Simpson

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

MODEL 215
VOLT-OHM-MILLIAMMETER

SIMPSON ELECTRIC COMPANY

5200-18 West Kinzie Street, Chicago 44, Illinois

In Canada, Bach-Simpson, Ltd., London, Ontario

#3

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Figure 1 Simpson Model 215 Volt-Ohm-Milliammeter

Size: 5½"x7"x3¼". Weight 3¼ lbs.

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Foreword

As the purchaser of a Simpson 215 you are now the owner of one of the most famous testing instruments in the world. Compact, of relatively high sensitivity (200 microamperes full scale), the Model 215 has earned its top-ranking reputation as the result of quality construction joined to exceptional engineering versatility. This engineering superiority is, in turn, the product of invaluable years of experience with every single unit comprising the complete assembly.

In no other instrument of its kind do you find features such as are contained in the Simpson Model 215. Its trim, scientific appearance — the 4½" modernistic instrument, the heavy bakelite case, the neat bakelite panel — gives 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. All the sub-assemblies are mounted on specially designed bakelite panels, or on a specially designed sub-panel, made and engineered expressly for a specific function in the Model 215.

When you purchase Simpson test equipment, you get equipment made almost entirely within the various plants of our Company. Each component part of the 215 has been designed and completely tooled and manufactured in our own plants, with the exception of the precision resistors and one or two other functionally least important parts. The Model 215, 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 215 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 215.

The Model 215 is a rugged instrument and will withstand a great deal of abuse. We urge you, however, to treat it with care as its 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 215 will give you a lifetime of accurate, dependable service.

OPERATOR'S MANUAL

SIMPSON MODEL 215 VOLT-OHM-MILLIAMMETER

SECTION I

GENERAL DESCRIPTION

1. GENERAL INTRODUCTION.

The Simpson Model 215 Test Unit offers a small, compact and complete instrument with high sensitivity for testing and locating trouble in all types of circuits. The large four and one-half inch meter provides a long scale that is easy to read and the compact arrangement of the controls allows the overall size of the bakelite housing to be comparatively small for maximum portability.

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

The electrical circuit is designed to give maximum insurance against inaccuracy and damage to the component parts. Impregnated cable wiring is used throughout. All resistors are made to close tolerances for accuracy and are firmly held in place on a special bakelite plate machined 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
0-10 volts
0-50 volts
0-250 volts
0-1000 volts
0-5000 VOLTS

} 20,000 ~~5,000~~ ohms per volt sensitivity

b. A. C. VOLTAGE.

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

c. A. F. OUTPUT VOLTAGE.

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

d. VOLUME LEVEL IN DECIBELS.

—12 to + 3 decibels	Calibrated for use across a 500 ohm line
0 to +15 decibels	
+14 to +29 decibels	
+28 to +43 decibels	
+40 to +55 decibels	

e. D. C. RESISTANCE.

~~0-4000~~ ohms	(~~30~~ ohms center)
~~0-400,000~~ ohms	(~~3000~~ ohms center)
~~0-4~~ megohms	(~~30,000~~ ohms center)

f. CURRENT IN D. C. CIRCUITS.

~~250~~ microamperes	~~200~~ millivolts
10 milliamperes	~~980 millivolts~~
100 milliamperes	~~998 millivolts~~
500 milliamperes	~~999.6 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 ~~200~~ microamperes at ~~200~~ millivolts with an internal resistance of 1,000 ohms, giving the instrument an overall sensitivity of ~~5,000~~ ohms per volt.

4. A. C. VOLTAGE MEASUREMENTS.

A. C. voltage measurements, including output and decibel readings, 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. Place the "OUTPUT-A.C.-D.C." switch in the "D.C." position.

b. Rotate the range selector switch to any one of the voltage positions required. **WHEN IN DOUBT OF THE VOLT-**

AGE PRESENT, ALWAYS USE THE HIGHEST RANGE AS A PROTECTION TO THE METER. After the first reading, the switch can be reset to a lower range, if needed, to get a more accurate reading.

c. Plug the black test lead into the jack marked "—" 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.

d. 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.

e. Read the voltage on the black arc second from the top marked "D.C."

For the 2.5 volt range use the 0-250 figures and divide by 100.

For the 10, 15 and 250 volt ranges, read the figures directly.

For the 1000 volt range, use the 0-10 figures and multiply by 100.

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

a. Place the "OUTPUT-A.C.-D.C." switch in the "A.C." position.

b. 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 reset to a lower range for a more accurate reading.

c. Plug the black test lead into the jack marked "—" 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.

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

e. For the 2.5 volt range, read the voltage on the red arc second from the bottom marked "2.5 V. A.C. Only."

For the other ranges use the red arc third from the bottom marked "A.C."

For the 10, 50 and 250 volt ranges, read the figures directly.

For the 1000 volt range read the 0-10 figures and multiply by 100.

3. A. F. OUTPUT MEASUREMENTS.

a. Place the "OUTPUT-A.C.-D.C." switch in the "OUTPUT" position. 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.

b. 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 reset to a lower range for a more accurate reading.

c. Plug the black test lead into the jack marked "—" and the red test lead into the jack marked "+". Clip the other ends of the test leads to the output of the circuit under test.

d. Turn on the power.

e. For the 2.5 volt range use the red arc second from bottom marked "2.5 V. A.C. only".

For the other ranges, use the red arc third from the bottom marked "A.C."

For the 10, 50 and 250 volt ranges, read the figures directly.

For the 1000 volt range, use the 0-10 figures and multiply by 100.

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.

4. VOLUME LEVEL MEASUREMENTS.

a. Set the "OUTPUT-A.C.-D-C." switch in the "A.C." position.

b. Rotate the range selector switch to any of the five ranges required.

c. Plug the test leads into the two jacks marked "—" and "+"

and connect the clips to the two sides of the circuit to be checked.

d. Turn on the power and read decibels on the black arc at the bottom of the scale marked "D.B." When reading decibels, add algebraically to the scale indications, the numbers shown at setting of range selector switch. For example, if the scale indication is —4 DB with the switch in the 12 DB position, the true reading will be + 8DB. (+12—4=+8).

5. 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. Place the "OUTPUT-A.C.-D.C." switch in the "D.C." position.

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

Rx1 for 0—4000 ohms.

Rx100 for 0—400,000 ohms.

Rx1,000 for 0—4 megohms.

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

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

e. Read ohms on the black arc at the top of the scale.

For range Rx1, read the figures directly.

For range Rx100, multiply the reading indicated by 100 or add two zeros.

For range Rx1,000 multiply the reading indicated by 1,000 or add three zeros.

Example: A ½ megohm resistor should be checked on the Rx1,000 range. The reading on the scale will be 500. Adding three zeros will give 500,000 ohms or ½ meghom.

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.

6. CURRENT MEASUREMENTS IN D.C. CIRCUITS.

a. Place the "OUTPUT-A.C.-D.C." switch in the "D.C." position.

b. 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 reset to a lower range if needed.

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

d. 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.

e. Turn on the power.

f. Read milliamperes on the black arc second from the top. 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.

For 250 microamperes, read the figures 0-250 directly.

For 10 milliamperes read the figures directly.

For 100 milliamperes read the figures 0-10 and multiply by 10.

For 500 milliamperes read the figures 0-50 and multiply by 10.

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 215 volt-ohm milliammeter is shown in Figure 9. The simplified sections are described in the followng paragraphs.

1. D. C. VOLTMETER CIRCUIT—5,000 OHMS PER VOLT.

Figure 2 shows the circuit used when the "OUTPUT-A.C.-D.C." switch is in the "D.C." position and the range selector switch is in one of the five voltage positions.

The total resistance of the bank of multiplier resistors and the meter is 5 megohms or 5,000,000 ohms from the 1,000 V. position to the "NEG." jack. Ohms law will show that when a 1,000 volt potential is applied between the two jacks, a current of 200 microamperes will flow through the circuit, causing a full scale deflection of the meter. Dividing the number of ohms, 5,000,000, by the number of volts, 1,000, gives 5,000 ohms which is the sensitivity per volt.

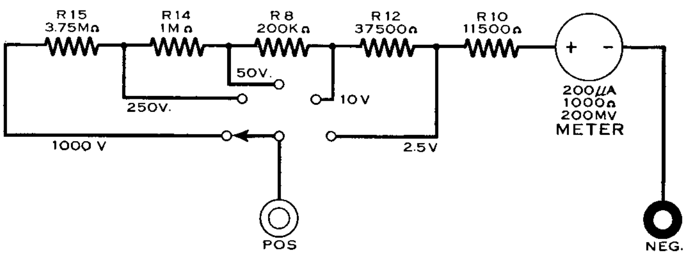


Figure 2 Simplified D.C. Voltmeter Circuit

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

Figure 3 shows the circuit used when the "OUTPUT-A.C.-D.C." switch is in the "A.C." position and 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-24 and the series resistor R-23 are precision wound and calibrated with the rectifier with which they are used. The resulting sensitivity is 1000 ohms per volt.

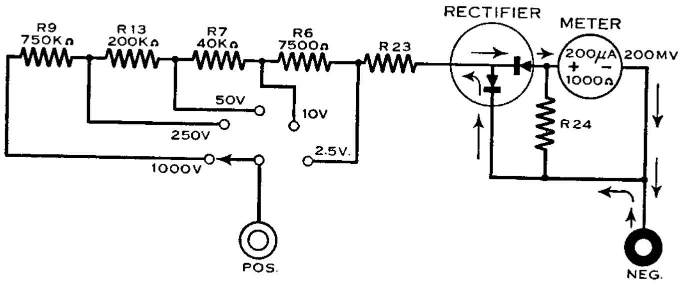


Figure 3 Simplified A.C. Voltmeter Circuit

3. A.F. OUTPUT METER.

Figure 4 shows the circuit used when the "OUTPUT-A.C.-D.C." switch is in the "OUTPUT" position and the range selector switch is in one of the five voltage ranges. This is the same as the A.C. voltmeter except that 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 cinsideration. 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.

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.

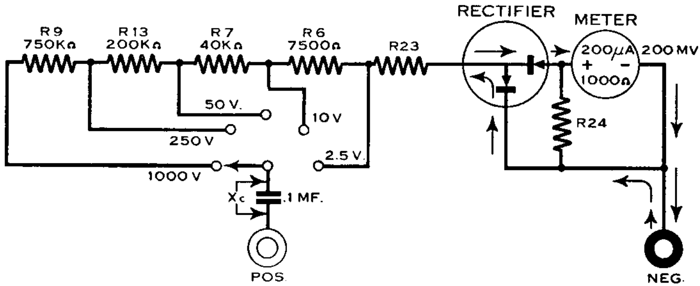


Figure 4 Simplified Output Meter Circuit

4. VOLUME LEVEL METER.

The decibel is a unit of measurement used in P.A. and telephone work. When a .006 watt signal is dissipated in a load of 500 ohms, a potential of 1.73 volts is developed across the load and it is at this point that the zero is placed on the decibel scale. Thus it can be seen that the decibel meter is the same as the A.C. voltmeter with a scale calibrated with the voltage terminated in a 500 ohm load.

The output meter is more commonly used in radio service work for comparative readings but if desired, A. C. Volts can be converted into decibels by means of a conversion chart. Refer to Section V—Supplementary Data.

5. D.C. OHMMETER.

Figures 5, 6 and 7 show the ohmmeter circuits when the range selector switch is in positions Rx1, Rx100 and Rx1,000 respec-

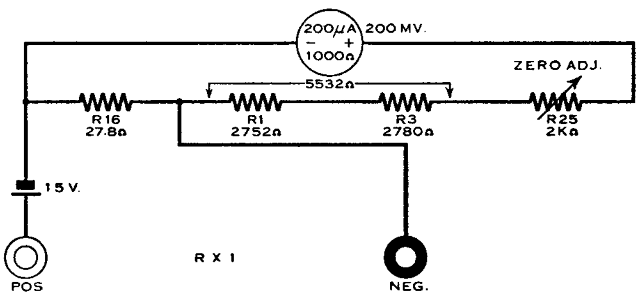


Figure 5 Ohmmeter Circuit with Selector Switch in Position Rx1

tively. This switch throws in the proper series and shunt resistors and batteries for each range so that when the test leads are shorted, the meter will read full scale.

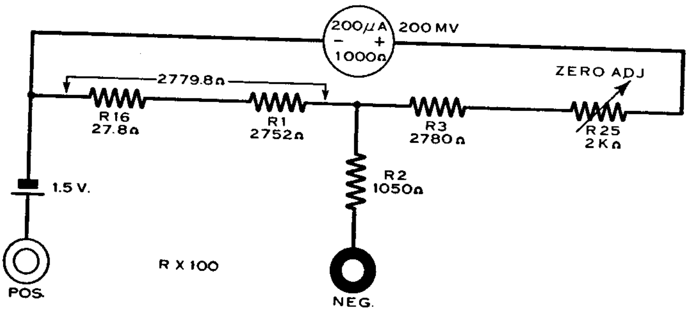


Figure 6 Ohmmeter Circuit with Selector Switch in Position Rx100

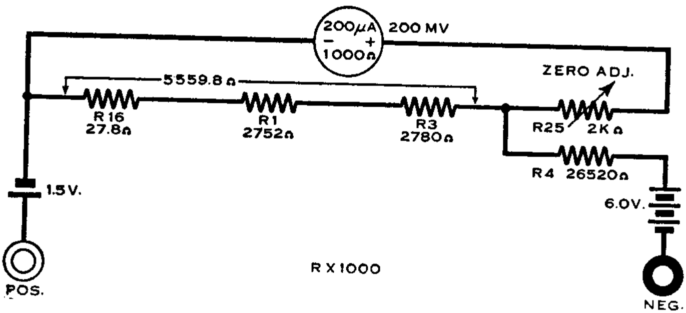


Figure 7 Ohmmeter Circuit with Selector Switch in Position Rx1,000

6. D.C. MILLIAMMETER AND AMMETER.

Figure 8a shows the circuit used when the "OUTPUT-A.C.-D.C." switch is in the "D.C." position and the range selector switch is in the 250 microampere position. The shunt resistors R5, R18, R19 and R17 are of such value that 50 micro-

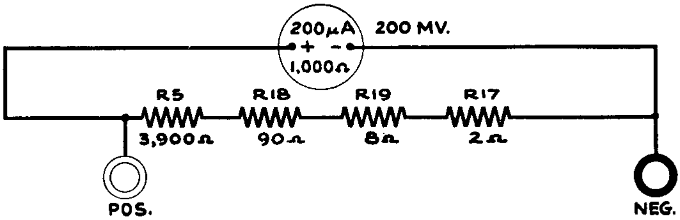


Figure 8a Simplified Microammeter Circuit—250 microampere range

amperes flow through them and 200 microamperes flow through the meter for full scale deflection.

Figure 8b shows the circuit used when the "OUTPUT-A.C.-D.C." switch is in the "D.C." position and 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 200 microamperes for full scale deflection. The voltage drop appearing across the various ranges is shown opposite the current ranges on page 8.

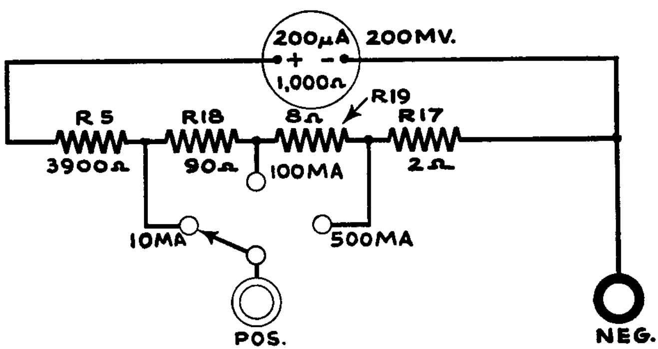


Figure 8b Simplified Milliammeter Circuit

SECTION IV

MAINTENANCE

1. The Model 215 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 of the case to provide current for the resistance measuring ranges.

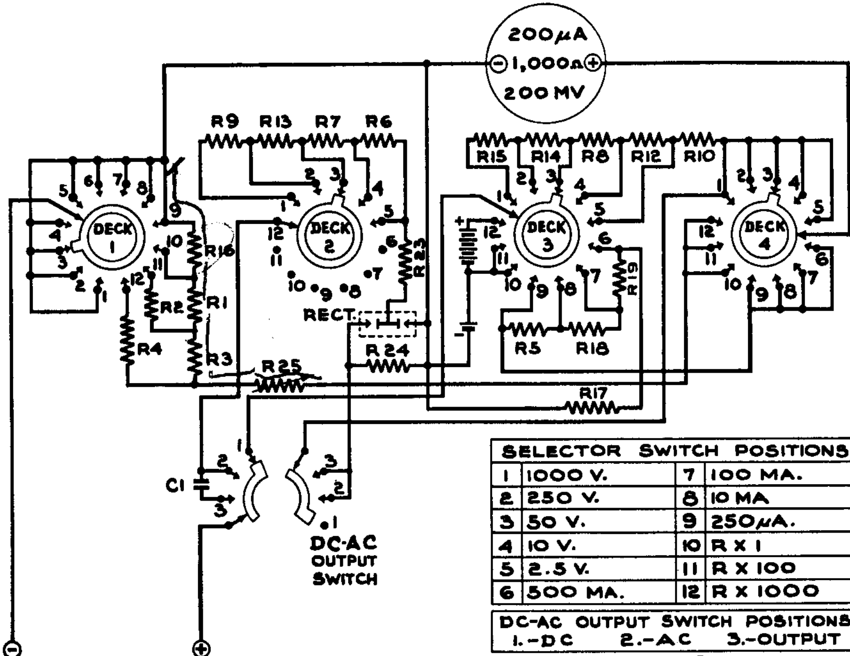
These are:

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.
or equivalent	
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 RX1 and RX100 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 RX1,000 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 four screws from the bottom of the case. Slide the bakelite battery retainers out and 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.



SELECTOR SWITCH POSITIONS			
1	1000 V.	7	100 MA.
2	250 V.	8	10 MA
3	50 V.	9	250µA.
4	10 V.	10	R X 1
5	2.5 V.	11	R X 100
6	500 MA.	12	R X 1000

DC-AC OUTPUT SWITCH POSITIONS
1.-DC 2.-AC 3.-OUTPUT

SWITCHES SHOWN IN 50 VDC POSITION

R1	2752Ω
R2	1050Ω
R3	2780Ω
R4	26520Ω
R5	3900Ω
R6	7500Ω
R7	40 KΩ
R8	200 KΩ
R9	750 KΩ
R10	11500Ω
R12	37500Ω
R13	200 KΩ
R14	1 MΩ
R15	3.75 MΩ
R16	27.8Ω
R17	2Ω
R18	90Ω
R19	8Ω
R23	RECT. SERIES CALIBRATED
R24	RECT. SHUNT CALIBRATED
R25	2 KΩ POT.
C1	.1 MFD 600 V.

Figure 9 Model 215 Schematic Diagram

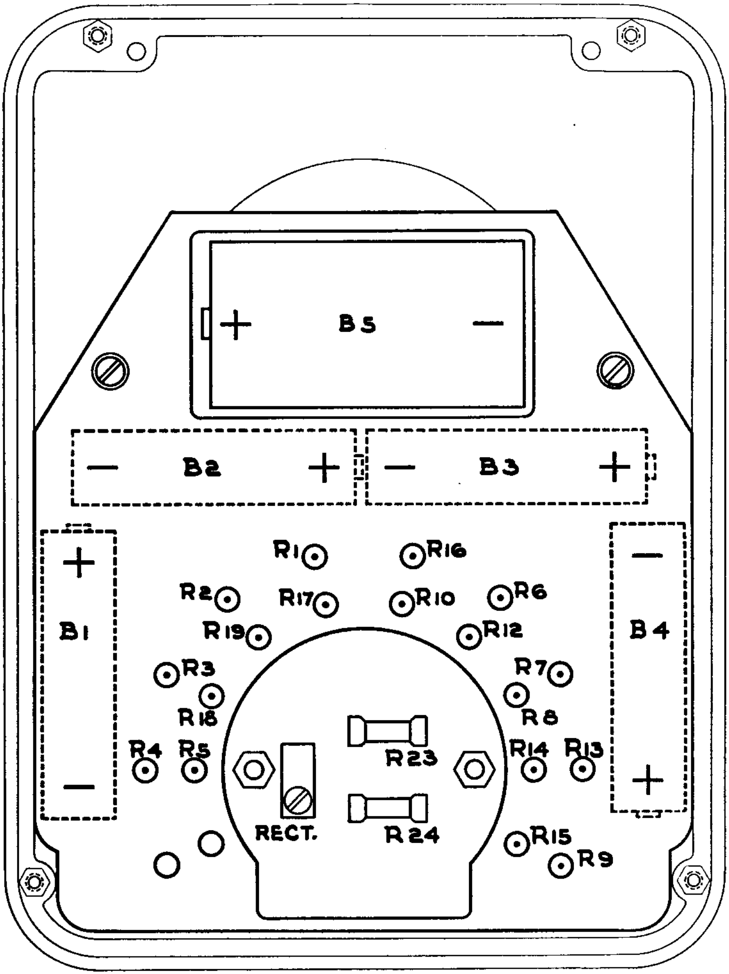


Figure 10a Model 215 Parts Layout—Rear View

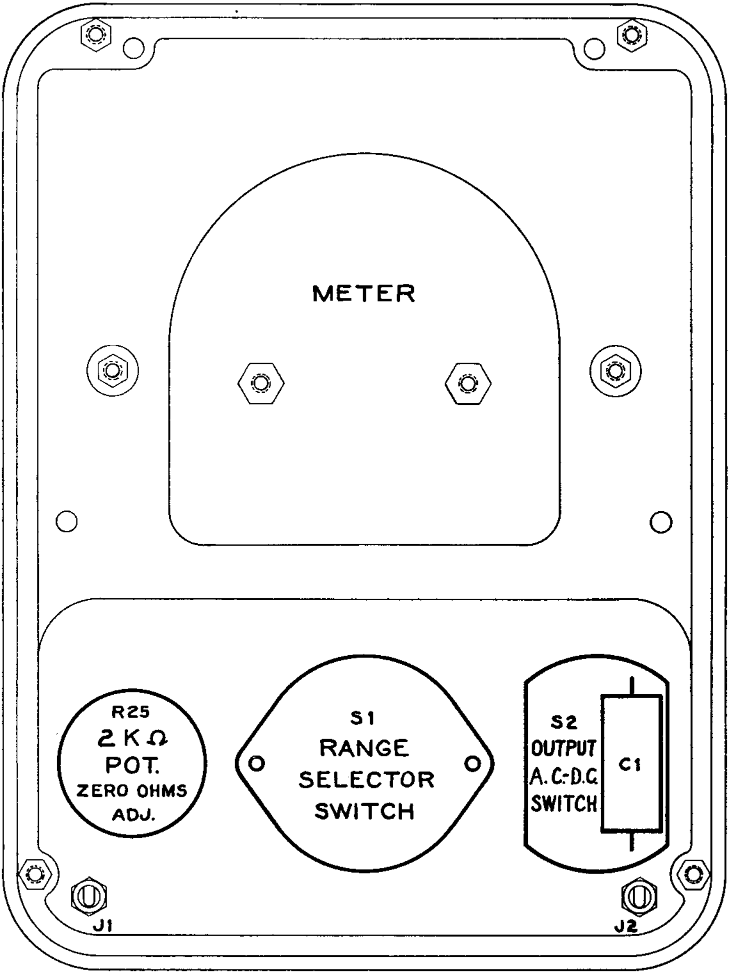


Figure 10b Model 215 Parts Layout—Rear View of Front Panel

4. PARTS LIST.

PART No.	DESCRIPTION	REFERENCE SYMBOL
1-113397	Fixed resistor, 2752 ohms	R1
1-113398	Fixed resistor, 1050 ohms	R2
1-113396	Fixed resistor, 2780 ohms	R3
1-113394	Fixed resistor, 26520 ohms	R4
1-113395	Fixed resistor, 3900 ohms	R5
1-113370	Fixed resistor, 7500 ohms	R6
1-113309	Fixed resistor, 40,000 ohms	R7
1-113365	Fixed resistor, 200,000 ohms	R8, R13
1-113364	Fixed resistor, 375,000 ohms (2 in series)	R9
1-113404	Fixed resistor, 11,500 ohms	R10
1-113393	Fixed resistor, 37,500 ohms	R12
1-113392	Fixed resistor, 1 megohm	R14
1-113391	Fixed resistor, 1.875 megohm (2 in series)	R15
0-008081	Fixed resistor, 27.8 ohms (bobbin)	R16
0-008059	Fixed resistor, 2 ohms (bobbin)	R17
0-008087	Fixed resistor, 90 ohms (bobbin)	R18
0-008066	Fixed resistor, 8 ohms (bobbin)	R19
0-008586	Copper oxide rectifier, Series resistor, Shunt resistor — calibrated together	Rect., R23, R24
1-113399	Potentiometer, 2000 ohms	R25
1-111679	Fixed condenser 0.1 MF, 600V paper	C1
1-113266	Range selector switch, 4 deck, 12 position	S1
1-111891	Output-AC-DC switch, 3 position	S2
1-111728	Jack, pin type (2)	J1 - J2
1-111802	Dry cell 1.5V (4) (Eveready 915 or equivalent)	B1 - B4
1-111798	Dry cell 1.5V (1) (Eveready 950 or equivalent)	B5
3-310308	Knob, zero ohms	
3-310307	Knob, output-AC-DC switch (pointer)	
15-302215	Meter—Simpson Model 29, 200 microamperes, 1000 ohms, 200 MV	
0-006190	Bakelite case with handle	
1-113283	Carrying handle (leather)	
0-008375	Test lead set	

Note—When ordering parts, specify serial number appearing on the bottom of the front panel of the Model 215.

SECTION V

SUPPLEMENTARY DATA

1. MODEL 215 AS A CONDENSER TESTER.

a. Condensers can be roughly tested for shorts and leakage with the Model 215, using the Rx1,000 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 215 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 215 in the 250 V. 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.

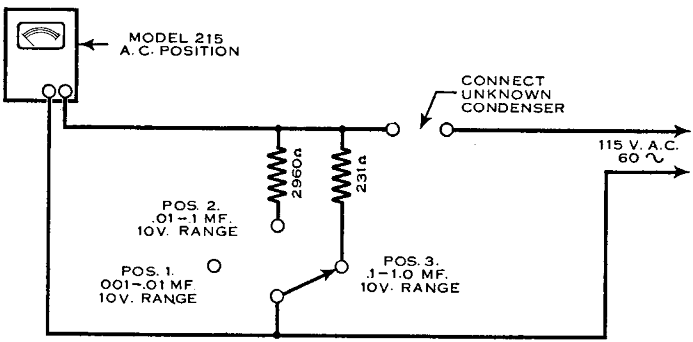


Figure 11 Model 215 Used as Condenser Tester

UNKNOWN CONDENSER MF.	METER RANGE	APPROXIMATE READING A.C. VOLTS	
.001	10 V. 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	10 V. A.C.	1	
.02	" "	2	
.03	" "	3	
.04	" "	4	Pos. 2
.05	" "	5	Figure 11
.06	" "	6	
.07	" "	7	
.08	" "	8	
.09	" "	9	
.1	" "	10	
.1	10 V. 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	

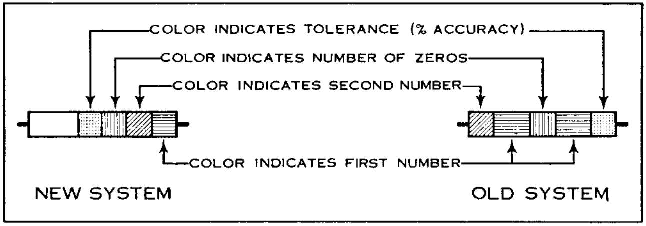


Figure 12 RMA Resistor Color Code Chart

2. 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).

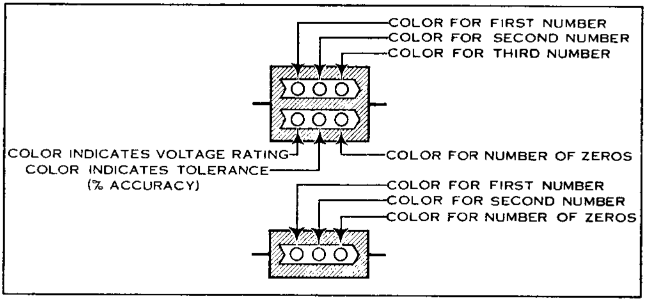


Figure 13 RMA Mica Capacitor Color Code Chart

3. 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 micromicrofarads (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.

4. 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		POWER LEVEL	DB. UP	
VOLTS	WATTS	— +	VOLTS	WATTS
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

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

a. AUDIO FREQUENCIES

$$\text{Formula: } Xc = \frac{1}{2\pi f c}$$

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

$$\text{Formula: } Xc = \frac{1}{2\pi f c}$$

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