WARTIME V.T.V.M. CIRCUITS

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Consulting Eng., RADIO NEWS

Constructional details of vacuum-tube voltmeters, permitting servicemen and experimenters to use available meters and tubes.

Vacuum-tube voltmeter described in the September, 1943 issue of RADIO NEWS. This instrument utilized a 0-200 microammeter. Circuits described herein will show how less sensitive meters can be substituted.

THE repeated appearance of vacuum-tube voltmeter circuits following certain well-known notions and specifications has encouraged an almost static viewpoint regarding these arrangements. Standard thus has favored a single "active" tube which invariably is a triode (or two such tubes in a bridge-type circuit), a low-range current meter having a full-scale deflection of 1 milliampere or less, and a half-wave circuit for diode probes. Few circuits published during the last two years have departed markedly from these conventionalities.

The situation has been altered somewhat by wartime scarcities of high-sensitivity meters and specific tubes. 0-1 milliammeters are harder to obtain than they were in the lush days; 0-200 and 0-500 microammeters are now rarely seen. All meters are hard to get, but the ones referred to are proverbial nuggets of gold. Particular tube types, without which most readers have believed a v.t.v.m. circuit would not work, likewise have disappeared from many store shelves. But, in experimental junk-boxes there may still be found the "less desirable" d.c. milliammeters (those with higher ranges) and numerous tube types seldom, if ever, specified by the designers of v.t. voltmeters.

With civilian stockpiles now somewhat more plentiful in high-range milliammeters than in the low-reading variety, and with certain odd tube types more readily available than those usually specified for instrument applications, inquiry is prevalent regarding use of these components in v.t. voltmeters. In answer to this question, we aim to show in this article how the reader may use large-size meter ranges and, to some extent, whatever tubes he has on hand in constructing these instruments.

Tube and Meter Matching

In the past, simplicity has dictated use of triodes in v.t.v.m. circuits. By eliminating the screen electrode, both voltmeter and d.c. power supply circuits have been kept rudimentary and initial adjustments simplified. In the more advanced instruments, degeneration, obtained in the d.c. stage by means of a large unbypassed cathode resistor, divorced instrument response from tube characteristics. In other circuits, for both a.c. and d.c. measurements, meter deflection for a given test voltage has been determined by tube transconductance. An example of the latter case is the arrangement of a triode, such as type 27, 6AE6-G, 7C6, etc., with a transconductance of 1000 micromhos, to give a 1-milliampere plate current increment for a 1-volt impressed grid-voltage increment. In general v.t. voltmeter design, it has

Fig. 1. With high-range meters, a single high-transconductance tube can be used (A). With low G_m tubes, two tubes can be connected in parallel (B).

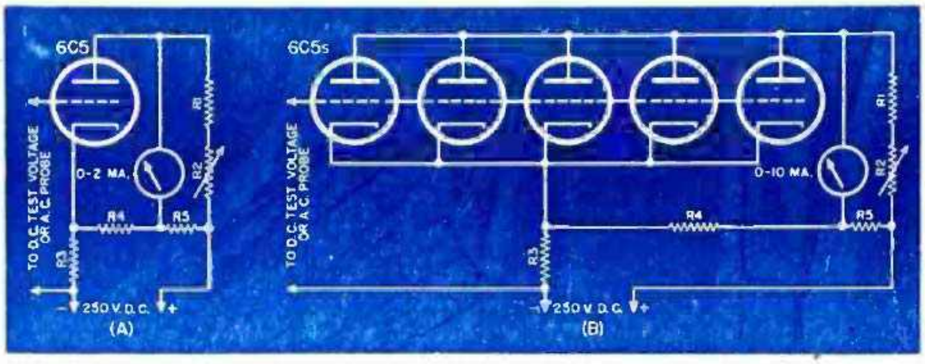


Fig. 2. (A) Single 6C5 tube normally employed with a 0-2 milliammeter. (B) Five 6C5 tubes connected in parallel so that a 0-10 milliammeter may be employed.

been customary to employ triodes, such as types 2A6, 6F5, 6K5, and 6Q7, which have amplification factors between 70 and 100 and E_p/I_p ratios in the neighborhood of ¼ megohm.

Tubes available to experimenters today, either on most store shelves or in spare-parts boxes, include tetrodes, pentodes, and beam power types, as well as triodes; and those found most frequently are in the high-transconductance class, having G_m values above 1000. Prevalence of high G_m values is a rather happy coincidence in this case, since this characteristic ties in very favorably with the high-range milliammeters lying idle.

Available tubes may be matched with available milliammeters, for use in v.t.v.m. circuits, by means of the familiar transconductance formula:

$$G_m = \frac{dI_p}{dE_g} (10^6) \ldots\ldots\ldots (1)$$

where G_m is transconductance in micromhos;

dI_p, a change in plate current (amperes);

dE_g, a change in grid voltage (volts).

Here is an example: A vacuum-tube voltmeter is usually arranged with the 1-volt range as a basis. Let us assume that a 0-10 d.c. milliammeter is on hand and we wish to obtain full-scale deflection of this meter when an unknown signal of 1 volt is applied to the v.t.v.m. input terminals. Our problem is to find a tube with the proper transconductance to enable a 10-milliampere plate current increment for a 1-volt grid-voltage increment. This required transconductance value may be determined at once by means of Equation (1), thus:

$$\begin{aligned} G_m &= .01/1 \times 10^6 \\ &= .01 \times 1{,}000{,}000 \\ &= 10{,}000 \end{aligned}$$

The nearest G_m values to this desired figure are 9000 (for the 6AC7/1852) and 11,000 (for the 6AG7). One volt will give a deflection of 9 milliamperes with the first tube, or 11 milliamperes with the second. A test voltage of 1.1 will be required for full-scale deflection (10 ma.) with the 6AC7; 0.909 volt with the 6AG7.

Working the other way around, when matching a meter to a tube, the following equation will be employed to determine desired meter range:

$$dI_p = dE_g\,(G_m)\,10^{-6} \text{ amps.} \ldots\ldots (2)$$

Which for a 1-volt test signal becomes simply:

$$I = G_m \times 10^{-3} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where:

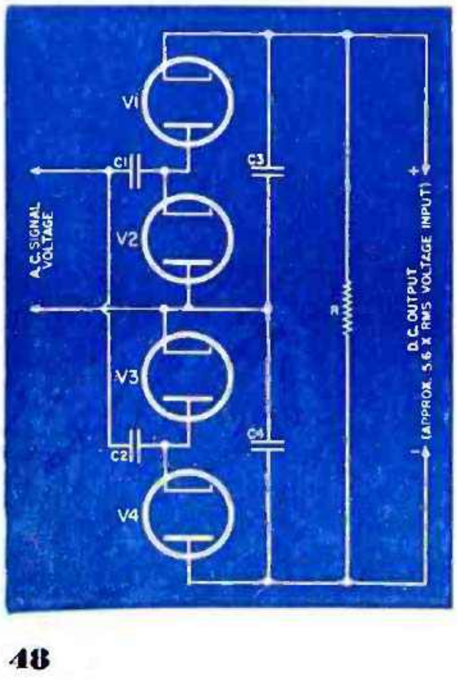
I is the full-scale deflection of the meter in *milliamperes,* and

G_m, the tube transconductance in *micromhos.*

As an illustrative example, let us assume our job to be selection of a milliammeter to match a 6J5 tube. This tube has a transconductance of 3000, and we desire to obtain full-scale deflection with an input test-signal voltage of 1 volt. Employing Equation (3), we find the full-scale deflection required to be $3000 \times 10^{-3} = 3000 \times .001 = 3.0$. This means that 1-volt applied to the grid input terminals of the v.t.v.m. circuit will give a plate current shift of 3 milliamperes, and that a 0-3 d.c. milliammeter will be most desirable for the job.

In each of the illustrative examples, it will be noted that the signal voltage is taken as 1 volt. The equations do not restrict the experimenter to this figure, however, except in the case of the simplified Equation (3). The 1-volt input happens to be a convenient value for the fundamental full-scale range of the instrument, all higher voltages in decade relationship to the first being stepped down to this value by means of a high-resistance input voltage divider (range selector).

Fig. 4. Four-tube arrangement used to obtain higher voltage output than that of the doubler type probe (Fig. 3).



High G_m and Parallel Tubes

From the foregoing discussion, it is readily seen that high-transconductance tubes permit meters with full-scale values higher than usual to be used for common v.t.v.m. signal voltages. This scheme is illustrated by Fig. 1A. This technique may be exercised freely by the experimenter who has on hand a number of odd-type tubes and high-range milliammeters. The high-characteristic tube may be of either triode, tetrode, pentode, or beam power type. Any of the common v.t. voltmeter circuits may be employed, provided recommended plate, screen, and bias voltages are supplied and appropriate adjustments are made in the values of resistors in the zero-adjusting circuit.

To aid the reader in selecting from his own stock tubes with high transconductance, Chart I has been arranged to list all types which have G_m values of 1500 and higher. One or more of these tubes and a matching meter doubtlessly will be available among spare parts.

In connection with the use of Chart I, the reader is cautioned that a number of the tubes listed are high plate current types and that, when using these, a series-limiting resistor of adequate ohmage must be employed in conjunction with the zero-adjusting rheostat to prevent damage to the meter. The "off-zero" current through the meter will in this way be limited to a safe value. The high-current tubes have been marked in the table, as indicated in the footnotes.

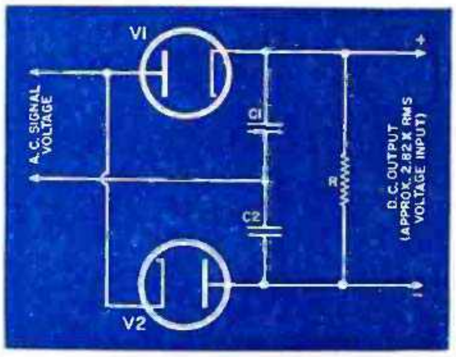


Fig. 3. Twin diode connected as a full-wave voltage doubler to obtain increased output.

In spite of the convenience of the scheme of employing high-G_m tubes, it is likely that in many cases transconductance values appropriate for an available high-range milliammeter will not be found among spare parts. But there is another scheme for obtaining the desired high plate current shifts, and this scheme may even be employed with lower G_m values: Two or more tubes may be connected in parallel in the v.t.v.m. circuit, as indicated in Fig.

1B. The signal voltage is applied simultaneously to both grids. The total plate current and plate current shift, however, are the sums of the individual values. It is possible by use of the parallel arrangement to obtain a larger plate-current shift for a given test voltage than is possible with a single tube of given transconductance.

In this connection, consider the case of a tube with a transconductance of 2000 (such as type 6C5). One such tube, connected in a v.t.v.m. circuit, will yield a plate current increment of 2.0 milliamperes when its grid signal voltage passes through an increment of 1.0 volt. But when two of these tubes are connected in parallel in the circuit, the same 1-volt signal produces a change of 4 milliamperes in plate current (this latter value being the combined plate current increments of both tubes). While the single tube would necessitate the use of a 0-2 milliammeter, the parallel connection would permit use of a 0-4 or 0-5 type. The effect of the parallel connection is to add the individual transconductance values.

It is not imperative to employ identical tube types in the parallel connection, as long as the tubes chosen require the same values of grid, heater, plate, and screen voltage. However, it is advisable not to attempt connection of filament-type tubes with cathode types. When the parallel-connected tubes have different G_m values, it is merely necessary to add the individual values for the electrode voltages employed, to obtain the total apparent transconductance.

When the same type of tube is employed in each position, the group should have characteristics as nearly identical as possible. This applies chiefly to transconductance. If reasonably careful matching is carried on, the total transconductance may be estimated simply by multiplying the transconductance of a single tube by the number of tubes.

An important factor which must not be overlooked when contemplating the parallel arrangement of tubes is the increased input capacitance of the combination. This will be the sum of the individual grid-cathode capacitances; and when the v.t. voltmeter is to be employed for r.f. measurements, the larger capacitance and grid current level will increase circuit loading.

The problem of circuit loading by parallel tube input capacitances is of little consequence in the case of electronic d.c. voltmeter circuits, where the frequency is zero. If grid current drain is kept at the lowest practicable minimum in these circuits, it likewise will introduce no considerable difficulty. But if grid current levels are high, it must be borne in mind that the increased input current, due to the grid

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Chart 1. List of tubes that have a transconductance of 1500 micromhos or more. One or more of these tubes and a matching meter probably will be available among spare parts.

TYPE	NAME	TRANSCONDUCTANCE (Max.)	MA. DEFLECTION FOR 1 v. INPUT
*1Q5-GT/G	Beam Power	2200	2.2
*1S4	Pentode	1575	1.57
*2A3	Triode	5250	5.25
*2A5	Pentode	2550	2.55
*3A5	Twin Triode	1800	1.8
*3Q4	Pentode	2150	2.15
*3Q5-GT/G	Beam Power	2200	2.2
*3S4	Pentode	1575	1.57
*6A3	Triode	5250	5.25
*6A4 (LA)	Pentode	2200	2.2
6AB7/1853	Pentode	5000	5.0
6AC7/1852	Pentode	9000	9.0
*6AC5-GT *6AC5-G	Triode	3400	3.4
*6AD7-G	Pentode Section	2500	2.5
*6AE7-GT	Twin-Input Triode (cathodes tied together; grids likewise)	3000	3.0
6AG7	Pentode	11,000	11.0
*6AK6	Pentode	2300	2.3
6C5	Triode	2000	2.0
6C8-G	Twin Triode (one section)	1600	1.6
6D6	Pentode	1600	1.6
*6E6	Twin Triode (one section)	1700	1.7
*6E7	Twin Triode (one section)	1600	1.6
6F5, 6F5-G, 6F5-GT	Triode	1500	1.5
*6F6, *6F6-G	Pentode	2550	2.55
6F8-G	Twin Triode (one section)	3000	3.0
*6G6-G	Pentode	2300	2.3
6J5	Triode	3000	3.0
*6K6-GT/G	Pentode	2300	2.3
6K7, 6K7-G, 6K7-GT	Pentode	1650	1.65
6L5-G	Triode	1900	1.9
*6L6, 6L6-G	Beam Power	6000	6.0
*6N7, 6N7-GT/G	Twin Triode (Both sections in parallel)	3200	3.2
*° 6R7, 6R7-GT/G	Triode Section	1900	1.9
6S7, 6S7-G	Pentode	1750	1.75
6SF5, 6SF5-GT	Triode	1500	1.5
° 6SF7	Pentode Section	2050	2.05
6SG7	Pentode	4000	4.0
6SH7	Pentode	4900	4.9
6SJ7	Pentode	2500	2.5
6SK7, 6SK7-GT/G	Pentode	2350	2.35
6SL7-GT	Twin Triode (each unit)	1600	1.6
*6SN7-GT	Twin Triode (each unit)	3000	3.0
° 6SR7	Triode Section	1900	1.9
6S7, 6S7-G	Pentode	1750	1.75
6SS7	Pentode	1930	1.93
° 6ST7	Triode Section	1900	1.9
6U7-G	Pentode	1600	1.6
*6V6, 6V6-GT/G	Beam Power	4100	4.1
*6Y6-G	Beam Power	7100	7.1
7A4	Triode	3000	3.0
*7A5	Beam Power	6000	6.0
7A7-LM	Pentode	2000	2.0
7B4	Triode	1500	1.5
*7B5-LT	Pentode	2300	2.3
7B7	Pentode	1700	1.7
*7C5-LT	Beam Power	4100	4.1
° 7E6	Triode Section	1900	1.9
° 7E7	Pentode Section	1600	1.6
*7F7	Twin Triode (each unit)	1600	1.6
7G7/1232	Pentode	4500	4.5
7H7	Pentode	3800	3.8
955	Acorn Triode	2200	2.2
956	Acorn Pentode	1800	1.8
*12A5	Pentode	2400	2.4
*12A6	Beam Power	3000	3.0
12AH7-GT	Twin Triode (each unit)	1900	1.9
12B8-GT	Triode Section	2400	2.4
12F5-GT	Triode	1500	1.5
12J5-GT	Triode	3000	3.0
12K7-GT/G	Pentode	1650	1.65
*12L8-GT	Twin Pentode (each section)	2150	2.15
12SF5, 12SF5-GT	Triode	1500	1.5
12SF7	Pentode Section	2050	2.05
12SG7	Pentode	4000	4.0
12SH7	Pentode	4900	4.9
12SJ7, 12SJ7-GT	Pentode	2500	2.5
12SK7, 12SK7-GT/G	Pentode	2350	2.35
12SL7-GT	Twin Triode (each unit)	1600	1.6
*12SN7-GT	Twin Triode (each unit)	3000	3.0
° 12SR7	Triode Section	1900	1.9
14A7/12B7	Pentode	2350	2.35
*25A6, 25A6-GT/G	Pentode	2450	2.45
* # 25A7-GT/G	Pentode	1800	1.8
25AC5-GT/G	Triode	3800	3.8
*25B6-G	Pentode	5000	5.0
25B8-G	Triode Section	1500	1.5
	Pentode Section	2000	2.0
*25C6-G	Beam Power	7100	7.1
*25L6, 25L6-GT/G	Beam Power	9500	9.5
# * 32L7-GT	Beam Power	6000	6.0
*35A5	Beam Power	5900	5.9
*35L6-GT/G	Beam Power	5900	5.9
*41	Pentode	2300	2.3
*42	Pentode	2550	2.55
*43	Pentode	2450	2.45
*45	Triode	2175	2.17
*46	Dual Grid (grid #2 connected to plate)	2350	2.35
*47	Pentode	2500	2.5
*48	Tetrode	3900	3.9
*50	Triode	2100	2.1
*50L6-GT	Beam Power	9500	9.5
*59	Pentode	2500	2.5
* # 70L7-GT	Beam Power	7500	7.5
*71-A	Triode	1700	1.7
*89	As Triode	1800	1.8
	As Pentode	1800	1.8
*112-A	Triode	1800	1.8
* # 117L7-GT	Beam Power	5300	5.3
* # 117M7-GT	Beam Power	2300	2.3
* # 117N7-GT	Beam Power	7000	7.0
* # 117P7-GT	Beam Power	5300	5.3
*183/483	Triode	1700	1.7

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* High plate current. A limiting resistor must be connected in series with zero-adjustment rheostat to prevent damage to milliammeter.

° Connect diode plates to cathode at socket.

Tube contains rectifier which may be used to supply d.c. voltages to v.t.v.m. circuit.

ever, should any school desire a film containing special code, they will need only to mail their request to the recording and processing station, where the desired film can be made and mailed back to the school in a week or two. All negatives will be saved and catalogued, and, in time, negatives will be on hand containing every conceivable type of code—perhaps even Japanese, if there are any Japs left.

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Wartime V.T.V.M. Circuits

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circuits in parallel, will reduce the input resistance of the electronic circuit inversely as the number of tubes.

Careful consideration of the characteristics of tubes which may be connected in parallel in v.t. voltmeter circuits will enable the experimenter to obtain any reasonable plate current shift for the convenient 1-volt signal voltage. He will in this way be allowed the advantage of high-transconductance tubes when the latter are not to be found in his stock.

No discussion of parallel-connected v.t.v.m. tubes would be complete without a word of caution that this connection increases the level of off-zero plate current flowing through the milliammeter. In order to protect the instrument against damage and almost certain burn-out, a limiting resistor must be included in the zero-adjusting bridge circuit. The resistor should be so chosen in ohmic value that the maximum amount of current flowing through the meter when the bridge circuit is unbalanced does not exceed 150 percent of the maximum full-scale deflection. And it is highly desirable that operation be confined even to closer limits.

The plate power supply must be capable of furnishing, with good regulation, the increased plate (and screen) current demanded by the parallel combination, and the low-voltage secondaries of the transformer must be capable of supplying the increased heater current.

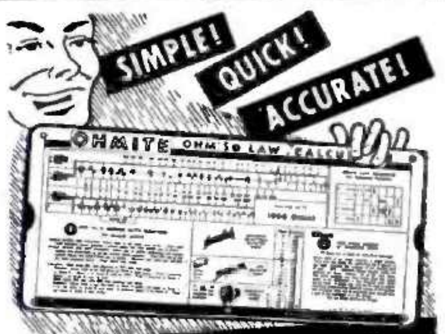
Parallel connection is not necessarily restricted to a pair of tubes. The number may be increased almost without restriction up to the limit of space requirements, power supply capability, grid-cathode capacitance restrictions, and allowable grid current. As an example, Fig. 2B shows a circuit containing five 6C5 type tubes parallel-connected to give a 10-milliampere plate current swing when 1 volt d.c. is applied to the grid circuit. The apparent transconductance of this combination accordingly is 10,000! A single 6C5 (G_m 2000) gives a 2-ma. shift for a 1-volt grid signal. The circuit normally employed with one tube is given with its constants in Fig. 2A.

In the circuit of Fig. 2A, off-zero plate current is 8 ma. at 250 volts. The required negative bias of 8 volts is developed across resistor R3. Resistance of the 6C5 plate-cathode path (31,250 ohms) acts with the resistance arms R1-R2, R4 and R5 to form a four-arm bridge for setting the meter initially to zero. Recommended resistor values, in this case, are : R1-R2, 31,250; R3, 200; R4, 3025; and R5, 3025 ohms. The total resistance of the R1-R2 arm is divided between the fixed and variable portions—R1, 31,000 and R2, 500 ohms. At balance, R2 will be set at half-range, and the ratio of R1 to R2 is proper to restrict the off-zero plate current to a safe value when the variable resistor is in other positions.

When additional tubes are connected in parallel (as in Fig. 2B) in any v.t. voltmeter circuit, the increased plate current of the combination lowers the plate resistance value for which the bridge resistor values were calculated. The bridge resistor values for the parallel combinations will accordingly be lower than those figured for single-tube circuits. In the five-tube 6C5 circuit shown, Rp and the bridge resistors are reduced to one-fifth of the single-tube values. Constants for Fig. 2B are: R1, 6200; R2, 100; R3, 40; R4, 605; and R5, 605 ohms. It must be borne in mind, however, that the single-tube resistor values may be divided by the number of tubes only when identical tubes (or tubes with identical characteristics) are employed. Otherwise, it will be mandatory that the total plate current of the parallel-connected tubes be determined experimentally at the recommended plate voltage, and that the four-arm bridge be designed according to the E_p/I_p ratio obtained from this measurement.

In the single-tube circuit (Fig. 2A), the d.c. power supply is called upon to furnish only 8 ma. to the tube and 40 ma. to the bleeder circuit. With good safety factor, a 75-100-ma. unit would be entirely satisfactory. In the five-tube version, on the other hand, the tubes require a total plate current of 40 ma. and the bleeder 200 ma.

Allowable grid current is usually the factor, in the final analysis, limiting the practical number of parallel-connected tubes. As grid current flow increases, the high-input impedance, which renders the v.t. voltmeter so useful, is lost. A condition is soon reached where the voltmeter circuit presents no higher resistance to the voltage source than does a common voltmeter, and the advantage of the electronic circuit disappears. Expected grid current for any parallel combination may be determined by applying 1-volt d.c. to the grid of a single tube operated at recommended plate (and screen) voltages. The positive terminal of the 1-volt source is connected to the grid; negative to cathode, and a d.c. milliammeter is connected at any point between voltage source and grid input circuit. The value of grid milliamperes is then multiplied by the number of tubes to be used, to obtain the total grid current to be expected. In order for the v.t. voltmeter circuit to be advantageous, the grid current must not exceed a few microamperes. (Cur-



rent required by the conventional 1000-ohms-per-volt meter is 1 ma. for the common type employing a 0-1 d.c. milliammeter).

Voltage-Multiplying Probe

The conventional diode-type v.t.v.m. probe, which permits the conventional d.c. circuit to be employed for the measurement of alternating voltages, employs a half-wave rectifier circuit. The d.c. voltage it delivers to the grid circuit is equal approximately to the peak value of the signal voltage.

In some instances, more convenient operation might be obtained if the diode output voltage were higher. For example, *smaller* a.c. voltages might be measured with a v.t. voltmeter having *normal* ranges. Likewise, the less sensitive instruments built under wartime restrictions might be adapted for low-voltage tests.

A convenient way of obtaining increased probe output is the connection of a twin diode as a full-wave voltage doubler, as shown in Fig. 3. This type of probe requires no larger mounting head than the conventional half-wave model and delivers a d.c. output voltage equal approximately to twice the signal peak voltage.

In Fig. 3, V1 and V2 are the two halves of a small twin diode, such as type 6H6. C1 and C2 are mica capacitors, each having a total capacitance of .02 μfd., and are each made up of two .01-μfd. units connected in parallel. Load resistor R is 50 megohms.

Where higher voltages than those delivered by the doubler-type probe are required, the quadrupler arrangement, shown in Fig. 4, may be employed. In this circuit, V1 and V2 are the diode sections of one 6H6, while V3 and V4 comprise a second tube of the same type. C1, C2, C3, and C4 are each .02 μfd. mica capacitors of the same type described for the doubler probe. Load resistor R is 50 megohms. Output voltage (d.c.) of the quadrupler probe is approximately four times the signal peak voltage—twice the level of that delivered by the doubler probe.

When the v.t. voltmeter is built into some other instrument, such as a signal generator, audio oscillator, or bridge, space requirements will generally be comparatively liberal and the space taken up by the input probe section will not be restricted. In such instances, the size of capacitors C1 to C4 may be increased to obtain more efficient doubler or quadrupler operation, by connecting more mica units in parallel. When low frequencies only (powerline and audio range) are to be encountered, it is entirely permissible to employ high-grade oil capacitors, .1 μfd. and higher in capacitance, in the doubler and quadrupler probes.

Both doubler and quadrupler probes present a large amount of input capacitance to the unknown-voltage source. They also demand an appreciable amount of current from the voltage source. These input circuits accordingly are not recommended for use where light loading is important. All such voltage-multiplying probes are best suited to measurements in the audio-frequency spectrum and at low radio frequencies (20 to 500 kc.), and then only when input capacitance will not interfere with normal operation of the measured circuit, and when considerable power may be delivered by the latter.

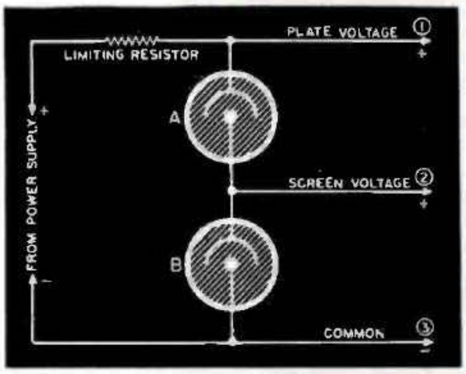


Fig. 5. Regulator tubes used to hold constant both the plate and screen voltages of v.t.v.m. circuits.

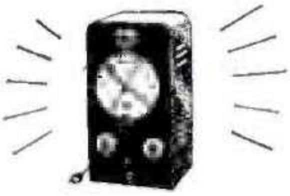
Screen Voltage Supply

No discussion involving the possible application of screen-grid tubes in v.t. voltmeter circuits would be complete without a word of caution regarding d.c. screen voltage. The presence of the extra electrode brings into the picture further considerations which are to be recognized in the interest of instrument efficiency.

Response of the voltmeter circuit, as well as permanence of calibration of the instrument, will depend upon maintaining the screen constantly at its recommended d.c. voltage value. With some tubes, particularly the beam power type, output variations are more closely related to screen circuit than plate circuit changes. The screen voltage accordingly must be set carefully at the proper value for the tube, with respect to other electrode values, and the d.c. power supply must be capable of maintaining this potential.

In most cases, it will be sufficient to obtain the screen voltage from a tap along a voltage divider. Usually, the series screen resistor will not be satisfactory in v.t. voltmeter circuits. The voltage-divider resistor must be of ample size, being capable of dissipating several times the amount of power which normally will flow through it, and its screen-voltage tap must be set *with the tube in operation,* the voltage value being measured with a high-resistance d.c. voltmeter (1,000 ohms per volt or better). In most cases, it will be desirable to by-pass the screen electrode *at the socket* with a capacitance of at least .1 μfd.

When it is desired to obtain regulated screen voltage for the v.t.v.m. circuit, gaseous regulator tubes of the VR type may be employed to regulate both screen and plate voltages, as indicated by Fig. 5. Two or more of these tubes are connected in series with each other, and the combination is connected in parallel with the d.c. output



of the power supply. Terminals 1 and 3 will then supply regulated plate voltage, while 2 and 3 will supply regulated screen voltage. When more than two tubes are employed, several screen and plate voltages are made available by appropriate taps.

The voltage available across the combination will be the total of the voltage drops across the tubes. For instance: if A is a VR105 and B is the same type, the output voltage (delivered to the plate) will be 210 volts. Likewise, the voltage available between the common terminal (3) and a tap will be the voltage drop across all tubes between those terminals. In the above example, the voltage at the tap (delivered to the screen) will be 105 volts. If tube B were a VR90, the screen voltage accordingly would be 90 volts, while the plate voltage (total of the drops) would be 195.

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International Short-Wave

(*Continued from page* 50)

9 p.m. (*EWT*). (Note: Berne is heard well in the Eastern United States.)

Brazzaville and Leopoldville (Africans) are tops in signal strength, and are the most consistent stations heard on the West Coast, Balbi reports.

"The Tokyo boys pound in day and night," he comments, "some in the Home Service; others to the United States, Australia, India, Europe, and South America."

Melbourne is excellent between 8:00 and 8:50 a.m. (EWT) on VLG2 (9.54) to East Coast; same again at 11 to 11:45 a.m. (EWT) on VLG6 (15.23), and is very strong and clear to West Coast.

London's GWO (9.62) and GSW (7.23), 12:15-12:45 a.m. (EWT) to India are strong on West Coast, where many of their European beamed programs on the 9- and 7-megacycle bands may be heard after 1:00 a.m. (EWT). Evenings, the General Forces Programs from London are very good for West Coast listeners.

USSR on 15.37 is local after 12 midnight at times in California. Leningrad (11.63) is also heard like a local after 1:00 a.m. Best is 12.27 megacycles from 11 p.m. to 2 a.m., or later, with music and native language, in parallel with 9.565 megacycles at times (EWT).

Other information of interest to Pacific Coast listeners, as well as listeners the country over, is furnished by Mr. Balbi, as follows:

* * *

EASTERN WAR TIME

Djarkata, Java (18.135), heard irregularly, 1:00 a.m. to 2:00 a.m., beamed to Australia. News, 1:00 a.m.

MTCY, Hsingking, Manchukuo (15.33), broadcasts 1:00 a.m. to 3:00 a.m. to the United States; 4:00 a.m. to 5:00 a.m. to Europe, replacing the 11.775 megacycles frequency. News, 1:30 a.m., 2:30 a.m. Prisoner-of-war messages, 1:00 a.m.

PIRM, Manila, Philippines (15.32), broadcasts 12:00 midnight to 1:00 a.m. to the United States. News, 12:30 a.m. Prisoner-of-war messages, 12:15 a.m.

Khabarosvk, USSR (13.13), broadcasts in native language from 1:00 a.m. to 2:40 a.m. (strong signal).

Brazzaville is heard on 11.97 between 1:00 a.m. and 2:30 a.m.

XMHA, Shanghai (11.86) is heard between 1:00 a.m. and 2:00 a.m. Weak. Full schedule is unknown.

DJD (11.77) is heard 1:00 a.m. to 3:00 a.m. transmitting to Asia. Weak signal.

JRAK, Tokyo (11.74) is heard irregularly, 12:00 midnight to 1:00 a.m., Home Service, same as JLG3 on 11.705 megacycles.

XGRS, Shanghai (11.695) is scheduled 1:00 a.m. to 12 noon. News, 1:15, 10:15 a.m. Strong during the early mornings.

GRG, London (11.68) heard well between 1:30 a.m. and 3:00 a.m. with the General Forces Program.

XGAP, Peiping (10.27) has moved from 6.105 megacycles. Signs off at 11:40 a.m.

RNB, Leopoldville (9.785) is heard on the West Coast at 11:00 a.m.; also, 12:00 midnight to 1:30 a.m.

(*Continued on page* 122)

RADIO TOKYO TRANSMISSION

BROADCAST SCHEDULE OF RADIO TOKYO BEAMED TO THIS HEMISPHERE. COMPILED THROUGH THE COURTESY OF D. BUCHAN OF THE BBC, NEW YORK OFFICE.

MEGACYCLES	CALL	TIME (EWT)	BEAMED TO:
9.535	JZI	9:00 a.m.—10:45 a.m.	E. North America and Brazil
		11:00 a.m.— 2:40 p.m.	W. North America
9.565	JRAK (Paulau)	7:00 p.m.— 8:00 p.m.	E. North America and Brazil
11.725	JVW3	7:15 a.m.— 8:15 a.m.	Latin America
		9:00 a.m.—10:45 a.m.	E. North America and Brazil
		11:00 a.m.— 2:40 p.m.	W. North America
11.80	JZJ	6:15 p.m.— 8:15 p.m.	E. North America and Brazil
		8:30 p.m.— 9:30 p.m.	Latin America
		11:00 p.m.— 4:00 a.m.	W. North America and Latin America
11.897	JVU3	6:15 p.m.— 8:15 p.m.	E. North America and Brazil
		11:00 p.m.— 4:00 a.m.	W. North America and Latin America
15.160	JZK	6:15 p.m.— 8:15 p.m.	E. North America
		11:00 p.m.— 4:00 a.m.	W. North America and Latin America
15.225	JLT3	7:15 a.m.— 8:15 a.m.	Latin America
		8:30 p.m.— 9:30 p.m.	Latin America
		11:00 p.m.— 4:00 a.m.	W. North America and Latin America
15.325	JLP2	8:30 p.m.— 9:30 p.m.	Latin America

Newscasts from Radio Tokyo are read on the hour, and are followed during all news-periods (mornings and evenings) by messages from American prisoners of war.