comprises several individual circuits which may be interconnected to perform desired functions by operation of a multi-contact rotary switch S1 (Refer to Figure 1). Each position of this switch sets up a different combination of terminal connections as described in the following paragraphs. In operation, the switch is started from the "OFF" position and rotated in a clockwise direction.

1. Off - When the switch is in this position the battery circuit is open and no current will flow in any part of the circuit.
2. MTR ADJ. - (Refer to Figure 2) When the switch is in this position, the battery BT1 is placed in series with the meter M1 through fixed current-limiting resistors R1 and R6 and a variable current adjusting resistor R2. The meter is shunted with R5 to provide the correct sensitivity for the resistance range. R2 is then adjusted to allow sufficient current to flow in the circuit to give full-scale deflections on the meter. In this position of the switch the terminals of the crystal rectifier holder are shorted, thus giving the effect of zero resistance.
3. FWD RES - (Refer to Figure 3) When the switch is rotated to this position the connections set up are the same as in (2) above, except that the short is removed from the terminals of the crystal rectifier holder and the crystal rectifier becomes part of the series circuit. Providing no change has been made in the position of the control R2, the additional resistance of the crystal rectifier introduced into the circuit causes a decrease in the current flow and the meter will indicate at some point on

the scale other than full scale. Since the meter scale (upper markings) is calibrated to express resistance in terms of the current flowing through the meter moving coil, the forward resistance of the crystal rectifier (in kilohms) is read directly from the scale.

4. BKWD RES. - (Refer to Figure 4) When the switch is rotated to this position, the same connections are made as in (3) above, except that the connections to the crystal rectifier are reversed. The subsequent reading obtained on the meter then represents the backward resistance of the crystal rectifier.
5. MTR ADJ. - (Refer to Figure 5) When the switch is in this position, the battery BT1, fixed resistor R1 and veri ble resistor R2 are connected in series with a two-branch parallel circuit consisting of the crystal rectifier and R4 (100 ohms) in one branch, and the meter (100 ohms) and R3 (900 ohms) in the other branch. The crystal rectifier holder terminals are connected so that the backward resistance of the crystal rectifier is in the circuit. Since the backward resistance of a crystal rectifier is of a high value, the effective resistance of the parallel circuit is essentially that of the branch containing the meter and R3, or 1000 ohms. The sensitivity of the meter being 1 milliampere top mark, adjustment of R2 to give full-scale deflection sets up a voltage of 1 volt across the parallel circuit.
6. BACK CUR. - (Refer to Figure 6) When the switch is rotated to this position, the effect of subsequent terminal connections is to reverse the positions of the crystal rectifier and R3 in the parallel circuit. The crystal rectifier is now in series with the meter and, with 1 volt impressed across this circuit (as set up above in (5)), the meter will indicate the current flowing through the crystal rectifier. The magnitude of this current (as read on the lower scale of the meter) will be inversely proportional to the backward resistance of the crystal rectifier.

4.2 Crystal Rectifiers

A crystal rectifier is a device used for converting RF power into DC or IF power. It usually consists of a small piece of silicon in contact with a thin tungsten wire (called "Catwhisker"), both mounted in a small cartridge, or container.

The rectification takes place at the contact between crystal and whisker, and is due to the fact that the resistance in one direction is greater than that in the other direction. The properties of the rectifier depend critically on the type of contact between crystal and whisker; that is, on the pressure, the contact area, the place of contact, etc. This has been carefully adjusted at the factory, and should not be upset by tampering with the set screw.

The area of contact is very small, and if too much power is passed through the cartridge, the resulting heat will damage it, and the crystal rectifier will be impaired. In extreme cases it will be burned out completely. The crystal rectifier may be damaged, for instance, by a static discharge through it. If the operator holds one end and touches the equipment with the other, any static charges on the body of the operator will discharge through the crystal rectifier. A crystal may also be damaged merely by being exposed to a strong RF field. The handling precautions outlined in Section 3 should be carefully observed.

In the equipment in which the crystal rectifier is used, it is normally protected by a TR tube. The purpose of the TR tube is to place a short across the line leading to the crystal rectifier by means of a gas breakdown in the tube during the firing of the main stransmitter pulse. The returning signal, or echo, being much smaller than the transmitter pulse, does not cause a breakdown, and comes through to the crystal rectifier. During the main pulse, some power does leak through the TR tube, since it is not a perfect short. However, this power is normally small enough to preclude damage to the crystal rectifier.

It is clear from the above that if the TR tube does not function properly, the crystal may be impaired. Improper functioming may be due either to the fact that the TR tube is defective, or to incorrect TR tuning, if tuning adjustments are provided. Another possible cause of crystal damage is a distortion of the pulse shape of the modulator. If the pulse has a sharp peak at the beginning, instead of being square, much more power will come through the TR tube than for a square pulse of equal energy although the TR tube may be operating normally. Faulty TR operation and distorted modulator pulses are the two main causes of crystal rectifier impairment. Continued impairment of good crystal rectifier is an indication that the TR tube and the modulator should be checked.

The deterioration of the crystal rectifier in a receiver produces an increase in noise or a decrease in signal, or both, assuming that the other controlling factors (such as receiver gain, transmitter strength, and target distance) remain the same. Such a change results in a decrease in signal-to-noise ratio. It is the signal-to-noise ratio that determines the over-all merit of the receiver. Conversely, when the signal-to-noise ratio is poor, it is most likely that the crystal rectifier is bad. Other possible causes of a low signal-to-noise ratio are improper functions of the first IF-stage, or excessive losses between crystal and first IF-stage (such as in the cable or connectors), and improper tuning of the local oscillator.

The impairment of a crystal rectifier when in operation is quite difficult to notice, if produced gradually. One possible method of detecting the impairment is to compare the operation of the crystal rectifier with that of a new one. If, for the same target and receiver gain, the noise is less, or the signal greater, the old crystal rectifier is probably impaired. Another clue to crystal rectifier deterioration is a decrease in crystal rectifier current for the same local oscillator coupling. However, if the crystal rectifier current remains unchanged, it does not necessarily mean that the crystal rectifier is unimpaired.

To test a crystal rectifier completely is an elaborate matter, and requires precision RF and IF test equipment. The equipment covered by this instruction book, however, will provide a sufficiently accurate means for checking crystal rectifier in the field. The table of limits shown below has been compiled on a comparison basis in carefully controlled laboratory tests of a large number of crystal rectifiers.

Crystal Rectifier Type	Res. Ratio (Min.)	Back Current (Max)
1N21	10 to 1	.40 ma
1N21A	10 to 1	.175ma
1N21B	10 to 1	.125ma
1N23	10 to 1	.40 ma
1N23A	10 to 1	.30 ma
1N23B	10 to 1	.175ma

The above limits, paticularly with regard to back current, have been determined for crystal rectifiers which were tested at an ambient temperature of 22°C (70°F). Since the DC characteristics of the crystal rectifier vary somewhat with temperature changes, the following table is shown in order that, where necessary, a more accurate test may be made.

Back Current at 1 Volt

	-15°C	0°C	+22°C	+50°C
1N21	0.32	0.35	0.40	0.50
1N21A	0.144	0.152	0.175	0.22
1N23	0.32	0.35	0.40	0.50
1N23A	0.24	0.26	0.30	0.375
1N23B	0.144	0.152	0.175	0.22

5.0 Maintenance

5.1 Replacement of Parts

5.1.1 Battery - The 1 1/2 volt battery BT1 should be replaced when it is not possible to adjust the meter to full scale deflection with the Selector Switch in MTR ADJ position as in paragraph 3.1.2.4.

5.1.2. Meter - If it is found necessary to replace the meter, a 0-1 ma. standard 3 1/2 inch AWS movement can be used if its resistance is 100 ohms or less. When the resistance is less than 100 ohms a series resistor should be added to bring the total resistance to 100 ohms. The movement should have a sensitivity of 1 milliampere.

TABLE 1

Parts and Spare Parts List by Symbol Designation

Model TS-268/U Crystal Rectifier Test Set

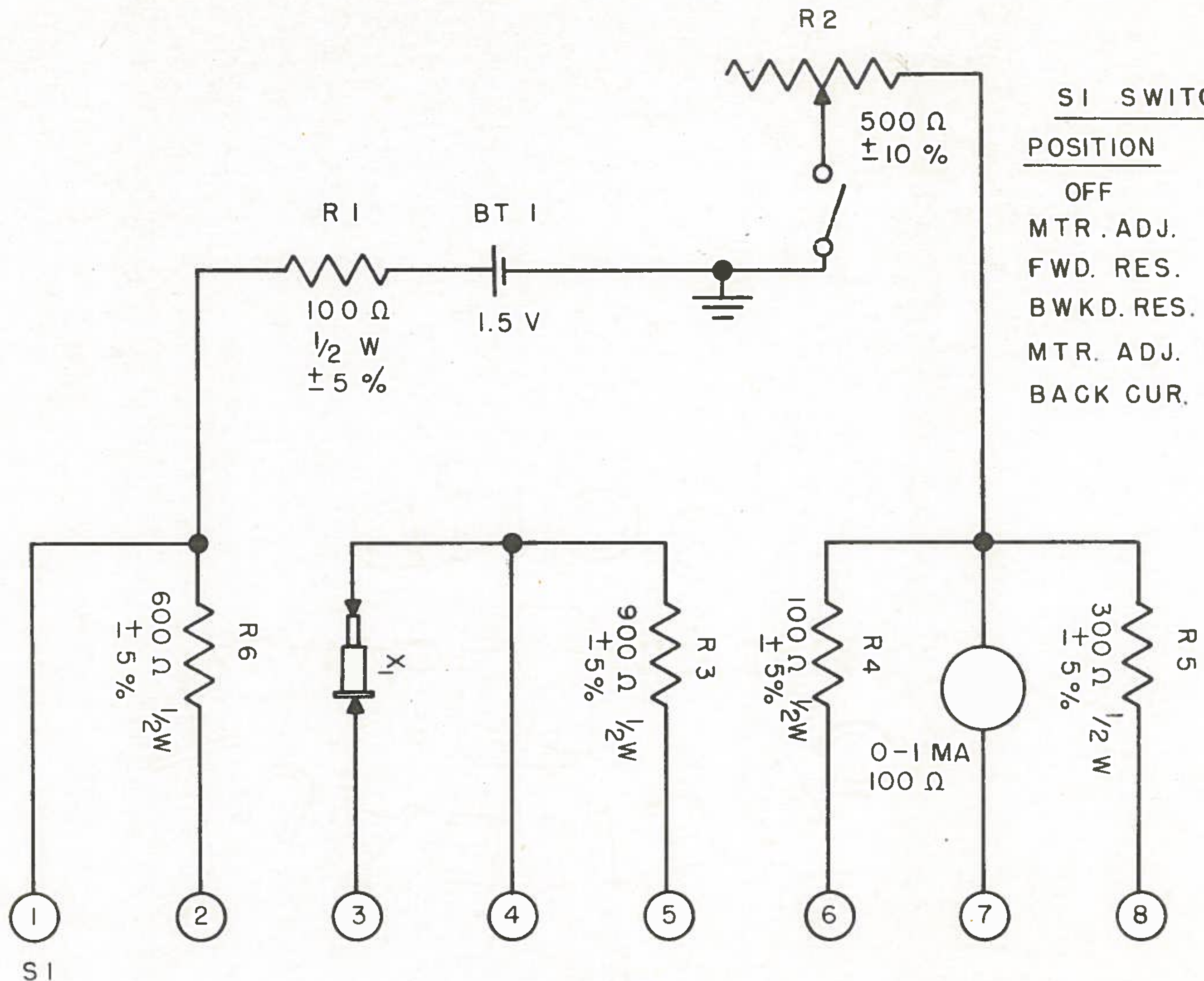
Part no.	Qty.	Item	JAN AWS or Navy Type #	Mfr.	Mfr's Type	Contr's Part #	Equip. Spare Part Qty.
BT1	1	1 1/2 Volt Battery Type C	-19031	2		H1076	
M1	1	1 MA. DC Milliammeter, Rect. Bakelite Case, 100 ohm Int. Res. Special Scale	-22510	3	301	H1213	
O1	1	Gasket, Rubber Case Sealing		7		H1200	1
R1,4	2	Resistor, WW, 100±5% 1/2W	-632502-101	4	BW1/2	H1220-2	
R2	1	Rheostat, WW, 500 ohms ±10%, 2W, Linear, Std. 3/8" Bush, 7/8" long shaft drilled for spec. switch (Complete with switch parts.)	-633288-10	5	C	H1303	1
R3	1	Resistor, Comp., 900 ±5% 1/2W	-63355-901	4	BTS	H1009-35	
R5	1	Resistor, Comp., 300 ±5% 1/2W	RC20BE301J	4	BTS	H1009-33	
R6	1	Resistor, Comp., 600 ±5% 1/2W	-63355-601	4	BTS	H1009-34	
S1	1	Switch, 1 gang, 6 position std. 3/8" Bush, 3/4" long flatted shaft		6	H	H1221	
X1	1	Crystal Holder Assy.	-40186	7		H1195	1

TABLE II

List of Manufacturers

Model TS-268/U Crystal Rectifier Test Set

Code Number	Mfr Prefix	Name	Address
1	CAOR	Radio Frequency Laboratories, Inc.	Boonton, N.J.
2	GBS	Bright Star Battery Company	Clifton, N.J.
3	CV	Weston Electrical Inst. Corp.	Newark, N.J.
4	CIR	International Resistance Co.	401 N. Broad St., Phila., Pa.
5	CMA	P.R. Mallory & Co.	1941 Thomas St., Indianapolis, Ind.
6	COC	Oak Manufacturing Co.	1200 N. Clybourne Ave., Chicago, Ill.
7		Valley Molding Co.	Boonton, N.J.



S1 SWITCH CONNECTIONS

POSITION	CONNECTION
OFF	1-2 3-8 4-7
MTR. ADJ.	1-2-3-4-5-6-7-8
FWD. RES.	2-3 4-7-8
BWKD. RES.	2-4 3-7-8
MTR. ADJ.	1-2-4 3-6 5-7
BACK CUR.	1-2-4 3-7 5-6

FIG. 1

SCHEMATIC OF XTAL RECTIFIER TEST SET

E R B 179

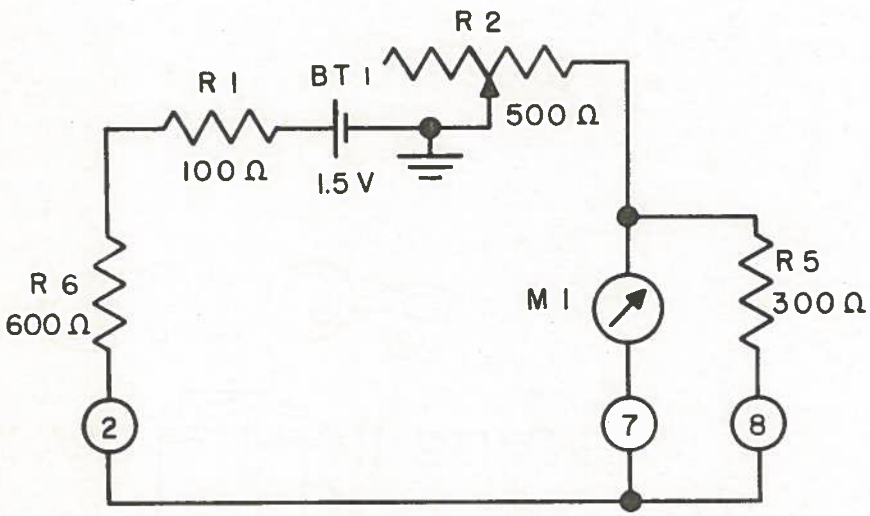


FIG. 2 MTR. ADJ.

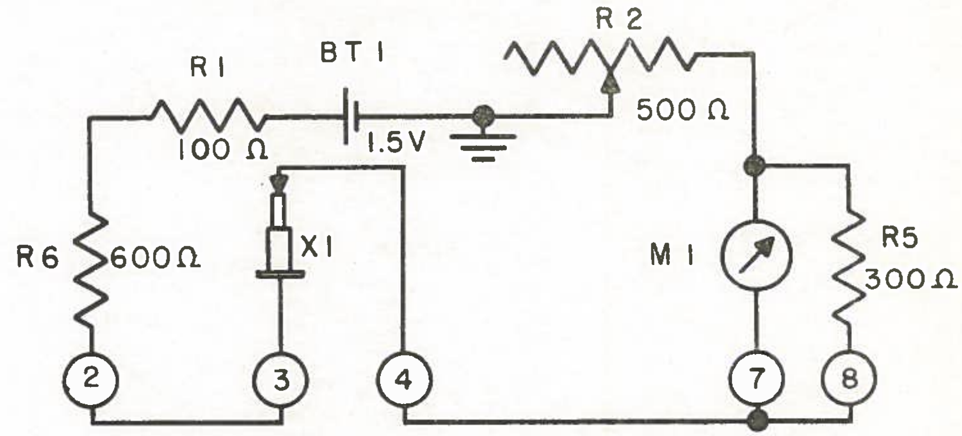


FIG. 3 FWD. RES.

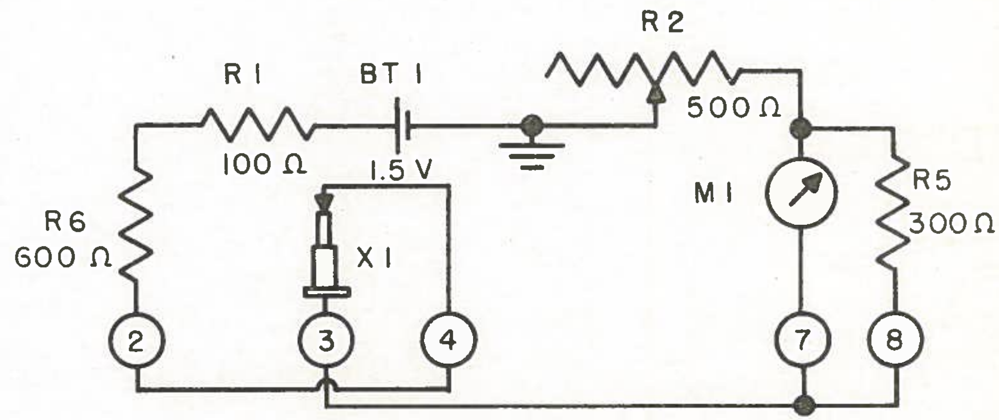


FIG. 4 BKWD. RES.

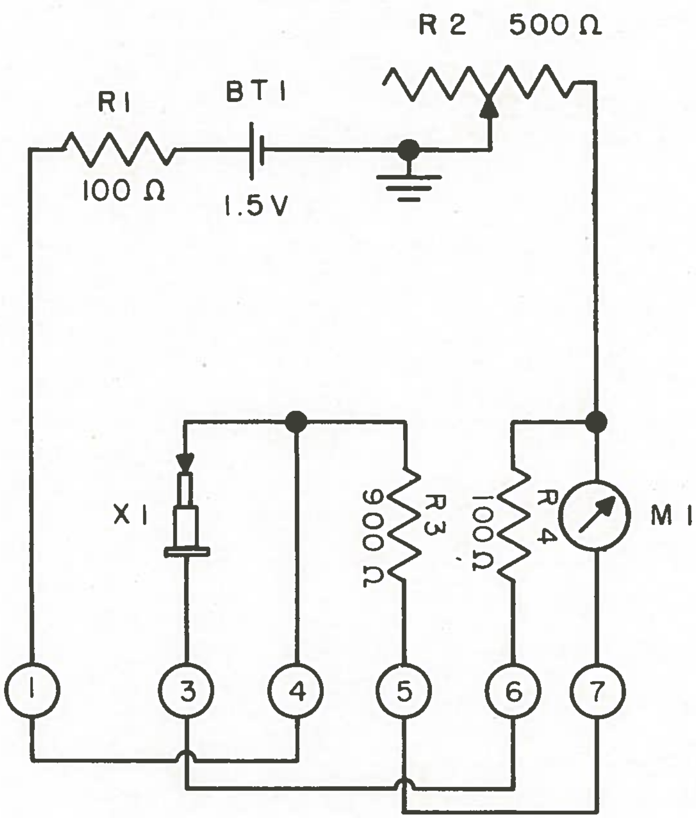


FIG. 5 MTR. ADJ.

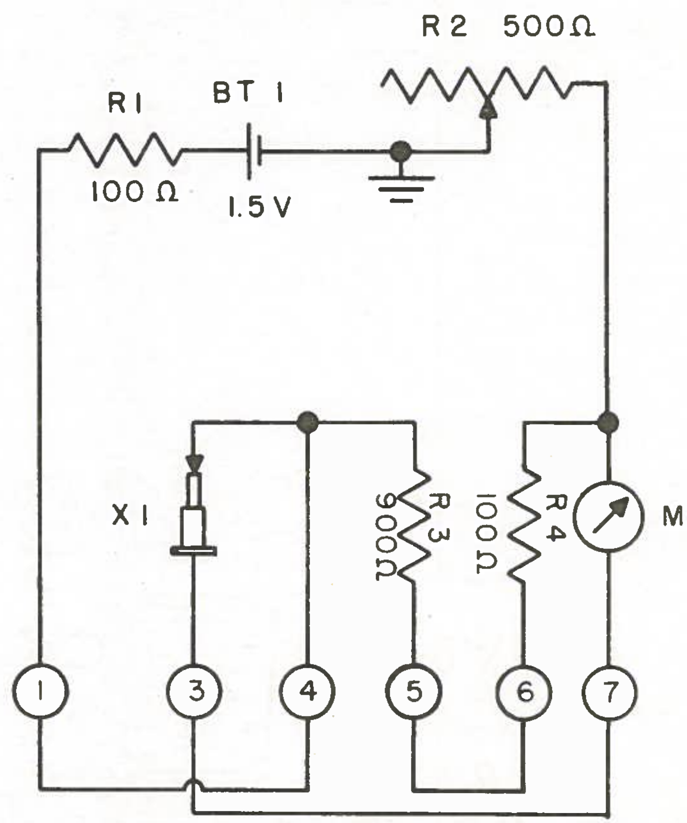
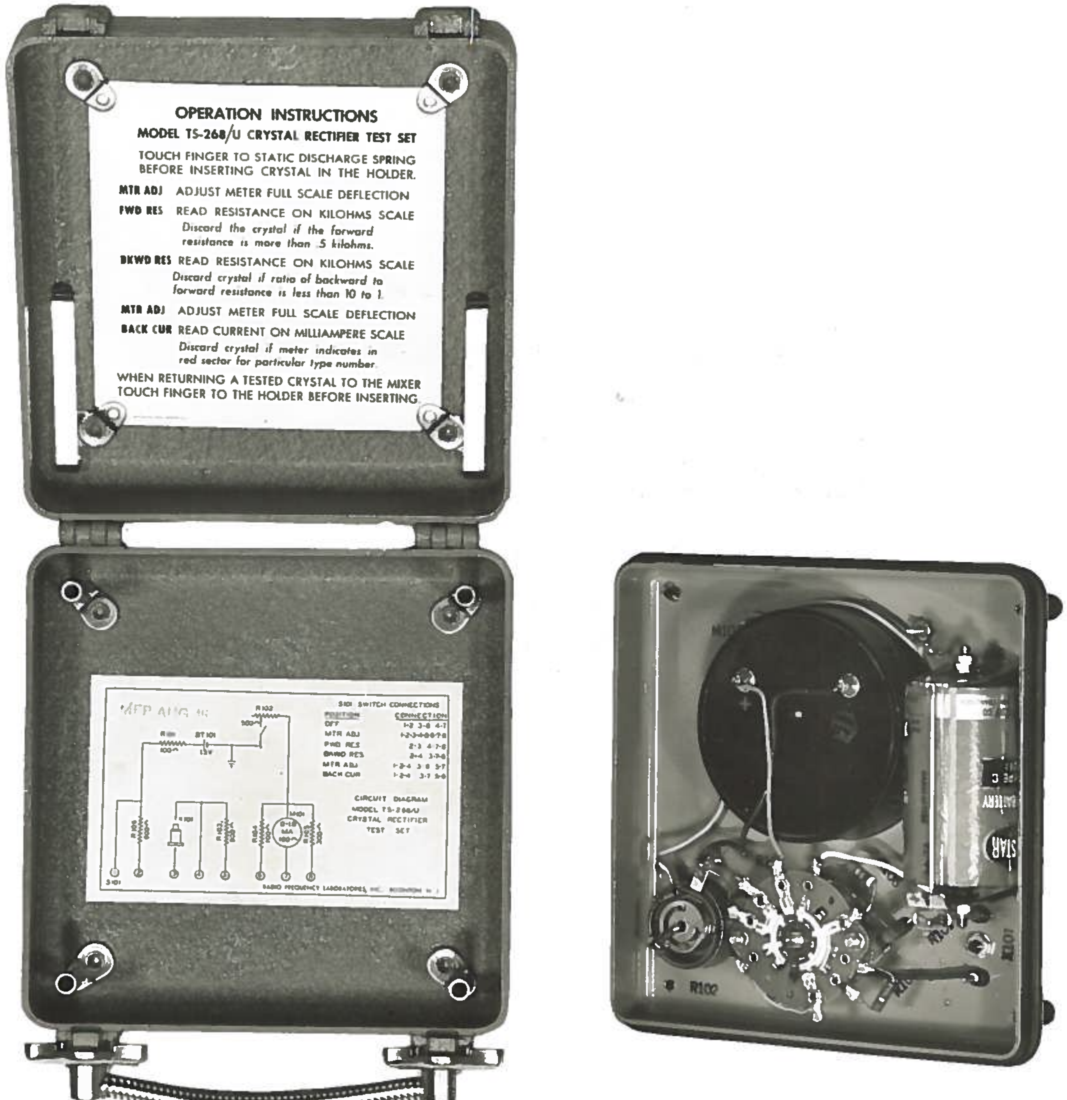


FIG. 6 BACK CUR.

CRYSTAL RECTIFIER TEST SET – CASE OPEN



CRYSTAL RECTIFIER TEST SET – CONSTRUCTION DETAILS

CRYSTAL RECTIFIER TEST SET – CASE CLOSED