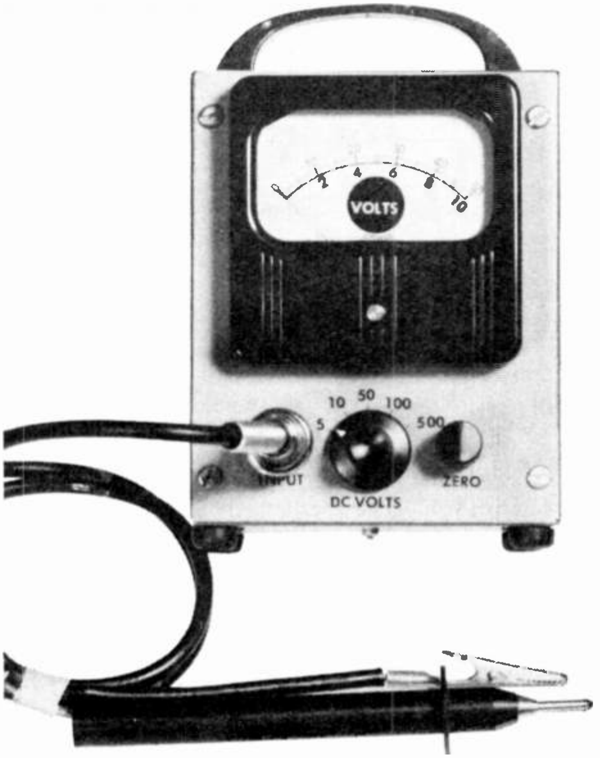


MINIATURE VTVM

Unit measures voltage in a.g.c., grid bias, oscillator and other high-impedance circuits without loading

By RYDER WILSON

ONE of the most useful test instruments in the electronics enthusiast's workshop is the vacuum-tube voltmeter. The VTVM enables the experimenter to measure small voltages accurately, especially in high-impedance grid bias, a.g.c., detector and oscillator circuits. Unlike the 1000- or 20,000-ohms-per-volt voltmeters which present different resistances on different ranges, the miniature VTVM to be described here has a constant resistance of 10 megohms on all ranges.

The miniature VTVM is a low-cost construction project and operates economically on batteries. It can measure d.c. voltages in five or six ranges, depending on whether a 5- or 6-point switch is used. Up to 500 volts can be measured directly; audio, r.f. and other a.c. voltages can also be measured with the demodulator probes. The miniature unit is completely self-contained in a 5" x 4" x 3" metal utility box and has a large, easy-to-read, reasonably-priced, 50-μa. meter movement.

How It Works. A CK6088 subminiature beam-power-pentode vacuum tube (*V1*) is "triode"-operated in a d.c. bridge circuit. The quiescent voltage drop across resistor *R8* is balanced out by applying just enough bucking voltage to zero the meter. You simply adjust potentiometer *R11* for a zero meter reading. Potentiometer *R9* serves as a current limiter and calibrator for the meter circuit.

A positive d.c. voltage applied to the grid of tube *V1* through resistor *R7* causes a proportional up-scale deflection. The more positive the grid, the more the tube conducts and the greater the voltage drop across resistor *R8*. The greater the voltage drop, the greater the deflection of the meter. The rotary switch (*S1*) specified in the Parts List selects one of the five voltage ranges from 5 to 500 volts. Precision ±5% resistors are used in the input voltage divider network. The VTVM's accuracy is dependent upon the selection of the proper value of resistors, as well as the quality of the meter movement.

If you can get a 6-position, single-circuit switch that will fit, you can wire the input voltage divider as shown in Fig. 3, to get a very desirable 1-volt range. Actually, no change in the arrangement of the resistors in this circuit would have to be made to accommodate the 6-position switch. Jack *J1* would be connected to the first contact which would become the position for the 1-volt range. All other positions would

MINIATURE VTVM

follow in the same consecutive order as in the 5-position switch.

Because of its d.c. operation, the miniature VTVM is relatively stable and free of drift. It does not require constant resetting of the zero control.

Construction. The interior view of the VTVM shows the layout of the various components. The tube (*V1*) is held in place by a cable clamp. The circuit board is mounted on the meter terminals. Resistors *R7*, *R8*, *R9* and filament battery *B2* are mounted on the board. Resistors *R1* through *R6* are mounted, turret style, directly on *S1*. (See Fig. 6.)

Position the meter as close as possible to the top of the case to allow room for the range selector switch and panel markings. Zero-adjust control *R11* and tube *V1* are then positioned to avoid interference with other components. Place battery *B1* on the bottom of the case and hold it in position with a suitable friction clip.

The d.c. probe shown with the meter is made from a 2′ length of 52-ohm coaxial cable and a test prod connected to the center conductor. An alligator clip and a short length of insulated wire are connected to the shield inside the probe handle. In use, the test prod point is connected to the positive side and the alligator clip to the negative side of the voltage to be measured.

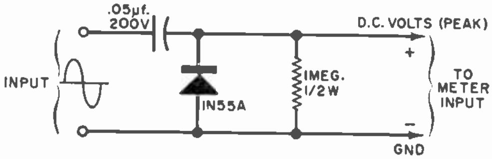


Fig. 2. Demodulator probe measures low a.c. peak voltages. Capacitance of probe leads acts as filter.

Calibration. Any known source of voltage can be used to calibrate the VTVM. A simple setup is shown in Fig. 5. However, before turning the instrument on, check for mechanical zero of the VTVM's meter. Next, set the range-selector switch to the 5-volt scale and adjust zero control *R11* until the switch just clicks on. The meter will probably read about 1.25 volts. Continue turning *R11* slowly, clockwise, until the meter reads zero. Do this with the probe connected to the meter and the alligator clip on the test prod's point, to prevent readings of stray voltages.

Adjust the 1000-ohm potentiometer on the calibrator rig to 5 volts, and apply the probe. Adjust calibrating potentiometer *R9* for full-scale deflection (the 5-volt mark on the VTVM). By successively reducing the input voltage to 4, 3, 2 and 1 volt, linearity of the meter can be compared with the meter in the test circuit. A slight nonlinearity may be observed as the input voltage is decreased, with an approxiate error of ±0.1 volt at the low end of the scale.

Fig. 1. The voltage drop across the cathode resistor is in proportion to voltage being measured. The more positive the applied voltage to the grid, the greater the voltage on the resistor.

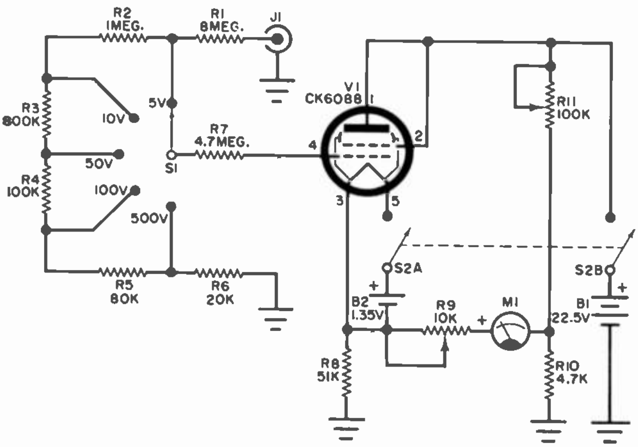
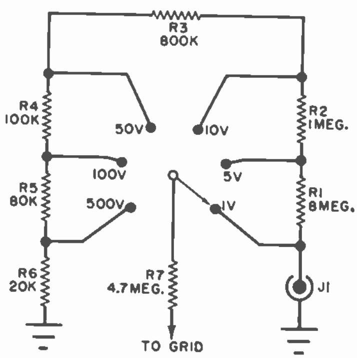


Fig. 3. Alternate hookup of voltage divider provides extra 0- to 1-volt range.



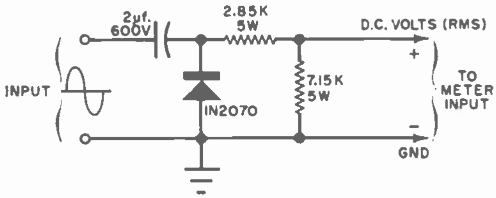


Fig. 4. Divider in demodulator probe delivers about 70% of peak voltage to meter circuit to enable direct readout of r.m.s. voltages.

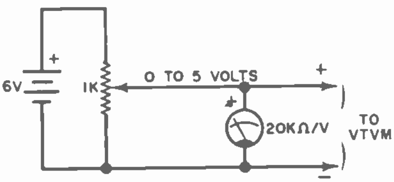


Fig. 5. Variable voltage divider circuit used to calibrate the miniature VTVM.

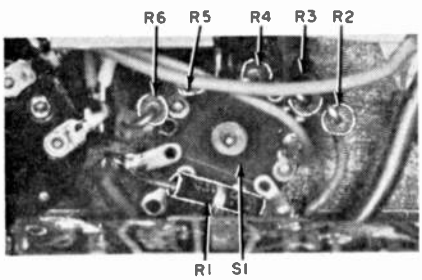
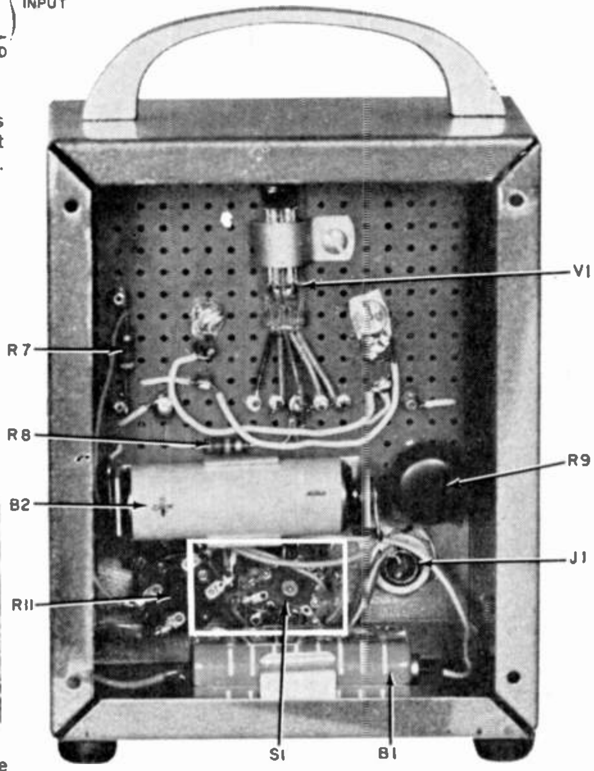


Fig. 6. Preassemble the resistors and the switch in "turret" fashion before mounting.

Fig. 7. Position meter as high as possible in case. Mount circuit board directly to back of meter.



PARTS LIST

B1—22.5-volt battery (NEDA No. 215)
B2—1.35-volt mercury cell battery (Mallory RM-12R or equivalent)
J1—Single-contact, male, panel-mounted mike connector
M1—0-50 microammeter (Lafayette 99 G 5042 or equivalent)
R1—8-megohm, ½-watt resistor (selected from 8.2-megohm stock)*
*R2—1-megohm, ½-watt resistor**
R3—800,000-ohm, ½-watt resistor (selected from 820,000-ohm stock)*
*R4—100,000-ohm, ½-watt resistor**
R5—80,000-ohm, ½-watt resistor (selected from 82,000-ohm stock)*
*R6—20,000-ohm, ½-watt resistor**
R7—4.7-megohm, ½-watt resistor
R8—51,000-ohm, ½-watt resistor
R9—10,000-ohm miniature potentiometer
*R10—4700-ohm, ½-watt resistor**
R11—100,000-ohm miniature potentiometer with d.p.s.t. switch (S2)
S1—2-circuit, 5-position switch (Lafayette 99 G 6164 or equivalent; use only 1 circuit)
S2—D.p.s.t. switch (on R11)
V1—CK6088 vacuum tube
1—5" x 4" x 3" metal utility box
Misc.—Probe tip, wire, battery clamps, etc.
*Resistors are ± 5% or better

If a greater error occurs, it could be due to a poor tube, or nonlinearity of the calibrator meter.

Use the same procedure only to check the VTVM on the other voltage scales. Actually, this is not necessary; once one scale is calibrated, all the other scales take their proper relative position. Significant errors on the other ranges would be due to employing wrong values (one or more) for resistors *R1* through *R6*. When the calibration is completed, the meter is ready for use.

Higher voltages applied to the tube's grid, beyond a certain point, have less and less effect on tube current, and at saturation have none. The meter cannot be subjected to "burn-out" currents no matter how high the voltage being tested or how low the selected voltage range on the meter. But don't poke the unit into a 16,000-volt circuit without a suitable high-voltage probe! —30—