Chapter 12

Practical VTVM

THE 20,000 ohms-per-volt multimeter has become the basic item of test equipment for shop and laboratory. The popularity of the vacuum-tube voltmeter has also increased substantially during the past few years. With greater complexity in FM and TV receiving equipment, the v.t.v.m. has become a necessity for many jobs which require high-impedance measurements.

The home constructor and small shop owner is confronted with the dilemma of either buying a ready-made instrument, assembling a kit, or making up a meter from scrap and surplus components lying around in the extra parts department. The technician who has learned to make full use of his 20,000 ohms-per-volt meter may not feel like spending the $50 to $200 required for a factory job, nor even making up one of the several kits on the market ranging from $20 upward. A home-built job may fill the bill insofar as basic measurements and ranges are concerned, and at the same time dent the pocketbook only slightly, depending, of course, upon the number of spare parts that can be gathered from the junk box.

A glance at the back issues of radio construction periodicals and at the various v.t.v.m.'s made up by acquaintances reveals that they fall into two classes: the super-duper jobs including ohms scales reading to thousands of megohms, supplied with 1% resistors, 4-inch meters and voltage-regulator tubes (and incidentally priced out of the average shop operator's budget) and the "look-it's-no-larger-than-a-match-box!" type (accompanied by a photo showing that it is, in fact, no larger than the box of safety matches posed beside it).

The v.t.v.m. shown in the photograph, Fig. 1201, was made up as a happy compromise between the extremes of high cost and tiny impracticability. Except for resistance measurements, it will perform most of the functions of the larger models at a considerable saving in original cost. Resistance measurements were omitted, as it is seldom necessary to obtain readings in excess of 20 megohms, and all values below that may be obtained with the usual high-resistance multimeter. Too, a measuring device of high input impedance for determining resistance is of limited value to the average repairman or experimenter. The additional switch and switch bank, resistances, voltage cell, and recalibrated

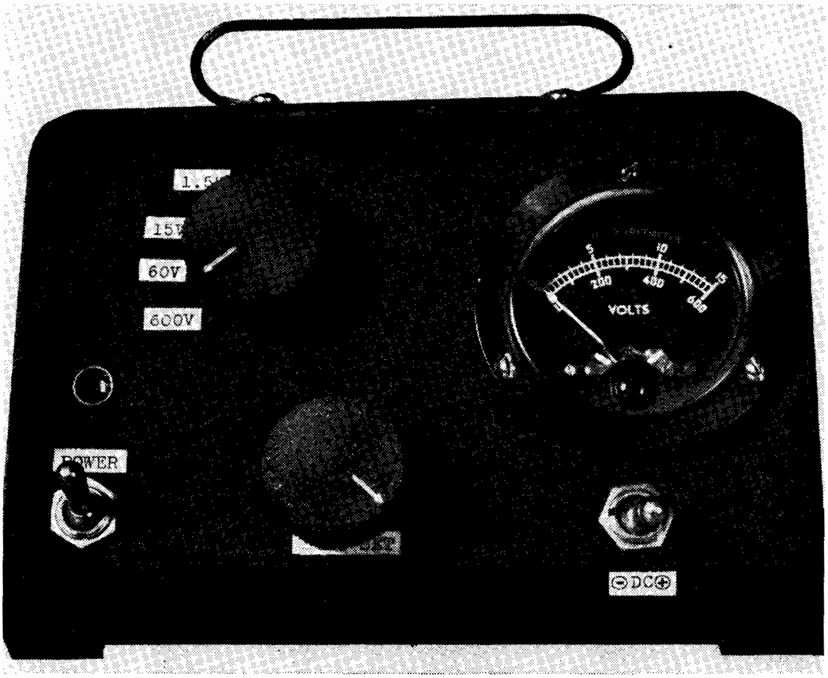


Fig. 1201. *Front view of the v.t.v.m. The sloping panel makes it easy to read the meter.*

meter-movement scale necessary for resistance measurements not only would increase the cost of complexity of the instrument but might also result in expanding its size or severely overcrowding the interior of the cabinet.

Construction details

The meter was constructed in a small sloping-front sheet-steel box more or less as a novelty, as horizontal face meters always seem to necessitate leaning over to observe small changes in readings, while the vertical models on a bench or work table usually require stooping for careful scrutiny. Dimensions of the cabinet are 4 by 4-1/2 by 7 inches long, a standard size readily obtainable from supply houses. It was adequate to house the parts without undue crowding. A miniature tube was decided against, on the basis of availability, lower replacement cost and greater ruggedness of the 6SN7-GT. A miniature-type 12AU7 might be substituted for the octal tube, with a saving of space, but the 6SN7-GT has furnished satisfactory service since the instrument was completed, and the decision against a miniature tube was apparently a wise one.

Details of construction are shown in Fig. 1202. The power

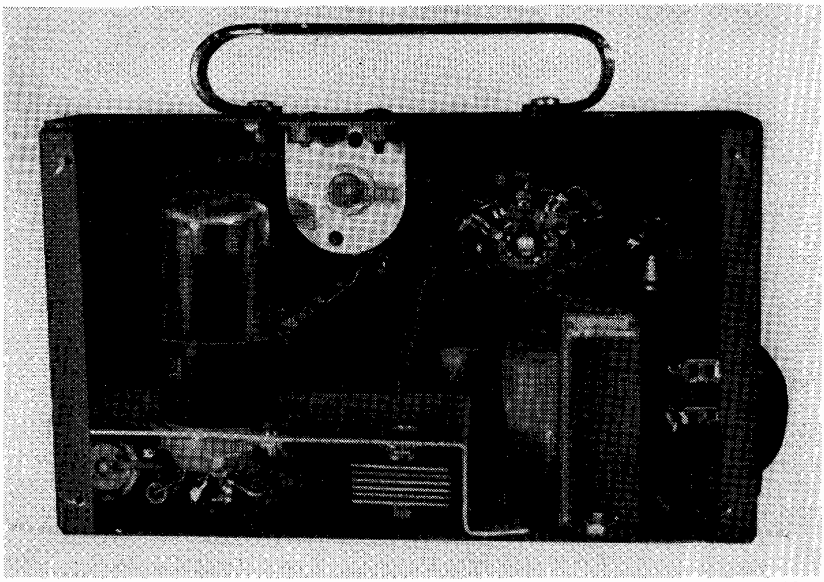


Fig. 1202. Rear view of the v.t.v.m. Note the mounting of the selenium rectifier.

transformer is mounted directly on the floor of the sloping-face cabinet, and the switches and controls are held to the front panel by their retaining nuts. The rest of the parts are mounted on a small aluminum chassis bent out of a 3 x 4-inch piece of scrap cut down to size and drilled for the socket and various mounting lugs. The chassis is provided with sheet-metal screws to the bottom and side of the cabinet to retain it in place. The scrap pile also furnished another piece of thin aluminum, which was used for a cabinet back. The back was carefully drilled near the tube to provide ventilation and prevent overheating, which might cause inaccurate readings.

The tube filament is heated by a transformer secondary winding rather than by a dropping resistor. (See Fig. 1203.) This precaution was incorporated so that the 117-volt a.c. supply would be divorced completely from the meter circuit, since much work involves a.c.-d.c. sets, and a direct 117-volt line in either the plate or filament power supplies is likely to produce fireworks and misfortune. The high-voltage secondary of the power transformer

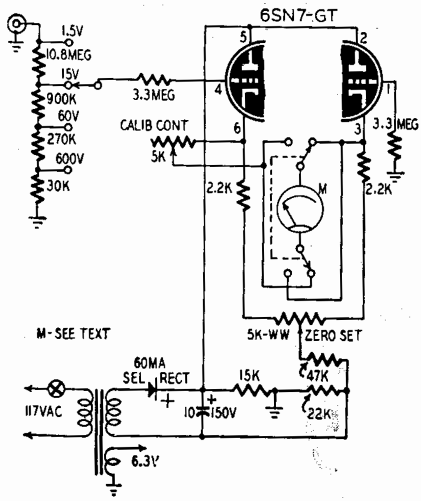


Fig. 1203. *Schematic diagram of the v.t.v.m.*

furnishes 117 volts, which, when used with the selenium rectifier, produces a low and stable plate supply for the tube.

The Meter Movement

A word about the meter movement. The one shown has a 500-microampere movement with 0–15 and 0–60 volt scales. These scales lend themselves to easy multiplication and the finished instrument was designed for a.c. and d.c. ranges of 0–1.5- 0–15-, 0–60, and 0–600-volt full-scale measurements, which have proved the most handy around the shop. Any other low-current movement that may be available can be pressed into service. Remember that the lower the basic movement the better. A 0–50 microampere movement, for example, will permit operation over a smaller portion of the tube's characteristic curve, and consequently allow greater linearity and accurac than a 0–1 milliampere meter. Of course, since the price of meters is generally directly proportional to their sensitivity, the limiting factor will be the expense.

unless a spare meter of high sensitivity is lying around the extra-parts bin.

Resistors for the "resistance stick" are of the inexpensive half-watt variety, but were chosen with care to assure values as close as possible to 30,000, 270,000, 900,000 and 10.8 megohms. Since the basic accuracy of the meter depends directly on the tolerance of these resistors, selections were made from the stocks of a tolerant retailer after many measurements with an accurate ohmmeter. Precision or semiprecision resistors could have been substituted but, again, the cost was the limiting factor and the more accurate and expensive units were decided against.

In the front-view photo, controls, from left to right, are: on-off

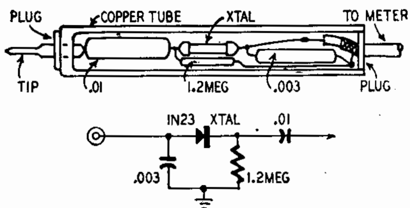


Fig. 1204. *Schematic and construction details of the test probe.*

switch in the power line, with pilot-bulb indicator above it, range-selector switch, balance-control potentiometer, polarity-reversing switch, and (at the right side) the connectors for input leads. At the rear, as shown by the photo, Fig. 1202, the calibration control is mounted behind the meter movement and once adjusted need not be moved unless the tube is changed or the resistance stick changes markedly in value.

Circuit operation

The circuit is of the balanced type. The balance control makes the two halves of the dual triode draw such current that both plates are at the same potential. A change in the grid voltage of one will upset the balance and cause the meter movement to register according to the impressed voltage. The 6SN7-GT was found to have sufficiently straight characteristic curves to make readings linear over the instrument's basic operating range, which is from – 1.5 volts to + 1.5 volts for full-scale movement.

The a.c. probe (Fig. 1204) contains a 1.2-megohm isolating resistor which results in reduced capacitive loading of the circuit under test. Most a.c. measurements are made at higher frequencies, so it was decided that no rectifier be built into the cabinet.

Instead, a probe with crystal and coupling capacitor was assembled from the junk box. It has been more than adequate for general shop and home construction work. The probe was constructed in a short section of 1/2-inch diameter thin-walled copper water pipe such as is used in ordinary house plumbing. Formica plugs for the ends were cut to general shape with a coping saw and turned down to size in the chuck of an electric drill. The tip consists of a screw-type earphone tip threaded into one plug. Shielded cable connects both the d.c. and a.c. plugs to the connector fitting at the side of the meter, reducing hand capacity to a negligible amount. The scale readings for a.c. measurements with the probe are a trifle higher than the actual values of potential. Since the difference is slight (about 10%) it can be ignored

Bill of Materials for Meter

Resistors: 2—2,200, 1—15,000, 1—30,000, 1—47,000, 1—270,000, 1—900,000 ohms ½ watt; 1—1.2, 2—3.3, 1—10.8 megohms, ½ watt; 1—22,000 ohms, 1 watt; 2—5,000-ohm wirewound potentiometers.

Capacitors: 1—.003, 1—.01 μf, paper; 1—10 μf electrolytic, 150 volts.

Switches: 1-single-pole, 5-positions; 1 s.p.-s.t., 1-d.p.d.t.

Miscellaneous: 1 60-ma selenium rectifier, 1-1N23 crystal; 1-half-wave power transformer, 117-120 volts, 40 ma or more, 6.3 volts, 1 amp or more; 1 meter, as per text, 1 6SN7-GT tube and socket for same, jack, plug material, hardware, wiring, etc.

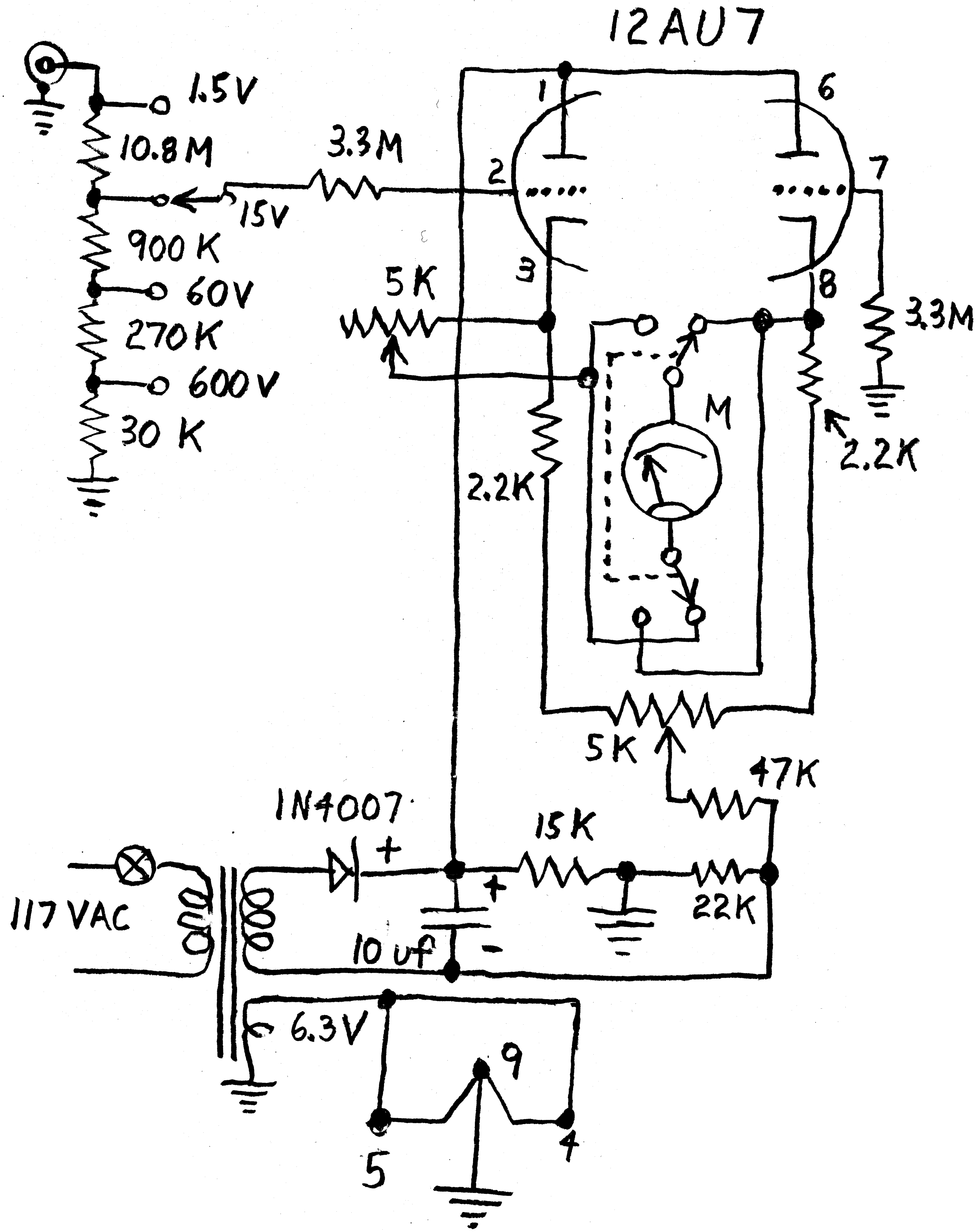
in favor of comparative measurements, or may be compensated for with a correction factor on the meter scale, if desired.

The v.t.v.m. shown has been in service for many months now. Though it lacks hairline accuracy and large-instrument versatility, it has provided creditable results for all service and the usual home-experimental type of work. An aluminum strap handle completes the job, and makes the instrument readily portable for service calls or movement about the house and shop. At a total outlay in the neighborhood of $5 plus parts salvaged from the average spare-parts bin, it will represent an asset of far greater value to the average radioman and experimenter.

Calibration

Calibration is no problem if your meter is identical to the one used in this instrument. Feed in a known voltage which has been measured on an accurate multimeter or v.t.v.m, and adjust the CALIBRATION CONTROL for a correct reading. If you use a different type of 500-μa meter, you will probably have to prepare a new dial scale or calibration chart. Use variable-voltage a.c. and d.c. supplies and an accurate meter to supply calibration points.

DIY - VTVM


12AU7
1.5V
10.8M
3.3M
15V
900K
60V
270K
600V
30K
5K
M
2.2K
3.3M
2.2K
5K
47K
1N4007
15K
22K
117 VAC
10 uf
6.3V
1
2
3
6
7
8
9
5
4