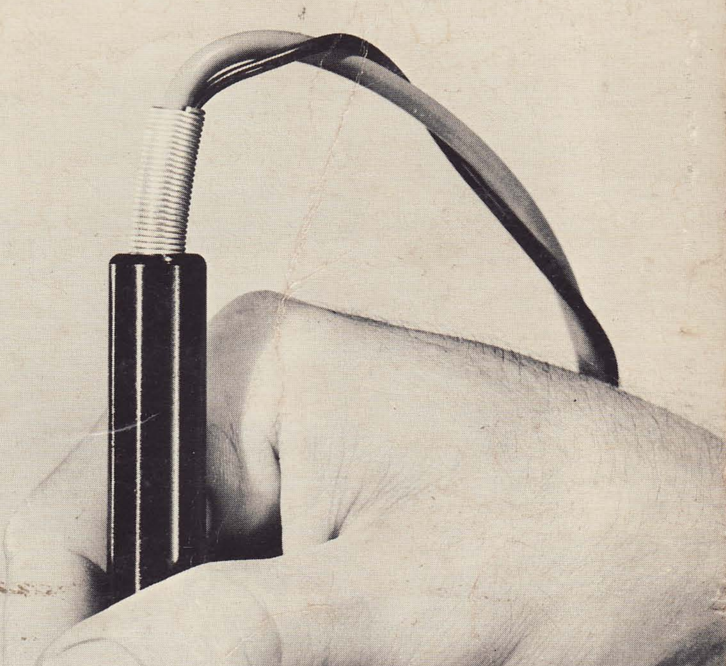
basic radio repair

MARVIN TEPPER



VOL. 1

TEST INSTRUMENTS

COMPONENTS

SERVICING PROCEDURES

SERVICING:

- Superheterodyne Receivers
- Portable Receivers
- Automobile Receivers

RIDER

Basic Radio Repair

VOL. 1

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PREFACE

Knowledge of radio receiver and transmitter circuits is one part of the job. An equally important part is to be able to apply this knowledge to the maintenance and repair of defective receivers or transmitters.

These books are a logical extension of *Basic Radio*, and are presented in a manner calculated to best instill a common-sense approach to servicing. Too often the author has observed good knowledge of circuits being wasted by a complete lack of an approach, or a poor approach to circuit trouble-shooting and repair.

The context of these books reflects an application of practical servicing procedures. The approach is to illustrate by a combination of words and pertinent artwork, as close an approximation as possible of repair techniques as they would actually be done on a workbench.

Starting as a single volume, it soon became apparent that there was more to say than could be covered in a single book. Rather than weaken its value the contents were expanded and placed in two volumes, allowing coverage of all phases of radio receiver and transmitter servicing.

The contents are carefully laid out. Beginning with an exhaustive discussion of the test equipment used in servicing, it goes into a complete discourse on significant aspects of different components. The next section thoroughly covers a most important subject, servicing procedures. No one servicing technique is favored—all are covered equally. The approach to superheterodyne receiver servicing was carefully set up to closely approximate the approach taken when actually serving a receiver. Servicing of each circuit is taken in the order most likely to be followed during actual receiver repairs. This also holds true for the chapters on portable, automobile, and FM receivers.

It was felt that to try and combine discussions of equivalent tube and transistor circuits side by side would be confusing. Accordingly a completely separate discussion is used on transistor receivers, allowing full concentration on servicing procedures peculiar to these receivers.

The final section, transmitter servicing, covers a neglected area. Previously very little has been written on this subject. The approach and coverage has been unstinting, covering all types of circuits, including FM and single sideband.

Those of you with extracurricular work activities will appreciate the long-enduring patience of my wife Celia, and my daughters Ruth and Shirley, who waited for me to compile and write these books, and then finally to rejoin the family.

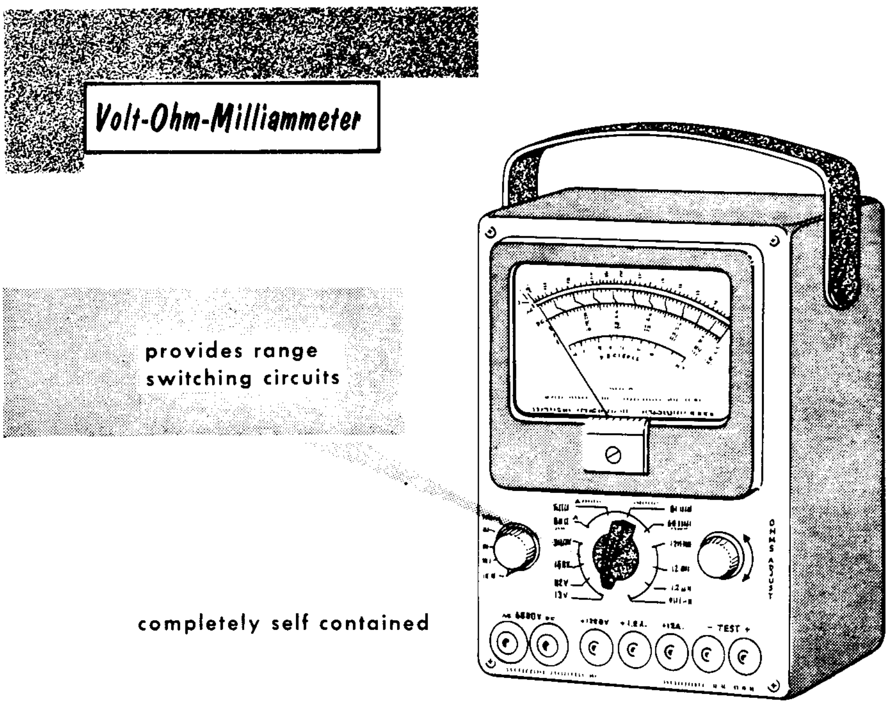
MARVIN TEPPER

Milton, Mass.
June 1963

Contents — Volume One

Volt-Ohm-Milliammeter

Later on in this book various techniques for rapid servicing of a defective radio will be discussed. One thing, however, is common to all these techniques — a method of measuring the values of resistance, voltage, and current. Individual meters, properly arranged with the correct values of multipliers or shunts, can be used to read those values. An assortment of individual meters would be a costly and clumsy method of servicing a radio receiver. The obvious answer is a combination of multipliers and shunts placed in a switching circuit with a single, basic meter movement. Those combination circuits are called multimeters, and in the case of the most commonly used type, they are called a Volt-Ohm-Milliameter, or VOM. The type of multimeter using vacuum tube circuits is called a Vacuum Tube Voltmeter, or VTVM. A VTVM is also capable of reading resistance by measuring a small value of voltage across the unknown resistor.

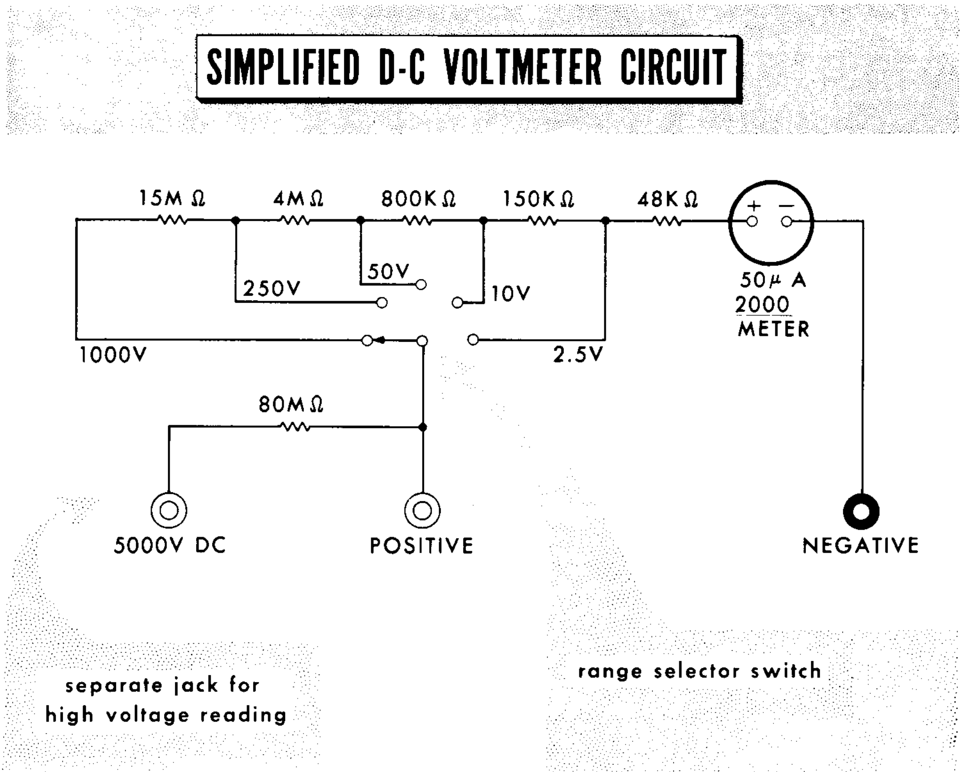


Discussing first the VOM, we find it to be one of the basic tools of servicing. It is convenient in that it is lightweight, portable, and completely self-contained, requiring no external source of power. It can measure voltage, resistance, and current. Switching circuits are required to provide the proper ranges for individual measurements. These circuits can be simplified and shown as individual circuits.

D-C Voltmeter Circuit

To simplify the discussion of the VOM, its individual circuits have been isolated and explained as though each were a single instrument using the same basic meter movement.

The basic d-c voltmeter circuit illustrated is a straightforward arrangement of multiplier resistors in series with the meter movement. The meter movement used in all circuits is a 50-microampere D'Arsonval type with a coil resistance of 2000 ohms. In order to read high voltages of 5000 volts, a separate jack terminal is provided on the bottom right-hand side of the meter panel. With the negative or common terminal on the bottom left-hand side, wide spacing between the input jacks is available, preventing possible arc-overs.



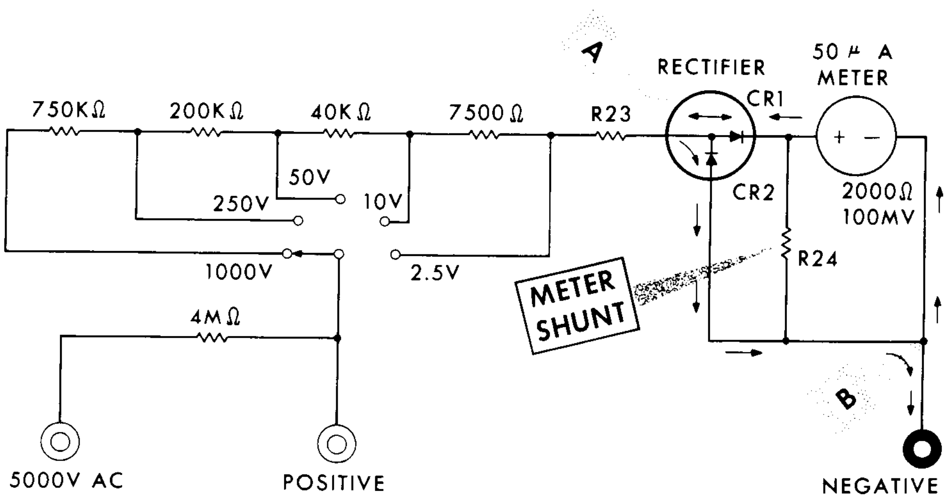
Courtesy of Simpson Electric Corporation

Although it is not noted on the switch positions, the meter will also read from 0 to 250 millivolts. The use of the meter to read this small a value requires *extreme care.* At this range it is easy to apply excessive voltage and damage the meter movement. To use the meter to read to 250 millivolts, it is set for a current reading of 100 microamperes. The 0-250 volt d-c scale is read directly in millivolts.

A-C Voltmeter Circuit

To read a-c volts a similar circuit to that of the d-c voltmeter is used with the addition of a rectifier circuit. Meter rectifier circuits are similar to other rectifier circuits previously discussed, but they have inherent problems that merit discussion. The most popular rectifier used is the copper oxide type. These consist of copper discs, each having a layer of copper oxide on one side. They are separated by lead washers and tightly clamped together. The symbol used for copper oxide rectifiers is the same as that used for crystal rectifiers — an arrow and bar, with the bar being the cathode. Copper oxide rectifiers are long-lived, but temperatures above 160°F will quickly shorten their life. The stray capacitance of the copper oxide rectifier restricts a-c measurements to the audio range of frequencies.

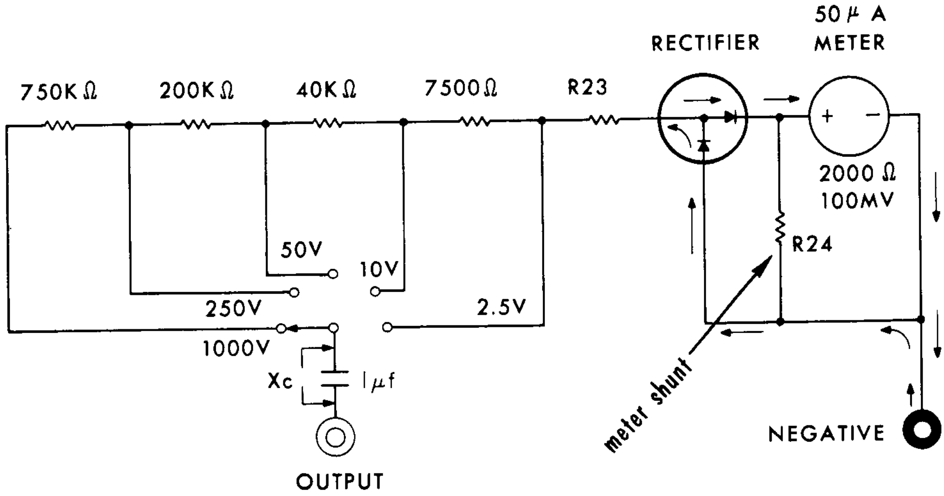
This rectifier circuit is a double section, half-wave rectifier circuit. During the first alternation, assume that point A is positive, and the electron flow is from point B, through the meter, through CR1 to point A. On the second alternation, the electron flow is from point A, through the low resistance of CR2 to point B. Diode CR2 prevents the possibility of any small reverse current flowing through CR1 and the meter. This small reverse current could cause the needle to deflect backwards. In addition the current flowing through CR2 removes the peak inverse voltage that would normally be applied between points A and B on the second alternation.



Simplified A-C Voltmeter Circuit

Courtesy of Simpson Electric Corporation

A-C Voltmeter Circuit (cont'd)



SIMPLIFIED OUTPUT METER CIRCUIT

Courtesy of Simpson Electric Corporation

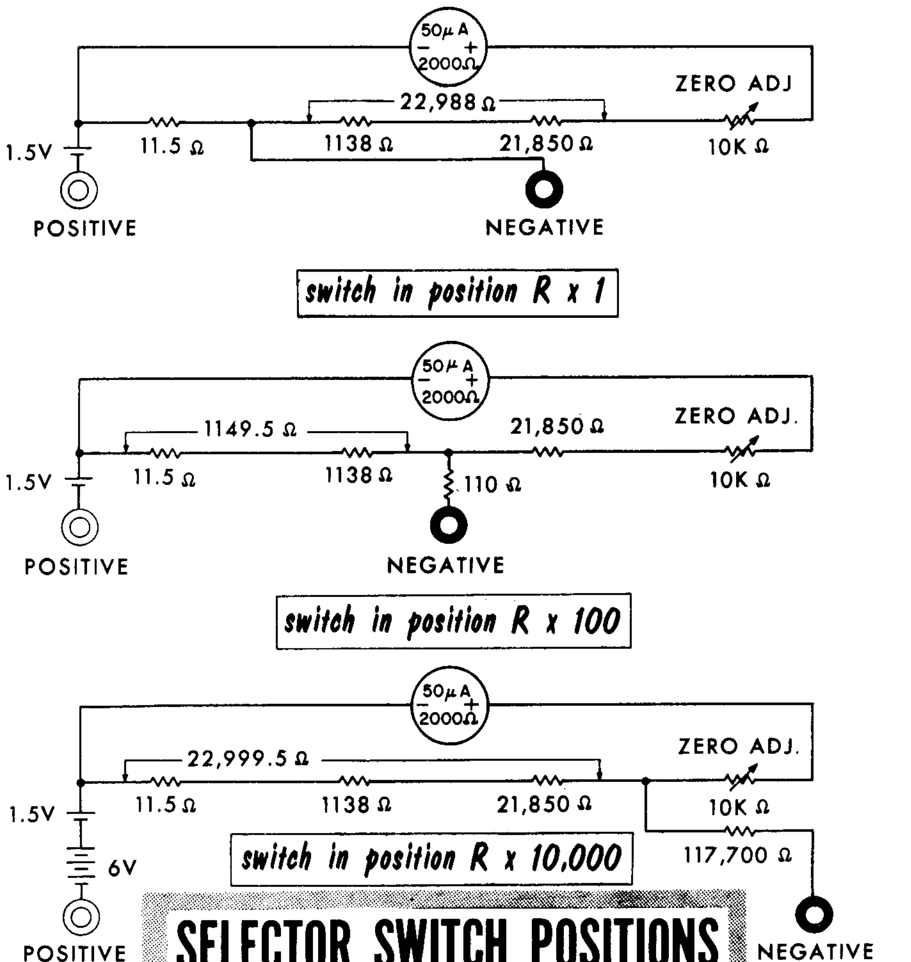
The resistance of a copper oxide rectifier varies with the value of current flowing through it, causing the meter readings to be crowded together at the lower ranges. Because of the rectifier resistance, the meter needle does not deflect as far as it would if dc had been applied. Reduced values of multiplier resistors are used to overcome this problem.

To overcome the crowding, or nonlinearity of the meter readings at lower values, a shunt is placed across the meter. When using a shunt with a 200-microampere movement, a typical value will be one-fourth of the meter resistance. This causes four times as much current to flow through the shunt as will flow through the meter. Full scale deflection now requires 1000 microamperes or 1 milliampere. Of this 800 microamperes flows through the shunt, 200 microamperes through the meter. Since it now takes 1 milliampere for full-scale deflection the sensitivity of the a-c voltmeter circuit is 1000 ohms per volt.

Where the a-c signal component is combined with a d-c voltage, such as at the plate of an amplifier tube, the a-c component can be isolated and read by use of a blocking capacitor. This feature is useful in reading the output of the audio circuits of a receiver during alignment. A blocking capacitor and a separate function switch position permits the use of the a-c voltmeter circuit as an output meter.

Ohmmeter Circuit

The two basic types of ohmmeter circuits are the shunt type and series type. The shunt type, excellent for use in reading low values of resistance, has a decided disadvantage in that the battery is always in use, and if left on by accident it quickly runs down. In the series type circuit, the scale becomes crowded on the left-hand side of the scale. To relieve this crowding a shunt resistor is placed across the meter. Different ohmmeter ranges can be switched in by varying the values of the shunt resistor and current-limiting resistors, the zero-adjust rheostat remaining the same. Although separate scales for each range can be used, a more practical method is to calibrate the ohmmeter on the lowest scale. Multiplying the range by multiples of 10 permits using the same scale.

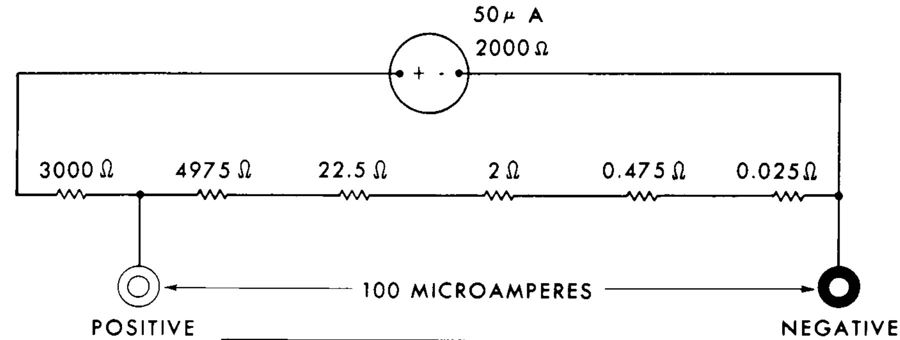


SELECTOR SWITCH POSITIONS OF OHMMETER CIRCUIT

Courtesy of Simpson Electric Corp

Current Meter Circuit

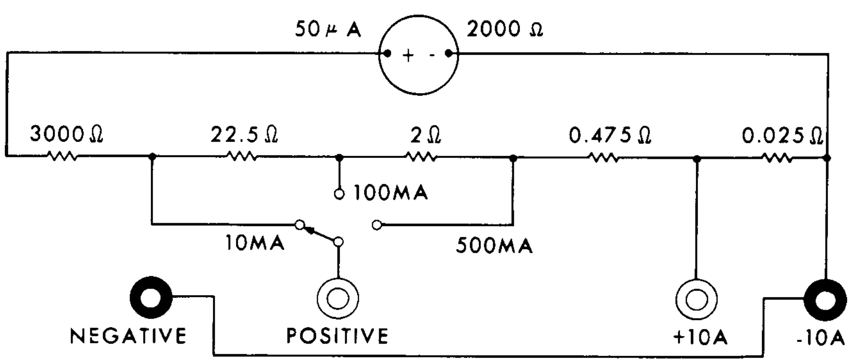
The simplified version of the current-reading microammeter circuit is shown. With 100 microamperes applied, the current will divide, half through the five shunt resistors that total 5000 ohms, the remaining 50 microamperes through the meter resistance of 2000 ohms, and the 3000-ohm series resistor. Thus, with 100 microamperes applied, the 50-microampere meter will read full scale.



SIMPLIFIED MICROAMMETER CIRCUIT

Courtesy of Simpson Electric Corporation

The combined milliammeter and ammeter circuit is shown. With the switch in the 10-milliampere position, the 3000-ohm resistor in series with the meter resistance of 2000 ohms (for a total of 5000 ohms) is shunted by a total resistance of 25 ohms. In the 100-milliampere position, the 22.5-ohm resistor is added to the 5000 ohms for a total of 5022.5 ohms. This is shunted by a total resistance of 2.5 ohms. In the 500-milliampere position, 24.5 ohms is added to the 5000 ohms for a total of 5024.5 ohms, and shunted by a total resistance of 0.5 ohms. In the 10-ampere position, 24.975 ohms is added to the 5000 ohms for a total of 5,024.975 ohms, and shunted by the 0.025-ohm resistor. In all ranges the current will divide so as to have full scale or 50-microamperes flow through the meter when 10, 100, 500 milliamperes, or 10 amperes are applied.

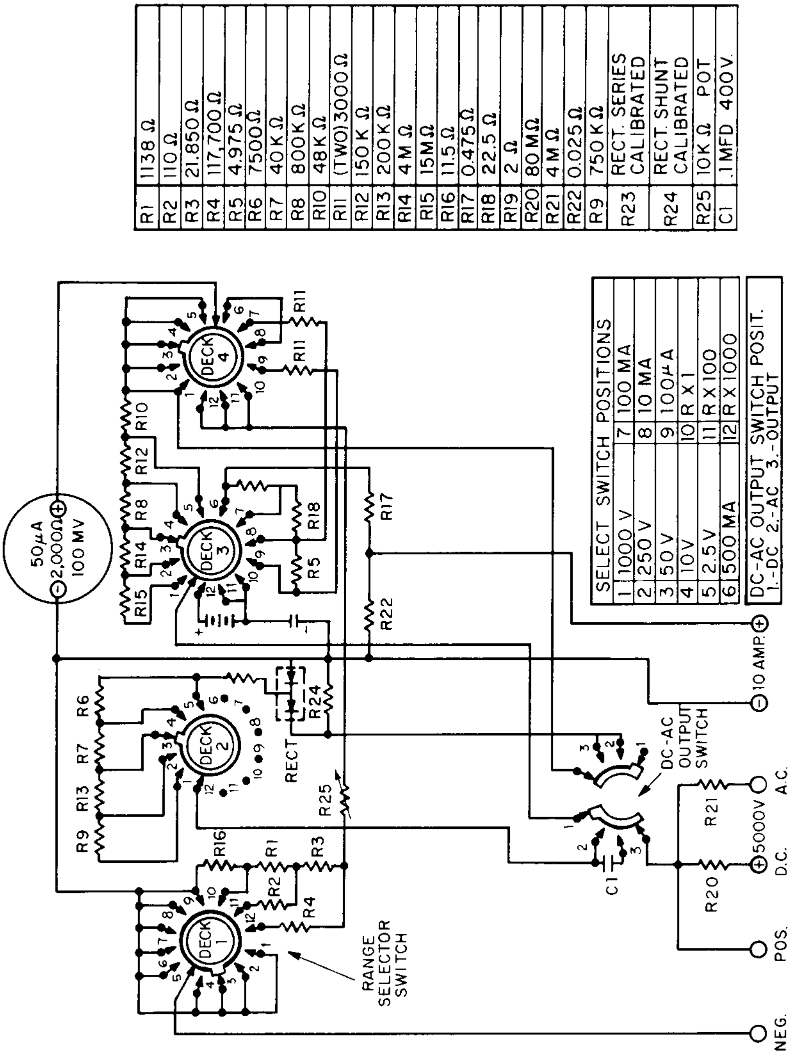


SIMPLIFIED MILLIAMMETER AND AMMETER CIRCUIT

Courtesy of Simpson Electric Corporation

Multimeter Circuit

The complete schematic of the VOM is shown below. There are two selector switches — one to select the range to be measured, and the function switch which sets the circuits to read dc, ac, or output. The combination of selector switches and separate test jacks permit reading six voltage ranges, five current ranges, and three ohmmeter ranges. These ranges plus the function switch permit one meter to be used to read any value of a-c or d-c voltage, of d-c current, or of resistance that would normally require twenty separate meter circuits.



R1	1138 Ω
R2	110 Ω
R3	21,850 Ω
R4	117,700 Ω
R5	4,975 Ω
R6	7500 Ω
R7	40 K Ω
R8	800 K Ω
R10	48 K Ω
R11	(TWO) 3000 Ω
R12	150 K Ω
R13	200 K Ω
R14	4 M Ω
R15	15 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
R9	750 K Ω
R23	RECT. SERIES CALIBRATED
R24	RECT. SHUNT CALIBRATED
R25	10 K Ω POT
C1	.1 MFD 400 V.

SELECT SWITCH POSITIONS			
1	1000 V	7	100 MA
2	250 V	8	10 MA
3	50 V	9	100 μA
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 POSIT.
1.-DC 2.-AC 3.-OUTPUT

Courtesy of Simpson Electric Corporation

Schematic Diagram of VOM

SUMMARY

All servicing techniques have one thing in common, a method of measuring values of resistance, voltage and current.

To replace a bulky assortment of individual meters, a combination of multipliers and shunts is used in a switching circuit with a single basic meter movement. This is called a Volt-Ohm-Milliammeter, or VOM.

The most popular type of meter movement is a 50-microampere D'Arsonval type movement with a coil resistance of 2000 ohms, providing a meter circuit sensitivity of 20,000 ohms per volt.

The d-c meter circuit reads a-c volts by adding a rectifier circuit.

A popular type meter rectifier is the copper oxide type. The rectifier is rugged and long-lived but sensitive to high temperatures. The stray capacity of the rectifier restricts accurate a-c voltage measurements to the range of audio frequencies.

The resistance of a copper oxide type rectifier does not vary directly with the value of current flowing through it. This nonlinearity causes crowding at the lower end of the scales.

A precaution taken to reduce crowding of the lower portion of the a-c voltage scales to place a shunt across the meter movement.

A shunt bypass, which increases the range of a meter, requires increased current for full scale deflection. The sensitivity of the voltmeter is therefore reduced.

The use of a blocking capacitor to isolate the d-c component of a varying voltage permits the use of the a-c voltmeter circuit as an output meter.

The shunt type ohmmeter circuit is excellent for reading low values of resistance, but has the disadvantage of high battery consumption.

In the series type ohmmeter circuits, the left-hand edge of the scale is crowded despite the use of shunting resistors.

All current reading ranges have shunts dividing the current so as to have 50 microamperes flow through the meter at a full scale value.

REVIEW QUESTIONS

1. Describe the metering functions available from a VOM.
2. What is the source of power that moves the meter needle of a VOM when measuring voltage or current?
3. In a comparison with a meter movement of 20,000 ohms per volt, a 1000 ohms per volt meter movement is *more/less* sensitive.
4. The circuit used to rectify a-c voltage for application to the d-c meter movement is a *half/full* wave rectifier circuit.
5. What are the two main drawbacks to the copper oxide rectifier?
6. How do we use the VOM to isolate and read the a-c signal component of a pulsating d-c voltage?
7. Describe the advantages and disadvantages of the shunt and series type ohmmeters.
8. What is the purpose of the battery in an ohmmeter circuit?
9. With 25 microamperes flowing through the meter movement of a 50 microampere meter, what would **the reading** be on the 0-1 milliampere scale?