ⓗⓟ MODELS 400D, 400H, AND 400L VACUUM TUBE VOLTMETERS TEST, ADJUSTMENT, AND CERTIFICATION METHODS

These Service Notes have been prepared as an aid in testing and adjusting all ⓗⓟ Model 400D, 400H, and 400L Vacuum Tube Voltmeters. The procedures that follow supersede those in other Service Notes or Operating and Servicing Manuals for these instruments.

All circuit references apply to one of the three reference schematic diagrams in these Service Notes. No attempt should be made to make an instrument agree completely with any one of these schematics.

All recommended circuit changes are described in Section I of these Service Notes.

Voltages mentioned herein are measured between the indicated points and the chassis unless specified otherwise. The voltmeter power supply should always be tested before undertaking repair and adjustment of any other section of the instrument.

These Service Notes are divided into five sections as follows:

SECTION I - MODIFICATIONS

Modifications in certain serials of ⓗⓟ Model 400D, 400H, and 400L Voltmeters can simplify testing. Specifications have not been changed. Modernization of instruments will simplify repair and testing and will add to instrument reliability. The changes that follow apply only to those 400D, 400H, and 400L instruments having the specified serial numbers.

A. MODEL 400D SERIAL NO. 2221 AND BELOW

Change V2 plate load resistor R23 from an 8200 ohm, ±5%, 1 watt, composition resistor to a metallic oxide film-type having the same resistance, tolerance, and wattage rating. This Corning Glass Works style N25 resistor is available under ⓗⓟ Stock No. 0761-0001.

This change is particularly recommended for those instruments in which the residual noise reading is too high and/or unstable. Mount the new resistor as nearly as possible in the same location as the old resistor.

B. MODEL 400D SERIAL NO. 3944 AND BELOW

Add resistor R67 in series with the control grid of the series regulator tube V7. Transfer the wire (usually green) from V7 pin 1 to vacant pin 6 on the same tube socket. Connect a 470 ohm ±10%, 1/2 watt composition resistor (ⓗⓟ Stock No. 0687-4711) between V7 socket pins 1 and 6.

This resistor prevents parasitic oscillation in the power supply. Such oscillation can cause the meter to be deflected full scale against the right hand stop.

C. MODEL 400D SERIAL NO. 4344 AND BELOW

Add 10 ohm ±10% 1 watt, composition resistor (ⓗⓟ Stock No. 0690-1001) R68 in parallel with heater voltage adjustment control R66. This resistor reduces power dissipation in R66 and extends the life of the control. Readjust the dc heater voltage after installing R68.

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D. MODEL 400D SERIAL NO. 5130 AND BELOW

Transpose the connections to electrolytic capacitor C30 so that C30B is 20 μf and C30C is 40 μf. This transposition will reduce power supply ripple.

E. MODEL 400D SERIAL NO. 14770 AND BELOW MODEL 400H SERIAL NO. 1137 AND BELOW

Replacement of control R29 or three-section resistor R28 in the amplifier feedback circuit will necessitate revising and rewiring the feedback circuit.

The parts for this circuit revision are supplied as a kit with complete instructions under hp Stock No. 400D-95A.

The revised feedback circuit is recommended for all 400D and 400H instruments whenever repair of the feedback circuit is necessary. The revised circuit is superior to earlier circuitry but does not offer sufficient advantages to warrant modification merely to include the new circuit in an instrument. The problem of adjusting frequency response following any changes in the feedback circuit would also make it advisable to avoid making unnecessary changes.

F. MODEL 400D SERIAL NO. 16371 AND ABOVE MODEL 400H SERIAL NO. 1338 AND ABOVE

The regulated power supply was changed. Series regulator tube V7 was changed from a 6AU5 to a 12B4A. Control tube V8 was changed from a 6CB6 to a 6U8 and reference tube V9 was changed from an OB2 to a type 5651. The circuit differences can be determined by referring to the schematic diagrams included in these Service Notes.

Field modification to incorporate this change is impractical and is not recommended.

G. MODEL 400H SERIAL NO. 1338 THROUGH 1537

Resistor R83 should be changed in value and location. The new value is 470,000 ohms $\pm 10\%$, 1/2 watt instead of 100,000 ohms. A second resistor with a value of 470,000 ohms $\pm 10\%$, 1/2 watt and a schematic reference of R85 is connected in series with R83. The series combination of R83 and R85 is then connected between the regulated B+ output at the cathode of the regulator tube and chassis ground. The transformer winding supplying heater voltage for V6, V7, and V8 is connected to the junction of R83 and R85. These connections can be made by mounting both resistors between terminals on the socket for V7.

H. MODEL 400D SERIAL NO. 17970 AND BELOW MODEL 400H SERIAL NO. 2237 AND BELOW

Residual noise as indicated by the meters in these instruments can be reduced by a modification of the input attenuator. A higher degree of residual noise reduction is obtained on the upper voltmeter ranges by this modification.

The input attenuator is changed from a capacity divider to a resistive divider system by the addition of a kit of parts available under hp Stock No. 400D-95B. The instructions supplied with the kit give all necessary details for changing the Input Attenuator Resistor Board.

Basic calibration and frequency response adjustments will be required after this modification has been completed.

I. MODEL 400D SERIAL NO. 25970 AND BELOW MODEL 400H/L SERIAL NO. 5225 AND BELOW

The value of resistor R45 can be varied to control low frequency response if cathode resistors R38, R47, and R53 are changed from 120 ohms to 100 ohms $\pm 10\%$, 1 watt. See Section IV step M1-d. The vtvm performance will be the same after changing the resistors but low frequency response adjustments are simplified.

SECTION II - TUBE & CRYSTAL DIODE REPLACEMENT

Tubes with standard JEDEC characteristics can be used for replacement. In a great number of cases, instrument trouble can be traced to a defective or weak tube. Replace only those tubes proven to be defective or weak. Check tubes by substitution. Results obtained through the use of a "tube checker" can be erroneous and misleading. Mark original tubes to insure that they are returned to the same socket if not replaced.

The power supply should be checked according to the instructions in these Service Notes after replacing V6, V7, V8, or V9 in the power supply.

Heater voltage must be checked and adjusted after replacing V1, V2, V3, or V4. Factory selected tubes are available for V1 and V2. These tubes are tested for low noise and microphonics. Contact your hp Sales Office for the hp Stock Numbers and prices on these tubes.

Special high-performance junction type silicon diodes are available for replacement of diodes CR1 and CR2. These special diodes are manufactured by hp and are available under hp Stock No. G-29B-5. Order directly from the factory or from your hp Sales Office.

The hp Stock No. 212-1N82S diodes once specified for CR1 and CR2 have been superseded by the superior G-29B-5 diodes. The cathode end of the diode has a gold plated wire. The anode end of this diode has a silver plated wire.

The G-29B-5 diodes have a junction that is less than 1/2 mil in diameter. If the diodes are dropped, a mechanical failure may occur at the junction. After installation the diodes will withstand any shock that the entire instrument can withstand.

Voltage calibration and frequency response should be checked and adjusted after replacing V1, V2, V3, V4, V5, CR1, or CR2.

SECTION III - TEST EQUIPMENT REQUIRED

The following equipment is required to test and calibrate ⓗ Vacuum Tube Voltmeter Models 400D, 400H, and 400L.

A. A dc voltmeter capable of measuring 250, 6.3, 12.6 volts. This voltmeter must have a sensitivity of 1000 ohms/volt or better. A vtvm such as the ⓗ Model 410B is satisfactory.

B. An ⓗ Model 738AR (formerly ⓗ Spec. 23678) Voltmeter Calibration Generator or equivalent. Model 738AR generator will deliver a 400-cps output voltage from 0.3 millivolt rms to 300 volts rms with an accuracy of ±0.25% and not more than 0.2% hum and distortion. This generator will also supply + dc or -dc voltages from 0.3 millivolt to 300 volts for calibration of dc voltmeters.

C. An ⓗ Model 739AR (formerly ⓗ Spec. 23679) VTVM Frequency Response Generator. This generator has an internal signal source to cover the frequency range from 350 kc to 11 mc. Up to a 3-volt output signal can be obtained. The internal attenuator and reference voltmeter are designed for frequencies from 10 cps to 11 mc. Internal impedance is 50 ohms.

D. An ⓗ Model 200S (formerly ⓗ Spec. 23680) Wide Range Oscillator. This oscillator has an internal impedance of 50 ohms and will deliver a 3-volt signal from 5 cps to 600 kc. Use with Model 739AR VTVM Frequency Response Generator.

E. A battery operated oscillator covering 60 and 120 cps with an output of at least 1 volt and not more than 1% distortion.

F. A square wave generator capable of delivering a 2-volt peak-to-peak 1 kc signal. The ⓗ Model 211A Square Wave Generator or the internal calibrator in the ⓗ Model 150A High Frequency Oscilloscope can be used.

G. A high frequency oscilloscope such as the ⓗ Model 150A.

H. An adjustable line voltage source.

The ⓗ Model 739AR VTVM Frequency Response Generator and the ⓗ Model 200S Wide Range Oscillator are designed to be operated together when making frequency response measurements. These two instruments greatly increase the speed and accuracy of frequency response measurement.

The frequency response adjustment procedure given in Section IV is particularly suited for use with Model 739AR and Model 200S instruments. The instruments in the following list are suitable alternates.

-- A low distortion oscillator covering the frequency range from 10 cps to at least 6 or 7 mc and an output voltage of at least 3.0 volts rms. The ⓗ Model 650A Test Oscillator will meet these requirements.

-- An rms reading, average responding, ac voltmeter with a known frequency response from 10 cps to at least 4.0 mc. The reference voltmeter can be an ⓗ Model 400H or Model 400L. A thermocouple type of reference meter can also be used. Absolute voltage values are not needed when making frequency response measurements.

SECTION IV - TEST & CALIBRATION PROCEDURE

When all the following procedures are to be completed, they can most easily be done in the order listed. In many instances, only one or two tests will be needed and they can be done without completing all other tests. For example, basic calibration can be checked and adjusted at any time without making any other adjustments.

A 10 to 15-minute warmup and a check of the power supply output voltages is always recommended before making any other tests or adjustments.

The specifications for your ⓗ Model 400D, 400H, or 400L Vacuum Tube Voltmeter are given in the front of the manual supplied with the vtvm. The following test procedure contains extra checks to help you analyze a particular instrument. These extra checks and the data they contain cannot be considered as specifications.

NOTE: The test frequencies and the voltages specified in many of the steps in this procedure are based upon the use of the test equipment listed in Section III. Other frequencies and voltages can be used. Any vtvm can be adjusted for optimum performance on the range you most commonly use.

A. <u>SETTING MECHANICAL ZERO IN MODELS 400D OR 400H</u>

1) Allow 400D 20 minute warm up. Turn instrument off.

2) Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

Continue to rotate adjustment screw clockwise; <u>stop</u> when pointer is right on zero. If pointer overshoots zero, repeat this adjustment.

3) When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step repeat entire adjustment.

B. <u>SETTING MECHANICAL ZERO IN MODEL 400L</u>

The special meter in the 400L is adjusted with the vtvm turned on since the meter pointer rests against the stop at the left end of the scale when the instrument is turned off.

In most 400L instruments the mechanical zero is preset during manufacture of the meter movement. The adjustment screw in such meters is inoperative. Most 400L instruments will have no adjusting screw on the front of the meter case.

The following procedure is for use only with those instruments in which the mechanical adjustment screw is effective.

1) Connect a 1.0 volt rms, 400 cps signal from the Voltage Calibration Generator to the 400L INPUT terminals. Set the 400L to the 1-volt range and adjust the feedback control (R29) for a full scale meter reading of 1.0 volt. Any convenient range could also be used along with a corresponding change in input signal level. The input signal frequency is also not critical.

2) Switch the Calibration Generator to deliver a signal of 0.3 volt, or 0.3 of the signal level used in step 1. Set the meter mechanical zero adjusting screw to obtain a reading that is 0.3 of the reference reading in step 1. Use the same vtvm range for both steps 1 and 2. If you overshoot, continue to rotate the screw clockwise and again approach the 0.3 point from the high side of the scale. The screw should not be turned counterclockwise during this procedure.

3) Repeat steps 1 and 2 until no further improvement can be noted. Compromise adjustment of the mechanical zero can be made for optimum tracking. After final adjustment, cover the screw with a small piece of black tape.

C. CHECK REGULATED POWER SUPPLY

1) The B+ voltage at the output of the regulated power supply should be 250 volts ±5 volts. Measure this voltage between the chassis and the cathode of the series regulator tube with the line voltage set to 115 volts.

2) Vary the line voltage between 103 and 127 volts. The regulated B+ will usually change no more than 2 volts from one extreme to the other. Ripple voltage in the regulated B+ is usually 3 millivolts or less under these same test conditions.

The dc voltage at the plate of the series regulator tube or at the cathode of the rectifier tube should be between 400 and 420 volts with a 115-volt line. Low voltage at this point may be from a defective rectifier tube, filter capacitor, or power transformer.

To check the rectifier tube, connect a dc voltmeter between chassis and the rectifier cathode. Reduce line voltage from 115 to 103 volts. The voltmeter reading should drop as line voltage is reduced and then remain steady. If the dc voltage continues to drop at a slow rate, the rectifier tube is probably weak and should be replaced.

If the regulated B+ voltage is not correct, replacement of any or all four tubes in the power supply may be necessary. If tube replacement does not correct the dc voltage, precision resistors R62 and/or R64 may have changed value and should be replaced. Abnormal current drain caused by component failure elsewhere in the vtvm can result in poor power supply regulation.

Excessive ac ripple may be from a defective tube in the power supply other than the rectifier tube. Capacitor C36 may be open.

D. SET DC HEATER VOLTAGE

1) Adjust control R66 to set the dc heater voltage for tubes V1 and V2 to 6.3 volts ±0.2 volt. The dc voltages across the heaters of tubes V3 and V4 must also be 6.3 volts ±0.2 volt. DO NOT USE A VOLTMETER THAT IS CONNECTED TO A COMMON GROUND WITH THE VTVM UNDER TEST WHEN MEASURING THESE HEATER VOLTAGES. A SHORT CIRCUIT WILL RESULT. Slight readjustment of control R66 will often bring these two voltages within tolerance.

2) If both voltages cannot be set to 6.3 volts, ±0.2 volt, adjust R66 to bring the lowest of the two voltages within tolerance. Connect a resistor in parallel with the two heaters with the highest voltage. The correct resistor value will enable you to bring both heater voltages within tolerance by readjusting control R66. Use only one resistor in parallel with one pair of tubes at a time. A resistor value below 220 ohms 1 watt should not be used.

3) If you are unable to obtain the correct heater voltage after completing steps 1 and 2, check electrolytic capacitors in the heater circuit. If both heater voltages are low, check selenium rectifier SR1.

E. INPUT DIVIDER CIRCUIT IDENTIFICATION

1) An identification of the type of input circuit will enable you to select the proper test required for your instrument. Instruments are classified by type of input circuit into two general groups:

a. Models 400D, serial 001-34370 and below; Models 400H/L, serial 001-11226 and below . . . these instruments may have either a "capacitive input divider" or a "resistive input divider". Complete steps 2 through 6 to determine which one is present.

b. Models 400D/H/L with serials prefixed 017- and 048- . . . all these instruments employ a "resistive divider". Omit steps 2 through 6 and proceed with Section IV-F.

2) Set the vtvm to the 1.0 volt range and connect a 1.0 volt rms, 400 cps signal from the Calibration Generator to the INPUT terminals. Any convenient range higher than the 1-volt range can be used. The signal frequency should be approximately 400 cps.

3) Rotate capacitor C4 (on input circuit board) one full turn while watching the vtvm meter reading. The meter reading will vary only about 5% in some instruments and approximately 50% in others.

4) If the meter indication varies approximately 50%, capacitor C4 is a Voltage Calibration Adjustment. This will be referred to as a "CAPACITIVE INPUT DIVIDER" circuit in the balance of the procedures in these Service Notes.

5) If the meter indication varies approximately 5%, capacitor C4 is a Frequency Response Adjustment. This will be referred to as a "RESISTIVE INPUT DIVIDER" circuit in the balance of the procedures in these Service Notes.

6) Mark the type of input circuit on the input circuit shield. This reference will be used in later steps of this Test Procedure.

F. INPUT CIRCUIT PRELIMINARY FREQUENCY RESPONSE ADJUSTMENT

This adjustment is for "RESISTIVE INPUT DIVIDER" circuits only:

1) Connect a 1 kc, 2 volt peak-to-peak, square wave signal to the INPUT of the vtvm under test. Connect the OUTPUT terminals of the same vtvm to the vertical input of a high frequency oscilloscope such as the ⓗⓟ Model 150A.

2) Switch the vtvm to the 1.0 volt range and adjust capacitor C4 for the best square wave pattern on the oscilloscope.

G. BASIC CALIBRATION (SETTING AMPLIFIER GAIN)

1) For Models 400D serial 001-34370 and below and Models 400H/L serial 001-11226 and below:

Connect a 0.3 volt rms, 400 cps signal from the Calibration Generator to vtvm INPUT. Switch the vtvm to 0.3 volt range and adjust the feedback control, R29, to obtain a reading of 0.3 volt.

2) For Models 400D/H/L with serials prefixed 017-:

Connect a 0.001 volt rms, 400 cps signal from the Calibration Generator to vtvm INPUT. Switch the vtvm to the 0.001 volt range and adjust the feedback control, R107, to obtain a reading of 0.001 volt.

H. BASIC CALIBRATION (SETTING INPUT DIVIDER)

1) For Models 400D serial 001-34370 and below and Models 400H/L serial 001-11226 and below:

a. Connect a 1.0 volt rms, 400 cps, signal from Voltmeter Calibration Generator to INPUT of vtvm. Switch vtvm to 1.0 volt range.

b. For "CAPACITIVE INPUT DIVIDER" circuits, adjust C4 for a reading of 1.0 volt.

c. For "RESISTIVE INPUT DIVIDER" circuits, the vtvm indication will normally be 1.0 volt. If reading is high, decrease value of pad (R87) in parallel with R3. If reading is low, increase value of pad (R87). Resistor R3 and pad R87 are on input circuit board.

2) For Models 400D/H/L with serials prefixed 017-:

a. Connect a 1.0 volt rms, 400 cps, signal from Voltmeter Calibration Generator to INPUT of vtvm. Switch vtvm to 1.0 volt range.

b. Adjust R101 for a vtvm reading of 1.0 volt.

I. MISCELLANEOUS CHECKS

NOTE: All checks in this section are made with the vtvm cabinet in place.

1) Noise and Switching Transients - This check will vary with the voltmeter model. Models 400D and 400H have one method while the 400L has a different method.

a. For 400D and 400H VOLTMETERS - Plug a shielded connector (ⓗⓟ Stock No. 1251-0019) over the INPUT terminals of the vtvm under test. A 100,000 ohm resistor should be connected between the terminals inside this shielded plug. The residual reading on the 0.001 volt scale will normally not be more than 0.00005 volt (5% of full scale).

b. For 400L VOLTMETER - Connect a 0.0003 volt rms (0.3 millivolt) signal of about 400 cps from the Calibration Generator to the INPUT terminals. The voltmeter reading should be steady with the range switch in the 0.001 position. Noise in V1 or V2 will cause this reading to vary erratically.

c. Connect the 100,000 ohm shielded resistor (see step a) between the INPUT terminals. Rotate the range switch through all 12 positions in both directions. The meter needle may be momentarily deflected as high as full scale between some switch positions. The meter pointer should always drop back to zero at a uniform rate without pause or a sudden change in the rate of fall.

d. Remove the shielded 100,000 ohm resistor and connect a 0.001 volt rms, 400 cps signal from the Calibration Generator to the INPUT terminals. The voltmeter reading should be steady with the range switch in the 0.001 position.

If the results obtained in this test are not satisfactory, check tubes V1 and V2, all coupling capacitors, electrolytic capacitors in screen and plate circuits, V2 plate load resistor, and cathode bypass capacitors.

2) Check for Microphonics

a. Connect a 0.001 volt rms, ac signal to the INPUT terminals and set the vtvm to the 0.001 volt range. Hold your hand palm-upward and sharply rap the front of the meter case with your knuckle. The pointer will usually not move more than about 1/8 inch along the meter scale.

b. Repeat step a at 300 volts on the 300-volt range. The results obtained should be the same.

Replace V1 and/or V2 to remove excessive microphonics. Pre-selected tubes are available from ⓗ for V1 and V2. See Section II of these Service Notes for details.

3) Check Output vs Shock

a. Connect a 1.0 volt rms, ac signal to the INPUT and set the vtvm to the 1-volt range. Connect the vtvm OUTPUT to an oscilloscope and adjust oscilloscope to display several cycles.

b. Strike either top front corner of the instrument with the palm of your hand. There should be no sudden change in amplitude nor a momentary collapse of the pattern. This test will detect another type of microphonic tube or poor electrical connections within the vtvm.

4) Check Beat Notes at 60 and 120 Cycles

a. Connect a battery operated oscillator to the INPUT terminals of the vtvm. Set the range switch to the 1-volt range. Adjust the oscillator output to provide a vtvm reading of 0.9 volt at about 58 cps. Adjust the oscillator frequency to obtain maximum meter swing which will normally not be more than about 1/8 in. along the meter scale.

b. Repeat step a at 120 cps. The maximum meter swing will usually not be more than about 1/8 in. along the meter scale.

High beat notes are usually caused by defective tubes anywhere in the instrument.

J. RECHECK DC HEATER VOLTAGE

Check the dc heater voltage by the method given in paragraph D.

If either electrolytic capacitor in the heater circuit has been replaced, a heat-run of several hours should be allowed. After the heat-run to form the capacitor plates, reset the heater voltage.

K. CHECK CALIBRATION AND TRACKING

1) Check full scale accuracy of each voltmeter range. Use the Voltmeter Calibration Generator. The calibration should be within ±2% of full scale for a 400D Voltmeter or ±1% of full scale for a 400H or 400L Voltmeter. The test voltage should be between 50 cps and 500 kc. Avoid using the power line frequency or a harmonic of the power line. Refer to the accuracy specifications if you use a test frequency outside of this range.

2) Check meter tracking on any mid-range. The 1-volt range is usually convenient. A sticky meter can cause the vtvm to be outside of the calibration specifications. Defective diodes for CR1 and CR2 can also introduce excessive tracking error. Refer to Section II of these Service Notes for details on suggested replacement diodes.

L. CHECK EFFECT OF LINE VOLTAGE CHANGE

1) Connect a sine wave signal to the INPUT of the vtvm under test. Use a convenient mid-range and adjust the input signal amplitude for a convenient reference level such as 0.9. Use any frequency within the frequency range of the voltmeter. The line voltage should be at 115 volts for at least 2 minutes before setting your reference level.

2) When the line voltage is changed from 115 to 103 or from 115 to 127 volts, the indication on the vtvm under test will normally not change from the reference level by more than ±2% of full scale after a 2-minute period.

These effects are more noticeable at the upper and lower limits of the vtvm frequency range. If the change is excessive, check tubes V5 through V1 in that order.

M. FREQUENCY RESPONSE ADJUSTMENT

In most applications, frequency response adjustments will not be necessary; particularly if the vtvm is used at frequencies below approximately 500 kc. The results obtained will depend entirely upon the "reference voltmeter" used to monitor input signal level to the vtvm under test. You are urged to avoid making frequency response adjustments unless the frequency response characteristics of your reference voltmeter are accurately known. The following frequency response adjustment data is given for use in those cases where frequency response is critical and the required test equipment is available.

The voltage at the input terminals of the vtvm under test must be monitored by the reference voltmeter. The reference voltmeter indication at 400 cps is called "reference level" in these instructions. The adjustments are listed in a sequence that is most convenient when using the ⓗ Model 739AR and 200S instruments described in Section III. If you use other equipment, you may have to change the sequence to suit the instruments.

1) For Models 400D serial 001-34370 and below and Models 400H/L serial 001-11226 and below:

Note: For Models 400D/H/L with serials prefixed 017-, proceed to step 2.

a. Adjust C21 at 4 mc on the .001 volt range after establishing a 400 cps "reference level" on the same range.

b. Adjust response at 1 mc on the .001-volt range. Use the same "reference level" as step a. Capacitor C26 in the plate circuit of V4 can be changed in value between limits of 15 and 82 pf to control 1 mc response. If you change C26, repeat step a.

c. Frequency response above 4 mc can be roughly adjusted by adding or adjusting the values of capacitor C40 and resistor R82 in the cathode circuit of V2.

If you change or add these parts, repeat steps a and b. Use same range and reference level as step a. A response that "falls-off" above 4 mc is more desirable than one that rises.

d. The 10 to 20 cps response adjustment varies with voltmeter circuitry.

If cathode resistors R38, R47, and R53 for tubes V3, V4, and V5 respectively all have values of 100 ohms, the value of R45 in the plate circuit of V4 can be adjusted between limits of 0.75 and 1.0 megohms to adjust the 10 to 20 cps response.

In any instrument, to increase the 10 cps indication, remove R80 if present in V2 grid circuit. Add R81 in V3 grid circuit if additional increase is needed after R80 removal. Conversely, to decrease the indication, remove R81 and add R80 if necessary. Either but not both resistors can be added. Both resistors can be omitted. A value of 2.2 megohms or higher should be used for R80 or R81. Check tubes, cathode capacitor C20, and coupling capacitors if you find that a resistor value below 2.2 megohms is required.

e. Adjust C14 at 4 mc on the .003-volt range after establishing a 400 cps "reference level" on the same range.

f. Adjust C16 at 4 mc on the .01-volt range after establishing a 400 cps "reference level" on the same range.

g. Check frequency response on the .03, .1, and .3 volt ranges. Establish a 400 cps "reference level" for each range and then check response at 4 mc. If an error greater than ±5% of full scale is noted, make a compromise adjustment of C21. If you change C21, repeat steps a, b, c, d, e, and f. The compromise setting of C21 must be used when repeating step a.

h. <u>For "CAPACITIVE INPUT DIVIDER" Circuits Skip step i.</u> See step E in Section IV to determine input circuit type.

i. <u>For "RESISTIVE INPUT DIVIDER" Circuits Adjust C4 at 20 kc on the 1.0 volt range after</u> establishing a 400 cps "reference level" on the same range.

j. Adjust R6 in the input divider to bring the 4 mc response within specifications on the 1.0-volt range after establishing a 400 cps "reference level" on the same range.

This resistor consists of several parallel resistors. Increasing the resistance of R6 will raise the response at 4 mc. Lowering the resistance will decrease the 4 mc response.

k. The response of the 3-volt range can now be checked. If other ranges have been properly adjusted, this range will be within specifications. The response of any range can now be checked at any frequency between 10 cps and 4 mc.

2) For Models 400D/H/L with serials prefixed 017-:

a. Adjust C102 "HIGH FREQUENCY COMP" at 4 mc on the 0.001 volt range after establishing a 400 cps "reference level" on the same range.

b. The oscillator should now be tuned through the band of 4 mc to 10 mc. Note the voltmeter indication during this time. If the reading increases more than 2% above the 4 mc level, adjust AMPLIFIER BIAS control R119 counterclockwise, and repeat 4 mc adjust (step a above). Repeat this procedure until peaking is less than 2% of the 4 mc response. Note: Be sure reference meter is set at SET LEVEL.

c. Set oscillator output to "reference level". Adjust LOW FREQUENCY RESPONSE control R118 to bring the 10 to 20 cps response within specified limits. If R118 will not bring both the 10 and 20 cycle response into specifications, the AMPLIFIER BIAS control R119 must be readjusted so that R118 can bring the 10 and 20 cycle response within limits.

d. If R119 is adjusted during the low frequency response calibration (step c), it will be necessary to repeat the high frequency response adjustment in step b. The adjustment of R119 will be a compromise to meet both low and high frequency specifications.

e. Adjust C14 at 4 mc on the 0.003 volt range after establishing a 400 cps reference level on the same range.

f. Adjust C16 at 4 mc on the .01 volt range after establishing a 400 cps reference level on the same range.

g. Adjust C4 at 20 kc on the 1.0 volt range after establishing a 400 cps reference level on the same range.

h. Adjust R6 in the input divider to bring the 4 mc response within specifications on the 1.0 volt range after establishing a 400 cps reference level on the same range. R6 consists of several resistors connected in parallel. Increasing the resistance of R6 will raise the frequency response at 4 mc. Lowering the resistance will decrease the 4 mc response. Note: Be sure input shield is in place before taking reading.

N. <u>FINAL CHECK AND ADJUSTMENT</u>

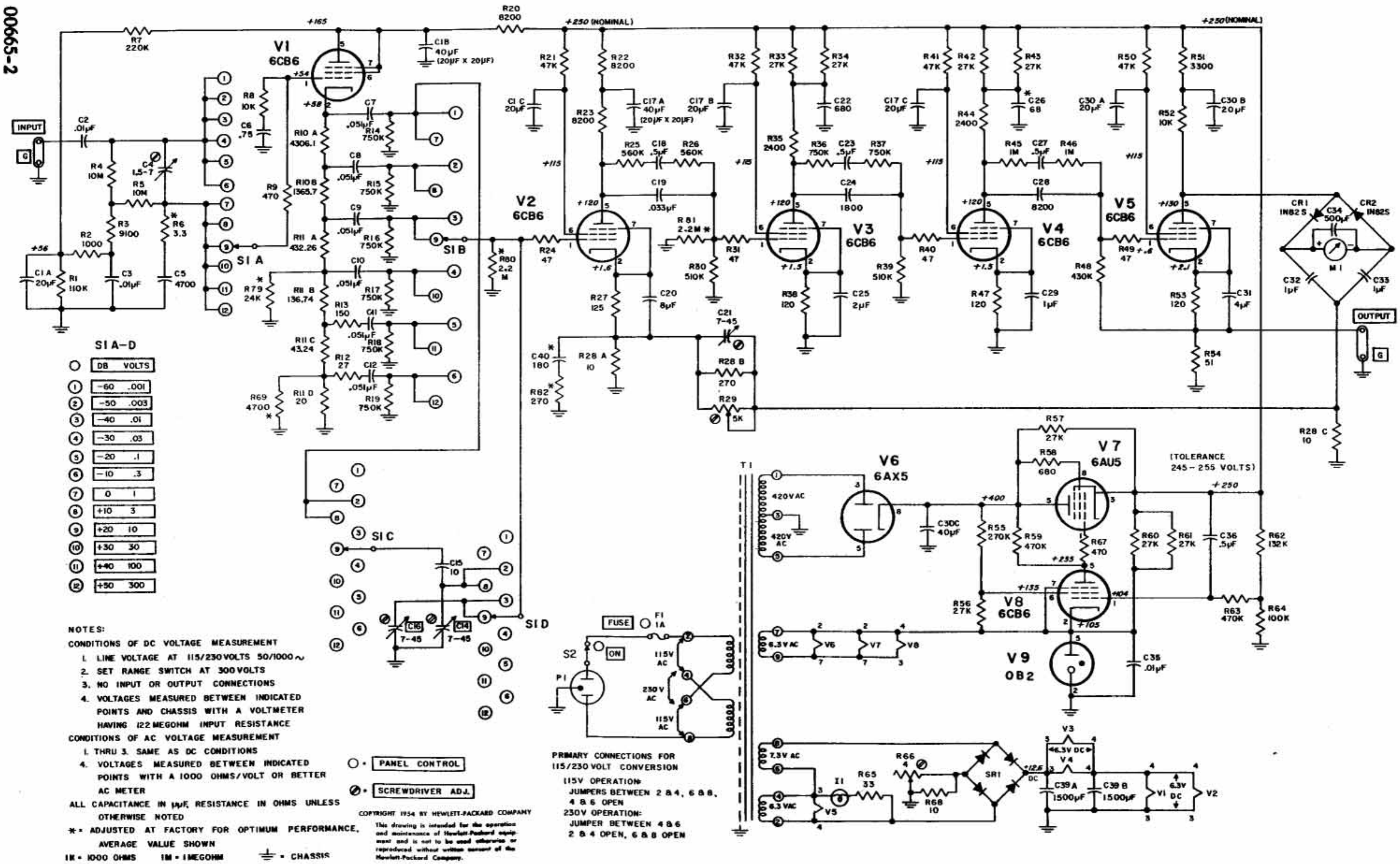
Repeat the Basic Calibration procedures given in steps G and H.

SECTION V - TEST FOR INSTRUMENT CERTIFICATION

To certify a 400D, 400H, or 400L Vacuum Tube Voltmeter it is only necessary to check the accuracy specifications. These specifications are given in the Operating and Servicing Manual supplied with your vtvm.

Certification is accomplished without removing the instrument cabinet and without making any instrument adjustments. Suggested procedures for checking the accuracy specifications are given in Section IV of these Service Notes in steps K, L, and M.

The procedures in steps K, L, and M contain adjustment methods. These adjustments must be omitted when certifying an instrument. Actually, if an instrument meets specifications no adjustments will be necessary.



S1 A-D

	DB	VOLTS
1	-60	.001
2	-50	.003
3	-40	.01
4	-30	.03
5	-20	.1
6	-10	.3
7	0	1
8	+10	3
9	+20	10
10	+30	30
11	+40	100
12	+50	300

NOTES:

CONDITIONS OF DC VOLTAGE MEASUREMENT
1. LINE VOLTAGE AT 115/230 VOLTS 50/1000 ~
2. SET RANGE SWITCH AT 300 VOLTS
3. NO INPUT OR OUTPUT CONNECTIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS AND CHASSIS WITH A VOLTMETER HAVING 122 MEGOHM INPUT RESISTANCE

CONDITIONS OF AC VOLTAGE MEASUREMENT
1. THRU 3. SAME AS DC CONDITIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A 1000 OHMS/VOLT OR BETTER AC METER

ALL CAPACITANCE IN μμF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED

* = ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE, AVERAGE VALUE SHOWN

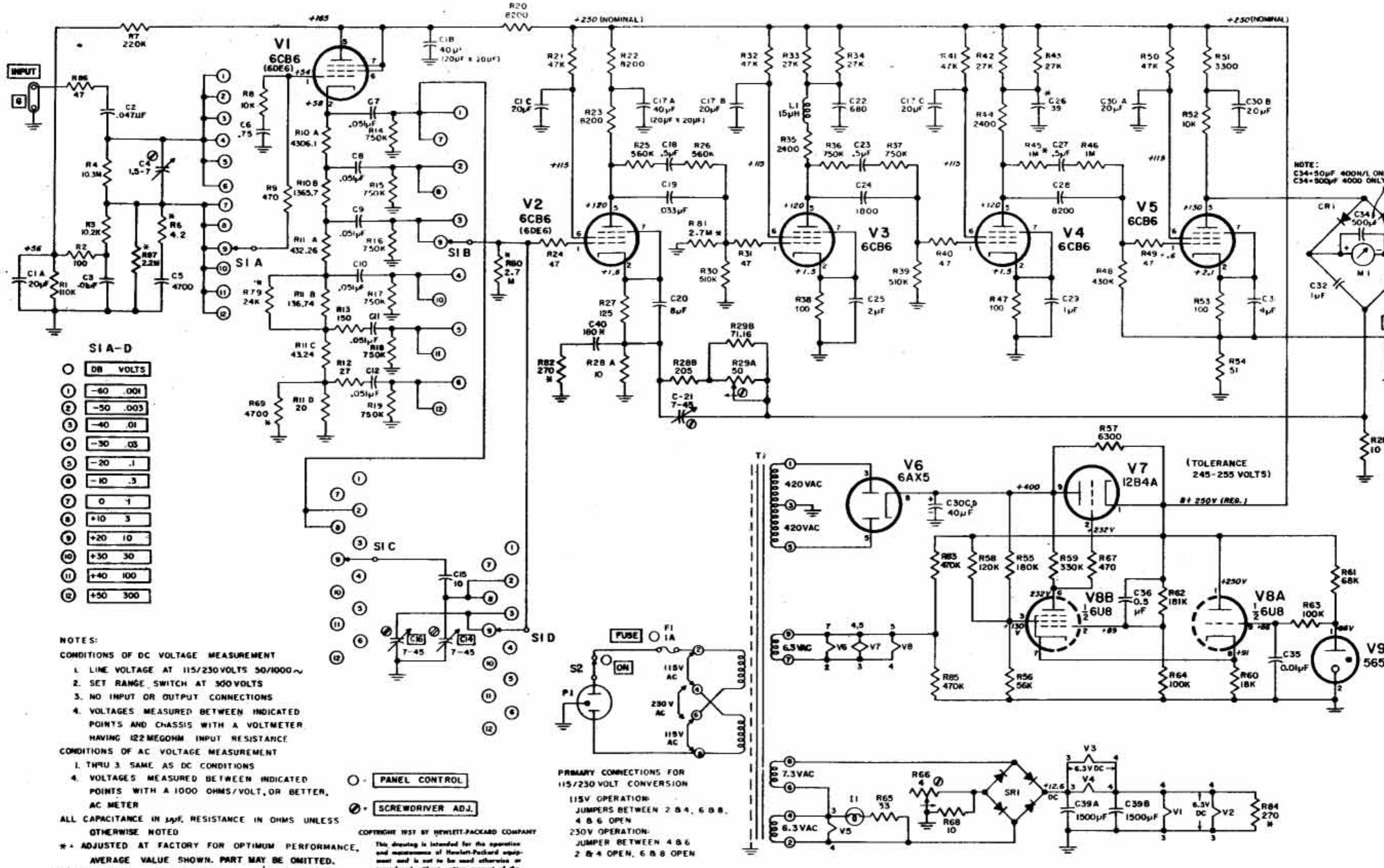
1K = 1000 OHMS 1M = 1 MEGOHM ⏚ = CHASSIS

○ = PANEL CONTROL

⊘ = SCREWDRIVER ADJ.

THIS CIRCUIT IS BASICALLY CORRECT, BUT SMALL DIFFERENCES MAY EXIST FOR ANY PARTICULAR INSTRUMENT. COMPARISION AND CROSS-CHECKING WILL ENABLE IDENTIFICATION OF NECESSARY PARTS.

Figure 1. Schematic Diagram with "Capacitive Input Divider" Circuit, Original Feedback Circuit, and Original Power Supply Circuit



NOTES:

CONDITIONS OF DC VOLTAGE MEASUREMENT

1. LINE VOLTAGE AT 115/230 VOLTS 50/1000~
2. SET RANGE SWITCH AT 300 VOLTS
3. NO INPUT OR OUTPUT CONNECTIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS AND CHASSIS WITH A VOLTMETER HAVING 122 MEGOHM INPUT RESISTANCE

CONDITIONS OF AC VOLTAGE MEASUREMENT

1. THRU 3. SAME AS DC CONDITIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A 1000 OHMS/VOLT, OR BETTER, AC METER

ALL CAPACITANCE IN μμf, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED

* = ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE. AVERAGE VALUE SHOWN. PART MAY BE OMITTED.

1K = 1000 OHMS 1M = 1 MEGOHM ⏚ = CHASSIS

THIS CIRCUIT IS BASICALLY CORRECT, BUT SMALL DIFFERENCES MAY EXIST FOR ANY PARTICULAR INSTRUMENT. COMPARISION AND CROSS-CHECKING WILL ENABLE IDENTIFICATION OF NECESSARY PARTS.

Figure 2. Schematic Diagram with "Resistive Input Divider" Circuit, Revised Feedback Circuit, and Modified Power Supply Circuit

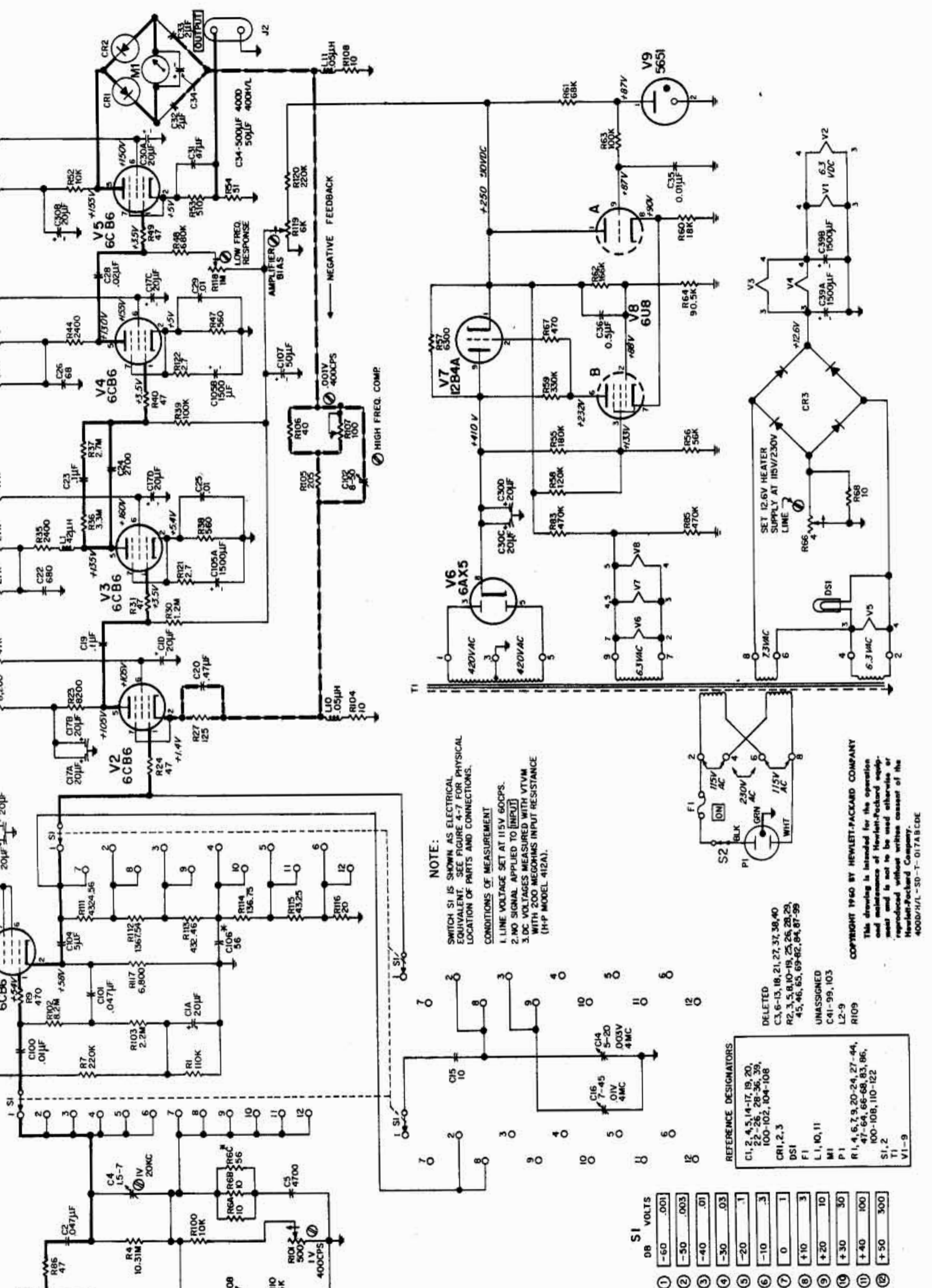


Figure 3. Schematic Diagram Models 400D/H/L with Serials Prefixed 017- or 048-