FLUKE 410A

John Fluke Manufacturing Co., Inc.
P.O. Box 7428, Seattle 33, Washington



FOR REFERENCE PURPOSES ONLY

# Model 410A

# POWER SUPPLY

Serial No. 559 and above

MODEL 410A DIRECT CURRENT POWER SUPPLY

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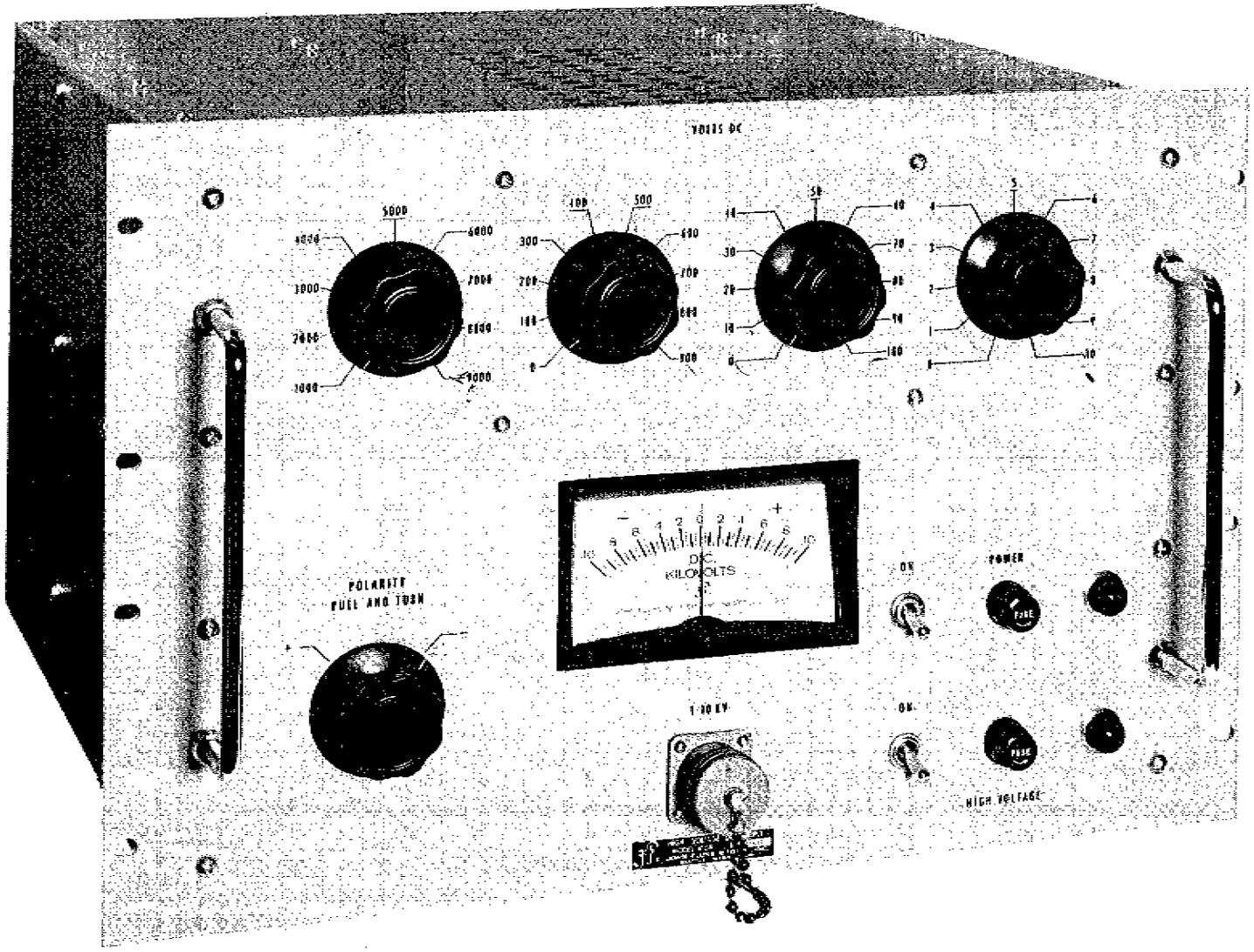

VOLTS DC
POLARITY
FUEL AND TUBE
DC
KILOVOLTS
ON
POWER
FUSE
1-30 KV
ON
FUSE
HIGH VOLTAGE

SECTION I

# MODEL 410A DIRECT CURRENT POWER SUPPLY

## SPECIFICATIONS

### Electrical Specifications

| | |
|---|---|
| Input Voltage: | 117V, 50 - 60 cps, single phase<br>(220/234V, 50 - 60 cps model available upon request) |
| Input Power: | 250 watts fully loaded, 60 watts standby |
| Output Voltage: | 1.00 KV to 10.01 KV direct current |
| Output Current: | 0 - 10 ma |
| Output Polarity: | Positive or negative with respect to chassis, selected via front panel switch. |
| Output Connector: | Amphenol MS-3102A-18-16S, one on front panel and one on rear skirt with protective caps. One mating connector, Amphenol type AN-3106A-18-16P furnished. |
| Regulation vs. Line: | 0.01% maximum for change in line voltage from 105 volts to 130 volts. |
| Regulation vs. Load: | 0.01% maximum from 0 to full load. |
| Stability: | 0.005% per hour maximum after warmup<br>0.05% per day maximum after warmup |
| Ripple: | Less than 5 mv RMS at any output voltage and current in either polarity |
| Voltage Calibration: | 9 - 1000 volt steps<br>9 - 100 volt steps<br>10 - 10 volt steps<br>1 - 10 volt vernier |
| Voltage Resolution: | 10 millivolts at any output voltage |
| Calibration Accuracy: | Better than 0.25% |

### Mechanical Specifications

| | |
|---|---|
| Mounting: | Standard relay rack. Panel 19" wide x 12-7/32" high. Chassis dimensions 17" wide x 17" deep x 11-3/4" high. Equipped with hardwood skids. |
| Weight: | 95 pounds |
| Finish: | Smooth gray baked enamel - panel machine engraved |

# SECTION II

## MODEL 410A DIRECT CURRENT POWER SUPPLY

### WARNING - HIGH VOLTAGE

The voltages available in this supply are of lethal magnitude. Extreme care should be exercised in utilizing the output of this supply and in servicing and inspecting it. Contact with high voltage conductors could easily prove fatal. Operating in the plus polarity mode, the plate of the 4-65A regulator tube may be as much as 15 kv above ground. In the minus polarity mode, the negative side of the supply commonly thought of as "ground", may be as much as 10 kv below ground. BE CAREFUL!

### INSPECTION

This instrument has been thoroughly checked and tested before being shipped from the factory. Upon receipt of the instrument inspect carefully for any damage which may have been incurred in transit. Refer to the WARRANTY section of this manual for the procedure to be followed if any shipping damage has occurred.

### INITIAL OPERATION

Connect supply to a source of 117 volts, 50 or 60 cycle power. Set the X-1000 switch to either the 1 or 2 position and set the POLARITY switch to the desired output voltage polarity. Setting it to "+" makes the center terminal of the output connector positive with respect to chassis; setting it to "-" makes the center terminal negative with respect to chassis. Make certain the POLARITY switch is fully engaged. Now turn both the "POWER" and the "HIGH VOLTAGE" switches to the "ON" position. In approximately 30 seconds the desired voltage will be available at the output connectors as shown by the high voltage pilot light and the panel meter. This time delay is caused by the anti-overshoot circuit which functions to delay the application of high voltage to the main rectifiers until all amplifier tube cathodes are at emitting temperature. This ensures proper operation with no output voltage overshoot upon application of high voltages to rectifiers and the series passing tube. This circuit is discussed in detail in the CIRCUIT DESCRIPTION section of this instruction book.

To remove voltage from output connectors throw HIGH VOLTAGE switch to "OFF"; this places the supply in standby condition.

### OUTPUT POLARITY

To reverse polarity of output, turn HIGH VOLTAGE switch to "OFF", wait until output voltage meter reads zero and then set POLARITY switch to the desired polarity. DO NOT REVERSE POLARITY WITH HIGH VOLTAGE SWITCH AT "ON" POSITION.

## CALIBRATION ACCURACY

The Model 410A uses a constant current precision resistor voltage sampling string. The resistors are 1/10% and 1/2% tolerance units wound with minimum temperature coefficient wire. While the accuracy of the Model 410A calibrated controls is specified as .25%, the actual calibration accuracy of these supplies as shipped is considerably better than .25%. An occasional adjustment of the screwdriver adjust control P1 (located through a side access hole) to compensate for the long term drift of the reference tubes (approximately 1% over 1000 hours) will maintain the high order of accuracy inherent in this power supply.

## SHORT CIRCUIT CONSIDERATIONS

Do not short circuit the output of this power supply, particularly at the higher output voltage settings. A protective circuit has been included in the instrument to prevent damage in case the output is shorted momentarily. This circuit provides a discharge path for the feedback capacitor C3, thus protecting tubes V3, V6, V7 and V8. Should a direct short circuit of the output occur, either accidental or otherwise, the supply should be checked for regulation, ripple, and stability to be sure that neither the OG3 tubes nor 12AX7 tube was damaged. If the OG3 reference tube voltage level was shifted by the arcing it may require from several hours to a few days for them to stabilize at a new operating potential. If erratic operation is traced to these tubes, replacement may be necessary and should this be the case the new tubes should be allowed to run for a day or so before checking stability of the supply.

## CIRCUIT DESCRIPTION

Essentially the supply consists of nine main elements, which are:

(1) An unregulated, filtered DC high voltage supply whose output is applied to the plate of a. .
(2) Tetrode series passing tube (cathode follower) whose control grid is driven by an error signal amplifier and at whose cathode appears the regulated output which is applied to
(3) A precision wirewound constant current voltage divider where it is attenuated to the level of a reference voltage and compared thereto by. .
(4) A differential amplifier. Any difference between the reference and sample voltages is amplified by the differential amplifier and applied to. . .
(5) A high mu triode amplifier where the amplified error signal is still further amplified and applied to the grid of the series passing tube to effect correction of DC level and maintain a very low DC output impedance.
(6) An AC feedback loop for reduction of residual ripple component and AC output impedance.
(7) Stable 500 volt auxiliary supply which shares the same reference tubes with the main regulator. Developing a constant 500 volts, it furnishes constant current of 2.50 milliamperes to the reference tubes. This 500 volt supply also furnishes polarizing potentials for the main differential and amplifier stages.

(8) A regulated 105 volt screen grid supply which "floats" between cathode and screen grid of the pentode series passing tube.
(9) An electronic, self-reset, time delay circuit for preventing output voltage overshoot.

Element (1) consists of T2, R1, CR1 through CR70, C1, C2, and C15 through C50.

Element (2) is a series passing tube.

Element (3) consists of R18 through R54, R66, associated switches S3B, S4 and S5, and potentiometer P1 and P2.

Element (4) is a type 12AX7 tube, V3. The heater of this tube is stabilized by V9, a type 9-7 ballast tube. Use of this regulator tube greatly improves line regulation, simplifies the tube replacement problem, and lengthens the life of tubes V3 and V5 which are the critical differential amplifier tubes for the main supply and the 500 volt auxiliary supply, respectively.

Element (5) is a type 6BK4 tube, V2 and associated components. A type NE2X neon bulb is connected across its grid and cathode to limit the voltage between these closely spaced elements to 70 volts when the supply is left in standby condition.

Element (6) includes C3, R17 and output capacitor C4.

Element (7) consists of CR71 through CR74, C6 through C9, V4, V5, V6, V7, V8 and associated components.

Element (8) is comprised of CR75, C13, C14, R67 through R69 and V10.

Element (9) consists of K1 and K2.

The excellent stability of the Model 410A is due chiefly to the use of highest quality precision wirewound resistors in sampling strings, a very stable reference element and carefully designed equating elements (differential amplifiers V3 and V5).

Gain of the triode amplifier in the 500 volt auxiliary supply is increased by returning the plate load resistor R8 to a point 70 volts above the cathode of the series passing tube V4. This is accomplished by R7 and a NE2X neon bulb. With this arrangement the plate current can never decrease below 70 microamperes and the $G_m$ of the tube is thereby increased considerably.

Potentiometer P1, a screwdriver adjust unit accessible from the small hole on the right side of the instrument, is provided for the occasional adjustment of sampling level to compensate for tube aging. With the supply fully warmed up (after approximately one hour operation in POSITIVE POLARITY) and output voltage controls set

at 5000 volts, P1 is adjusted until the output voltage as read on a high precision meter is exactly 5000 volts. The front panel voltage controls will be accurate within 0.25% at any voltage setting.

NOTE: This adjustment MUST be made in the positive polarity with a non-metallic screwdriver, as the pot can be 10 kv below chassis in the negative polarity.

The Model 410A uses a reset type time delay circuit consisting of K1, K2 and S8 for positive protection against output voltage overshoot, not only at startup and shutdown but for the special case of temporary power failure as well. K1 is a thermal time delay relay which controls K2. Upon application of power, K1 closes after 30 seconds causing K2 to close. K2 latches closed and remains closed until the primary switch is opened. As K2 closes, the voltage is removed from the coil of K1. After two or three minutes K1 has cooled and is ready for a repeat delay operation. S8 is actuated by the polarity switch when it is fully engaged. As the polarity switch is pulled out, S8 opens breaking the circuit of the coil of K2. This causes the time delay circuit to recycle even though the polarity switch is immediately closed. This gives added protection to the instrument when reversing polarities.

## MAINTENANCE

Very little maintenance, other than routine cleaning and tube replacement, will be required with this supply. Periodic removal of dust and other foreign substance is recommended owing to the high voltage present. It is again emphasized that extreme caution should be exercised when servicing this equipment. Note that C1 and C2 are very high quality oil-filled capacitors capable of maintaining a charge for hours or even days. Note also that should the bleeder resistor across these capacitors open and should the series passing tube V1 lose emission there would be no discharge path for them with the result that they might maintain a 15,000 volt charge for hours after shutting the supply down. It is a good practice to short all capacitors and plate caps to the chassis before servicing or removing tubes. To short capacitor, connect clip lead first to chassis and then to one side of the capacitor to be shorted. Connect another clip lead first to chassis and then to the other side of capacitor. This ensures against accidental contact with an ungrounded hot capacitor terminal.

Do not touch any of the components with the fingers or dirty cleaning cloths. Any contaminated matter present may give rise to corona which will appear as bounce and jitter in the regulated output. Dirty components should be wiped clean with a lint-free rag saturated with Metriclene Solvent M-4 (manufactured by the John B. Moore Corp., Nutley, New Jersey). This is a high grade non-toxic solvent for use on delicate electrical equipment. Many other solvents have very poor electrical properties and leave a residue which may be slightly conductive. Switches may be washed using a stiff bristled brush dipped in Metriclene. After washing, the ceramic surface should be recoated with a 10% solution of Dow Corning 200 fluid (100 viscosity grade) in Metriclene.

Should replacement of V3, the 12AX7 differential amplifier tube, be necessary, some output voltage drift may be noted for the first few hours operation. This usually decreases to a small value after the tube has aged a bit. Occasionally a tube with contaminated grid or poor balance between halves will be found which will not settle down or which causes the supply to regulate poorly for line voltage changes. This should be discarded in favor of another. The same applies to replacement of V6, V7, and V8, the type OG3 reference tubes. A few hours running in is usually necessary to realize the high order of long term stability which is inherent in the Model 410A.

## TROUBLESHOOTING HINTS

WARNING - HIGH VOLTAGE. The voltages available in this supply are of lethal magnitude. Extreme care should be exercised in utilizing the output of this supply and in servicing and inspecting it - contact with high voltage conductors could easily prove fatal. Operating in the plus polarity mode, the plate of the 4-65A regulator tube may be as much as 15 kv above ground. In the minus polarity mode, the negative side of the supply, commonly thought of as "ground", may be as much as 10 kv below ground. BE CAREFUL!

1. NO OUTPUT. Generally when no output voltage is obtained, the fault will be due to an incorrect starting procedure.

To start the supply:

1. Set the X-1000 switch to the 1 or 2 position.
2. Make certain the POLARITY switch is fully engaged, that is, the knob must be pushed in as far as it will go.
3. Turn on both the POWER and the HIGH VOLTAGE switches. After about 20 seconds power should be available at the output connector.

If power is still not available at the output connector, check for open heater of V1, the series passing tube, or V3, the differential amplifier. Check plate voltage of main supply using a well insulated high voltage probe for making contact with the high voltage conductors. Check R1 for open circuit - severe prolonged overload will cause this to open up or greatly increase in value. Check output of auxiliary supply. Check for open R66 or shorted C4.

2. INCORRECT OUTPUT VOLTAGE. If constant percentage error is noted over the entire output voltage range R66 may be defective or one or more of the three reference tubes V6, V7, and V8 may have drifted out of the normal operating voltage range. This often happens as the tubes approach end of life, usually after 10,000 hours or more of operation. If only slightly out of calibration, adjust P1, screwdriver adjust control on side panel with the supply in the "POS" polarity ONLY.

If error is noted over only part of the output voltage range, trouble is due to a defective wirewound resistor on one of the three voltage selector switches. To isolate the defective resistor, set output voltage to maximum and decrease voltage one step at a time until error disappears. The defective (out-of-tolerance) resistor will be found just above the switch position at which error disappeared.

If the percentage error decreases as the output voltage is increased, trouble is out-of-tolerance R18.

3. OUTPUT ERRATIC. This is usually caused by a defective wirewound resistor in the main sampling string. If present at all output vol ages check R18 and R66 as well as the reference tube feedback capacitor C3 and differential amplifier V3. Also check stability of auxiliary supply output voltage.

If erratic condition disappears below a certain output voltage, trouble is probably a defective resistor just above the po nt trouble clears up.

4. COMPLETE LOSS OF CONTROL. If output voltage follows line voltage variations, check or a gassy series passing tube or a defective 6BK4 amplifier (V2). Loss of emission in V2 will cause loss of regulation of this type. Also check for defective differential amplifier tube V3 A systematic check of element potentials should pinpoint the defective component if trouble is not found to be a defective tube.

5. POOR REGULATION If poor load regulation, check for weak driver amplifier V2. If line regulation poor, check differential amplifier V3 If replacement of V3 is required, select a tube which produces output voltage variation of .01% or less for a change in line voltage from 105 volts to 130 volts The Amperex brand of 12AX7 generally evidences better balance between halves and considerably lower grid current than most other brands.

6 OSCILLATION. Che k for open feedback capacitor C3 or open output capacitor C4. If oscillation is traced to the aux liary suppl check for open C10 or C12.

7. EXCESSIVE DRIFT I output voltage fails to stabilize after unit is fully warm trouble is probably in one of three places - (a) defective reference tube or tubes V6, V7, V , (b) defective ifferential amplifier tube V3, or, (c) leaky feedback capacit r, C3. Check reference voltage stability using a Model 801 - should vary less than 20 millivolts per hour after warmup; if more than this replace one or all of them. MAKE THIS MEA UREMENT WITH OUTPUT POLARITY SWITCH SET TO "+". NEVER MAKE MEASUREMENTS WITH OUTPUT NEGATIVE.

## RECALIBRATION INSTRUCTIONS

In order to properly calibrate the Model 410A, a voltmeter of 1/4% accuracy or better is required. The John Fluke Models 800 or 801 with a 20 to 1 volt box are ideal for this purpose since accuracy of these instruments is .05%. ← 80B-10

1. Be sure instrument is operating properly and is fully warm. Set voltage dials to 5000 volts in the POSITIVE polarity ONLY.

2. Adjust P1, the screwdriver adjust potentiometer located on right side of the instrument, until output is exactly 5000 volts.

3. Check output at 1000 volts and then at 10,000 volts. Adjust P1 slightly, if necessary, to produce best accuracy over entire range. When properly calibrated, accuracy should be better than .25% over entire range. If impossible to realize this figure, check for a defective wirewound resistor somewhere in the main sampling string. See heading 2 in TROUBLE SHOOTING HINTS for help in isolating the out-of-tolerance resistor.

# SECTION III
# MODEL 410A
# LIST OF REPLACEABLE PARTS

| CIRCUIT SYMBOL | DESCRIPTION | FLUKE STOCK NO. |
|---|---|---|
| C1, C2 | Capacitor, oil<br>0.5 mfd, 10 kv | CO33 |
| C3 | Capacitor, oil tubular<br>0.02 mfd, 12.5 kv | CO34 |
| C4 | Capacitor, oil<br>0.5 mfd, 12.5 kv | CO32 |
| C5 | Capacitor, ceramic<br>680 mmf, 500 v | CT3 |
| C6, C7, C13 | Capacitor, ceramic<br>0.001 mfd, ±5%, 3 kv | CT16 |
| C8, C9 | Capacitor, electrolytic<br>10 mfd, 500 v | CE50 |
| C10 | Capacitor, paper<br>0.1 mfd, 400 v | CP4 |
| C11 | Capacitor, paper<br>0.022 mfd, 600 v | CP28 |
| C12 | Capacitor, paper<br>0.047 mfd, 1 kv | CP12 |
| C14 | Capacitor, electrolytic<br>8 mfd, 250 v | CE10 |
| C51 | Capacitor, ceramic<br>0.1 mfd, 500 v | CT20 |
| C52 | Capacitor, mylar<br>.1 mfd, 600 v | CF20 |
| R2 | Resistor, composition<br>56k, ±10%, 1 w | GB5631 |
| R3, R10 | Resistor, composition<br>1 m, ±10%, 0.5 w | EB1051 |

| CIRCUIT SYMBOL | DESCRIPTION | FLUKE STOCK NO. |
|---|---|---|
| R4 | Resistor, wirewound<br>20 Ω, 5%, 5 w | R20WA |
| R5, R67 | Resistor, composition<br>100 Ω, 10%, 1 w | GB1011 |
| R6, R70 | Resistor, composition<br>330 k, 5%, 1 w | GB3345 |
| R7 | Resistor, composition<br>150 k, 10%, 2 w | HB1541 |
| R8, R9 | Resistor, composition<br>270 k, 10%, 1 w | GB2741 |
| R11, R12 | Resistor, deposited carbon<br>500 k, 1%, 1 w | DR619 |
| R13 | Resistor, precision wirewound<br>100 k, 0.5%, 1 w | PR62 |
| R15, R14 | Resistor, deposited carbon<br>300 k, 1%, 1 w | DR614 |
| R16 | Resistor, deposited carbon<br>250 k, 1%, 1 w | DR613 |
| R17 | Resistor, composition<br>330 k, 10%, 1 w | GB3341 |
| R18 | Resistor, precision wirewound<br>243 k, 0.1%, 1 w | PR634 |
| R19 thru R35 | Resistor, precision wirewound<br>500 k, 0.1%, 1 w | PR636 |
| R36 thru R44 | Resistor, precision wirewound<br>100 k, 0.1%, 0.5 w | PR624 |
| R45 thru R54 | Resistor, precision wirewound<br>10 k, 0.5%, 0.5 w | PR51 |
| R55, R56 | Resistor, deposited carbon<br>5 m, 1%, 1 w | DR710 |

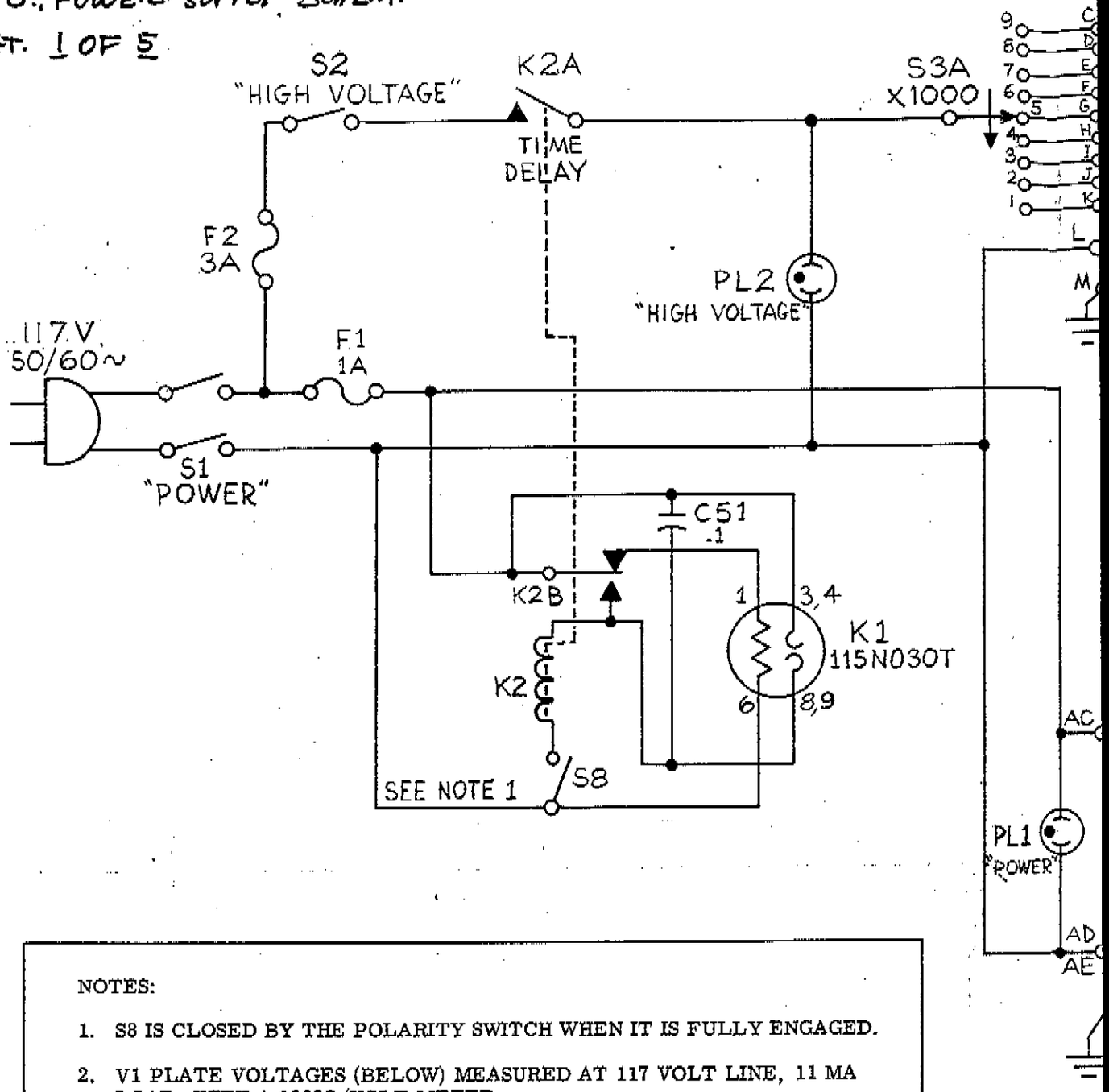
| CIRCUIT SYMBOL | DESCRIPTION | FLUKE STOCK NO. |
|---|---|---|
| R57 thru R65 | Resistor, deposited carbon 10 m, ±1%, 2 w, 1700 v | DR714 |
| R66 | Resistor, precision wirewound 247 k, ±0.1%, 1 w | PR635 |
| R68 | Resistor, composition 4.7 k, ±10%, 1 w | GB4721 |
| R69 | Resistor, composition 100 k, ±10%, 1 w | GB1041 |
| R71 thru R76 | Resistor, composition 1.5 m, ±10%, 2 w | HB1551 |
| R77 | Resistor, composition, 100k, ±10%, 1/2 w (factory selected value may vary) | EB1041 |
| P1 | Potentiometer, precision wirewound, 10 k, ±10%, 0.5 w | P10KT |
| P2 | Potentiometer, wirewound 10 k, ±5%, 4 w | P10KH |
| V1 | Tube, power tetrode selected 4-65A | 155184 |
| V2 | Tube, high mu triode Type 6BK4 | 6BK4 |
| V3, V5 | Tube, dual triode Type 12AX7 | 12AX7 |
| V4 | Tube, dual triode Type 12AT7 | 12AT7 |
| V6, V7, V8 | Tube, voltage reference aged OG3 | OG3-2 |
| V9 | Tube, ballast Type 9-7 | 9-7 |
| V10 | Tube, voltage regulator Type OB2 | OB2 |

| CIRCUIT SYMBOL | DESCRIPTION | FLUKE STOCK NO. |
|---|---|---|
| V11, V12 | Neon Lamp NE2X | X40A |
| CR1, CR2 | Rectifier, silicon 20,000 PIV, 250 ma | RE51 |
| S1 | Switch, toggle, DPST 125/250 v, 6 amperes | ST1 |
| S2 | Switch, toggle, SPST 250 v, 3 amperes | ST5 |
| S3 | Switch, rotary, ceramic 2 pole, 9 position | SR48 |
| S4, S5 | Switch, rotary, ceramic 1 pole, 11 position | SR5 |
| S6 | Switch, ⓕ assembly 4 pole, 2 position | 410A-4003 |
| S8 | Switch microswitch, SPST | SP2 |
| K1 | Relay, Time Delay | CK19 |
| K2 | Relay, 115 VAC, DPDT | 148940 |
| SG1 | Spark gap, .005" | X327 |
| F1 | Fuse, 1 ampere, slo-blow | F1A |
| F2 | Fuse, 3 ampere, slo-blow | F3A |
| T1 | Transformer, filament | 410A-602 |
| T2 | Transformer, plate | 410A-601 |
| PL1, PL2 | Pilot light assembly | X15A |
| M1 | Meter, DC, 100-0-100 microamp, 10-0-10 kv scale | M33 |

| CIRCUIT SYMBOL | DESCRIPTION | FLUKE STOCK NO. |
|---|---|---|
| | Cordset, power 3 conductor | X27E |
| | Fuse holder, bayonet type | X12 |
| | Output connector | X22E |
| | Cap, output connector | X22D |
| | Connector, cable | X22A, B |
| | Cap, anode, ceramic 3/8" | X75 |
| | Skid, hardwood | 410A-218 |
| | Knob, 2", No pointer | X317A |
| | Knob, 2", with pointer | X317 |
| | Handle, chrome plated | X309 |
| | Insert, Output connector Teflon for X22D | 410A-242 |

D.C., POWER SUPPLY SCHEM.

SHT. 1 OF 5




NOTES:

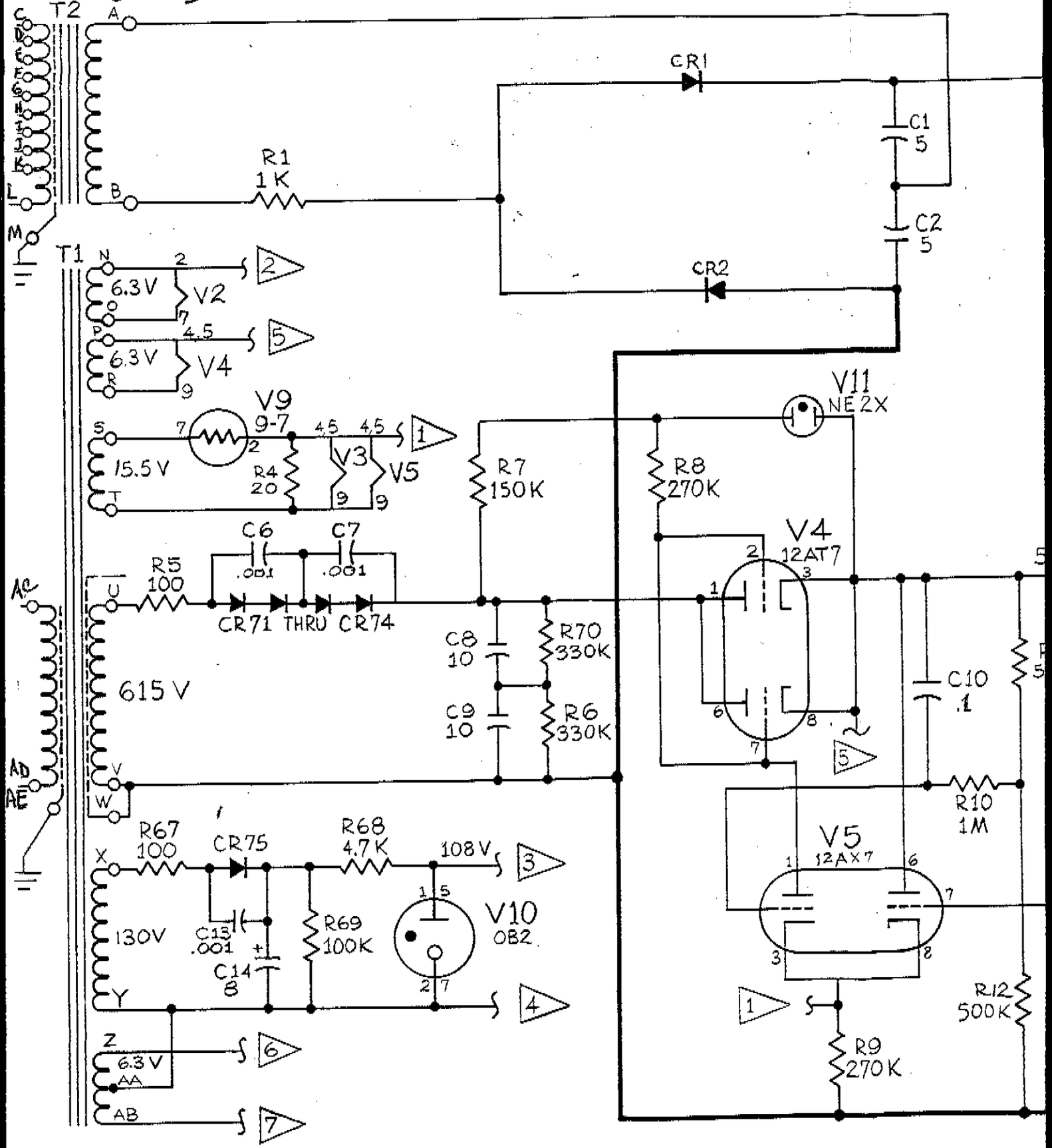
1. S8 IS CLOSED BY THE POLARITY SWITCH WHEN IT IS FULLY ENGAGED.
2. V1 PLATE VOLTAGES (BELOW) MEASURED AT 117 VOLT LINE, 11 MA LOAD, WITH A 1000Ω/VOLT METER.
3. ALL CAPACITORS ARE IN UF EXCEPT AS NOTED.

▷ ALL FLAGNOTES WITH THE SAME NUMBER ARE CONNECTED.

* FACTORY SELECTED

| X-1000 SW SETTING | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| V1 PLATE VOLTS | 2700 | 4000 | 5200 | 6400 | 7700 | 8850 | 10200 | 11500 | 12950 |

D.C. POWER SUPPLY SCHEM.
SHT. 3 OF 5



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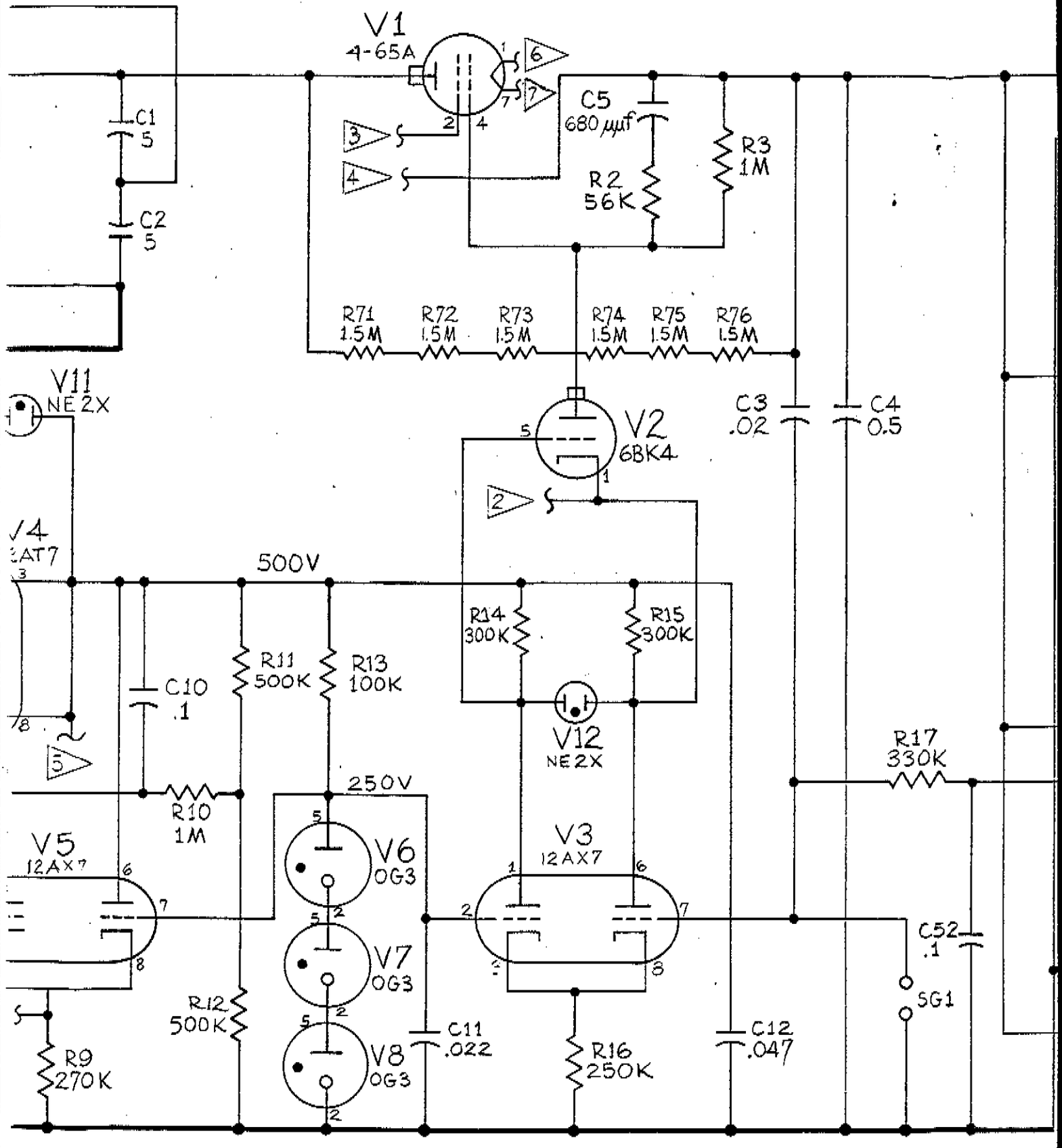
SHT. 3 OF 5



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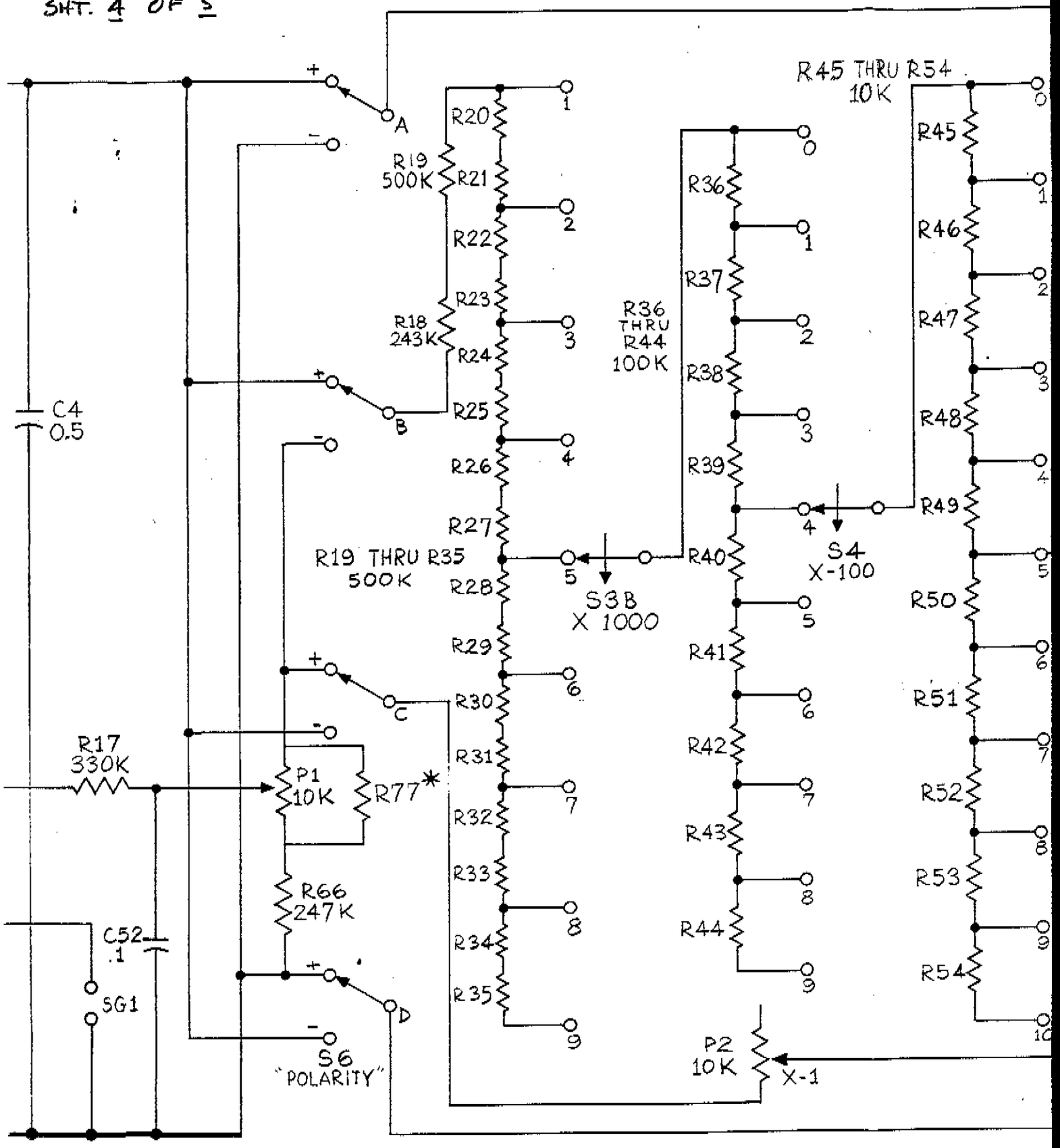
SHT. 4 OF 5

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FLUKE JOHN

MODEL 41

D.C. POWER SUPPLY SCHEM.
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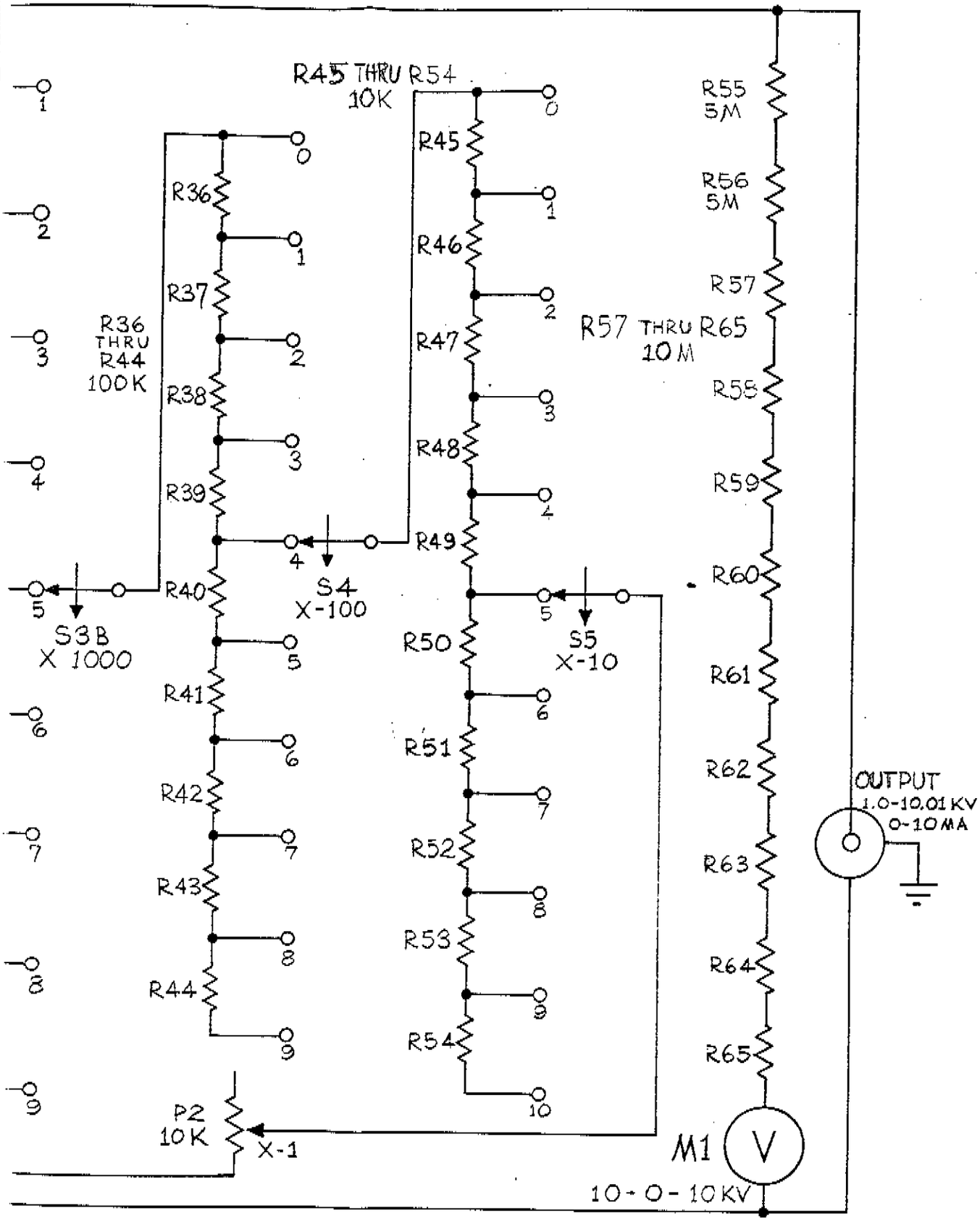


SER. NO 559 & ON

FLUKE JOHN FLUKE MFG CO INC

MODEL 410A D.C. POWER SUPPLY