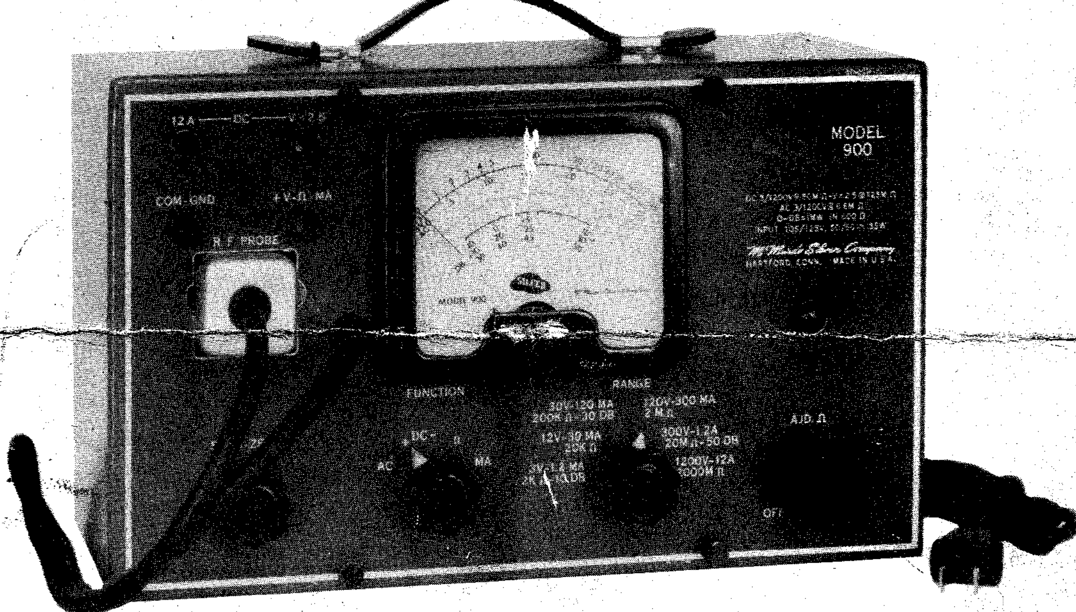
5000 Kc
1285 42.1
9325 42.3

SILVER

INSTRUCTIONS
FOR
MODEL 900 "VOMAX"



A jack and ob-

Figure 1

VACUUM TUBE VOLT-OHM-DB-MA-METER
AND
VISUAL DYNAMIC SIGNAL TRACER

INPUT: 105/125 V., 50/60 CYCLE A.C.

OVER 34 YEARS OF RADIO ENGINEERING ACHIEVEMENT

McMurdo Silver Company

1240 MAIN STREET, HARTFORD 3, CONNECTICUT

GENERAL

Model 900 "VOMAX" is a true vacuum-tube voltmeter of new and markedly advanced design. It makes possible d.c. voltage measurement at such astronomically high input resistances as to substantially eliminate loading effects upon sensitive circuits. It provides for a.c. voltage measurements at extraordinarily high meter input resistance throughout the frequency range of 20 cycles to above 100 megacycles. Vacuum-tube resistance ranges cover .2 ohms through 2,000 megohms, while insulation resistance well beyond this range may be measured with the addition of an external battery. Direct currents from 50 microamperes through 12 amperes may be measured. Decibel ranges are from −10 through +50 db. Capacitances over a wide range of commercial values may be measured by the addition of two external rheostats and reference to a chart.

Through new war-born inventions the effects of fluctuations in mains input voltage and of aging of vacuum tubes are practically completely eliminated. The usual deleterious effects of vacuum-tube grid and gas currents heretofore so ruinous of accuracy have been practically eliminated through design features exclusive to "VOMAX".

One knob adjustment sets meter zero for all ranges at start of operation. A second knob establishes full scale ohmmeter set, when resistance ranges may be shifted without requiring re-zeroing.

The name "VOMAX" is basically descriptive of functions — "V" for volts, "O" for ohms, "MA" for milliamperes/amperes, and "X" for capacitative reactance, decibels, a.f. and r.f. volts and visual dynamic signal tracing. No such short title can be adequately descriptive of the multitude of ranges and functions which "VOMAX" makes available to the research engineer and serious service technician, not to mention its unusually high accuracy. Stability rivals that of the basic meter movement itself.

ELECTRICAL SPECIFICATIONS

INPUT: 105/125 volts, 50/60 cycles alternating current only. ("VOMAX" may be adapted to higher mains voltages, of frequency between 50 and 60 cycles **only** by a conventional reducing transformer, or by insertion of a series input resistance — 30 watts per 100 volts — in mains cord having total resistance determined upon the basis of 3.46 ohms per volt of increased mains voltage above nominal "VOMAX" input of 115 volts.)

RANGES: Fifty-one effective ranges divided as follows:

D.C. volts 3, 12, 30, 120, 300 and 1200 at 51 megohms constant input resistance (1 megohm in capacity-isolating test prod). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.

D.C. volts 7.5, 30, 75, 300, 750 and 3000 at 126 megohms constant input resistance (obtained at Vx2.5 and COM-GND jacks). Same six ranges in reverse polarity by shift of FUNCTION knob. Accuracy ±3%.

A.C. volts 3, 12, 30, 120, 300 and 1200 volts at circuit loading equivalent to 6.6 megohms shunted by 50 mmfd. (diode probe plugged into panel socket). Accuracy ±5%.

R.F. volts same as A.C. volts but at circuit loading equivalent to 6.6 megohms shunted by 8 mmfd. (diode probe withdrawn for direct contacting to circuit to be measured). Accuracy ±5%.

OHMS: Six resistance ranges, all zero-left, of 2,000, 20,000, 200,000 ohms and 2, 20 and 2,000 megohms. Accuracy ±2% of full scale, ±1% of indicated resistance.

DECIBELS: Three db. ranges (0 db. =1 milliwatt in 600 ohms) of −10/+10, +10/+30 and +30/+50 db.

CURRENT: Six direct current ranges of 1.2, 30, 120, 300 and 1200 milliamperes and 12 amperes. Accuracy ±3%.

FREQUENCY RANGE: 20 cycles through 100 megacycles. "VOMAX" may be employed up to several hundred megacycles with lesser accuracy due to progressively increasing errors occasioned by resonance and transit-time effects in diode rectifier probe.

METER: 4⅝" D'Arsonval movement, 0-1 ma. full scale. Accuracy ±2% of full scale.

MULTIPLIERS/SHUNTS: Multiplier resistors are ±1% matched pairs aged for stability. Current shunts are ±1% wire-wound resistors.

CAPACITORS: Capacitors are hermetically sealed molded-mica, and oil impregnated and electrolytic units hermetically sealed in metal cases. Electrolytic units, though of standard easily replaceable commercial type, are plug-in through employment of new spring contact clips.

ACCESSORIES: Two Burgess No. 2 1½-volt flashlight batteries for ohmmeter circuit.
One tube complement consisting of 1 — 6AL5 miniature dual diode, 2 — 6SN7GT dual triode cathode follower and meter-actuating tubes, 1 — 5Y3GT (or 5Z4) rectifier.
One red and one black test prods with 48" leads (red prod with reversible tip for a.c. and d.c. voltage measurements).

OVERLOAD PROTECTION: Meter protected against burn-out due to overload on volts, ohms, db., but not on ma/a.

NEW CIRCUIT

The extraordinary stability and dependability of "VOMAX" are due to entirely new and war-born engineering advances. The circuit diagram of Fig. 3 will upon careful study reveal these advanced design features and differences from conventional instruments.

The high order of stability, independence of mains voltage fluctuations and aging of vacuum tubes are obtained by full-balanced circuits in which possible variations in each tube circuit are balanced out by equal and opposite variations in complementary balancing tubes (second sections of each dual tube). Unusually heavy degeneration in each triode circuit, coupled with high diode load resistance, operate to almost completely wash out variations due to voltage fluctuations and tube aging.

The sections of the 6AL5 and 6SN7GT tubes at the top of Fig. 3 comprise the "signal" or measurement circuit. The duplicate sections of these tubes toward the bottom of the diagram constitute the balancing circuits. Each measurement tube is seen to have its companion balancing tube. Three dual-purpose tubes are employed in preference to six single-purpose tubes, since manufactured and processed identically the uniformity between sections of the same tube may be anticipated to be greater over time than can be expected of separate tubes which might be manufactured under markedly different circumstances.

The upper section of the 6AL5 functions as the diode rectifier for a.c. and r.f. voltage measurements, being switched into circuit when so required by ganged switches S1e and S1f. Any diode generates within itself "contact potential" which will produce an initial voltmeter reading. This contact potential is balanced out by that similarly generated within the second diode of the 6AL5 to yield an initial voltmeter zero. Exactly as the contact potential of the upper measurement diode (as well as the rectified a.c. employed to actuate the d.c. voltmeter) is divided down by voltmeter range "stick" R8 through R13 and RANGE switch S2b, so is the balancing potential controlled in step therewith by R2 through R5 and RANGE switch S2c. Initial balance between measurement and balancing contact potentials is established by factory adjustment of R42.

The central 6SN7GT dual triode in Fig. 2 is the cathode follower measurement and balancing tube combination. Operated Class A at very low plate voltage and with extraordinarily heavy degeneration, it explains the unusual freedom of "VOMAX" from usual grid and gas current effects. Its plate voltage is so low as to prevent ionization of residual gas or the appearance of grid current. This is its exclusive and vitally important function. Input voltages are fed to its upper grid through RANGE "stick" R8 through R13 and switches S2B and S1B. In a.c. operation balancing contact potential is fed to its lower grid, which is grounded for all other functions, by switch S1a.

The right hand 6SN7GT tube in Fig. 3 is the meter-actuating triode; top section for measurement, bottom section for balancing. Switches S1c and S1d reverse the meter polarity as required for a.c., d.c.+, and d.c.− measurements, and shift the meter alone over to direct current shunts R27 through R32 and RANGE switch S2e. R34 is the front panel SET-V-ZERO knob, one single adjustment of which sets meter zero for all functions.

Ohmmeter operation involves use of the d.c. vacuum-tube voltmeter comprised by the two 6SN7GT tubes and their associated components switched over to 3-volt dry battery B, ohms RANGE switch S2d and ohms multiplier resistors R14 through R19.

The d.c. voltmeter employed for all voltage and ohms measurements (the two 6SN7GT tubes and associated components) has a basic range of 0-3 volts, which is multiplied to yield higher ranges by 50 megohm "stick" R8 through R13. For the Vx2.5 ranges, 75 megohms (R6, R7) is placed in series with this "stick" and the Vx2.5 panel jack. Switch S2a selects the appropriate factory adjusted wire-wound RANGE SET resistors; R22 for d.c., R23, R24, R25 and R26 for a.c.; and panel ADJ Ω control R33 for setting meter initially to full scale in resistance measurements.

Transformer T and 5Y3GT power supply rectifier develop approximately 360 volts across voltage divider-bleeder R37, R38, R39 and R40, with required filtration accomplished by plug-in capacitors C5 and C6. Half of this voltage is effectively across plate-to-cathode of the right-hand 6SN7GT, approximately 10% thereof on the center cathode follower 6SN7GT. Substantially equal negative voltages developed across R39, R40 operate to offset the large voltage drops across degenerative cathode resistors. R35, R36 and R20, R21 to insure Class A operation of these tubes.

One of the particular advantages of "VOMAX" is that, used as an a.c. or d.c. voltmeter, it can measure its own internal operating voltages. Used as an ohmmeter it can measure its own internal multiplier resistors. It is thus practically self-servicing.

PANEL CONTROLS

The panel nomenclature of "VOMAX" is so self-explanatory as to enable the veriest tyro to operate the instrument in practically all routine measurements. A complete understanding of all controls and functions will insure greatest satisfaction, however.

FUNCTION knob (switches S1a through S1f) has five positions. Its setting determines the type of measurements to be made. AC position is for a.c., r.f. and d.b. measurements. The COM-GND jack is **always** connected through the black test prod to the chassis or common ground of the equipment under test. With FUNCTION knob in +DC position "VOMAX" will measure selected d.c. voltages upon application of the tip screwed into the far end of the red test prod to any point of voltage positive with respect to chassis of equipment under test. FUNCTION knob in DC— position will measure the same range of d.c. voltages, but negative with respect to equipment chassis. FUNCTION knob thus reverses d.c. polarity when required and makes unnecessary reversal of test leads. Ω position of FUNCTION knob provides for resistance measurements; MA position provides for direct current measurements.

RANGE KNOB (switches S2a through S2e) selects the desired voltage, resistance or current range. Its six positions are so clearly identified as to require little comment. It is merely necessary to set RANGE knob to the position providing the full-scale meter range desired for any particular type of measurement.

PANEL JACKS

Two of the four jacks at the upper left of the panel provide additional ranges when correctly utilized. The COM-GND jack is common to all except r.f. measurements (r.f. probe withdrawn from instrument). It is grounded to "VOMAX" panel and circuit. By means of the black test lead it should be connected to the chassis or common grounded circuit of equipment under test. The red test prod with its small cord tip inserted into the +V — Ω —MA jack provides the remaining meter connection to the circuit being tested.

The 12 ampere direct current range is obtained between the COM-GND (negative) and 12A (positive) jacks.

The six positive and six negative (polarity determined by FUNCTION switch position) d.c. voltage ranges of 7.5, 30, 75, 300, 750 and 3000 volts are obtained between COM-GND (negative) and Vx2.5 (positive) jacks.

READING METER

The top scale is graduated directly in ohms from 0 to 2,000. The six RANGE knob positions yield six different resistance ranges differing only in the number of zeros to be added to the scale figures, the full-scale reading in each case being directly indicated by the RANGE knob figures.

The 3-volt a.c. range only is read on the scale immediately below the ohms figures.

All other voltage ranges, and direct current as well, are read on the green center scales. The graduations upon upper and lower green scales are identically spaced, the scales being linear. All voltage ranges beginning with the figure "3" are read upon the upper green scale, with appropriate number of zeros added as indicated by the RANGE switch setting. Similarly all ranges beginning with the figures "12" are read upon the lower green scale with appropriate zeros added.

When using the d.c. ranges beginning with the figures "7.5" provided by connecting the Vx2.5 panel jack, correct voltage is that indicated upon the upper green scale multiplied by 2.5, with appropriate zeros added. The high ranges so obtained but beginning with the figure "3" are read directly from the upper green scale with appropriate zeros added.

The decibel scale at the bottom of the meter scale is read directly, selecting the appropriate group of which the right-hand figure corresponds to the RANGE knob position. (For simplicity of meter face a small error has been intentionally allowed in the lowest db. range. This error corresponds to the difference in slope between the 3 V.AC meter scale and the upper green scale. It amounts to less than 2 db. from 0 to +10 db., and increases somewhat below 0 db., where the meter reads low.

PROPER USE OF TEST PRODS

A pair of insulated test prods accompany "VOMAX". One is conventional, black in color, and should **always** be plugged into the COM-GND jack. The second is red, and is of special design in that its circuit-contacting metal tip may be screwed into either end of the red prod sleeve. This tip must be inserted properly if serious error is to be avoided.

For all measurements except d.c. voltage screw the tip into the end nearest the point of rubber cord emergence.

For d.c. voltage measurement screw the tip into the far end of the red prod (the end furthest distant from the point of cord emergence).

This shift of red prod tip position allows one prod to do the work of two. When the tip is screwed into the cord end it connects directly to the cord, as for a.c. volts, ohms and ma. measurements. When the metal tip is screwed into the far end of the red prod a 1 megohm 1% resistor isolates it from the connecting cord, and so isolates the capacity of the instrument itself from any circuit under measurement. This permits measurement of d.c. operating voltages directly at the tube socket connections in an operating radio receiver without upsetting circuit behavior. Meter calibration is made at the factory with this 1 megohm resistor in the red prod in circuit upon d.c. voltage ranges, with it out of circuit on all other functions. If d.c. voltages are measured with the prod tip in the cord end of the red prod the meter will read 2% high.

INITIAL ADJUSTMENTS

Examine meter upon unpacking to make sure pointer reads exactly zero. If it does not, bring it to zero by adjusting the screw found on the meter housing at bottom center. If this mechanical zero-set operation is necessary, tap the meter as it is made to make sure that the pointer returns to exact zero after adjustment.

Insert mains plug into 105/125 volts, 50/60 cycle a.c. power outlet only. (For higher mains voltage see Page 1).

Set FUNCTION knob to MA. Turn ADJ. Ω knob to illuminate pilot lamp.

Allow two or three minutes for "VOMAX" tubes to warm up.

Set FUNCTION knob to +DC.

Set RANGE knob to 3V.

Set SET V-ZERO knob to bring pointer exactly to zero on the meter scale. **Don't** insert test leads in panel jacks.

Rotate RANGE knob through all six positions and note insignificant change of meter zero reading. (ALWAYS ZERO METER ON 3 VOLT +DC. RANGE.)

Shift FUNCTION knob to DC — and note absence of zero shift as RANGE switch is rotated.

With zero established as above, set FUNCTION knob to Ω position RANGE to 2K Ω, and set ADJ. Ω knob to bring meter pointer exactly over 3.0 graduation on 3V AC scale. Rotate range knob and note absence of shift in meter reading.

Turn FUNCTION knob back to +DC, RANGE knob to 3V, and note zero. If it has shifted due to failing to allow sufficient time for "VOMAX" tubes to attain proper operating temperature, reset zero with SET-V-ZERO knob. Now set FUNCTION knob to AC and note constancy of zero reading as RANGE switch is rotated through all ranges.

(NOTE — AC and DC meter zero readings will differ less than 2% when tubes are new and when AC balance resistor R42 is properly set, as when "VOMAX" leaves the factory. As tubes age AC and DC zero readings will tend to separate slightly. Until this difference becomes significant it may be ignored or may be compensated for by readjustment of SET-V-ZERO knob for AC. When it exceeds 2% proceed as follows: set zero on +DC, 3V RANGE, shift FUNCTION knob to AC, adjust R42 to bring meter pointer to zero.)

Now insert the red test lead into the +V —Ω —MA jack and observe the meter reading obtained upon the 3V ranges, DC or AC. This is not an indication of meter instability, for in setting zero the meter was entirely stable — remained so until the red prod was inserted in +V —Ω —MA jack. This reading as the red prod is handled, touched, or moved about is simply a proof both of the high input resistance and the high sensitivity of "VOMAX" — both sufficiently high to reveal electrostatic pickup upon the short test lead itself. Check this fact by inserting the tip of the red prod into the COM-GND jack, when meter pointer will fall to zero.

With FUNCTION knob set to AC, withdraw r.f. diode probe from its panel socket and note the absence of zero shift. Touch the probe tip with the finger and note the meter shift — the measure of high input resistance and high sensitivity. Short-circuit the probe tip to its shell and observe how the meter pointer falls to zero.

D.C. VOLTAGE MEASUREMENTS

Set FUNCTION and RANGE knobs to appropriate settings and contact the black and red prod tips (tip in far end of red prod) to the source of voltage to be measured, black **always** to chassis or common circuit ground, red to "hot" or "high" side of circuit. If meter reads in wrong direction, shift FUNCTION knob from +DC to DC—, or vice versa.

Check protection of meter against overload burnout by applying anything up to 3000 volts to the test prods with RANGE switch set to 3V. (Do not leave overload on meter for any length of time, for meter can be injured by lengthy overload.)

Gain familiarity with operation of the high voltage Vx2.5 ranges by measuring some d.c. voltage as above, then remeasure it after shifting red prod lead to Vx2.5 jack, notice the 60% reduction in meter reading when so measured (60% low since meter reading must be multiplied by 2.5 to obtain correct voltage when reading any "3" RANGE on upper green scale; "3" meter scales are correct for "12" RANGES when using Vx2.5 jack).

A.C. VOLTAGE MEASUREMENTS

Proceed as above with R.F. PROBE in its panel socket, using red and black test prods (tip in cord end of red prod). If a radio receiver or audio amplifier is handy, note how "VOMAX" will measure not only a.c. mains voltages, but a.f. voltages present at grids and plates as well.

In measuring a.c. voltages on the 1200 V range, contact the test prod to such high voltage briefly and as infrequently as possible to avoid damaging overload upon the 6AL5 rectifier tube. This range has been efficiently and usefully obtained at the expense of possible deterioration on the 6AL5 tube if it is used excessively.

R.F. VOLTAGE MEASUREMENTS

Withdraw R.F. PROBE from "VOMAX" and measure r.f. voltages present in a radio receiver tuned to a strong signal by contacting the probe tip to grid or plate while probe shell simultaneously contacts chassis ground. (Below 10 mcs. short test leads may be clipped to probe tip and can without serious error.)

The R.F. PROBE adds 8 mmfd. to any circuit to which it is contacted. True voltage measurement will require temporary retuning of the trimmer capacitor of the circuit being measured to offset this added capacity. Once measurement has been made the trimmer may be retuned to its proper setting by contacting the R.F. PROBE to a following tube grid or plate circuit and returning the upset trimmer to the point of greatest voltage reading on "VOMAX".

RESISTANCE MEASUREMENTS

Set FUNCTION knob to Ω, RANGE knob to appropriate range, set ADJ. Ω knob to full-scale meter reading (if not previously done after setting SET-V-ZERO knob in +DC, 3V positions) and contact test prods to resistance to be measured. Read resistance directly on top meter scale, adding appropriate zeros as determined by setting of RANGE knob.

(NOTE — In checking battery-operated, low-current tubes for filament continuity DO NOT use the 2K Ω range for this applies nearly 3 volts to such filaments and may burn them out. Use the 20K Ω range, or an even higher one. This will check continuity properly and avoid burnout of battery tubes.)

Use the 2K Ω range no more than necessary, since load on ohmmeter dry batteries is greatest upon this range.

Ohmmeter accuracy being greatest at mid-scale, most accurate resistance measurements will result when a range is used which yields a reading thereabouts. "VOMAX" has sufficient resistance ranges to usually make this convenient.

When measuring resistance below 1 ohm, allow for resistance of test leads by noting resistance reading when their tips are touched together, and subtract this value of resistance from the measured value of the resistor being measured.

INSULATION RESISTANCE MEASUREMENTS

The 2000 megohm range allows measurements of leakage in capacitors, transformers, cables and insulation generally which have heretofore been almost impossible to the service technician. This range may be greatly extended by the addition of an external source of d.c. voltage (a battery or a radio receiver power supply). To measure resistances above 1000 or 2000 megohms, first measure the voltage (using COM-GND and +V −Ω −MA jacks only) of the external d.c. source used and note same. Then upon a low range of "VOMAX", measure the voltage which may appear when the capacitor (or the insulator) is connected between the voltage source and the red test prod inserted in +V −Ω −MA jack. The resistance in megohms of the insulator (?) will be given by the formula

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{\text{Source voltage} - \text{series voltage}}{\text{series voltage}}$$

For example, suppose a source of 300 volts (read on +DC, 300V settings) and a series voltage of 1.2 volts (read on +DC, 3V settings with test specimen connected between red test prod and positive terminal of voltage source), then

$$\text{UNKNOWN RESISTANCE} = 51 \times \frac{300 - 1.2}{1.2} = 12{,}699 \text{ megohms}$$

DIRECT CURRENT MEASUREMENTS

Set FUNCTION knob to MA, RANGE knob to 12A, insert black test prod lead into COM-GND jack and red test lead into 12A jack. Pass current to be measured through test prods and note meter reading. If current is too low to deflect meter usefully, shift red prod to +V −Ω −MA jack and turn RANGE knob to left, one position at a time, until useful reading is obtained.

(NOTE — ALWAYS proceed as above in making current measurements. The meter has no protection against overload in current measurements. Starting with RANGE knob set to too low a range can result in immediate meter burn-out. It is better to start out in current measurement on the highest range and spend a few seconds reducing range to obtain final reading than to hurry things and ruin the entire instrument.)

DECIBEL MEASUREMENTS

Set FUNCTION knob to AC, RANGE knob to selected db. range, and contact black and red prods to a.f. power source to be measured.

NOTE: As a db. meter "VOMAX" contains its own d.c. isolating capacitor. Its impedance is so high as not to noticeably load any usual power amplifier output circuit. Such amplifier output circuit must be terminated in its own specified output impedance in the form of usual load such as a loud-speaker voice coil, or in a non-inductive resistor of resistance equal to amplifier output impedance.

"VOMAX" will indicate db. directly upon its meter scale when connected across a 600 ohm amplifier output upon the basis of 1 milliwatt =0 db. In most cases amplifier output will not be 600 ohms, but some lower value suitable for direct connection to a loud-speaker voice coil. To read db. correctly across impedances other than 600 ohms, ADD the db. figure below to the meter indication when measurements are made across the corresponding impedance.

OUTPUT IMPEDANCE	ADD DB.	OUTPUT IMPEDANCE	ADD DB.
600	0	30	13.0
500	1.08	25	13.8
400	1.3	20	14.7
300	3.0	16	15.7
250	3.8	10	17.7
200	4.7	8	18.75
150	6.0	6	20.0
125	6.8	5	20.8
100	7.7	4	21.7
70	9.33	2.5	23.8
50	10.8	2.0	24.7

Power output in watts may be determined as

$$\text{WATTS} = \frac{\text{Output Voltage Squared}}{\text{Load Impedance}}$$

For example, the measured voltage across an 8-ohm voice coil load is 2 volts.

$$\text{WATTS} = \frac{2^2}{8} = \frac{4}{8} = .5 \text{ watts}$$

POWER INPUT MEASUREMENT

"VOMAX" can be used as an a.c. (or r.f.) ammeter to determine approximate power input to a radio receiver, etc. This involves measurement of the a.c. voltage drop across a low resistance resistor connected in series with the mains input to the equipment drawing power. Such resistor should be of low resistance in order that only a volt or two at most out of 117 nominal input volts appears across it.

For example, 2 ohms placed in series with a receiver power input circuit shows a voltage drop measured across it of 1.1 volts,

$$I = \frac{E}{R} = \frac{1.1}{2} = .55 \text{ amperes}$$

Measure the voltage across the receiver mains input and finding it to be 115 volts for example, multiplying volts by amperes gives power input in watts

115 volts X .55 amperes =63.25 watts.

This would be true if the receiver were a pure resistive load. This is substantially true for an a.c./d.c. receiver. An a.c. receiver having a power transformer presents a reactive load, and the statement for power input is not therefore strictly true. It is close enough in most cases to yield a good approximation of power input in watts, however.

By the same method, substituting a series capacitor in an antenna lead, for example, r.f. current may be measured, and power computed if load impedance is known.

VISUAL DYNAMIC SIGNAL TRACING

Measurement of a.c. heater voltages and d.c. grid, cathode, screen and plate voltages is the first step in serious receiver servicing. Check of the supply voltages so measured against the set manufacturers circuit diagram test voltage chart will reveal deteriorated tubes, faulty resistors, capacitors, transformers, reactors and open- or short-circuits. In the majority of cases of trouble these measurements, made with such a high resistance meter as "VOMAX", will localize the trouble and allow immediate replacement of the faulty part. The high resistance of "VOMAX" on d.c. voltage measurements is of inestimable advantage in checking a.v.c. systems, wherein the development of leakage in an a.v.c. bypass capacitor cuts down the a.v.c. voltage on one or more tubes. Such faults can be rapidly located by "VOMAX" through direct measurement of a.v.c. voltage at each successive controlled grid. Measure questionable resistors, and leakage resistance of capacitors.

When the procedure above shows everything to be correct, but operation poor, dynamic signal tracing becomes the service technicians invaluable aid. Actually this is nothing more than the measurement of the received signal voltage itself at every grid and plate successively through the entire amplifying chain of tubes in a radio receiver. Obviously if amplifier tubes are actually amplifying the signal voltage will appear greater as the R.F.PROBE is moved along successively from antenna input to power amplifier plate, circuit by circuit.

Quantitative signal tracing involves application of a strong signal from a local broadcast station or signal generator to the receiver input and the measurement of this signal voltage across antenna and ground, then across first grid to ground. The increase or decrease in voltage is the direct measure of gain or loss of antenna transformer. The same process is repeated for every amplifying stage in the receiver. Each measurement preferably includes a tube and coupling transformer, and is most easily made first at one grid, then at the immediately following grid. The gain or loss is the larger voltage observed divided by the smaller.

Because of the inescapable though small input capacitance of any vacuum-tube voltmeter R.F.PROBE, shunting the probe across grid to ground of an r.f. or i.f. stage adds capacity thereto — about 8 mmfd. in the case of "VOMAX" R.F.PROBE contacted directly tip to grid or plate and shell to chassis. This added capacity will slightly detune the circuit being measured and so reduce the voltage appearing across it at the instant of measurement. In preliminary qualitative tests this effect may often be ignored, but for precise measurements the trimmer of the circuit across which voltage is being measured should be adjusted, while the R.F.PROBE is contacted to the circuit, to give maximum voltage reading. The trimmer may be reset by moving the R.F.PROBE along to the next grid circuit and then readjusting the preceding circuit trimmer for greatest voltage reading.

In visual dynamic signal tracing as above the effect of the receivers a.v.c. system must be allowed for. When a strong signal is applied to the antenna input the a.v.c., if functioning properly reduces the gain of each stage enough to hold the i.f. input to the second detector substantially constant. To measure true stage gains the a.v.c. must be rendered inoperative by connecting a jumper from ground to the r.f./i.f. grid side of the first a.v.c. series filter resistor.

From the above it is apparent that a.v.c operation may be accurately checked, and curves plotted if desired, by contacting "VOMAX" R.F.PROBE to the second detector input, retuning the appropriate i.f. trimmer temporarily to give greatest voltage reading, and then reducing antenna input in progressive steps. Plotting a curve of second detector input voltage versus r.f. antenna input voltage gives a basic a.v.c. curve.

In preliminary visual dynamic signal tracing it is convenient to dispense with the necessity of retrimming each circuit measured when the R.F.-PROBE is contacted to it. This is made possible by reducing the 8 mmfd. input capacitance of the R.F.PROBE to some value so low as not to necessitate retrimming. A capacitor of .5 to 1 mmfd. placed in series with the R.F.PROBE tip and the grid or plate to be contacted will reduce R.F.-PROBE capacitance-loading to a value so low as not to significantly upset the tuning of the circuit being measured. Such a capacitance must be as small in physical size as possible. It is most easily obtained by cutting a length of spaghetti insulating tubing of size which will just slip over the R.F.PROBE tip to a length which will completely cover the tip.

This spaghetti sleeve acts as the dielectric of a small capacitor, the plates of which are formed by the R.F.PROBE tip and the socket lug against which the spaghetti (with tip inside it) is contacted. This is a most effective method of simplifying signal tracing. It reduces the sensitivity of the meter considerably, but the 1 volt obtainable from the average local broadcast station or signal generator will usually be sufficient to give a perceptable meter deflection at antenna, first r.f. grid, or certainly at second r.f. grid.

MISCELLANEOUS TESTS

OSCILLATOR VOLTAGE: The strength of oscillation of a superheterodyne or other oscillator may be measured directly in volts with "VOMAX". Contacting the R.F.PROBE to oscillator grid and ground will give a direct indication of the r.f. voltage being developed by the oscillator. It may also be estimated as the negative d.c. voltage developed at the oscillator grid, FUNCTION switch set to DC—, RANGE to appropriate voltage range, and tip in far end of red prod contacted to grid. The first method measures oscillator r.f. voltage directly, the second is indirect and less desirable. By the direct R.F.PROBE method uncertainty is eliminated. Oscillator voltages over each and every band of a receiver up beyond 100 megacycles may be so measured directly.

A.V.C. VOLTAGE: This important class of measurements has been covered under VISUAL DYNAMIC SIGNAL TRACING. A.v.c. voltages are usually negative with respect to chassis ground. FUNCTION knob should therefore be set to DC—, and red prod with tip in far end successively contacted to a.v.c. load resistor, then to each a.v.c.-controlled grid. A stable and reasonably strong input signal should be employed, as from a local broadcast station or signal generator. IT IS CONVENIENT TO CONNECT "VOMAX" ACROSS THE SECOND DETECTOR, OR A.V.C., LOAD RESISTOR IN ALIGNMENT — WHEN ALIGNMENT SHOULD BE EFFECTED TO GIVE GREATEST METER READING.

FM AND A.F.C. DISCRIMINATOR VOLTAGE: The d.c. voltage developed by the discriminator in FM receivers, and in a.f.c. systems, may be measured directly across the discriminator load resistors with "VOMAX". Because this voltage shifts from positive to negative as signal frequency is varied, a zero-center meter is desirable. When properly aligned to a carrier frequency, discriminator output should be zero. Use of a zero-left meter can indicate deviation in only one direction. "VOMAX" can be converted to a zero-center meter for discriminator voltage measurement by simply adjusting the SET V-ZERO knob to bring the meter pointer up to 0 on the db. scale, when deviations in both directions may be readily observed.

TELEVISION RECEIVER VOLTAGE MEASUREMENTS: All types of voltages in television receiver video and audio channels may be measured by "VOMAX". As a peak-reading a.c. voltmeter "VOMAX" is calibrated in R.M.S. values of the sine wave, or .707 of peak value. It may be employed to measure the peak values of sweep oscillator voltages and of saw-tooth or square-wave sources.

AUDIO VOLTAGES: With R.F.PROBE in panel socket, FUNCTION knob at AC and tip in near end of red prod, audio voltages throughout all successive circuits of an audio amplifier may be measured from 20 cycles on up. At high frequencies, and in resistance-capacitance coupled a.f. amplifiers, the effect of the 50 mmfd. input capacitance of "VOMAX" when so used must be allowed for. In making accurate measurements over a wide frequency range it is desirable to do so with the R.F.PROBE directly. However, the 500 mmfd. input capacitor in the R.F.PROBE is so small as to cause error at usual audio frequencies. This may be obviated if one lead from a capacitor of .025 to .1 mfd. is temporarily soldered to the small screw-head found on the R.F.PROBE ceramic head and the other lead of this capacitor used as the probe tip to the circuit under measurement.

SUPERIMPOSED VOLTAGES: D.C. voltages present in a circuit simultaneously with a.c. voltages, and vice versa, can be independently measured by "VOMAX" with no special precautions. When using a.c. functions the series input capacitor blocks out d.c. When using d.c. functions, the a.c. filter R41, C4 filters out a.c.

INSULATION RESISTANCE: Measurement of insulation resistance of capacitors transformers, reactors and other insulators has been covered under INSULATION RESISTANCE MEASUREMENTS.

PRECAUTIONS: To keep input capacitance to a minimum in AC voltage functions of "VOMAX", and to similarly hold down input capacitance in DC operation, the red test lead has not been shielded. In making measurements on high resistance circuits, therefore, the red test lead should be kept away from a.c. mains conduits or wiring. In AC operation, grasp the red prod at its far end, vice versa in DC. Keep the red lead away from the body. Observation of these precautions, coupled with possible grounding of "VOMAX" panel in extreme cases of local electrostatic fields, will avoid errors or instability due to "floating "a.c. lines while keeping meter capacitance at a minimum.

CAPACITANCE MEASUREMENTS: Accurate capacitance measurement is possible only with a bridge circuit which takes into account both capacitance and resistance; which has a dissipation factor or power factor balance. The same is true for inductance measurements. However, rough but useful capacitance measurements may be made in an emergency with "VOMAX". What is so measured is the capacitance reactance, Cx, of the capacitor under test. The method involves connecting the unknown capacitor and a variable resistor in series across a source of 5 to 120 volts of 60 cycle a.c., and adjusting the resistor until the voltage measured across it equals exactly the voltage measured across the capacitor. The resistor is then measured upon the OHMMETER of "VOMAX" and its value located upon Fig. 4, from which point the capacitance may be read directly. One 3000 ohm rheostat and one 3 megohm rheostat will serve for capacitors between 10 and .01 mfd. (When using 50 cycles, true capacitance is 5/6 of the value so indicated.)

MAINTENANCE

Built of the high quality parts, no trouble need be anticipated over long periods of time. Accuracy will maintain even though the same tubes are used in continuous operation for long periods. Variation in and aging of tube characteristics have little effect upon operation.

OHMMETER BATTERIES: Ohmmeter batteries should be replaced when they measure less than 2.2volts total as measured by +DC FUNCTION, 3V RANGE of "VOMAX" itself or when OHMMETER readings become unstable. Connections to batteries should be unsoldered, old batteries removed, new ones inserted and connections thereto resoldered.

VACUUM TUBES: 6SN7GT Vacuum tubes may be replaced when SET V-ZERO knob will not bring meter pointer to zero, or when zero appears unstable after 10 to 15 minutes warm up time. Known-good tubes, R.C.A. only, may be substituted for original tubes. The same applies to the 6AL5 R.F.PROBE tube. It should be replaced when no adjustment of R42 only will make AC zero coincident with DC zero. If the first 6AL5 tried will not permit establishing AC zero coincident with DC zero through adjustment of R42, a second tube should be tried. If no second tube is available, requiired of AC and DC zeros brought about through adjustment of R42 only may be obtained by interchanging the connections to lugs 2 and 7 at the R.F.PROBE tube socket or by connecting a 5 Meg. ½ w. resistor from right lug of R42 to GND. jack.

CALIBRATION: Recalibration should practically never be necessary unless the instrument is abused, damaged or its internal RANGE SET resistor adjustments are tampered with. DC calibration may be affected by applying 2 or 3 volts of precisely known d.c. voltage (measured by an external precision laboratory-type meter standard) to the 3V, +DC range of "VOMAX" and then carefully adjusting R22 for identical readings between the external standard meter and "VOMAX" meter. Higher voltage ranges when tested will then be found to be in step. AC calibration requires an equally good meter having ranges of 2/3, 8/12, 20/30 and 80/120 volts, together with a low-frequency a.c. voltage source within these limits. Having zeroed "VOMAX", calibration consists of applying a definitely known 50 or 60 cycle a.c. voltage to "VOMAX" input, and adjustment of internal a.c. RANGE SET resistors to identicality of meter readings for the four different a.c. voltages on the four meter ranges. Using an external voltage which will give a meter reading somewhere upon the upper ⅓rd of "VOMAX" scale for each of the 3, 12, 30 and 120 volt ranges, adjust the appropriate RANGE

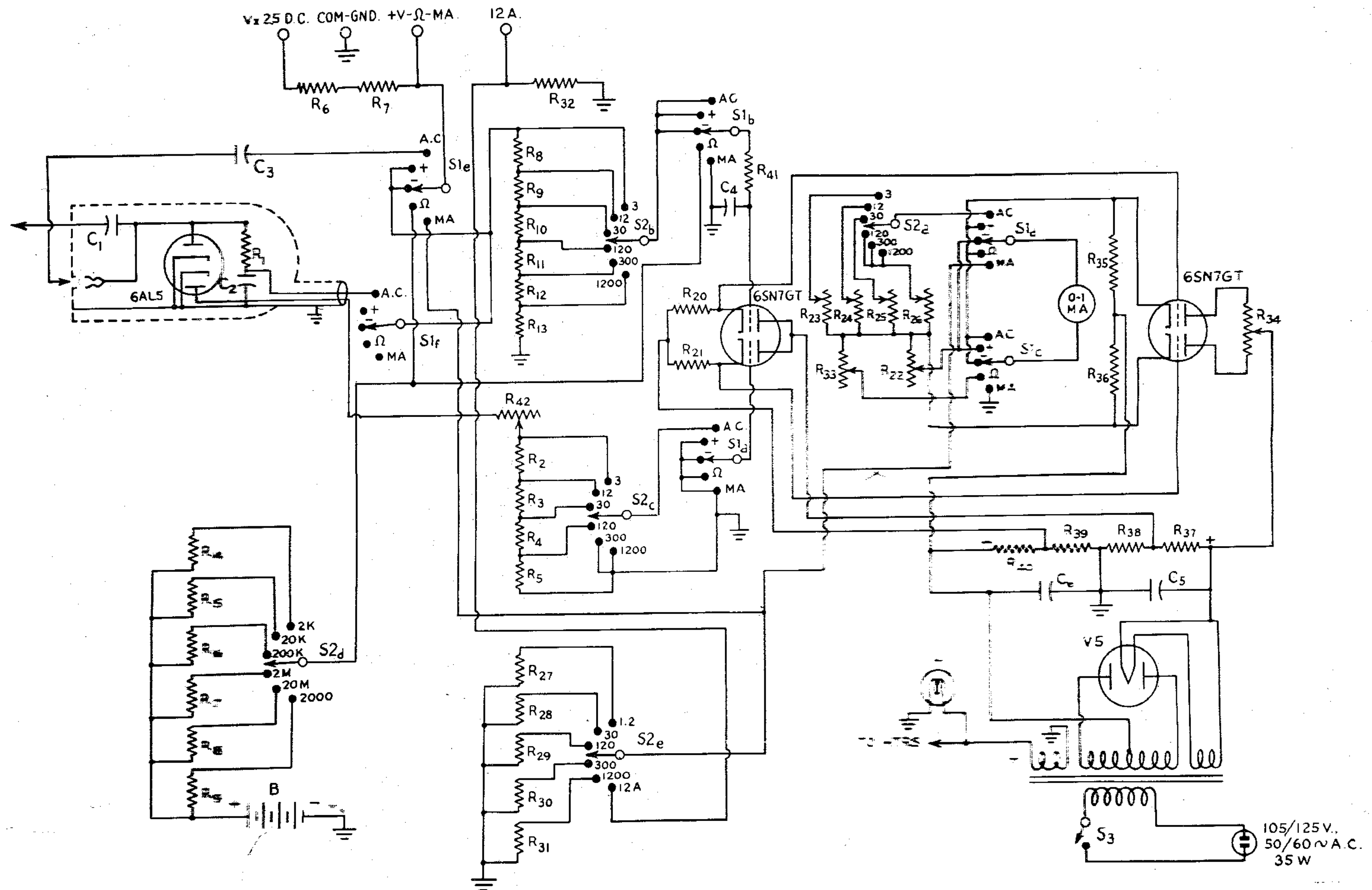


Figure 3

SET resistor for each of these ranges; R23 for 3 volt range, R24 for 12 volt, R25 for 30 volt and R26 for 120 volt range. Adjustment of R26 on the 120 volt range will bring 120, 300 and 1200 volt AC ranges into proper step.

TESTING "VOMAX": The chart appended to Fig. 3 gives voltages correct to 20% which should be observed when the red prod is contacted to the d.c. voltage points listed. Internal a.c. voltages may be similarly measured upon appropriate ranges of "VOMAX" by using both red and black prods to measure mains input voltage, and red prod only for 6.3 volt heater circuits and high voltage power transformer secondaries.

FILTER CAPACITORS: Electrolytic capacitors C5, C6 are polarized. Their + terminals must contact their + spring contactors. Reversal of C5, C6 polarity will ruin them and damage the power transformer and rectifier tube.

CAUTION: HIGH VOLTAGES ARE DEADLY. When measuring high voltages attach black test lead to one side of circuit to be measured, put one hand in pocket, stand on well insulated floor, and holding red test prod lightly between thumb and fore-finger at middle of red prod, contact its tip to high voltage point to be measured. DON'T TAKE CHANCES — YOU HAVE ONLY ONE LIFE — DON'T RISK LOSING IT.

CAUTION: To obtain the extremely useful 1200 volt AC range of "VOMAX" has necessitated operation of the 6AL5 rectifier beyond tube manufacturers' ratings. Extensive tests have revealed no evidence of premature tube deterioration. However, to insure long tube life use the 1200 volt AC range no more than absolutely necessary, and then only briefly. For example, contact prod to source to be measured, read meter, remove prod from source at once.

OPERATING VOLTAGE CHART

Cathode ends of R20, R21 to ground, +2 V d.c.
Cathode ends of R35, R36 to ground, +2 V d.c.
Cathode end of R39 to ground, −17 V d.c.
Cathode end of R40 to ground, −180 V d.c.
Plate end of R38 to ground, +17 V d.c.
Plate end of R37 to ground, +180 V d.c.
Heaters to ground, 6.3 V a.c. (at transformer)
Plates of 5Y3GT to center-tap (tube out of socket) 320 volts a.c.

PARTS LIST

C1 — 0.0005-ufd. silver-mica
C2 — 0.001-ufd. mica
C3 — 0.03-ufd. 3000-volt tubular oil
C4 — 0.005-ufd. mica
C5, C6 — 8-ufd. 350-volt electrolytic
R1 — 20-megohm, ±5 per cent, ¼-watt carbon resistor
R2, R9 — 7.5 megohms, ½ watt metalized resistors*
R3 — 1.5 megohms, ½ watt metalized resistors*
R4, R11 — 750,000 ohms, ½ watt metalized resistors*
R5 — 250,000 ohms ½ watt metalized resistors*
R6, R7, R8 — 37.5 megohms, — watt metalized resistors*
R10 — 3.75 megohms, ½ watt metalized resistors*
R12 — 375,000 ohms, ½ watt metalized resistors*
R13 — 125,000 ohms, ½ watt metalized resistors*
R14 — 10-ohm, 1 per cent ½ watt wire-wound
R15 — 100 ohms, ½ watt metalized resistors*
R16 — 1,000 ohms, ½ watt metalized resistors*
R17 — 10,000 ohms, ½ watt metalized resistors*
R18 — 100,000 ohms, ½ watt metalized resistors*
R19 — 10 megohms, ½ watt metalized resistors*
R20, R21, R41 — 5.1 megohm, ±5 per cent, ½ watt metalized resistor
R22, R23, R24, R25, R26 — 3000 ohm wire-wound potentiometer
R-27 — 258.4 ohm, 1 per cent wire-wound resistor
R28 — 1.758 ohm, 1 per cent wire-wound resistor
R29 — 0.423 ohm, 1 per cent wire wound resistor
R30 — 0.161 ohm, 1 per cent wire-wound resistor
R31 — 0.028 ohm, 1 per cent wire-wound resistor
R32 — Special-Set in test to give 12-ampere range
R33 — 10,000 ohm, wire-wound potentiometer with s.p.s.t. switch
R34 — 3000 ohm wire-wound potentiometer
R35, R36, R37, R40 — 43,000 ohms, ±5 per cent, 2 watt metalized resistors.
R38, R39 — 4,300 ohm, ±5 per cent, ½ watt metalized resistors.
R42 — 10 megohm potentiometer
S1 — 5-position, 6-circuit, 3-section ceramic switch
S2 — 5-circuit, 6-position, 5-section ceramic switch (front section shorting)
T — Power Transformer; 115-volt, 50/60 primary; 5-volts, 2 amp.; 6.3 volts, 1.6 amp.; 640 volts, 50 ma.
*Pairs of I.R.C. BT-½ resistors matched in series to give specified values.

SILVER

McMurdo Silver Company
INCORPORATED
1249 MAIN STREET . HARTFORD 3, CONNECTICUT
Incorporated

1249 VS-1

Dear "VOMAX" Owner:

Your letter indicates that you are having difficulty in obtaining the results from your "VOMAX" which make it overwhelmingly the largest selling V.T.V.M. manufactured today - superior performance which has made it decisively the purchase of such experts as the Bureau of Standards in Washington, to cite but a single one of many examples of top-competent selection.

To obtain best results you must know any instrument you use. "VOMAX" is quite new and unusual, which makes it even more important for you to understand what it is and will do. You will not get satisfying results unless you carefully read the Instruction Book packed with it. Read this carefully and completely, please. Only as a result of intelligent and correct operation will "VOMAX" fully measure up to all of your expectations for it.

The newness of "VOMAX" design is best typified by its extraordinarily high input resistance and sensitivity upon a.c. You must set meter zero with red test lead removed from +V-Ω-MA jack. So set, zero will be the same within 2% for DC+, DC- and AC. Zero will not change with different settings of RANGE switch (it may shift very slightly in prolonged high humidity due to very desirable high "VOMAX" input resistance, but about 30 minutes warm-up will dry out this rare and occasional effect). Zero will not shift with red lead tip in +V-Ω-MA jack and FUNCTION switch in DC+ or DC- (unless there are extraordinarily high local "floating" voltages, which grounding a panel thumb-nut will correct). But when you turn to AC, with red lead inserted, the meter will probably go off scale on 3 volt and possible 12 volt ranges. This is not a defect, but rather is proof positive of the unequalled high input resistance of "VOMAX" on a.c. This considerable voltage indicated upon low a.c. ranges is real and true -- is radiation from electric wiring, etc., being picked up by the red test lead acting as an antenna! You've never seen this condition before since no other meter equals "VOMAX" in attaining desirably high input resistance -- so high a 3-ft. "antenna" connected to it will pick up and register "floating" electrostatic voltages measurable upon no other meter! As soon as the antenna pick-up of the unterminated red lead is eliminated as by removing it from the +V-Ω-MA jack, or touching its tip to the black lead tip or to a panel thumb-nut (allow for slow decay due to large C3 to giving high accuracy down to 20 cycles), this electrostatic voltage pick-up can no longer register on the a.c. meter ranges. Nor is it present when both test leads are contacted to a voltage source to be measured, for then the low internal resistance of such voltage source prevents such "false", but quite real, voltage reading from appearing in actual measurement.

If you withdraw the R.F. PROBE and touch your finger to its prod-tip your body will act as an antenna and pick up a.c. voltages for "VOMAX" meter to register. If the same finger simultaneously contacts the R.F. PROBE metal shell no voltage will be registered -- unless your finger is very dry and your body resistance, therefore, unusually high at the time.

Remember that in measuring r.f., i.f. or a.f. voltages in a receiver as in visual dynamic signal tracing, two connections must exist between "VOMAX" and the circuit carrying the voltage to be measured. One must be made to the "high" (grid, plate, etc.) side of the circuit. The other must be made from the metal shell of the R.F. PROBE to the "low" (chassis grounded) side of the measured circuit. At high frequencies, as from about 15 megacycles up, the connections to the measured circuit must be as above -- must be short as possible. At broadcast and usual intermediate frequencies the inconvenience of simultaneously contacting the R.F. PROBE tip to grid or plate, shell simultaneously to receiver chassis, may be obviated. At such frequencies the black test lead may be used to connect the COM-GND. jack of "VOMAX" to the receiver chassis, when it is then only necessary to touch to R.F. PROBE tip to the grid or plate to be measured.

If you doubt that the R.F. PROBE is working properly, test it by first measuring your 115 volt a.c. mains using 120 volt-a.c. range of "VOMAX", with connection thoreto by means of the test leads in the panel jacks. Then withdraw the R.F. PROBE and measure the same voltage by contacting it the R.F. PROBE tip and shell 115 volts, 50/60 cycle a.c. will measure only about 80 volts at the R.F. PROBE. This is correct, for withdrawing the R.F. PROBE has substituted 500 mmfd. C1 for .03 mfd. C3, and the reactance of C1 at low frequencies is so high as to cut down the voltage applied to the 6AL5 diode rectifier. C1, contained in the R.F. PROBE, is for use only above 15,000 cycles, by which frequency its reactance falls to negligably low value. But remember that if "VOMAX" will measure low-frequency a.c., giving a reading about 30% low directly at the R.F. PROBE, then it is okay for measuring signal voltages and will measure them in any circuit to which the R.F. PROBE is properly contacted -- but not correctly across a tuned circuit until the trimmer capacitor thereof has been adjusted to reduce the total circuit capacity by the 8 mmfd. added to it by the R.F. PROBE itself. See Instruction Book.

Tubes in any electronic equipment will eventually deteriorate -- that is why they're made plug-in! This is just as true of "VOMAX" as of any other piece of electronic apparatus. It is seldom, however, that 6AL5 or 5Y3GT tubes will deteriorate to a point necessitating replacement in much under a year. The 6SN7GT tubes are more critical, however -- in a unique way which leaves those unsuitable to "VOMAX" perfectly good for other usages. If you notice a slow long-time drift of DC VOLTS meter zero once it has been set, this means the development of heater-to-cathode leakage in one of its two 6SN7GT tubes. Replacement of one or both tubes, as indicated by test in "VOMAX", is the cure. In the first 6,000 "VOMAX" manufactured 6SN7GT heater voltage was nominally 6.3. After 6,000, permission was obtained from the tube manufacturers to reduce this voltage, and so put off the time of eventual development of heater-to-cathode leakage. Thereafter to reduce heater voltage a .9 ohm, 1.5 watt resistor was mounted between one 6.3 volt lug of "VOMAX" power transformer and the nearest chassis-grounded transformer core mounting screw. If you find no such resistor in your "VOMAX", send us the serial number stamped in ink on the outer side of the R.F. PROBE receptacle and we'll send you such a resistor free.

Remember, please that we want you to be fully satisfied with your "VOMAX" -- our interest does not cease at time of sale. Under Standard RMA 90-day Guarantee we'll gladly replace or repair any defective "VOMAX", or part therefrom, at no charge if returned to the factory prepaid. On items over guarantee, we'll make the smallest possible repair charge --- just enough to cover our labor costs. Fortunately we can afford to be generous, for we have mighty few defective parts or occasions to repair "VOMAX".

If you experience any trouble with this letter, or careful reading of your Instruction Book, won't enable you to correct yourself, a) write us asking for recommendations; b) write us for name of nearest Authorized Service Station; or c) carefully pack your "VOMAX" and ship to us by prepaid Express, not Parcel Post, with a letter telling what you want done, and we'll fix it fast and well with pleasure.

Cordially,

McMURDO SILVER COMPANY, INC.

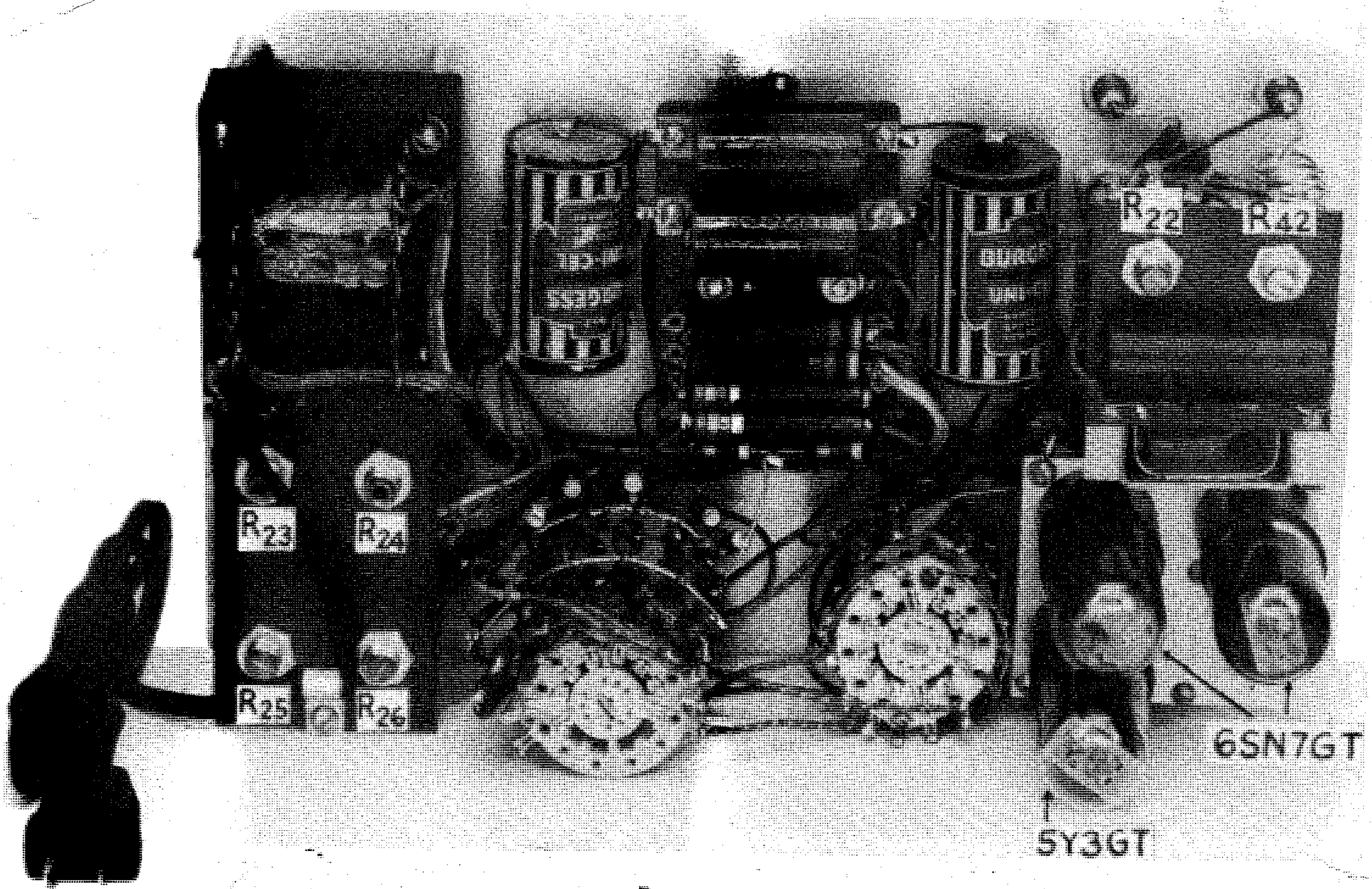
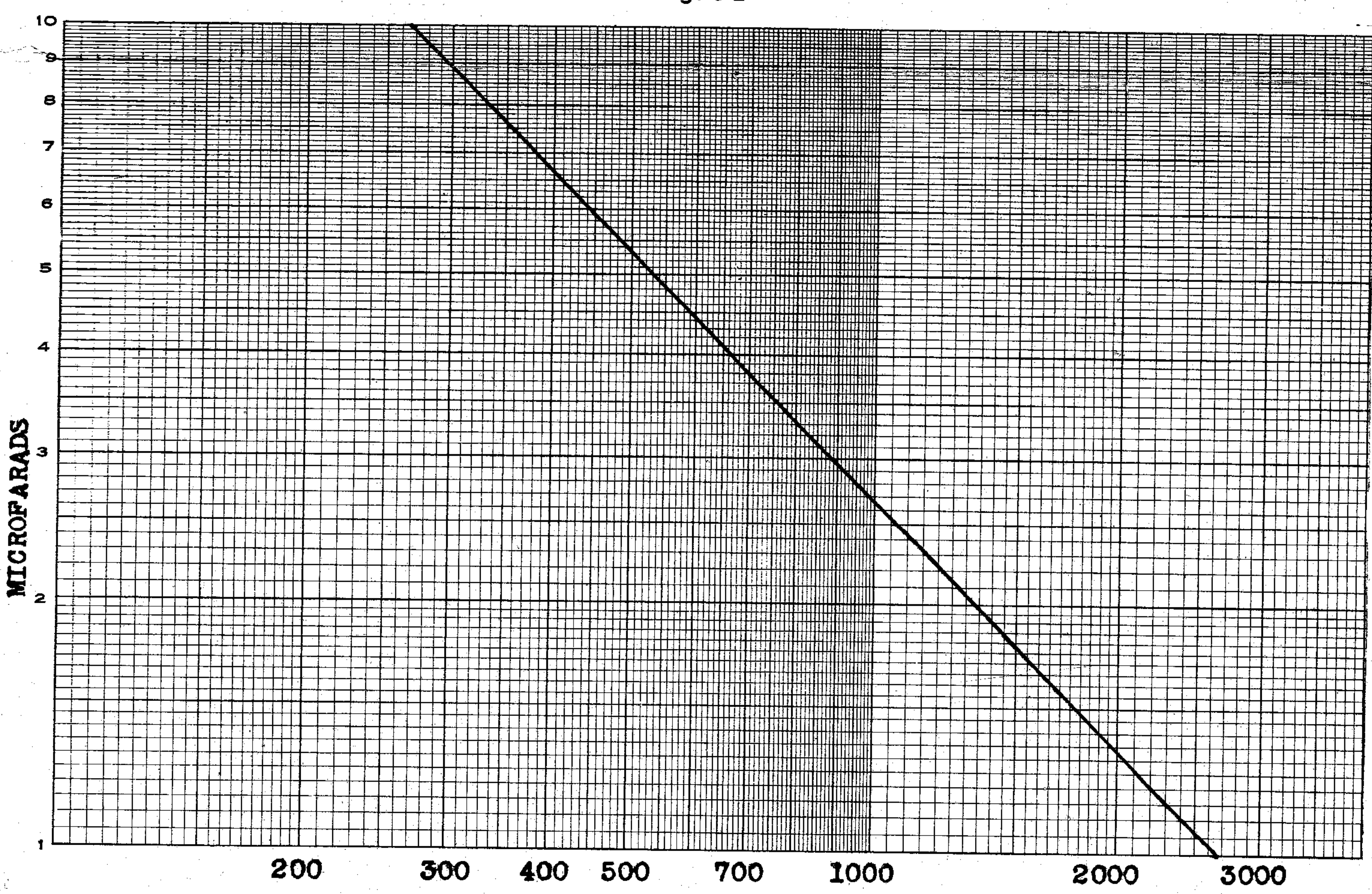


Figure 2



FOR EACH ZERO ADDED TO RESISTANCE (BOTTOM SCALE) ADD ONE DECIMAL POINT IN FRONT OF MICROFARADS

FIGURE 4