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FOREWORD

The Simpson Model 221 brings a new and revolutionary principle to the service dealer's most useful instrument, the Volt-Ohm-Milliammeter.

The patented Roto-Ranger principle eliminates the confusion of numerous scales and multiplying factors common to the ordinary multi-range testers by providing a separate scale for each range.

For each position of the range switch there is a separate full length dial, calibrated to its specific function and divided into the most convenient steps of major and minor degrees for easy and rapid readability.

In no other instrument do you find features such as are contained in the Simpson Model 221. Its trim, scientific appearance - the 5½ inch modernistic instrument, the substantial anodized aluminum panel, the sturdy leatherette case - all give evidence of inner quality. These hidden features are too numerous to mention here, but your pride in your new instrument will grow as you learn of them. Parts are assembled and placed in position so they cannot become loose or detached from their original positions. Specially designed parts, engineered expressly for a specific function are used throughout the Model 221.

When you purchase Simpson test equipment, you get equipment made almost entirely within the various plants of our Company. Each component part of the 221 has been designed and completely tooled and manufactured in our own plants, with the exception of the matched resistors and one or two other functionally less important parts. The Model 221, like all other Simpson testers, is not an assembly job made up from purchased parts such as is true of the majority of testers offered on the market.

We are by far more self-contained than any other manufacturer of test equipment. This is your assurance that the testers we offer will not quickly become obsolete. Our tremendous investment in expensive production tools is your safeguard against obsolescence and further assurance of unvarying quality.

Here at Simpson we do not think of making instruments merely to *sell*. We think of making instruments to *serve*. Our interest in your Model 221 and in your satisfaction with it never ceases. That is the reason for this Operator's Manual. We want you to know how to get the most from your 221.

The Model 221 is a rugged instrument and will withstand a great deal of abuse. We urge you, however, to treat it with care as the meter mechanism is actually more delicate than that of a watch. If you will keep it clean, free from continuous, severe vibration and avoid dropping it, your Model 221 will give you a lifetime of accurate, dependable service.

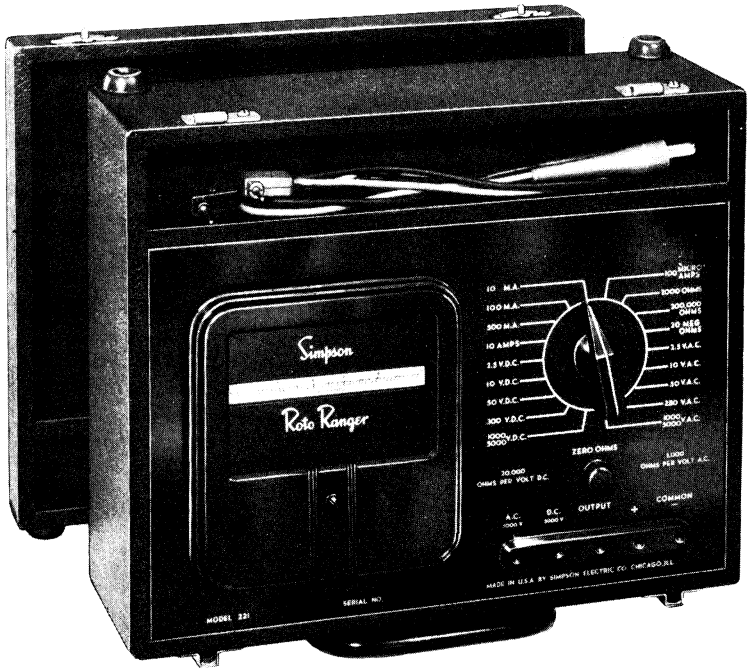

Figure 1 Simpson Model 221 Volt-Ohm-Milliammeter
Size: 12 3/4" x 10 1/8" x 5 3/8". Weight 8 lbs. 9 oz.

OPERATOR'S MANUAL

SIMPSON MODEL 221 VOLT-OHM-MILLIAMMETER

SECTION 1

GENERAL DESCRIPTION

1. GENERAL INTRODUCTION.

The Simpson Model 221 Test Unit is equivalent to 25 separate instruments in one compact unit. The large five and one-half inch meter provides twenty separate scales, all full length, for accurate and rapid readings. Its high sensitivity makes it an ideal instrument for modern test procedures.

It comes complete with one set of red and black test leads with insulated clips and operator's manual.

The electrical circuit is designed to give maximum insurance against inaccuracy and damage to the component parts. Highly accurate carbofilm resistors are used to insure long life and dependability and are firmly held in place in a special bakelite housing designed for this purpose. The entire assembly is truly rugged and can well withstand the wear and tear of the service work for which it is designed. Accuracy is 3% D.C. and 5% A.C. of full scale deflection.

2. MEASUREMENT RANGES AVAILABLE.

a. D. C. VOLTAGE

0-2.5	volts	20,000 ohms per volt sensitivity
0-10	volts	
0-50	volts	
0-300	volts	
0-1000	volts	
0-5000	volts	

b. A. C. VOLTAGE

0-2.5	volts	
0-10	volts	
0-50	volts	1,000 ohms per volt
0-250	volts	sensitivity
0-1000	volts	
0-5000	volts	

c. A. F. OUTPUT VOLTAGE

0-2.5	volts	
0-10	volts	
0-50	volts	.1 Mf. internal series
0-250	volts	condenser
0-1000	volts	

d. D. C. RESISTANCE.

0-2000 ohms	(12 ohms center)
0-200,000 ohms	(1200 ohms center)
0-20 megohms	(120,000 ohms center)

e. CURRENT IN D. C. CIRCUITS.

100 microamperes	250 millivolts
10 milliamperes	248.75 millivolts
100 milliamperes	249.88 millivolts
500 milliamperes	249.98 millivolts
10 amperes	249.99 millivolts

3. D. C. VOLTAGE MEASUREMENTS.

D. C. Voltage is measured by applying the unknown voltage to the meter through suitable internal series resistors. The meter has a full scale sensitivity of 50 microamperes at 100 millivolts with an internal resistance of 2,000 ohms, giving the instrument an overall sensitivity of 20,000 ohms per volt.

4. A. C. VOLTAGE MEASUREMENTS.

A. C. voltage measurements, including output, are made possible by the use of an internal copper oxide rectifier connected in series with the meter. A precision wound internal shunt resistor is connected in parallel with the meter resulting in a sensitivity of 1,000 ohms per volt.

5. D. C. RESISTANCE MEASUREMENTS

D. C. resistance is measured by the use of suitable internal series and shunt resistors in series with a battery to give accurate scale deflection of the meter when an unknown resistance is to be measured.

6. CURRENT MEASUREMENTS IN D. C. CIRCUITS

Current is measured by the use of suitable internal shunts so that the maximum current in each range will produce a full scale deflection of the meter.

SECTION II

OPERATING INSTRUCTIONS

CAUTION: When making measurements, turn off the power to the circuit under test, clip the test leads to the desired points and then turn on the power to take the reading. Turn off the power to disconnect the meter.

ZERO ADJUSTMENT: Before taking readings, be sure that the pointer is on zero. If pointer is off zero, adjust by means of the slotted screw located in the bakelite case directly below the meter scale as shown in Figure 1. Use a small screw-driver to turn this adjustment slowly right or left until the pointer is directly over the zero point on the scale.

1. D. C. VOLTAGE MEASUREMENTS 0-1000 VOLTS.

a. Rotate the range selector switch to any one of the D. C. voltage positions required. WHEN IN DOUBT OF THE VOLTAGE PRESENT, ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After the first reading, the switch can be re-set to a lower range, if needed, to get a more accurate reading.

b. Plug the black test lead into the jack marked "COMMON —" and the red test lead into the jack marked "+". Clip the other end of the black lead to the negative side of the circuit to be checked and the other end of the red lead to the positive side.

c. Turn on the power to the circuit to be tested. If the pointer deflects to the left of zero, the connections are incorrect. Turn off the power and reverse the position of the test clips.

d. Read the voltage as indicated on the scale.

2. D. C. VOLTAGE MEASUREMENTS 1000-5000 VOLTS.

CAUTION: Use extreme care when checking high voltage. Always turn off power before making connections and do not touch meter or test leads while taking the reading.

a. Set the range selector switch in the 1000-5000 volt position.

b. Plug the black test lead into the jack marked "COMMON —" and the red test lead into the jack "D. C. 5000 V."

c. Be sure power is turned off to the circuit to be tested and condensers discharged and then clip the black test lead to the negative side and the red test lead to the positive side.

d. Turn on the power.

e. Read the voltage using the 0-5000 volt arc. Turn off power before disconnecting meter.

3. A. C. VOLTAGE MEASUREMENTS 0-1000 VOLTS

a. Rotate the range selector switch to any of the five A. C. ranges required. WHEN IN DOUBT OF THE VOLTAGE PRESENT, ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After the first reading the switch can be re-set to a lower range for a more accurate reading.

b. Plug the black test lead into the jack marked "COMMON —" and the red test lead into the jack marked "+". Clip the other ends of the test leads to the two sides of the circuit to be tested. A.C. voltage will read correctly regardless of which way the test leads are connected.

c. Turn on the power to the circuit to be tested.

d. Read the voltage as indicated on the scale.

4. A. C. VOLTAGE MEASUREMENTS 1000-5000 VOLTS.

CAUTION: High voltage is dangerous. Always turn off power when connecting or disconnecting test leads. Do not handle meter or test leads while power is on.

a. Rotate the range selector switch to the 1000-5000 volt position.

b. Plug the black test lead into the jack marked "COMMON —" and the red test lead into the jack marked "A. C. 5000 V."

c. Be sure power is turned off in circuit to be tested and then clip the test leads to the two sides of the circuit. A.C. voltage will read correctly regardless of which way the leads are connected.

d. Turn on the power.

e. Read the voltage on the 0-5000 volt arc. Turn off power before disconnecting meter.

5. A. F. OUTPUT MEASUREMENTS.

a. Rotate the range selector switch to any of the five ranges required. WHEN IN DOUBT OF THE VOLTAGE PRESENT, ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After the first reading, the switch can be re-set to a lower range for a more accurate reading.

b. Plug the black test lead into the jack marked "COMMON —" and the red test lead into the jack marked "OUTPUT". In this position an internal condenser is connected in series for blocking out the D. C. component when connections are made directly to the plate of a tube. Clip the other ends of the test leads to the output of the circuit under test.

c. Turn on the power.

d. The reactance of the series condenser used when reading output volts causes a slight error which varies with frequency. This is explained in paragraph 3 of Section III.

6. D. C. RESISTANCE MEASUREMENTS.

CAUTION: Before making any resistance measurements in a radio circuit, be sure the current is turned off so that no voltage exists. Otherwise the meter may be damaged.

a. Rotate the range selector switch to any of the three ranges required.

b. Plug the test leads into the two jacks marked "+" and "COMMON —". Short the ends of the leads and set the pointer to zero by rotating the "ZERO OHMS" knob.

c. Separate the ends of the test leads and clip them across the portion of the circuit to be measured.

d. Read ohms or megohms as indicated on the scale.

CAUTION: Do not leave the range selector switch set in a resistance measurement position when the meter is not in use as test leads may become shorted and run down the internal battery. It is also possible that they may be connected across a voltage accidentally and damage the meter.

7. CURRENT MEASUREMENTS IN D. C. CIRCUITS

a. Rotate the range selector switch to any of the ranges required. WHEN IN DOUBT OF THE CURRENT PRESENT, ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After the first reading, the switch can be re-set to a lower range if needed.

b. Plug the black test lead into the jack marked "COMMON —" and the red test lead into the jack marked "+".

c. Break the circuit to be tested and insert the meter in series by connecting the red test lead to the positive side and the black test lead to the other side.

d. Turn on the power.

e. Read milliamperes or amperes as indicated on the scale. If the pointer is forced against stop at left of scale, the connections are incorrect. Turn off the power and reverse the position of the test clips.

CAUTION: For current measurements, the meter must always be connected in series with the circuit. Never connect the meter across a voltage source when the range selector switch is set for current measurement as this may damage the meter. Always observe polarity.

SECTION III

FUNCTIONING OF PARTS

The complete schematic diagram of the Model 221 volt-ohm-milliammeter is shown in Figure 9. The simplified sections are described in the following paragraphs.

1. D. C. VOLTMETER CIRCUIT--20,000 OHMS PER VOLT.

Figure 2 shows the circuit used when the range selector switch is in one of the five D. C. voltage positions.

The total resistance of the bank of multiplier resistors and the meter is 100 megohms or 100,000,000 ohms from the "5000 V." jack to the "NEG." jack. Ohm's law will show that when a 5000 volt potential is applied between the two jacks, a current of 50 microamperes will flow through the circuit, causing a full scale deflection of the meter. Dividing the number of ohms, 100,000,000, by the number of volts, 5000, gives 20,000 ohms which is the sensitivity per volt.

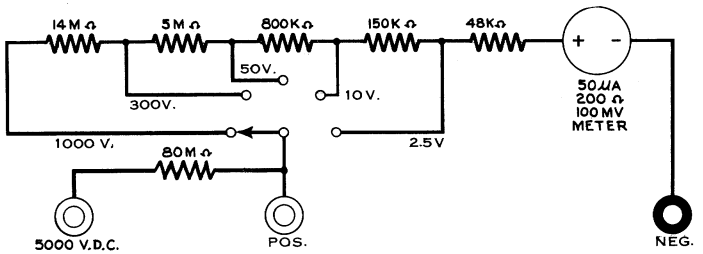

Figure 2 Simplified D.C. Voltmeter Circuit

2. A. C. VOLTMETER CIRCUIT--1000 OHMS PER VOLT.

Figure 3 shows the circuit used when the range selector switch is in one of the five voltage positions.

In this circuit the A. C. is rectified by a copper oxide rectifier to supply the microammeter with direct current. The other half of the cycle passes around the meter and through the rectifier in the opposite direction as shown by the arrows in Figure 3. The shunt resistor R-1 and the series resistor R-2 are precision

wound and calibrated with the rectifier with which they are used. The resulting sensitivity is 1000 ohms per volt.

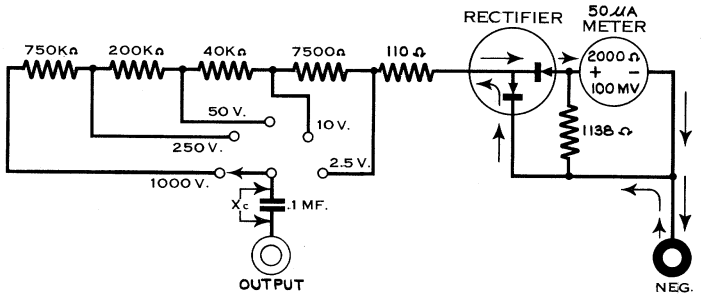

Figure 3 Simplified A.C. Voltmeter Circuit

3. A. F. OUTPUT METER.

Figure 4 shows the circuit used when the range selector switch is in one of the five A.C. voltage ranges, and the test leads connected to the "COMMON" and "OUTPUT" jacks. This is the same as the A.C. voltmeter except that the 5000 V. range is omitted and a .1 mf. condenser is placed in series with the "POS." jack to block the D.C. component when connection is made direct to the plate of a tube.

In reading A. C. voltage with the output meter the impedance of the blocking condenser which is in series with the voltage multipliers must be taken into consideration. This will cause considerable error at 60 cycles but the percent of error will decrease with an increase in frequency. The actual effective resistance is equal to $\sqrt{Xc^2+R^2}$ where Xc is the capacitive reactance of the .1 mfd. condenser and R the multiplier resistance.

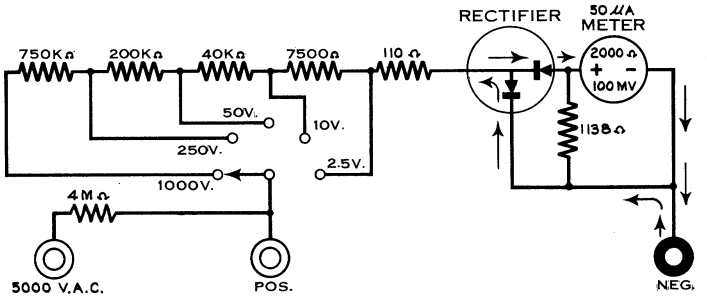

Figure 4 Simplified Output Meter Circuit

For the 2.5 volt range R=2500 ohms and Xc at 60 cycles=26,500 ohms. Therefore $\sqrt{26,500^2+2500^2}=26,618$ ohms, the actual effective resistance in the circuit.

4. D. C. OHMMETER.

Figures 5, 6, and 7 show the ohmmeter circuits when the range selector switch is in the 2000 ohms, 200,000 ohms, and 20 megohms positions.

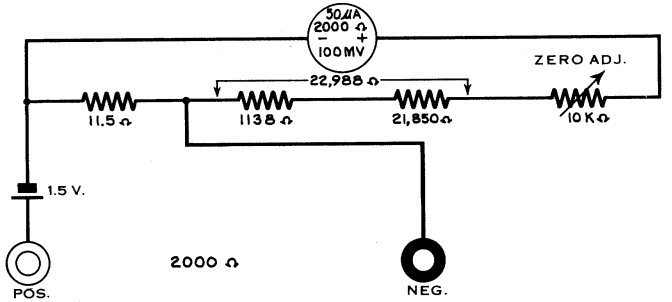

Figure 5 Ohmmeter Circuit with Selector Switch in the 2000 ohms position

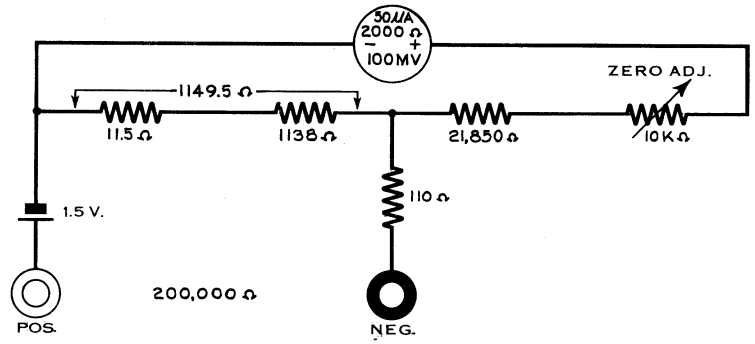

Figure 6 Ohmmeter Circuit with Selector Switch in the 200,000 ohm position

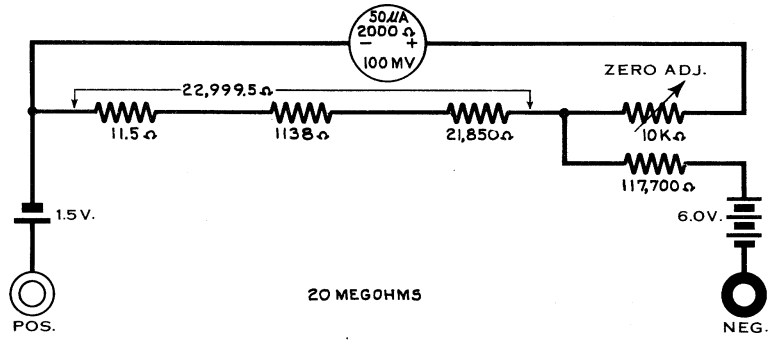

Figure 7 Ohmmeter Circuit with Selector Switch in the 20 megohms position

5. D. C. MILLIAMMETER AND AMMETER.

Figure 8a shows the circuit used when the range selector switch is in the 100 microampere position. This is equivalent to two equal resistors in parallel, the 3000 ohm resistor and 2000 ohm meter forming one 5000 ohm leg and the five resistors between the "POS." and "NEG." terminals forming the other. As a result, when

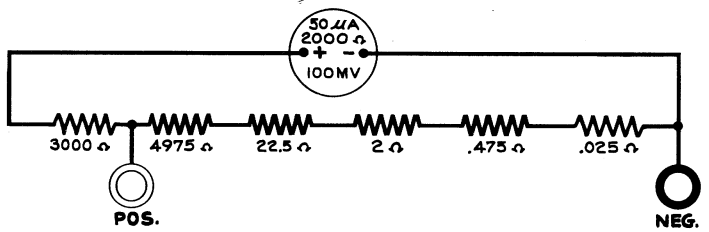

Figure 8a Simplified Microammeter Circuit

a current of 100 microamperes is flowing through the circuit, 50 microamperes flows through the shunt resistors and 50 microamperes flows through the meter, causing full scale deflection.

Figure 8b shows the circuit used when the selector switch is in the 10 M.A., 100 M.A., or 500 M.A. positions. It can be seen that the resistance of the shunt resistors becomes lower as the higher current positions are used, thereby permitting a larger amount of current to flow through them, the amount flowing through the meter remaining at 50 microamperes for full scale deflection. The voltage drop appearing across the various ranges is shown opposite the current ranges on page 6.

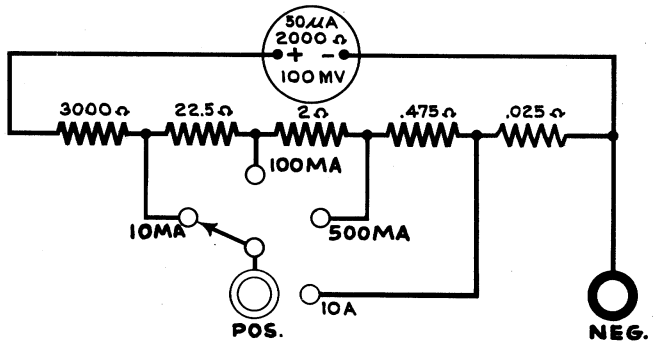

Figure 8b Simplified Milliammeter and Ammeter Circuit

SECTION IV

MAINTENANCE

1. The Model 221 volt-ohm-milliammeter is a very rugged instrument designed to take the wear and tear of every day service work. Nevertheless, care should be used against dropping or other excessively rough treatment.

2. Always be sure of the character of the circuit to be tested and see that the selectors are properly set before connecting. When in doubt of the amount of voltage or current present, always use the highest range first.

3. BATTERY REPLACEMENT

Five batteries are mounted inside the case to provide current for the resistance measuring ranges.

These are:

One Burgess No. 2 Uni-cel.....	1.5 V.
or Eveready No. 950.....	1.5 V.
or Ray-o-Vac No. 2.....	1.5 V.
Four Burgess No. Z Uni-cel.....	1.5 V.
or Eveready No. 915.....	1.5 V.
or Ray-o-Vac No. 7R.....	1.5 V.
or equivalent	

a. When it is no longer possible to bring the pointer to zero on the 2000 and 200,000 ohm ranges, with the test leads shorted and rotating the "ZERO OHMS" knob, the single large 1.5 V. battery should be replaced.

b. When it is no longer possible to bring the pointer to zero on the 20 megohm range, with the test leads shorted and rotating the "ZERO OHMS" knob, the four small 1.5 V. batteries should be replaced.

c. To replace the batteries, remove the instrument from the case. This is done by removing the six screws from the front panel. Slip the batteries out of the spring clips holding them in place. Insert the new batteries, being careful that the polarity corresponds to the markings on the bakelite base.

R1	113.8 Ω
R2	110 Ω
R3	21,850 Ω
R4	117,700 Ω
R5	4,975 Ω
R6	7,500 Ω
R7	40 K Ω
R8	800 K Ω
R9	750 K Ω
R10	48 K Ω
R11	(TWO) 3000 Ω
R12	150 K Ω
R13	200 K Ω
R14	5 M Ω
R15	14 M Ω
R16	11.5 Ω
R17	0.475 Ω
R18	22.5 Ω
R19	2 Ω
R20	80 M Ω
R21	4 M Ω
R22	0.025 Ω
R23	RECT. SERIES CALIBRATED
R24	RECT. SHUNT CALIBRATED
R25	10 K Ω POT.
C1	.1 MFD 400V.

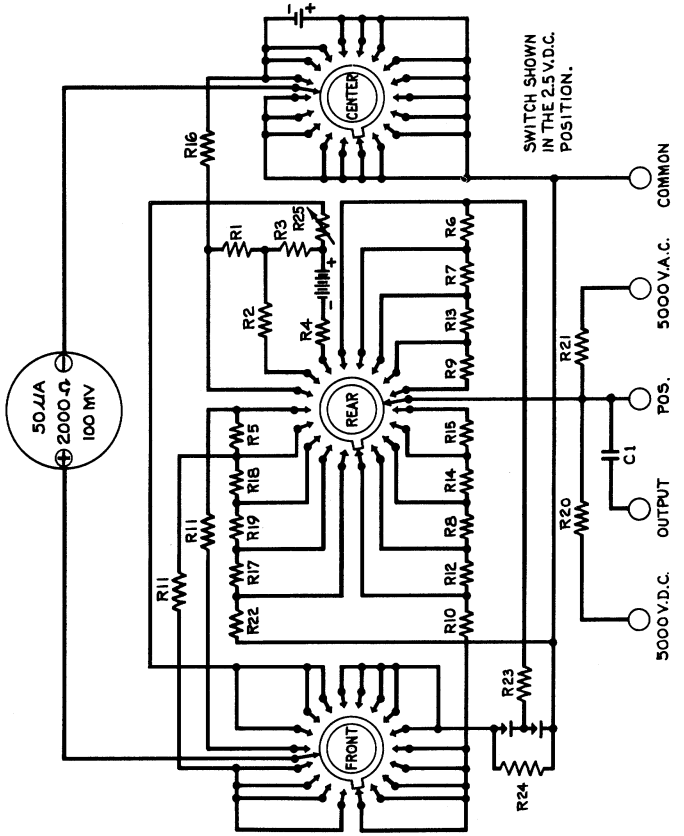

Figure 9 Model 221 Schematic Diagram

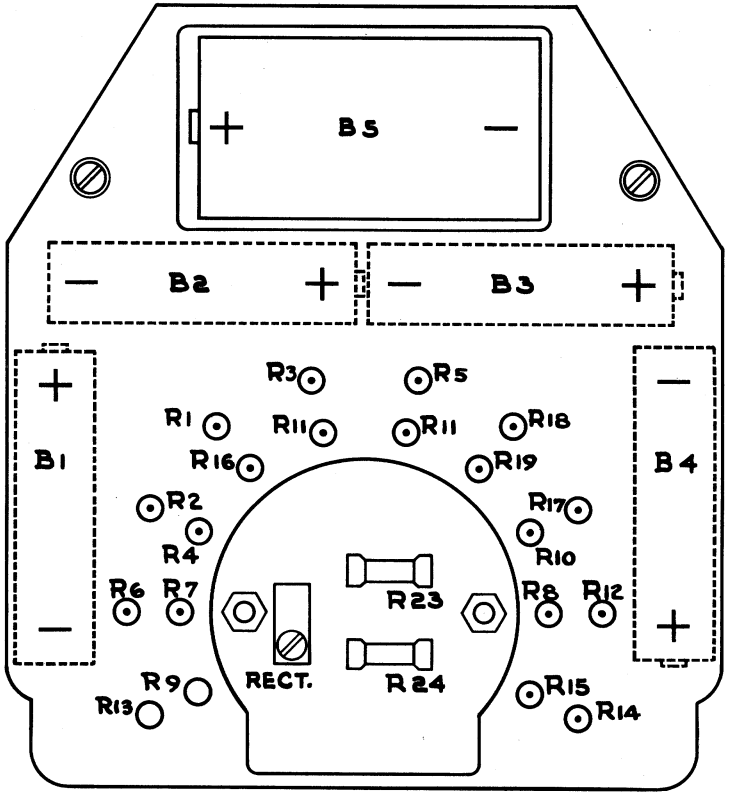

Figure 10a Model 221 Parts Layout--Rear View

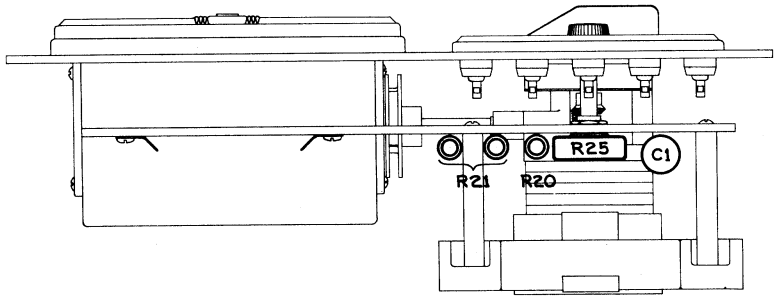

Figure 10b Model 221 Parts Layout

4. PARTS LIST

PART No.	DESCRIPTION	REFERENCE SYMBOL
1-113372	1138 ohm resistor	R1
1-113373	110 ohm resistor	R2
1-113369	21850 ohm resistor	R3
1-113367	117700 ohm resistor	R4
1-113371	4975 ohm resistor	R5
1-113370	7500 ohm resistor	R6
1-113309	40000 ohm resistor	R7
1-113363	800000 ohm resistor	R8
1-113364	750000 ohm resistor	R9
1-113368	48000 ohm resistor	R10
1-113287	3000 ohm resistor	R11
1-113366	150000 ohm resistor	R12
1-113365	200000 ohm resistor	R13
1-113433	5 megohm resistor	R14

PART No.	DESCRIPTION	REFERENCE SYMBOL
1-113654	14 megohm resistor	R15
0-008070	11.5 ohm resistor (bobbin)	R16
0-008285	.475 ohm resistor (bobbin)	R17
0-008133	22.5 ohm resistor (bobbin)	R18
0-008060	2 ohm resistor (bobbin)	R19
1-113353	80 megohm resistor	R20
1-113352	4 megohm resistor	R21
0-008033	.025 ohm shunt assembly 10 amp. 250 MV-DC	R22
0-008585	Copper oxide rectifier Series resistor Shunt resistor Calibrated Together	Rect. R23 R24
1-113703	10000 ohm potentiometer Type 37	R25
1-111679	0.1 MF 600 V. condensor	C1
0-008824	Range Selector switch	S1
1-111728	Jack, pin type	J1-5
1-111802	Dry cell 1.5 volt (4)	B1-4
1-111798	Dry cell 1.5 volt (1)	B5
3-260143	Range selector knob	
1-111756	Zero ohms knob	
15-302215	Meter -- Simpson Model 29 50 microamperes -- 2000 ohms	
0-008990	Case	
0-008375	Test lead set	

Note--When ordering parts, specify serial number appearing on the bottom of the front panel of the Model 221.

SECTION V

APPLICATIONS

The high sensitivity of the Model 221 volt-ohm-milliammeter not only makes it suitable for all of the applications of a lower sensitivity meter but also makes it adaptable to many special uses. The following suggestions are only a few of the many uses for which you will find the Model 221 a superior instrument.

1. MEASURING GRID CURRENTS.

The Model 221, with its 100 microampere scale is so sensitive that it is possible to measure grid currents of many tubes. A readable value as low as 1 microampere can be obtained.

2. F. M. ALIGNMENT.

By opening the load resistor circuit of the limiter in a F.M. receiver and inserting the Model 221 as a microammeter in series, a reading may be obtained for I.F. alignment purposes. Adjust the circuit for maximum indication. Manufacturers' alignment instructions should be consulted for exact procedure.

3. A.V.C. DIODE CIRCUITS.

An ordinary low sensitivity meter cannot be used across an A.V.C. network due to the low resistance altering the constants of the circuits. The Model 221, however, requires so little current that sufficient indication can be obtained to determine if the A.V.C. circuit is functioning.

4. HIGH Mu PLATE VOLTAGE.

High Mu tubes require a high resistance plate resistor. For this reason a low resistance meter will not give a satisfactory reading. Due to the high resistance and low current consumption of the Model 221, it will give a much more accurate indication.

5. BIAS OF POWER DETECTOR.

A power detector uses a high resistance cathode resistor.

A high sensitivity meter such as the Model 221 is essential to obtain a reading of the bias voltage on such a tube.

6. MODEL 221 AS A CONDENSER TESTER.

a. Condensers can be roughly tested for shorts and leakage with the Model 221, using the 20 megohm range. A shorted condenser will cause a large deflection of the pointer of the ohmmeter and a condenser with high leakage will show a partial deflection of the pointer.

Any condenser, other than electrolytic, will normally cause a slight deflection of the pointer until the condenser becomes charged, when the pointer will return to zero. If the initial deflection is not present, it probably indicates an open lead. The resistance of a good paper condenser should be above 50 megohms per microfarad and that of mica condensers--above 100 megohms per microfarad. This resistance varies inversely according to the size of the condenser, and is so high that it will not register on the ohmmeter.

When testing electrolytic condensers with the ohmmeter, the positive jack should be connected to the positive terminal of the condenser. Otherwise the reading will be too high because of the high leakage in the reverse polarity. After connecting the test leads to the condenser, allow sufficient time for the pointer to reach its maximum resistance reading.

In general, a high grade, high voltage electrolytic condenser should read about .5 megohm or above and a low voltage electrolytic by-pass should read above .1 megohm. A more accurate test is to apply the rated polarizing D. C. voltage to the condenser with a milliammeter in series. It should read about 0.1 ma. per mfd., the maximum for a useful unit being about 0.5 ma. per mfd. New electrolytics that have been idle for considerable time may show high leakage but after "aging" at their rated voltages for a few minutes will return to normal.

b. A rough test of comparative capacity of PAPER condensers can be made with the Model 221 by connecting it as shown in Figure 11. The larger the unknown condenser being tested, the smaller its reactance and therefore the higher the reading will be on the A.C. voltmeter.

The chart shows the approximate readings that will be obtained when testing condensers from .001 mf. to 1.0 mf.

CAUTION: Before connecting an unknown condenser for test, place the range selector switch of the Model 221 in the 250 volt A.C. position. Connect the condenser and if it is shorted, the meter will read line voltage which would damage the meter if it were in the 10 v. position.

Do not try to test electrolytic condensers in this way as only D. C. can be applied to them.

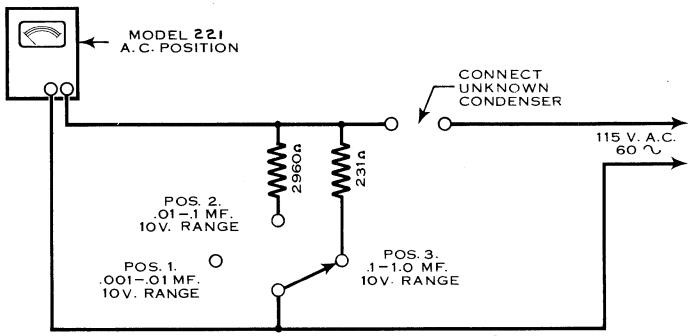

Figure 11 Model 221 Used as Condenser Tester

UNKNOWN CONDENSER MF.	METER RANGE	APPROXIMATE READING A.C. VOLTS	
.001	10V. A.C.	.6	
.002	" "	1.1	
.003	" "	1.5	
.004	" "	1.9	
.005	" "	2.5	Pos. 1
.006	" "	3.0	Figure 11
.007	" "	3.6	
.008	" "	4.0	
.009	" "	4.4	
.01	" "	4.8	

.01	10V. A.C.	1	
.02	" "	2	
.03	" "	3	
.04	" "	4	
.05	" "	5	Pos. 2
.06	" "	6	Figure 11
.07	" "	7	
.08	" "	8	
.09	" "	9	
.1	" "	10	

.1	10V. A.C.	1	
.2	" "	2	
.3	" "	3	
.4	" "	4	
.5	" "	5	Pos. 3
.6	" "	6	Figure 11
.7	" "	7	
.8	" "	8	
.9	" "	9	
1.0	" "	10	

SECTION VI

SUPPLEMENTARY DATA

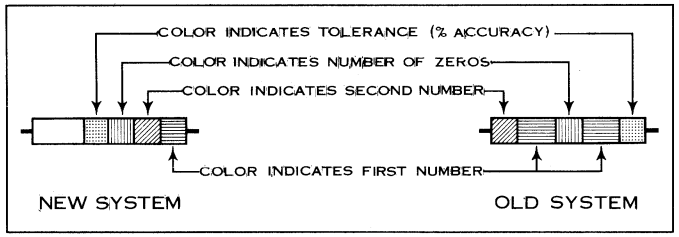

Figure 12 RMA Resistor Color Code Chart

1. RMA RESISTOR COLOR CODE CHART.

COLOR	NUMBER	COLOR	NUMBER
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Gray	8
Yellow	4	White	9

Gold (green--old system) .... 5% tolerance
Silver (blue--old system).... 10% tolerance
None ..... 20% tolerance (Standard)

EXAMPLE: A 50,000 ohm resistor of standard tolerance is indicated by a green ring (5), a black ring (0) and an orange ring (000) as shown in the new system of marking in Figure 12. In the old system of marking, at the right of Figure 12, the resistor would be painted green (5) with a black end (0) and an orange dot or ring in the center (000).

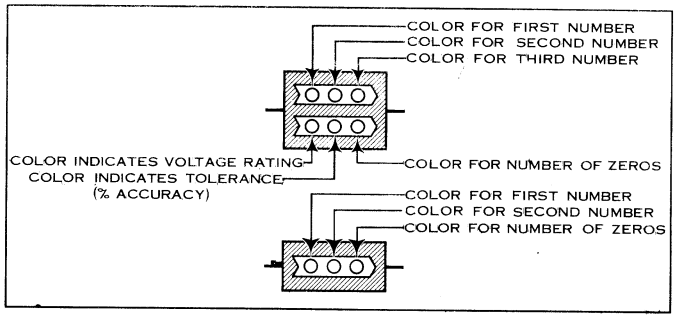

Figure 13 RMA Mica Capacitor Color Code Chart

2. RMA MICA CAPACITOR COLOR CODE CHART.

COLOR	NUMBER	TOLERANCE	VOLTAGE RATING
Black	0		—
Brown	1	1%	100
Red	2	2%	200
Orange	3	3%	300
Yellow	4	4%	400
Green	5	5%	500
Blue	6	6%	600
Violet	7	7%	700
Gray	8	8%	800
White	9	9%	900
Gold		5%	1000
Silver		10%	2000
None		20%	500

EXAMPLE: A 56,300 MMF (0.0563 MF.) capacitor of 10% tolerance and a 500 volt rating is indicated by a green dot (5), a blue dot (6), and an orange dot (3), on the top row; a red dot (2 zeros) (00), a silver dot (10% tolerance) and a green dot (or no color) (500 volts) arranged in the order shown in Figure 13. All capacitance values are given in micro-microfarads (MMF). To convert to microfarads (MF.) move the decimal point 6 places to the left. Small capacitors are often marked with 3 dots as shown in Figure 13. For example, a 250 MMF. unit (.000250 MF.) would be marked red (2), green (5), and brown (1 zero) (0).

The RMA Condenser marking code is in wide use, although there will be some cases where other codes will be found.

3. DECIBELS ABOVE AND BELOW REFERENCE LEVEL EXPRESSED IN WATTS AND VOLTS.

Reference level 6 milliwatts into 500 ohms

Note that the power in watts holds for any impedance, but the voltage holds only for 500 ohms.

DB. DOWN VOLTS	WATTS	POWER LEVEL —	+ VOLTS	DB. UP
1.73	6.00×10^{-3}	0	1.73	.00600
1.54	4.77×10^{-3}	1	1.94	.00755
1.38	3.87×10^{-3}	2	2.18	.00951
1.23	3.01×10^{-3}	3	2.45	.0120
1.09	2.39×10^{-3}	4	2.75	.0151
.974	1.90×10^{-3}	5	3.08	.0190
.868	1.51×10^{-3}	6	3.46	.0239
.774	1.20×10^{-3}	7	3.88	.0301
.690	9.51×10^{-4}	8	4.35	.0387
.615	7.55×10^{-4}	9	4.88	.0477
.548	6.00×10^{-4}	10	5.48	.0600
.488	4.77×10^{-4}	11	6.15	.0755
.435	3.87×10^{-4}	12	6.90	.0951
.388	3.01×10^{-4}	13	7.74	.120
.346	2.39×10^{-4}	14	8.68	.151
.308	1.90×10^{-4}	15	9.74	.190
.275	1.51×10^{-4}	16	10.93	.239
.245	1.20×10^{-4}	17	12.26	.301
.218	9.51×10^{-5}	18	13.76	.387
.194	7.55×10^{-5}	19	15.44	.477
.173	6.00×10^{-5}	20	17.32	.600
.0974	1.90×10^{-5}	25	30.8	1.90
.0548	6.00×10^{-6}	30	54.8	6.00
.0308	1.90×10^{-6}	35	97.4	19.0
.0173	6.00×10^{-7}	40	173	60.0
.00974	1.90×10^{-7}	45	308	190
.00548	6.00×10^{-8}	50	548	600
.00173	6.00×10^{-9}	60	1,730	6,000
.000548	6.00×10^{-10}	70	5,480	60,000
.000173	6.00×10^{-11}	80	17,300	600,000

4. CAPACITATIVE REACTANCES (Correct to three significant figures.)

a. AUDIO FREQUENCIES

Formula: $Xc = \frac{1}{2\pi fc}$

Capacitance Microfarads	Reactance in ohms at: 30 c/s	60 c/s	100 c/s	400 c/s	1000 c/s	5000 c/s
.00005	---	---	---	---	---	637,000
.0001	---	---	---	---	1,590,000	318,000
.00025	---	---	---	1,590,000	637,000	127,000
.0005	---	---	3,180,000	796,000	318,000	63,700
.001	---	2,650,000	1,590,000	398,000	159,000	31,800
.005	1,060,000	530,834	318,000	79,600	31,800	6,370
.01	531,000	265,000	159,000	39,800	15,900	3,180
.02	263,000	132,500	79,600	19,900	7,960	1,590
.05	106,000	53,083	31,800	7,960	3,180	637
.1	53,100	26,500	15,900	3,980	1,590	318
.25	21,200	10,584	6,370	1,590	637	127
.5	10,600	5,308	3,180	796	318	63.7
1	5,310	2,650	1,590	389	159	31.8
2	2,650	1,325	796	199	79.6	15.9
4	1,310	663	398	99.5	39.8	7.96
8	663	332	199	49.7	19.9	3.98
16	332	166	99.5	24.9	9.95	1.99
25	212	106	63.7	15.9	6.37	1.27
35	152	86	45.5	11.4	4.55	.910

b. RADIO FREQUENCIES

Formula: $Xc = \frac{1}{2\pi fc}$

Capacitance Microfarads	Reactance in ohms at: 175 Kc/s	252 Kc/s	465 Kc/s	550 Kc/s	1000 Kc/s	1,500 Kc/s
.00005	18,200	12,600	6,850	5,800	3,180	2,120
.0001	9,100	6,320	3,420	2,900	1,590	1,060
.00025	3,640	2,530	1,370	1,160	637	424
.0005	1,820	1,260	685	579	318	212
.001	910	632	342	290	159	106
.005	182	126	68.5	57.9	31.8	21.2
.01	91.0	63.2	34.2	28.9	15.9	10.6
.02	45.5	31.6	17.1	14.5	7.96	5.31
.05	18.2	12.6	6.85	4.79	3.18	2.12
.1	9.10	6.32	3.42	2.89	1.59	1.06
.25	3.64	2.53	1.37	1.16	.637	.424
.5	1.82	1.26	.685	.579	.318	.212
1	.910	.632	.342	.289	.159	.106
2	.455	.316	.171	.145	.0796	.0531
4	.227	.158	.0856	.0723	.0398	.0265

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