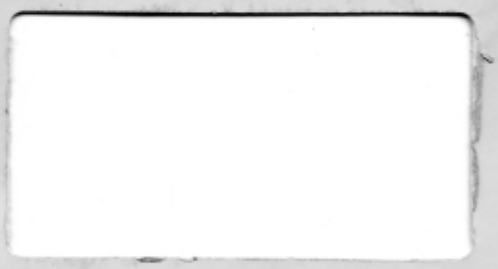
Instruction Manual



FLUKE

ELECTRONICS FOR INDUSTRY
INSTRUMENTS / COMPONENTS

JOHN FLUKE MANUFACTURING CO., INC.

P.O. Box 7428 Seattle, Washington 98133

MODEL 407

POWER SUPPLY

407 1049 and above

407R _____ and above


D.C.
MA.
D. C. VOLTS
JOHN FLUKE MFG. CO., INC.
SEATTLE, WASH.
MTR CKT
MTR RANGE
ON
POWER SUPPLY
MODEL 407


MTR CKT
HV OFF
HV
BIAS
D.C.
D.C. VOLTS
JOHN FLUKE MFG. CO., INC.
SEATTLE, WASH.
BIAS
MTR RANGE
600 V
60 V
5A
FUSE
ON
6.3
5A
G
0-555 V
300 MA
0-25V
BIAS
POWER SUPPLY

MODEL 407 HIGH RESOLUTION D-C POWER SUPPLY

TABLE OF CONTENTS

Section I.

Section II.

Section III.

Section IV.

MODEL 407 HIGH RESOLUTION DC POWER SUPPLY

SPECIFICATIONS

Input Voltage:	117/234 volt, 50/60 cycles single phase
Input Power:	425 watts at full load, 100 watts standby
Main Output Voltage:	0 to 555 volts
Main Output Current:	0 to 300 milliamperes
Line Regulation:	0.01% or 50 mv, whichever is greater for line change from 105 volts to 130 volts
Load Regulation:	0.01% or 50 millivolts, whichever is greater, for 300 milliampere load change
Output Impedance:	Less than 0.5 ohm dc to 100 kc at full load
Stability:	0.01% or 50 millivolts per hour 0.05% or 250 millivolts per day
Ripple:	1 millivolt RMS or less
Voltage Resolution:	2 millivolts over entire range
Voltage Controls:	0 to 500 volts in ten 50 volt steps 0 to 55 volts, smoothly variable 0 to 0.55 volts, smoothly variable
Calibration Accuracy:	Better than 0.5% from 50 to 500 volts when set up by 0 - 500 volt control
Output Polarity:	Either plus or minus side of main output may be grounded, or both sides may be left floating. Two supplies may be series connected
Meter:	Illuminated 4-1/2 inch. Selectively reads main output voltage, bias voltage, main output current
Meter Ranges:	0 - 600 volts, 0 - 60 volts, 0 - 300 milliamperes
Auxiliary Outputs:	(DC) 0 to minus 250 volts and 0 to minus 25 volts, variable via BIAS control. Maximum output 5 milliamperes at minus 250 volts. Plus side connected to minus side of main output. Line regulation 0.02%, 1 millivolt maximum ripple. Output impedance 0 to 10,000 ohms, depending on setting of BIAS control. At 250 volt setting, load regulation 0.01% for 5 ma load change. (AC) Two independent 6.3 volt, 5 ampere outputs. May be series or parallel connected. Each insulated for 1500 volts RMS to ground and each other.
Output Connectors:	Binding posts on 3/4 inch centers. Also terminal strip at rear on rack model
Mechanical:	Portable Model: 9-3/4" W x 13" H x 14" D, 32 lbs. Rack Model: 19" W x 8-3/4" H x 16" D, 32 lbs.

JOHN FLUKE MFG. CO., INC.
P. O. BOX 7128
Seattle 33, Washington

MODEL 407 HIGH RESOLUTION DC POWER SUPPLY

GENERAL DESCRIPTION

The Model 407 is an extremely stable highly regulated source of direct current in the 0 to 555 volt, 0 to 300 milliampere range. It is a light-weight, highly portable unit incorporating silicon diode rectifiers and printed circuits throughout. The power transformer is a specially designed, conservatively rated unit, provided with a dual primary for operation from either 117 or 234 volts, and a tapped high voltage secondary winding for minimizing heat dissipation in the pentode series passing tubes. Precision wirewound resistors using Evanohm alloy (minimum temperature coefficient and thermal EMF) are used in all sampling strings and at other critical points in the circuit. This permits the use of calibrated output voltage controls and insures excellent long term stability. This stability plus the high degree of isolation of the output from line voltage and load current variations permit full utilization of the high resolution feature and greatly enhance the supply's use in meter calibration work.

A dual range negative bias output with excellent resolution, and dual 6.3 volt, 5 ampere outputs phased to permit series or parallel operation are also provided, making the Model 407 an ideal laboratory or general purpose power supply, as well as a high resolution d-c source for meter calibration.

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.

TRANSFORMER PRIMARY CONNECTION

The power transformer T1 in the Model 407 has a dual primary. For operation from 117 volt power line the two primaries are connected in parallel; for operation from 234 volt power line the two primaries are connected in series. Unless otherwise specified the transformer in this unit is connected for 117 volt operation. Units with transformers connected for 234 volt operation are shipped with a red tag tied to the handle clearly stating "THE TRANSFORMER IN THIS POWER SUPPLY IS CONNECTED FOR 234 VOLT OPERATION".

To change connection of primaries, remove this instrument from its case and refer to chart printed on the left side sheet. When operated from 234 volt a-c main, change 5 ampere slo-blo fuse to 3 ampere instant blow fuse.

INITIAL OPERATION

Connect the instrument to single phase 50 or 60 cycle source of proper line voltage. Set up output voltage desired on the three calibrated output voltage controls.

Set MTR. CKT. switch to HV OFF position and throw PWR switch to ON position. Meter should light up. After 30 seconds turn MTR. CKT. switch to HV position and the desired voltage will appear at the 0 to 555 volt output posts at the bottom right side of panel and will be read on the front panel meter. This supply has calibrated output voltage controls accurate to better than 0.5%, whereas the panel meter is a 2% instrument. Since the accuracy of all long scale indicating instruments is expressed as a percentage of FULL scale, the meters may read in error by as much as 12 volts anywhere on the scale and still fall

within the meter manufacture 's specifications. Consequent.y, it should not be used for setting up prec se voltages; rel on the calibrated controls. Should a la·ge discrepancy between meter reading and di l etti igs appear, refer to th SERVICE NOTES & RECALIBRATION sections of this book

TO USE AS GENERAL PURPOSE LABORATORY SUPPLY

Four different outputs are available at four sets of binding posts on the Model 407. All four may be used simultaneously at maximum outputs over the e tire 105 to 130 volt range of line voltage, no derating is necessary under any condit'ons These outputs are:

1. 0 to 555 volts d-c at 300 milliamperes maximum, available at right hand binding posts. This output is adjusted via the thre.e calibrated ontro . Controls a e calibrated to an accuracy of 0.5% and output 's egula·ed to 0 01% or 50 millivolts against 300 milliampere load .urrent change or 20% l.ne voltage change. Output voltage may be monitored on the 4-1/2 inc panel meter b setting the MTR. CKT. switch to HV. Fo volt.ges under 60 vo'ts t e me e·s ale may be expanded by a factor of 10 by tu ning the m·mentar- ype MTR RANGE swit·h to the 60V position. The switch s m e momentary o prevent he meter being damaged by accidentally leaving the swi·ch in the 60 volt posit on w ile setting up a voltage of several hundred vo ts O tput current may be read on the 0 to 300 milliampere meter scale by setting h· MTR CKT. swi ch to I HV

   Output voltage may be removed from ·ind ng posts by turning the MTR CKT. switch to HV OFF. This switch opens he c rcu·· between regula ·r and positive binding post. An anti-arcing c'r uit b ases the ou·put t·bes o ·ut off before the output circuit is interrupted, thus pr vent'ng switch arcing.

2. 0 to minus 250 volts at 5 milliamper ·s max'mum, ava.lable at center th ee binding pos s. This output is adjusted via he BIAS contro. to the right o the meter. Control is not calibrated since output s der ved from a 50,000 ohm potent o-meter and is therefore load current sen it ve. Output voltage 's reg la ed to 0.02% or 50 millivolts against 20% line voltage ·hange. With control set to max mum (250 volt) output is regulated to 0 0 % against a 5 m·lliampere load current change. This bias voltage may be mo·itored on the 4-·/2 inch panel me er by setting the MTR. CKT. switch to BIAS. Some e·ror will be introduced if the expanded meter range is used since the meter resistance of 60,000 ohms is ·hunted acro.s the top on the 50,000 ohm B AS control. Negligible error is ·troduced by the meter n the 600 volt range howeve·. For setting up bias voltages for receiving type tubes a 0 to minus 25 volt ou put is available at the center bind ng post. Since this 's derived from a 10 to voltage divider across the minus 250 volt output It too is load current sensitive. To determine output voltage at this tap divide meter reading by 10.

3,4. 6.3 volts a-c at 5 amperes unregulated, ava·lable at the two pairs of binding posts on left side of panel. These w·ndings are insulated for 1500 volts RMS to chassis and each other. They are exactly balanced and may be series or pa allel con ected to give 12.6 volts at 5 amperes or 6 3 vo·t· a· 10 amperes. The lower binding post of each pair is marked plus or minus to indicate the start of each winding. For 12.6 volts connect he top binding post of one pair to the bo tom post of he other pair. For 6 3 volt, 10 ampere output connect top to top and bottom to bottom.

TO USE FOR METER CALIBRATION

The Model 407 may be used for the direct calibration of d-c voltmeters to an accuracy of better than 0.5% at 10 cardinal 50 volt points from 50 through 500 volts. An additional 55 volts of range is available via the 0 to 55 volt control. Used in combination with the John Fluke Model 801 it may be used to calibrate d-c instruments to an accuracy of 0.05% over the range of 0.1 volt to 500 volts.

For direct calibration, set up the desired voltage on the three calibrated voltage controls and connect the instrument to be calibrated to the 0 - 555 volt binding posts. The ten 50 volt steps are accurate to considerably better than 0.5%. The voltage change effected by the 0 to 55 volt control is accurate to better than 5% while the voltage change effected by the 0 to 0.55 volt control is accurate to better than 5%. Simple arithmetic will enable the user to compute the maximum error at any setting.

Since the accuracy of an instrument of this type is dependent almost entirely upon the accuracy of the precision resistors used in the main sampling string (assuming the proper sampling string current, proper reference voltage and adequate error amplifier gain) it will at once be apparent that the use of 0.25% resistors will certainly produce better than 0.5% calibration accuracy, particularly if the internal calibration controls are occasionally adjusted (every few hundred hours) to compensate for ageing of the reference and equating tubes.

For calibration of high precision indicating instruments such as 0.25% laboratory models we recommend using the Model 407 in conjunction with the Fluke Model 801 (or 800). In this case the Model 407 serves as a high resolution voltage source and the Model 801 Potentiometric D-C Voltmeter serves as a 0.05% voltage standard. These instruments are described in the Short Form Catalog at the rear of this instruction manual.

CIRCUIT DESCRIPTION

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

(1) An unregulated, filtered d-c high voltage supply the output of which is applied to the plates of
(2) Pentode series passing tubes (cathode followers) whose control grids are driven by an error signal amplifier and at whose cathodes 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 cathode follower pentode amplifier where the amplified error signal is still further amplified and applied to the grids of the series passing tubes to effect correction of d-c level and maintain a very low d-c output impedance.
(6) An a-c feedback loop for reduction of residual ripple component and a-c output impedance.

(7) A high stability negative 250 volt reference supply which shares the same reference tube with the main regulator. Developing a constant minus 250 volts, it furnishes an absolutely constant current of 2.15 milliamperes to the reference tube. The 86 volt sample of the main output voltage is dropped this 250 volts below the 0 volt bus of the main output in order to furnish polarizing potentials for the main differential and pentode amplifier stages. This is obviously necessary since the grids of the main series passing tubes must be driven a maximum of 60 volts negative with respect to the cathodes. This puts them well below the zero volt bus when operating at a few volts main output.

(8) An unregulated screen grid supply which "floats" between cathode and screen grids of the pentode series passing tubes.

(9) A 4-1/2 inch meter and associated function and range switches.

Element 1 consists of silicon diode rectifiers RE1 through RE8, capacitors C1 and C2, and bleeder resistors R1 and R2. The high voltage winding which furnishes power to this full wave bridge rectifier is tapped and switched by a section of the 0-500 volt control. Thus the voltage drop and hence the power dissipation of the series passing tubes is minimized.

Element 2 consists of V1, V2, and V3.

Element 3 is comprised of S2B and associated precision wirewound resistors R33 through R42, R43, R44, and wirewound potentiometers P2, P3 and P4.

Element 4 consists of V5 and associated components.

Element 5 is composed of V4 and associated components.

Element 6 includes C10, R28 and output capacitors C3 and C4.

Element 7 consists of rectifier filter RE11 through RE12 and C6, series passing tube V8, cathode follower-triode driver amplifier V7, differential amplifier V6, reference tube V9, and associated components. The 86 volt sample of the 250 volt output is derived from precision wirewound resistors R15 and R16 and wirewound potentiometer P1. Constant current for the reference tube is insured by precision wirewound dropping resistor R21. A-C feedback and amplifier stabilization is accomplished by C8, R47 and output capacitor C11.

Element 8 includes RE9 through RE10 and C5.

Element 9 consists of M1, S3, S4, R8, R9 and shunt R10.

NOTES ON CIRCUIT OPERATION

The excellent stability of the Model 407 is due chiefly to the use of highest quality precision wirewound resistors in sampling strings, a very stable reference element (Type 5651 reference tube) operated at constant current and carefully designed equating elements (differential amplifiers V5 and V6).

The heater current of these differential amplifiers is regulated by an Amperite type 9-7 ballast tube, V10, which greatly improves the regulation of the supply against large fluctuations in line voltage.

Gain of the pentode driver amplifier is increased by returning the plate load resistor R12 to a point 70 volts above the cathodes of theseries passing tubes. This is accomplished via R11 and neon regulator V13. With this arrangement the plate current can never decrease below 150 microamperes and the Gm of the tube is thereby increased considerably.

An arc prevention circuit is used in connection with MTR. CKT. switch. This circuit functions as follows: The space between the HV OFF position and the HV position is 60 degrees, whereas the space between all other adjacent switch positions is only 30 degrees. As the switch knob is rotated from the HV position counterclockwise toward the HV OFF position the rotor of the "D" section connects the grids of the main series passing tubes to a point 60 volts below the zero bolt bus. This occurs as the switch rotor passes through the first 30 degrees of its rotation toward the HV OFF position. The output voltage immediately falls toward zero. The circuit to the positive output post established via the "A" sections is still maintained at this point and for a few degrees beyond (both the "D" and "A" sections of S3 have shorting type rotors). As the knob is rotated through the second 30 degrees of travel toward the HV OFF position the circuit to the positive binding post is opened but by this time the output voltage is at or near zero so there is little or no energy available to cause switch arcing. Neon bulbs V11 and V12 are connected between control grids and cathodes of the series passing tubes to prevent the voltage between these elements exceeding 140 volts as the MTR. CKT. switch is thrown to the HV OFF position with the supply operating at high output voltages.

MAINTENANCE NOTES

Very little maintenance, other than routine cleaning and tube replacement, will be required with this supply. If replacement of V5 is necessary a tube should be selected which will give 50 millivolts or less regulation at 500 volts main output against 20% line voltage change (105 to 130 volts). In common with all differential dc amplifiers, these tubes are somewhat sensitive to heater voltage change. Tubes with poor balance between halves or excessive grid current may cause excessive output voltage offset with line voltage changes (poor line regulation). These should be discarded (or used for V7) in favor of tubes which perform properly. Excessive or prolonged output voltage drift sometimes results when a new un-aged 12AX7 is used. This drift will frequently c ear up after a few hours operation; if not, it should be replaced. If the heater voltage regulation of these tubes exceeds 0.5 volt for a line voltage change from 105 to 130 volts the ballast tube V10 should be replaced.

Excessive drift may be caused by a defective reference tube V9. The life of these is usually in excess of 2,000 hours but as they approach end of life their running voltage tends to drift excessively, which causes drift in both the minus 250 volt and the ma in outputs. Should this occur, replacement will be necessary. We recommend either an RCA or Amperex tube in this case.

Aging of the reference tube and equating tubes will cause slight calibration error. For maximum accuracy check the calibration every two or three hundred hours against a good voltage standard such as a John Fluke Model 801 or a Leeds & Northrup type K potentiometer with suitable volt boxes. See instructions under RECALIBRATION section of this manual.

TROUBLE SHOOTING HINTS

1. NO OUTPUT. Check for open heater in one of the three type 807 series passing tubes. Heaters of these tubes are connected in series so that if one fails all three will lose emission. This prevents the remaining two from being badly overloaded. A 0 - 20 volt ac meter connected between pins 1 and 5 of each tube in turn will read 20 volts across the tube with open heater.

   Check all tubes to see that they are lit. Check plate voltage of main supply - should read approximately as shown in table on circuit diagram. Check screen voltage - should read as shown. Check resistance from slider of P2 to negative 250 volt bus; if either P2 or R44 is open, output voltage will be zero. Check for shorted feedback capacitor C10 - check tube element potentials - these should be within 10% of the values shown on the circuit diagram. Check for open resistors R3, 4 and 5.

2. INCORRECT OUTPUT VOLTAGE. If only a slight error is noted over the entire 555 volt range, unit may only require recalibration. If error is large it is usually due to an out-of-tolerance wire-wound resistor in one of the two sampling strings.

   Check main supply by setting 0 to 55 volt and 0 to 0.55 volt controls to zero and decreasing the 0 to 500 volt control one step at a time. If error disappears at some point the trouble is an out-of-tolerance resistor just above the switch position where error disappears. If error persists at all positions of the 0 - 500 volt control, check output of negative 250 volt supply by setting BIAS control fully clockwise, and checking voltage across minus 250 volt binding posts. Should read within 1 volt of 250 volts - if error exceeds this trouble is probably one of the two sampling resistors R15 and R16. If both are okay check all element potentials to determine source of trouble. Check also for a leaky feedback capacitor in either supply - C8 and C10. Also check accuracy of R43 and R44.

3. COMPLETE LOSS OF CONTROL. Output rises to within a few volts of main supply unregulated voltage and is variable with line voltage. Check for a gassy or shorted series passing tube. Check also for loss of emission in V4 or for a short in one section of V5. A systematic check of element potentials should pinpoint the defective component if trouble is not found to be a defective tube.

4. OSCILLATION. Check for open feedback capacitor C10 or C8. Check also for open main output capacitor C3 or C4 in main supply, C11 in auxiliary supply.

5. POOR REGULATION. If poor load regulation, check for weak driver amplifier V4. If poor line regulation check minus 250 volt supply line regulation. If it is poor it will affect regulation of main supply. Poor line regulation in either supply is usually due to a defective differential amplifier tube or a defective ballast tube V10.

6. EXCESSIVE RIPPLE. Check auxiliary minus 250 volt supply ripple. If okay, trouble is probably defective feedback capacitor C10 or heater cathode leakage in V4. Check for defective filter capacitor C1 or C2.

7. OUTPUT ERRATIC. This is usually caused by a defective wire-wound resistor in one of the two sampling strings. If erratic condition appears in both main output and minus 250 volt output the trouble is probably in R15 or R16. If only in main output, determine if it is present at all outputs or disappears below certain position of the 0 to 500 volt control. If present at all outputs, trouble is either with R43 or R44. If it disappears at some point, the resistor at the switch position just above that point is defective. Trouble is generally caused by a few turns shorting out intermittently in one of the resistors. If all resistors are okay check for defective feedback capacitors C10 and C8. Check all tubes and finally check for some intermittent component.

8. POOR STABILITY. Long slow drift in output voltage beyond specified value of 0.05% or 500 millivolts per day is often caused by the reference tube V9 approaching end of life. Replace with a new one and allow unit to run for an hour before making stability check. Poor stability may also be caused by a defective differential amplifier tube V4. Trouble may be drift in the minus 250 volt bias supply. Drift in the bias supply will cause drift in the main supply but not vice versa. If both drift, check bias supply differential amplifier tube V5 as well as feedback capacitors in both supplies - C8 and C10.

9. FUSE BLOWS REPEATEDLY. Usually caused by shorted main filter capacitors C1 and C2. If one of these shorts the full voltage appears across the other one causing it short also. This, of course, causes fuse to blow. Chief cause of capacitor shorting is failure of one of the two bleeder resistors R1 and R2. If one of these opens, full voltage appears across the opposite capacitor causing it to short which in turn causes the other capacitor to short. Never replace these capacitors without first checking both bleeder resistors R1 and R2.

10. OPEN RESISTOR R45. Caused by shorted C5 or internal tube short. This resistor is designed to open up thus protecting transformer winding and selenium rectifiers. Check C5 before replacing.

11. OPEN RESISTOR R46. Caused by shorted C6. This resistor, like R45, is designed to open up in case of capacitor short thus protecting transformer winding and selinium rectifiers.

RECALIBRATION INSTRUCTIONS

In order to properly calibrate the Model 407 a voltmeter of 0.1% accuracy should be used. The John Fluke Models 800 or 801 (with accuracy of 0.05% are ideal for this purpose.

1. Allow instrument to warm up for one half hour. Then set BIAS control fully clockwise and slide instrument far enough out of the case to gain access to printed circuit board. Adjust P1 for output of minus 250 volts as measured at BIAS terminals on front of instrument.

2. Set 0 to 55 volt and 0 to 0.55 volt controls to zero and set 0 to 500 volt control to 500 volts. Adjust P2, the lower screw-driver adjust control, on the right hand printed circuit board, for output of 500 volts.

3. Set 0 to 500 volt control to zero and check output; adjust P1 (if necessary) to bring output to zero or a few millivolts negative. Recheck output of minus 250 volt supply. It should still be within a volt or two of minus 250.

4. Set 0 to 500 volt control all the way clockwise again and recheck 500 volts. Touch up P2 again for maximum accuracy and then go back to zero and trim P1 for zero output. If all of the resistors in the main string are within 0.25% tolerance, one or two readjustments of P1 and P2 will bring unit into excellent calibration over all 11 positions of the 0 to 500 volt control.

MODEL 407

LIST OF REPLACEABLE PARTS

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
C1,2	Capacitor, electrolytic 90 mfd, 500 v	CE17
C3,4,11	Capacitor, electrolytic 16 mfd, 450 v	CE3
C5	Capacitor, electrolytic 40 mfd, 450 v	CE4
C6	Capacitor, electrolytic 20 mfd, 500 v	CE16
C7	Capacitor, paper, printed circuit type 0.01 mfd, 400 v	CP16
C8	Capacitor, paper 0.01 mfd, 600 v	CP7
C9	Capacitor, paper 0.002 mfd, 1600 v	CP9
C10,12	Capacitor, paper 0.047 mfd, 1000 v	CP12
C14	Capacitor, paper 0.022 mfd, 600 v	CP15
C15	Capacitor, paper 0.22 mfd, 400 v	CP2
C16,17	*Capacitor, mylar 0.01 mfd, 400 v, 20%	CF1
C18	Capacitor, paper 0.022 mfd, 600 v	CP15
C19	Capacitor, ceramic 0.001 mfd, 3000 v	CT16
C21	Capacitor, paper 0.1 mfd, 1 kv	CP31

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
C22	Capacitor 10 mmfd, 500 v	CT4
C23	Capacitor, 0.1 mfd, 500 v	CT20
C24	Capacitor, paper 0.04 mfd, 1600 v	CP35
C25,26	Capacitor, paper 0.047 mfd, 1 kv	CP12
R1,2	Resistor, wirewound, power 10 k, 10%, 20 w	R10000WA
R3,4,5	Resistor, composition 10 Ω, 10%, 2w	HB1011

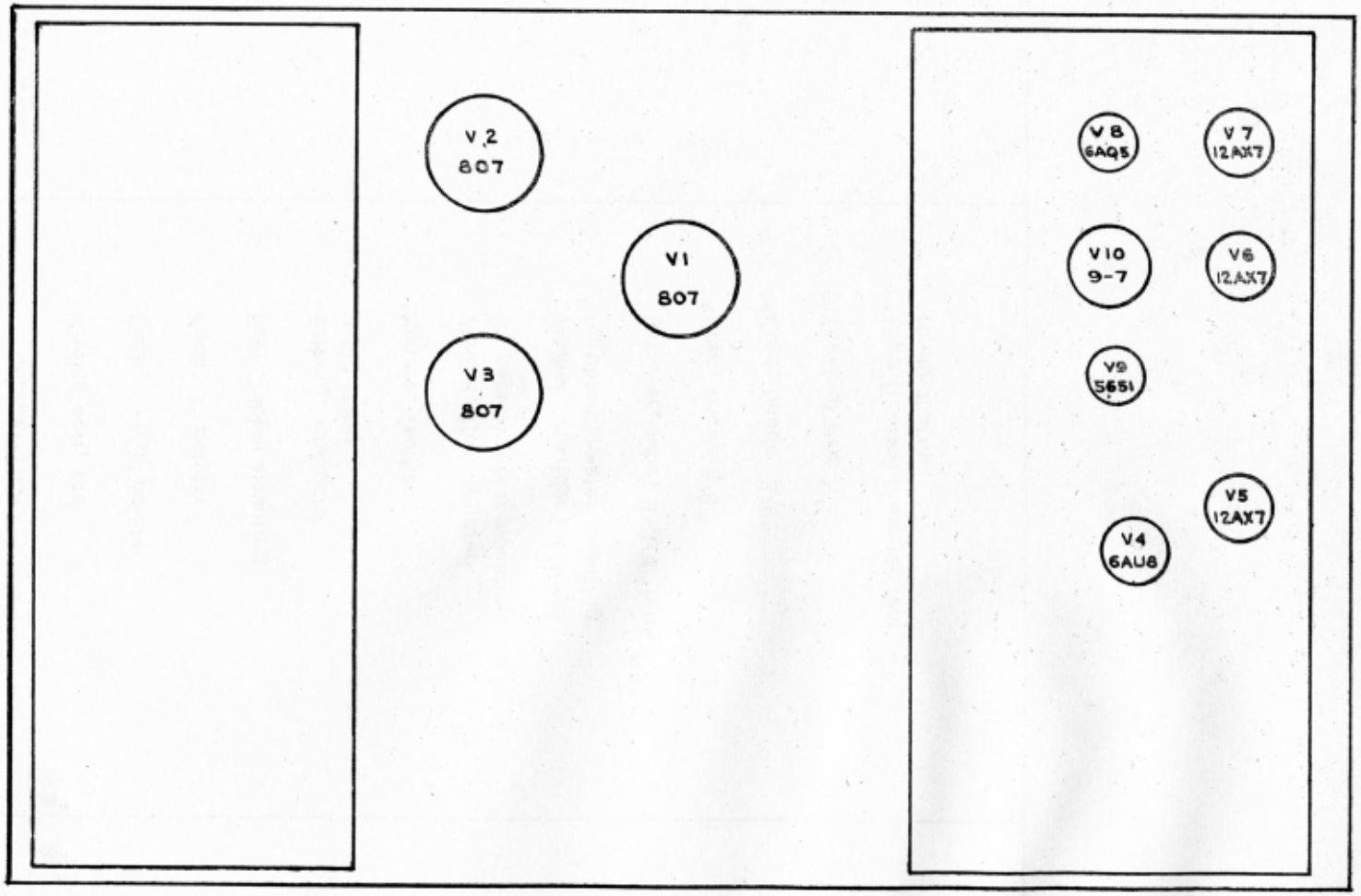
CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R6,7	Resistor, composition 100 k, 10%, 1 w	GB1041
R8	Resistor, deposited carbon 60 k, 1%, 1 w	DR516
R9	Resistor, deposited carbon 600 k, 1%, 2 w	DR626
R10	Resistor, wirewound 0.15Ω approximately (meter shunt)	
R11, 12,20, 30,47	Resistor, composition 470 k, 10%, 1/2 w	EB4741
R13	Resistor, composition 27 k, 10%, 1 w	GB2731
R14	Resistor, composition 220 k, 10%, 1/2 w	EB2241
R15,43	Resistor, wirewound, precision 144 k, 0.25%, 1 w	PR619
R16,21	Resistor, wirewound, precision 76 k, 0.5%, 1/2 w	PR59
R17, 18, 19,28	Resistor, composition 680 k, 10%, 1/2 w	EB6841
R22,23	Resistor, deposited carbon 1 m, 1%, 1/2 w	DR71
R24	Resistor, deposited carbon 450 k, 1%, 1/2 w	DR625
R25,26	Resistor, composition 56 k, 10%, 1 w	GB5631
R27	Resistor, composition 270 k, 10%, 1/2 w	GB2741
R29	Resistor, composition 150 k, 10%, 1/2 w	EB1541
R31	Resistor, deposited carbon 10 k, 1%, 1/2 w	DR51

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R32	Resistor, deposited carbon 90K, 1%, 1 W	DR514
R33 thru 42	Resistor, wirewound precision 45K, 0.25%, 1/2 W	PR516
R44	Resistor, wirewound precision 76K, 0.25%, 1/2 W	PR517
R45, 46	Resistor, composition 56Ω, 10%, 1 W	GB5601
R48	Resistor, wirewound 10 Ω, 10%, 5 W	R10WA
R50 thru 57	Resistor, composition IM, 10%, 1/2 W	EB1051
R58 thru 60	Resistor, composition 1.5K, 10%, 1/2 W	EB1521
R61, 62	* Resistor, composition 3.3K, 10%, 1/2W	EB3321
R63	Resistor, composition 68K, 10%, 1/2 W	EB6831
P1, 2	Potentiometer, wirewound 5K, 10%, 2W	P5000A
P4	Potentiometer, wirewound 500 Ω, 2%, 2 W	P500AA
P5, P3	Potentiometer, wirewound 50K, 10%, 3 W	P50KB
V1, 2, 3	Tube, tetrode Type 807	807
V4	Tube, triode-pentode Type 6AU8	6AU8
V5, 6, 7	Tube, dual triode Type 12AX7	12AX7
V8	Tube, pentode power amplifier Type 6AQ5A	6AQ5A

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
V9	Tube, voltage reference Type 5651	5651
V10	Tube, current regulator Type 9-7	9-7
V11 thru 13	Neon bulb, Type NE2X	X40A
RE1 thru 12	Rectifier, silicon 600 V, PIV, 0.5 amp	RE10
S1	Switch, toggle, SPST 115/230 volts, 3 amp	ST5
S2	Switch, rotary 2 pole 11 position, 3 deck	SR31
S3	Switch, rotary 4 pole 4 position, 2 deck	SR30
S4	Switch, rotary, momentary 1 pole, 2 position, 1 deck	SR16
M1	Meter, 0-1 ma, 4-1/2" with special scale	M13
F1	Fuse, cartridge, 5 amp Slow blow, for 117 volt operation	F5A
F1	Fuse, cartridge, 3 amp Instant blow for 234 volt operation	F3
T1	Transformer, power	407R-601-0
PI1,2	Lamp, miniature, bayonet base	X34
	Cable, power, 3 conductor #18	X27D
	Fuse holder, bayonet type	X12
	Binding post, black	X7

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
	Binding post, red	X7A
	Knob, 1-1/2" pointer	X234
	Knob, 1" pointer	X231
	Feet, rubber mounting	X224
	Bushing, line cord strain relief	X138
	*Handle, leather	X373
	Washer, flat insulated for potentiometer mounting	X93
	Washer, shoulder insulated for potentiometer mounting	X94
	Retainer, tube, 1-3/8" base	X14
	*Caps, anode 3/8"	X35
	**Caps, anode, 3/8"	X75
	**Terminal strip	X105
	**Identification plate for rear terminal strip	X120

*Used on cabinet model only
**Used on rack mounting model only



MODEL 407

TUBE LOCATION CHART - TOP VIEW

WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON

APPENDIX A

FEDERAL SUPPLY CODE FOR MANUFACTURERS

A-1. CODE TO NAME

A-2. The following five-digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name. Suppliers not listed in the Federal Supply Code for Manufacturers have been assigned an alphabetical code by FLUKE.

00213 Sage Electronics Corp.
Rochester, New York

00327 Welwyn International, Inc.
Cleveland, Ohio

00656 Aerovox Corp.
New Bedford, Massachusetts

01121 Allen-Bradley Company
Milwaukee, Wisconsin

01281 Pacific Semiconductors Inc.
Lawndale, California

01295 Texas Instruments, Inc.
Semiconductor Components Div.
Houston, Texas

01730 Circle Mfg. Co. Inc.
Little Falls, New Jersey

01884 Dearborn Electronic Labs Inc.
Orlando, Florida

01963 Cherry Electrical Products Corp.
Highland Park, Illinois

02660 Amphenol-Borg Elect. Corp.
Chicago, Illinois

02606 Fenwal Laboratories Inc.
Framington, Massachusetts

02799 Arco Capacitors, Inc.
Los Angeles, California

03614 Bussmann Mfg. Div. of
McGraw-Edison Co.
Los Angeles, California

03615 Ohmite Mfg. Co.
Los Angeles, California

03877 Transitron Electronic Corp.
Wakefield, Massachusetts

03911 Clairex Corp.
New York, New York

03980 Muirhead Instruments, Inc.
Mountainside, New Jersey

04009 Arrow Hart and Hegeman
Electronic Company
Hartford, Connecticut

04062 Elmenco Products Company
New York, New York

04202 Winchester Electronics Co.
New Milford, Connecticut

04221 Telex-Aemco Division
of Telex Corp.
Mankato, Minnesota

04645 Kurz-Kasch, Inc.
Chicago, Illinois

04713 Motorola Inc.
Semiconductor Products Division
Phoenix, Arizona

05082 Tung-Sol Electric Inc.
Melrose Park, Illinois

05276 Penn-East Engrg. Corp.
Kutztown, Pennsylvania

05397 Union Carbide Corp. Linde
Division Kemet Dept.
Cleveland, Ohio

05571 Sprague Electric Company
Culver City, California

05704 Alac, Inc.
Glendale, California

06001 General Electric Company
Capacitor Department
Irmo, South Carolina

06136 Ward Leonard Electric Co.
Los Angeles, California

06473 Amphenol Space and Missile Sys
Chatsworth, California

06555 Beede Electrical Inst. Co.
Penacook, New Hampshire

06751 Nuclear Corporation of
America, Inc.
U. S. Semcor Div.
Phoenix, Arizona

06980 Gould National Batteries Inc.
La Puente, California

07115 Corning Glass Works
Electronic Components Dept.
Bradford, Pennsylvania

07263 Fairchild Semiconductor
Div. of Fairchild Camera
and Instrument Corp.
Mountain View, California

07344 Bircher Co., Inc.
Rochester, New York

07792 Lerma Engineering Corp.
Northampton, Massachusetts

07910 Continental Device Corp.
Hawthorne, California

08530 Reliance Mica Corp.
Brooklyn, New York

08863 Nylomatic Corp.
Morrisville, Pennsylvania

08988 Skottie Electronics Inc.
Peckville, Pennsylvania

11237 Chicago Telephone of Calif Inc.
South Pasadena, California

11503 Keystone Mfg. Co.
Warren, Michigan

12060 Diodes, Inc.
Chatsworth, California

12136 Philadelphia Handle Co.
Camden, New Jersey

12400 International Resistance Co.
Control Components Division
Philadelphia, Pennsylvania

12617 Hamlin Inc.
Lake Mills, Wisconsin

12697 Clarostat Mfg. Co.
Dover, New Hampshire

14099 Semtech Corp.
Newbury Park, California

14193 California Resistor Corp.
Santa Monica, California

14298 American Components Inc.
Conshohocken, Pennsylvania

14752 Electro Cube Inc.
South Pasadena, California

15818 Ameloo Inc.
Mountain View, California

15909 Daven Division
Thomas A. Edison Ind.
McGraw Edison Co.
Livingston, New Jersey

16332 Milwaukee Relays Inc.
Cedarburg, Wisconsin

16473 Cambridge Scientific
Industries Inc.
Cambridge, Maryland

17069 Circuit Structures Lab
Santa Ana, California

17856 Siliconix Inc.
Sunnyvale, California

17910 Continental Device Corp.
Hawthorne, California

18083 Clevite Corp.
Transistor Division
Palo Alto, California

19429 Montronics, Inc.
Seattle, Washington

19701 Electra Mfg. Co.
Independence, Kansas

24655 General Radio Co.
West Concord, Mass.

28520 Heyman Mfg. Co.
Kenilworth, New Jersey

33173 General Electric Co.
Tube Dept.
Owensboro, Kentucky

37942 P. R. Mallory and Co., Inc.
Indianapolis, Indiana

38315 Honeywell Inc.
Precision Meter Division
Manchester, New Hampshire

42498 National Company, Inc.
Malden, Massachusetts

44655 Ohmite Mfg. Co.
Skokie, Illinois

49671 Radio Corp. of America
New York, New York

53021 Sangamo Electric Co.
Springfield, Illinois

55026 Simpson Electric Company
Chicago, Illinois

56289 Sprague Electric Co.
North Adams, Mass.

58474 Superior Electric Co.
Bristol, Connecticut

60399 Torrington Mfg. Co.
Torrington, Connecticut

62460 USHCO Mfg. Co., Inc.
Buffalo, New York

64834 West Mfg. Co.
San Francisco, California

65092 Weston Instruments
Div. of Daystrom, Inc.
Newark, New Jersey

66150 Winslow Tele-Tronics Inc.
Asbury Park, New Jersey

70563 Amperite Co.
Union City, New Jersey

70903 Belden Mfg. Co.
Chicago, Illinois

71400 Bussman Manufacturing
Division of McGraw Edison Co.
St. Louis, Missouri

71450 CTS Corp.
Elkhart, Indiana

71468 Cannon Electric Company
Los Angeles, California

71482 Clare, C. P. and Company
Chicago, Illinois

71590 Centralab Div. of Globe
Union, Inc.
Milwaukee, Wisconsin

71707 Coto Coil Co., Inc.
Providence, Rhode Island

71744 Chicago Miniature Lamp
Works
Chicago, Illinois

71785 Cinch Mfg. Co. and
Howard B. Jones Div.
Chicago, Illinois

72005 Driver, Wilbur B., Co.
Newark, New Jersey

72092 Eitel-McCullough, Inc.
San Bruno, California

72136 Electro Motive Mfg. Co.
Willimantic, Connecticut

72354 Fast, John E. Co.
Div. of Victoreen Instr. Co.
Chicago, Illinois

72559 Essex Electronics Inc.
Berkeley Heights, New Jersey

72619 Dialight Corp.
Brooklyn, New York

72665 Mallory Battery Company
Cleveland, Ohio

72982 Erie Tech. Products Inc.
Erie, Pennsylvania

73138 Helipot Division of
Beckman Instruments Inc.
Fullerton, California

73293 Hughes Products Div. of
Hughes Aircraft Co.
Newport Beach, California

73445 Amperex Electronic Co.
Div. of North American
Philips Co., Inc.
Hicksville, New York

73559 Carling Electric Inc.
Hartford, Connecticut

73586 Circle F Mfg. Co.
Trenton, New Jersey

73899 JFD Electronics Corp.
Brooklyn, New York

73949 Guardian Electric Mfg. Co.
Chicago, Illinois

74217 Radio Switch Corp.
Marlboro, New Jersey

74306 Piezo Crystal Company
Carlisle, Pennsylvania

74542 Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970 Johnson, E. F., Co.
Waseca, Minnesota

75042 International Resistance Co.
Philadelphia, Pennsylvania

75915 Littelfuse Inc.
Des Plaines, Illinois

76854 Oak Mfg. Co.
Crystal Lake, Illinois

77342 American Machine
and Foundry Company
Potter & Brumfield Div.
Princeton, Indiana

77969 Rubbercraft Corp. of
California Ltd.
Torrance, California

78277 Sigma Instruments, Inc.
South Braintree, Mass.

79136 Waldes Kohinoor Inc.
Long Island City, New York

79497 Western Rubber Company
Goshen, Indiana

80031 Mepco Division of
Sessions Clock Co.
Morristown, New Jersey

80294 Bourns Laboratories, Inc.
Riverside, California

80583 Hammarlund Company, Inc.
New York, New York

80640 Stevens, Arnold Co., Inc.
Boston, Massachusetts

81073 Grayhill Company
La Grange, Illinois

81439 Therm-O-Disc Inc.
Mansfield, Ohio

81483 International Rectifier Corp
El Segundo, California

81590 Korry Mfg. Co.
Seattle, Washington

82376 Astron Division
Renwell Industries Inc.
East Newark, New Jersey

82389 Switchcraft Inc.
Chicago, Illinois

82872 Roanwell Corp.
Brooklyn, New York

82877 Rotron Mfg. Co., Inc.
Woodstock, New York

82879 Royal Electric Corp.
Pawtucket, Rhode Island

83003 Varo Mfg. Co., Inc.
Garland, Texas

83298 Bendix Corp.
Red Bank Division
Red Bank, Eatontown,
New Jersey

83330 Smith, Herman H., Inc.
Brooklyn, New York

83478 Rubbercraft Corp. of Am.
New Haven, Connecticut

84411 Good All Electric Mfg. Co.
Ogallala, Nebraska

86689 R.M.B. Corp.
Los Angeles, California

88419 Cornell-Dubilier Elec. Corp.
Electro-Mechanical Div.
Fuquay Springs,
North Carolina

88690 Essex Wire Corp.
R.B.M. Division
Detroit, Michigan

89536 Fluke, John, Mfg. Co., Inc.
Seattle, Washington

89730 General Electric Company
Newark Lamp Works of
Lamp Division of Consumer
Products Group
GECO
Newark, New Jersey

90205 Best Stamp and Mfg. Co.
Kansas City, Missouri

90211 Square D Company
Chicago, Illinois

90303 Mallory Battery Company
North Tarrytown, New York

91293 Johanson Mfg. Co.
Boonton, New Jersey

91407 Superior Electric Company
Oak Park, Illinois

91662 Elco Corp.
Willow Grove, Penn.

91737 Gremar Mfg. Co., Inc.
Wakefield, Massachusetts

91802 Industrial Devices, Inc.
Edgewater, New Jersey

91929 Minneapolis Honeywell
Regulator Company
Micro Switch Division
Freeport, Illinois

91934 Miller Electric Co., Inc.
Pawtucket, Rhode Island

93332 Sylvania Electric Products Inc.
Semiconductor Products Division
Woburn, Massachusetts

94145 Raytheon Company
Semiconductor Division
California Street Plant
Newton, Massachusetts

95146 Alco Electronics Mfg. Co.
Lawrence, Massachusetts

95264 Lerco Electronics Inc.
Burbank, California

95303 Radio Corp. of America
Comm. Receiving Tube &
Semiconductor Division
Cincinnati, Ohio

95354 Methode Mfg. Co.
Chicago, Illinois

95712 Dage Electric Co., Inc.
Franklin, Indiana

96733 San Fernando Electric Mfg. Co.
San Fernando, California

96881 Thomson Industries, Inc.
New Hyde Park
Long Island, New York

97945 S. S. White Dental Mfg. Co.
Plastics Division
New York, New York

97966 CBS Electronics Div. of
Columbia Broadcasting
System, Inc.
Danvers, Massachusetts

98094 Penta Laboratories, Inc.
Santa Barbara, California

98388 Accurate Sales Company
Culver City, California

98743 James Vibrapower Corp.
Chicago, Illinois

98925 Semiconductor Division
of Clevite Corp.
Waltham, Massachusetts

99120 Plastic Capacitors, Inc.
Chicago, Illinois

99217 Southern Electronics Corp.
Burbank, California

99515 Marshall Industries
Electron Prod. Div.
Pasadena, California

Revised May 15, 1966
Using H4-2 Dated March 1963

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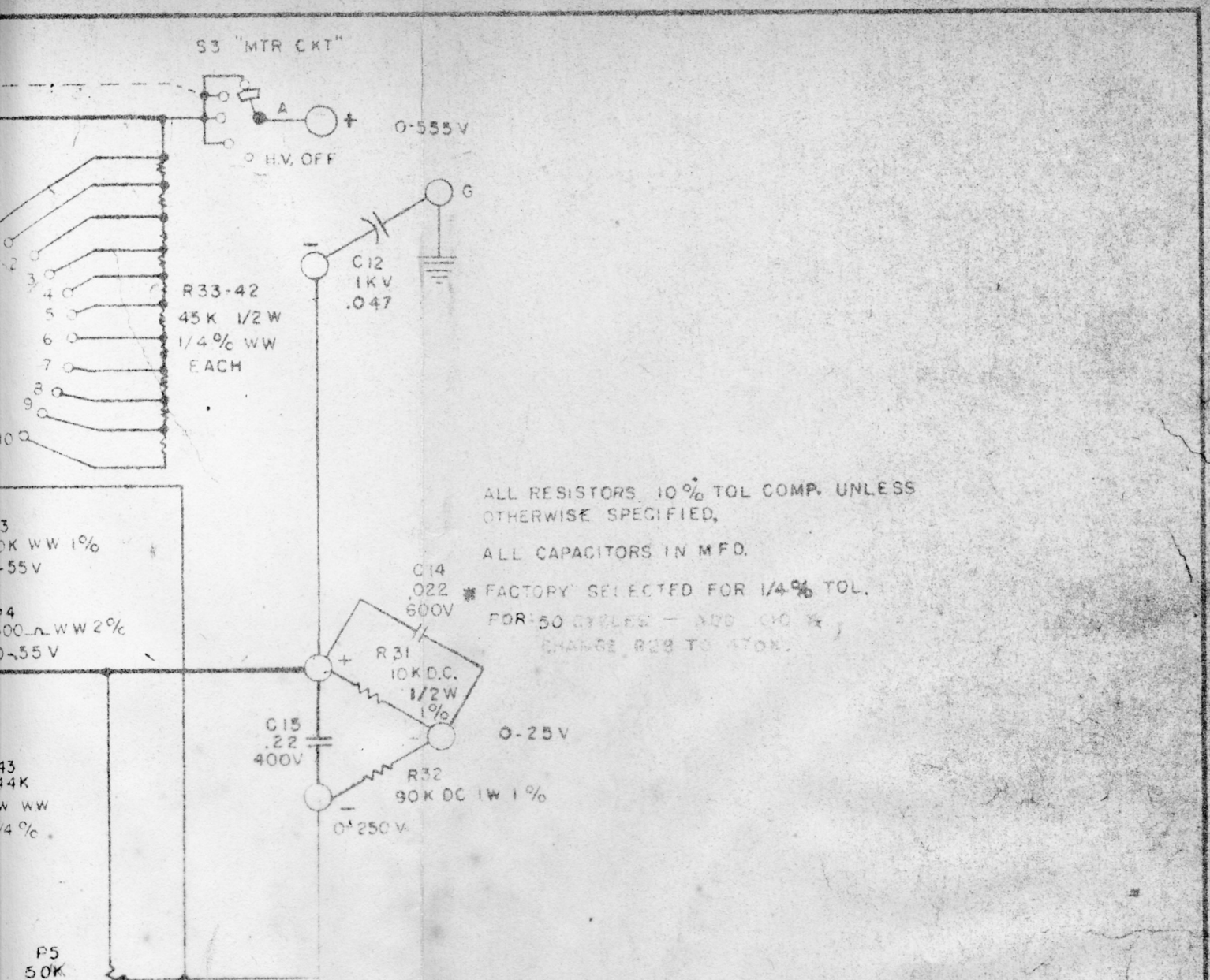


ALL RESISTORS 10% TOL COMP. UNLESS OTHERWISE SPECIFIED.

ALL CAPACITORS IN MFD.

* FACTORY SELECTED FOR 1/4% TOL.

FOR 50 CYCLES — ADD C40 .5 MFD 600V. CHANGE R28 TO 470K.

NOTE

WHILE VOLTAGES ARE SHOWN TO PRECISE VALUES, THESE MAY VARY BY SEVERAL VOLTS BETWEEN UNITS, PARTICULARLY PLATE VOLTAGES. GRID-CATHODE POTENTIAL DIFFERENCES OF V4 THRU V7 SHOULD VARY BY LESS THAN 1 VOLT FROM VALUES SHOWN HERE HOWEVER.

ALL VOLTAGES MEASURED WITH RESPECT TO THIS BUS USING FLUKE MODEL 800 OR 801 DIFFERENTIAL DC VOLTMETER.

TEST CONDITIONS:
LINE VOLTAGE = 117 V
OUTPUT VOLTAGE = 10 V
OUTPUT CURRENT = 0 MA

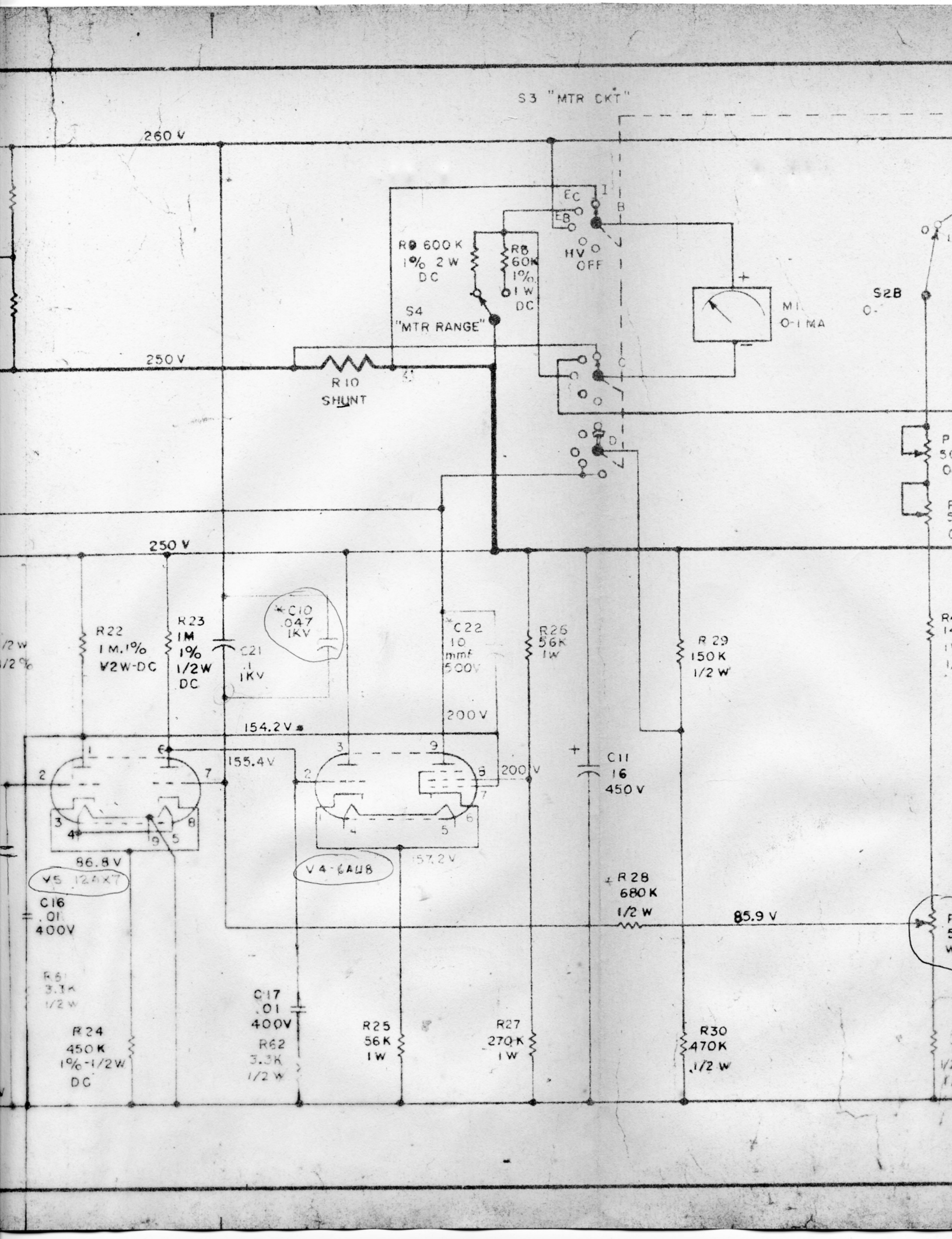
MODEL 407R
SER. NO. 960 AND ABOVE

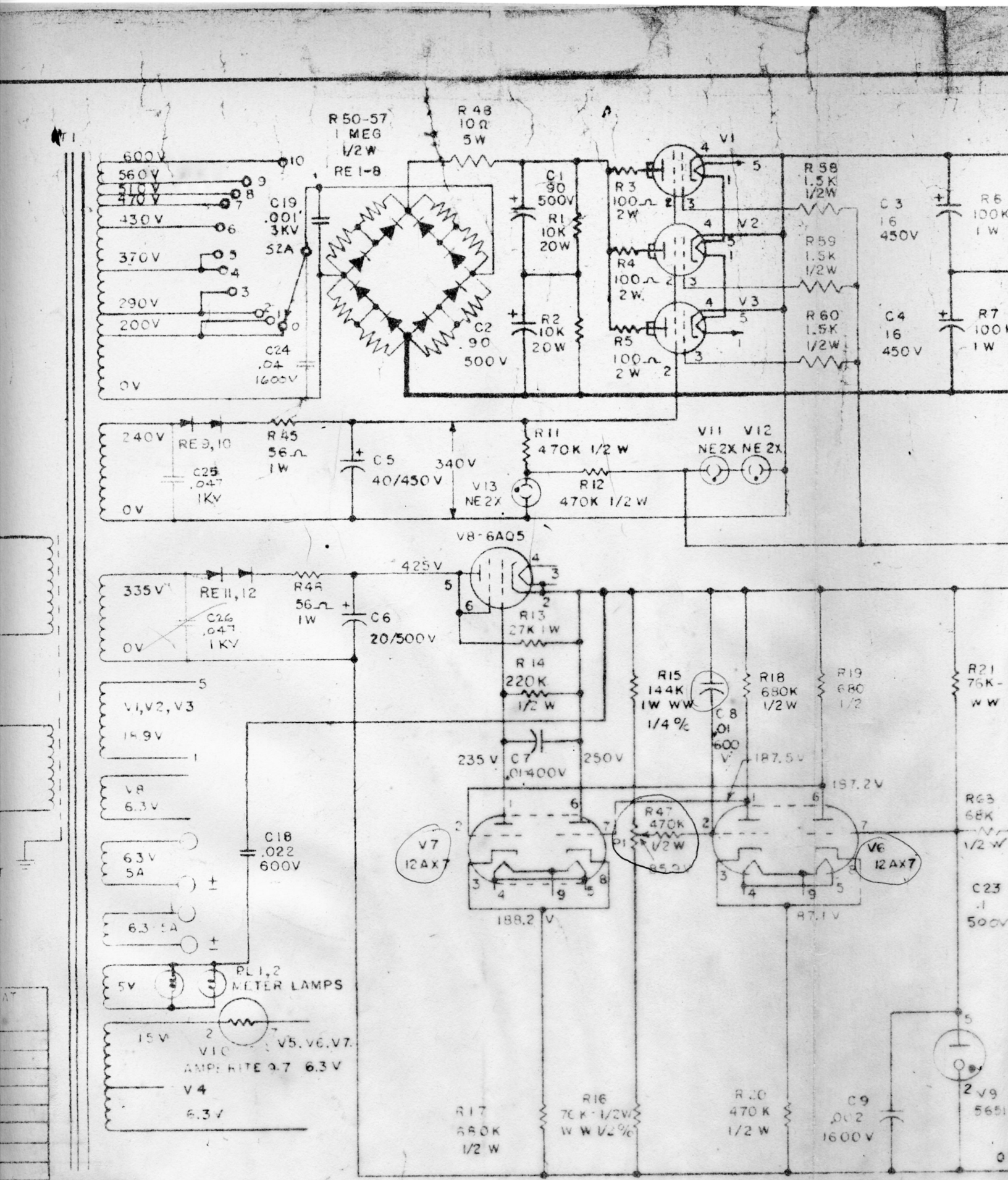
MODEL 407
SER. NO. 1049 AND ABOVE

CIRCUIT DIAGRAM

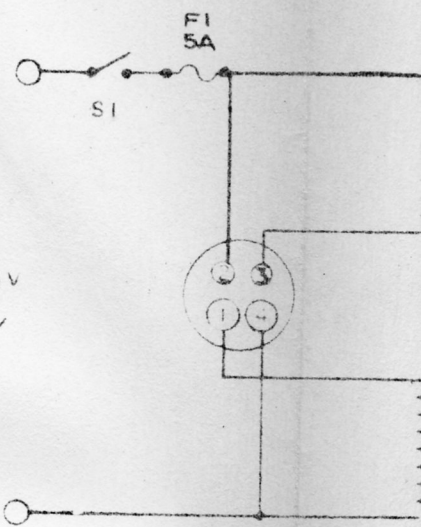
MODEL 407	DWG. 407-3
DATE 9/6/57	DRAWN BY VH — CHECKED BY RWH

JOHN FLUKE MFG. CO., INC.
SEATTLE, WASH.


S3 "MTR CKT"
260 V
250 V
250 V
EC
EB
I
B
C
D
HV OFF
R9 600 K 1% 2W DC
R8 60K 1% 1W DC
S4 "MTR RANGE"
R10 SHUNT
M1 0-1 MA
S2B
R22 1 M. 1% 1/2W-DC
R23 1M 1% 1/2W DC
C21 .1 1KV
C10 .047 1KV
C22 10 mmf 500V
R26 56K 1W
R29 150K 1/2 W
154.2 V
155.4 V
200 V
200 V
C11 16 450 V
86.8 V
V5 12AX7
V4-6AU8
157.2 V
C16 .01 400V
R28 680K 1/2 W
85.9 V
R61 3.3K 1/2 W
C17 .01 400V
R62 3.3K 1/2 W
R24 450K 1% 1/2W DC
R25 56K 1W
R27 270K 1W
R30 470K 1/2 W


T1
600V
560V
510V
470V
430V
370V
290V
200V
0V
C19 .001 3KV
52A
C24 .04 1600V
R50-57 1 MEG 1/2W
RE 1-8
R48 10Ω 5W
C1 90 500V
R1 10K 20W
C2 .90 500V
R2 10K 20W
V1
V2
V3
R3 100Ω 2W
R4 100Ω 2W
R5 100Ω 2W
R58 1.5K 1/2W
R59 1.5K 1/2W
R60 1.5K 1/2W
C3 16 450V
C4 16 450V
R6 100K 1W
R7 100K 1W
240V
RE 9,10
C25 .047 1KV
R45 56Ω 1W
C5 40/450V
340V
V13 NE2X
R11 470K 1/2W
R12 470K 1/2W
V11 NE2X
V12 NE2X
V8-6AQ5
425V
335V
RE 11,12
C26 .047 1KV
R46 56Ω 1W
C6 20/500V
R13 27K 1W
R14 220K 1/2W
R15 144K 1W WW 1/4%
C8 .01 600V
R18 680K 1/2W
R19 680 1/2
R21 76K WW
235V
C7 .01 400V
250V
187.5V
187.2V
R47 470K 1/2W
V7 12AX7
V6 12AX7
R63 68K 1/2W
C23 .1 500V
188.2V
187.1V
V1,V2,V3
18.9V
V8
6.3V
63V
5A
C18 .022 600V
6.3V 5A
5V
PL1,2 METER LAMPS
15V
V10
V5, V6, V7
AMPERITE 9.7 6.3V
V4
6.3V
R17 680K 1/2W
R16 70K 1/2W WW 1/2%
R20 470K 1/2W
C9 .002 1600V
V9 5651

NO.	CHANGES	SER.
		•



NOTE

FOR 117 VOLT OPERATION CONNECT 1 TO 2 AND 3 TO 4

FOR 234 V OPERATION CONNECT 1 TO 3

S2A POSITION	VOLTS D.C. ACROSS C1 & C2 AT 117 V LINE, NO LOAD
0,1	280
2,3	410
4,5	520
6	600
7	660
8	715
9	780
10	840