INSTRUCTION MANUAL

MODEL 421

LOG N PERIOD AMPLIFIER

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof (except tubes and batteries) which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the factory, DDD 216-795-2666. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments maintains a complete repair service and standards laboratory in Cleveland, and has an authorized field repair facility in Los Angeles.

To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

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*Yellow Change Notice sheet is included only for instrument modifications affecting the Instruction Manual.

GENERAL DESCRIPTION MODEL 421 LOG n PERIOD AMPLIFIER

1-3. SPECIFICATIONS.

LOG N AMPLIFIER.

RANGE: Single scale, from 10^{-12} to 10^{-4} ampere; positive currents only.

ZERO DRIFT: Less than 1/6 decade in 24 hours after a one-hour warmup.

RISE TIME: Seconds to 90% of final current value (DAMPING control at minimum setting):

Current Change Amperes	With No Significant External Capacitance	With 5000 pf Across Input
10^{-12} to 10^{-11}	3 seconds	6 seconds
10^{-11} to 10^{-5}	1 second	2 seconds

ACCURACY: Within 0.2 decade.

LINEAR-LOG RELATIONSHIP: Within 2% of full scale from 10^{-12} to 10^{-5} ampere; within 5% of full scale from 10^{-5} to 10^{-4} ampere.

OUTPUTS: 1) Zero at 10^{-12} ampere, increasing as a negative voltage 10 volts per decade to -80 volts at 10^{-4} ampere; up to one milliampere may be drawn.
2) Recorder output of 50 millivolts full scale is supplied for servo rebalance recorders.

PERIOD CIRCUIT

RANGE: Single scale, from -30 to infinity to +3 seconds.

ACCURACY: 3% at -6 seconds.

RESPONSE SPEED: 3 seconds maximum to 90% of final value.

RECOVERY TIME: 10 seconds maximum.

OUTPUTS: 1) Minus one volt for -30 second period; zero for infinite period; +10 volts for 3-second period.
2) Recorder output of 50 millivolts full scale is supplied for servo rebalance recorders.

GENERAL

POLARIZING POTENTIAL: +225 volts for ion chambers.

TABLE 1 (Sheet 1). Model 421 Specifications

CONNECTORS:	Input: Type HN (UG-560/U) receptacle. +225 Volts: Amphenol 80-C receptacle. All Outputs: Microphone receptacles.
TUBE COMPLEMENT:	One EA52, one 0A2, one 0G3, one 12AU7, two 12AX7, one 12BH7, four 5886, one 6AV6, one 6BW4, two 6CB6, one 6C4, one 6Y6GA.
TRANSISTOR COMPLEMENT:	One 2N1183, four 2N1381, one 2N1535.
POWER:	105-125 volts or 210-250 volts, 50-60 cps, 50 watts.
ACCESSORIES SUPPLIED:	Set of six mating plugs.
ACCESSORIES AVAILABLE:	Model 4102 Input Assembly, two 5886 electrometer tubes in a plug-in can (replacement spare).
DIMENSIONS:	8-3/4 inches high x 19 inches wide x 12 inches deep.
NET WEIGHT:	23 pounds.

TABLE 1 (Sheet 2). Model 421 Specifications.

1-4. EQUIPMENT SHIPPED. The Model 421 Log n Period Amplifier is factory-calibrated and is shipped with all components in place. The shipping carton also contains the Instruction Manual and a set of six mating input and output plugs.

1-5. REGISTRATION CARD. The registration card is attached to the front cover of the Instruction Manual. Please fill it out and mail it when you receive the instrument.

1-6. DAMAGE IN SHIPMENT. If the Model 421 is damaged or faulty when received, follow the instructions given at the back of the manual for reporting the defect.

SECTION 2. OPERATION

2-1. FRONT PANEL CONTROLS.

a. ON-OFF. The ON-OFF control is a double-throw toggle switch which turns the instrument on. The pilot light is directly above the switch.

b. OPERATE - SET 10^{-5} - SET 10^{-11}. In OPERATE position, the switch allows the log n amplifier to function as a logarithmic micro-microammeter. The switch also allows the amplifier to be calibrated at two points, 10^{-5} and 10^{-11} ampere.

c. SET 10^{-11}. The SET 10^{-11} potentiometer on the front panel adjusts the log n amplifier to 10^{-11} ampere when the OPERATE switch is in SET 10^{-11} position.

d. SET 10^{-5}. The SET 10^{-5} potentiometer on the front panel adjusts the log n amplifier to 10^{-5} ampere when the OPERATE switch is in SET 10^{-5} position.

e. RECOVER. The RECOVER switch shorts out the feedback diode and allows quick dissipation of spurious charges which sometimes accumulate on the input terminal. It also allows the amplifier to recover quickly from large overloads.

f. AMPLIFIER BALANCE SET 10^{-12}. This potentiometer adjusts the amplifier balance to read 10^{-12} ampere on the meter when the RECOVER switch is depressed.

g. OPERATE-CHECK ∞. With this switch in OPERATE position, the period circuit is normal with the period input connected to the log n amplifier output. In the CHECK ∞ position, the switch removes the signal from the log n amplifier to the period circuit. When the switch is at CHECK ∞, the period meter should read ∞.

h. SET ∞. This potentiometer adjusts the period meter to ∞ when the OPERATE-CHECK ∞ switch is at CHECK ∞.

2-2. REAR CHASSIS CONTROLS AND TERMINALS.

a. INPUT. The INPUT is a HN series receptacle, Military type UG-560/U (Amphenol 82-805).

b. +225. A polarizing potential of +225 volts can be supplied to ion chambers through an Amphenol 80C receptacle.

c. 80 V LOG N OUTPUT. Minus 80 volts are developed for full-scale log n amplifier meter deflection, and one milliampere can be drawn without upsetting the circuits, through a microphone-type receptacle (Amphenol 80 PC2F).

d. 50 MV LOG N OUTPUT. Fifty millivolts are provided for convenient, direct connection to servo rebalance recorders. The internal resistance is approximately 50 ohms.

e. 10 V PERIOD OUTPUT. Ten volts are developed by the period circuit for a +3 second period. One milliampere can be drawn.

f. 50 MV PERIOD OUTPUT. Fifty millivolts are provided for convenient, direct connection to servo rebalance recorders. The internal resistance is approximately 50 ohms.

g. DAMPING. The damping control slows the response of the log n amplifier. Maximum damping is obtained by rotating the control fully clockwise. The control varies the response time over a ten-to-one ratio.

2-3. INPUT CONNECTION.

a. The current source should be connected to the INPUT with the high impedance side of the current source associated with the central conductor of the HN type receptacle. Avoid movements of the cable during measurements, since spurious input signals will occur caused by capacitance changes and generation of static charges.

b. The lead-in cable should be Polyethylene-, Polystyrene- or Teflon-insulated coaxial cable; the plug should have Teflon insulation. For large cables, Amphenol 82-804 plugs are recommended; for small cables, Amphenol 82-816 plugs are recommended. During the preparation of the cable and plugs, it is essential that all high impedance surfaces be kept scrupulously clean to avoid leakage. With graphite coated cables, it is necessary to avoid tracking graphite onto the high impedance surfaces of the cut end of the insulation and onto the Teflon surface of the plug.

2-4. OPERATING PROCEDURES.

a. Turn on the power switch. After a 15-minute warmup, check the amplifier balance by depressing the RECOVER switch. The log n meter should read 10^{-12} ampere; if necessary, adjust the meter with the AMPLIFIER BALANCE control. Turn the log n OPERATE switch to SET 10^{-11} and set the log n meter to 10^{-11} with the SET 10^{-11} control. Check calibration by turning the OPERATE switch to 10^{-5} position. If necessary, adjust the meter to 10^{-5} ampere with the SET 10^{-5} control.

b. Check the period circuit by putting the OPERATE-CHECK ∞ switch in CHECK ∞ position. If the period meter does not read ∞, adjust the SET ∞ control for the correct reading.

c. Occasionally recheck the calibration of the log n amplifier and the period circuit. Adjust if necessary. After warmup, only infrequent adjustments should be necessary.

2-5. DAMPING.

a. The speed of response, or the time constant of the ion chamber and the log n amplifier, depends upon the speed of response of the circuitry of the instrument and also upon the capacitance of the current source and its connecting cable. Because of the method of negative feedback applied to the log n amplifier, the significance of the external input capacitance is de-

creased; quite large capacitances can be tolerated without greatly increasing response times. Therefore, a cable run from an ion chamber to the instrument is permissible.

b. Variable damping of the log n amplifier is provided by the potentiometer on the back of the chassis adjacent to the input receptacle. Maximum damping is obtained by rotating the control fully clockwise. The damping slows the response of the log n amplifier so that it tends to average the statistical noise of the ion chamber current and the noise generated in the input cable. Therefore, when the log n amplifier output is differentiated in the period circuit, false short periods will not be indicated.

2-6. RECORDING.

a. The log n amplifier and the period circuit both have two outputs: one for 50-millivolt recorders, and the other for auxiliary panel meters or controls.

b. Fifty-millivolt recorders are plugged directly into the 50-millivolt output receptacles. Both 50-millivolt receptacles are Amphenol 80 PC2F. The internal impedance is approximately 50 ohms. Resistor dividers for more sensitive recorders can easily be made at the recorder input.

c. Alarm and remote indicating circuits can easily be connected to the high-level outputs. Amplifiers and cathode ray oscilloscopes are also connected to the high-level outputs. Terminal No. 1 of each connector is at ground potential.

2-7. +225 VOLTS. A receptacle has been mounted on the back of the chassis to provide +225 volts for polarizing an ion chamber. The potential is derived directly from the electronically regulated power supply. The chassis connector is Amphenol 80 C; the mating plug is Amphenol 80 M.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Model 421 contains three principal circuits, the log n amplifier, the period circuit and the power supply.

NOTE

The circuit designations used in this section refer to the schematic diagram, 16298D, found at the back of the Manual.

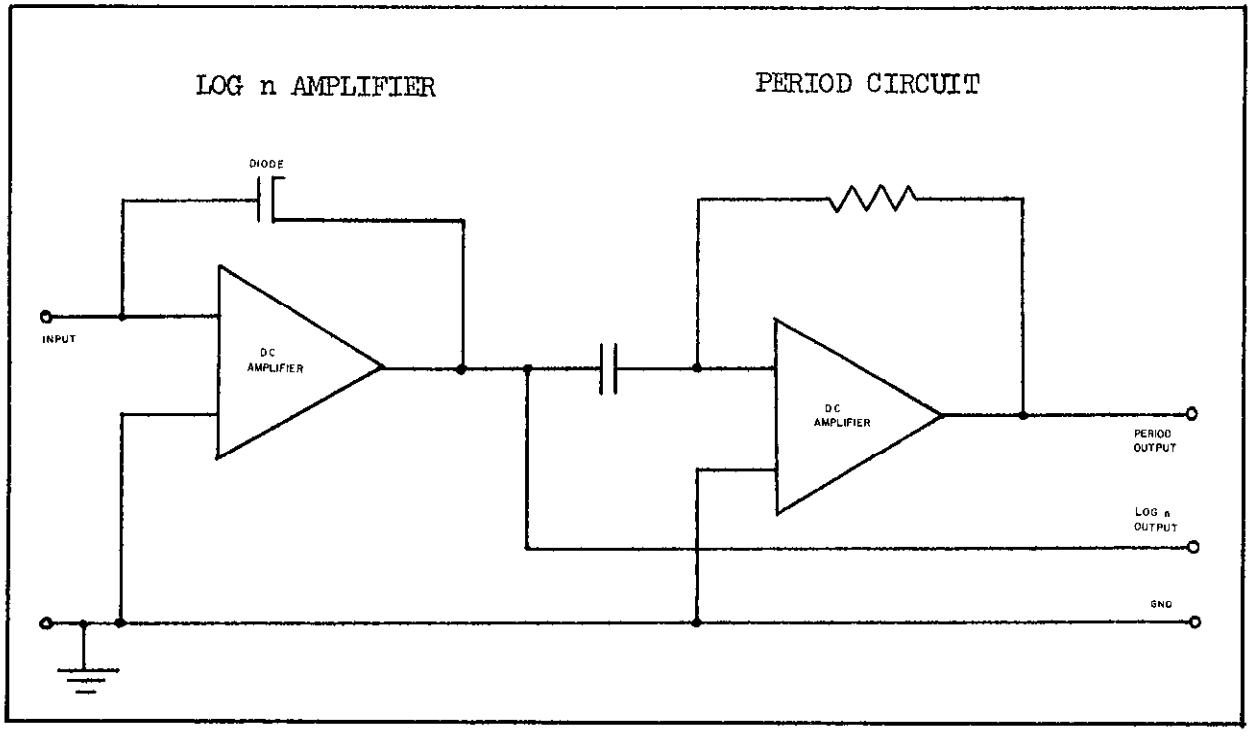


FIGURE 2. Simplified Circuit Diagram of Model 421.

3-2. LOG N AMPLIFIER CIRCUIT.

a. The log n amplifier is principally a micro-microammeter whose logarithmic scale is obtained by negative feedback from output to input through a diode operated in the velocity field region. The diode used is an EA52 special purpose tube.

b. The EA52 offers outstanding advantages in this application:

1. The insulation of the EA52 is of a very high order. Therefore, the diode plate has very little leakage which would cause erratic effects in the low current region.

2. Since this tube is an uhf diode, the capacity across it is minimal. This results in a considerable improvement in response speed over instruments which employ conventional diodes.

c. The feedback from the output is connected through potentiometer R106 so that adjusting R106 will control the potential in series with the output. This potential is necessary to buck out the voltage across the diode in order that the log n amplifier output can be kept at ground potential when the input is at ground potential.

d. The amplifier of the log n circuit consists of two 5886 electrometer tubes, V2 and V3, followed by high gain pentodes, V4 and V5. Feedback from the cathodes of V4 and V5 to the screens of V2 and V3 stabilizes the plate potentials of V2 and V3. Additional gain is provided by V6a. V7 is a constant-current coupling element between V6a and V6b, which is the cathode follower output for the log n amplifier. The constant-current coupling element eliminates attenuation so that the output will develop -80 volts for full-scale deflection. The output drives the diode feedback circuit, the panel meter, the high-level and the 50-millivolt outputs plus the period circuit. The circuit output potential is zero for 10^{-12} ampere meter indication, and -80 volts for 10^{-4} ampere indication. The 50-millivolt output is supplied through a resistive voltage divider. The open loop gain of the amplifier is approximately 10,000; the feedback factor is approximately 1000.

e. The calibration circuit consists of a 1.34-volt mercury battery, B1, and resistors R101, R102, R103 and R104. The log n OPERATE switch S1 is used to select the desired signal, either 10^{-11} or 10^{-5} ampere.

f. The meter calibration is established by alternating between the 10^{-11} and the 10^{-5} positions of the OPERATE switch, which causes 10^{-11} or 10^{-5} ampere to flow in the input. The potentiometers R111 and R106 are adjusted until these calibration signals read properly on the meter. The SET 10^{-11} control, R111, adjusts the feedback voltage in series with V1 and thus sets the static resistance of the diode at one point. The SET 10^{-5} control, R106, adjusts the gain of the amplifier and thus adjusts the change of the diode voltage with current, so that the remainder of the scale reads correctly. Once these adjustments are made, only the SET 10^{-11} control needs to be used to compensate for diode drift. The other controls will require infrequent adjustment.

g. With the RECOVER switch depressed, the log diode, V1, is shorted out. In this condition the logarithmic characteristic of the amplifier is removed and the circuit is simply a linear feedback amplifier whose zero corresponds to the 10^{-12} position on the meter. The AMPLIFIER BALANCE potentiometer R116 adjusts the amplifier zero. With proper balance of the amplifier, dc voltage at the input will be less than five millivolts in normal operation.

h. C101 is the damping capacitor which slows the response of the log n amplifier. With the low impedance end of C101 connected to ground, the response is damped the least. As more and more feedback signal from the output is introduced at the low impedance end of C101, the damping is increased. The damping control, R109, increases the feedback voltage until the desired amount of damping is obtained.

3-3. PERIOD CIRCUIT.

a. The period circuit is an operational amplifier connected as a different-

iator. C201 is the differentiating capacitor and R201 is placed in series with the capacitor to lessen response to very high frequencies. The feedback resistor R211 determines the sensitivity of the period amplifier. R211 is returned to potentiometer R221 so that the feedback factor can be varied. In this way, the calibration of the period circuit may be adjusted. Capacitor C204 slows the circuit response to about one second full scale.

b. The period amplifier consists of balanced 5886 tubes followed by a 12AU7 tube connected as a differential amplifier. Feedback from the 12AU7 cathodes to the screens of the 5886 tubes stabilizes the operating point of the 5886 tube plates. V11, a cathode follower, drives the output meter and the feedback loop. The open loop gain of the amplifier is approximately 200. The circuit output is 10 volts for a positive period of three seconds.

c. The CHECK ∞ switch S3 in the CHECK position grounds one terminal of C201 and leaves only the grid of V8 connected to the feedback resistor. This condition corresponds to infinite period or no change in output from the log n amplifier. If the period meter does not point to infinity in this position, it may be adjusted by R206.

d. D201 and D202 are zener diodes connected back-to-back to limit the amplifier input voltage in case of overload. Substantial decrease in recovery time is provided by these diodes.

3-4. POWER SUPPLY.

a. The Model 421 uses an electronically regulated +225 volt supply, a VR tube regulated -150 volt supply, and a transistorized -12 volt supply.

b. The +225 volt supply utilizes a type 6Y6 series tube, V13, which is controlled by a two-stage differential dc amplifier, V14 and V17. V17 compares the B plus voltage, sampled via R312 and R314, to the voltage of reference tube V16. The output of V17 is amplified by V14 and used to control the resistance of the series tube V13. The polarizing potential which appears on the back of the chassis is taken directly from the +225 volt supply.

c. The -150 volt supply is derived from full-wave rectifier V12 and a conventional RC filter network. The minus supply is derived from a half-wave rectifier, D301 through D304, and filtered with a three-stage RC filter, R304 and C302, R305 and C303, R306 and C304, and finally regulated at -150 volts by V15.

d. The log diode filament voltage power supply consists of an ultra-stable transistor regulator which supplies 12 volts at 1.2 amperes. The regulation of this power supply is better than 0.005% for a line voltage variation of 100 to 130 volts.

SECTION 4. MAINTENANCE

4-1. GENERAL.

a. The Keithley Model 421 Log n Period Amplifier has been designed to give long, trouble-free service. High quality components have been used throughout, and the circuits are stabilized by a substantial amount of negative feedback.

b. The detailed circuit schematic diagram 16298D is at the back of the manual. Circuit designations in this section refer to this diagram. Section 3, Circuit Description, contains an explanation of the function of the principal circuit components.

4-2. ELECTROMETER TUBES.

a. Two pairs of electrometer tubes, V2 and V3, V8 and V9, are each located in an aluminum can which plugs onto the top of the chassis. Each can is labeled Model 4102 Input Tube Assembly. These tubes have been selected, matched and labeled; the Keithley part number is EV5886-5. It is recommended that the complete input tube assembly be kept on hand for replacement purposes.

b. A type EA52 electrometer tube, V1, is used as the log diode element. This tube is tested for logarithmic characteristics over the range of 10^{-12} to 10^{-4} ampere. This tube must be selected to operate over this range; order replacements only through Keithley Instruments.

4-3. INSULATION. All insulation for the high impedance conductors is made of Teflon, as are the contact insulators on the log n OPERATE switch. This should give satisfactory service in all humidities. Occasionally, the high impedance insulators should be inspected to insure that they are free from dirt and dust, and they should be brushed off if necessary.

4-4. CONNECTOR CAP. The cap for the input receptacle should be kept in place whenever the input is not being used. In storage and in transport, it keeps the insulation from accumulating dust, dirt and moisture. Before screwing the cap back onto the receptacle, be certain that it is clean, so the insulation will not be contaminated and so a low impedance bridging conductor will not be formed between the high impedance contact and the grounded cap.

4-5. REFERENCE VOLTAGE BATTERY. Battery B1 should be replaced at least yearly. It is mounted on the PC board near the input receptacle; it is easily seen when the bottom plate is removed. Replace with either a Mallory RM-401R or a Burgess Hg-401R battery.

4-6. CALIBRATION OF LOG n AMPLIFIER.

a. Connect a voltmeter (recommended instrument is the Keithley Model 610A Electrometer) to the 80 V LOG N OUTPUT receptacle. Observe proper polarity. Depress the RECOVER switch on the front panel and adjust the AMPLIFIER BALANCE control until the voltage at the output is 0 volts (+0, -10 millivolts).

There must be no positive output or the instrument will not calibrate properly.

b. Apply a 10^{-4} ampere current to the INPUT to obtain a full-scale deflection on the log n meter. Adjust the LOG CAL potentiometer R135 (located inside the Model 421 immediately behind the log n meter) for -80 volt output.

c. Adjust the SET 10^{-5} and the SET 10^{-11} controls as described in paragraph 2-4, a.

4-7. CALIBRATION OF PERIOD CIRCUIT. If period calibration is to be checked, a test setup as described below is recommended.

a. To simulate the exponential change in reactor power level, a capacitor discharge may be used to set up an electrical analog. The voltage discharge may be converted into a current by using a Himeg resistor to connect the capacitor into the log n amplifier input as shown in Figure 3.

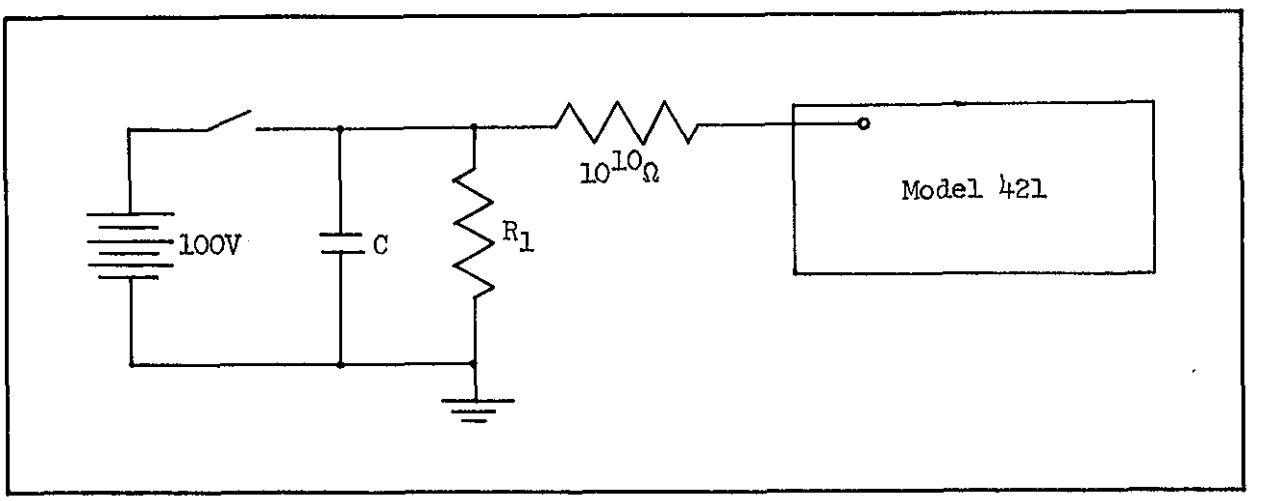


FIGURE 3. Diagram for Calibration of Period Circuit

b. The period circuit, if correctly calibrated, should read directly the time constant of the RC network (R_1 and C) as C is allowed to discharge through R_1 when the key is opened. With a 100-volt source and the key closed, the Log n Amplifier will read 10^{-8} ampere. When the key is opened, after an initial transient, the period circuit should read R_1C. In practice, C should be 1 to 10 microfarads and R_1 varied to give various period readings. A time constant or period of six seconds is a convenient calibration point. With the values shown, the period indication will be accurate from a current reading of about 5×10^{-9} to about 10^{-10} ampere and any period calibration should be made while the current is in this range. Adjust the period meter with the CALIBRATE PERIOD potentiometer R221, located inside the Model 421 immediately behind the period meter.

c. Note that since the instrument can only be calibrated on negative period with this arrangement, the meter leads of the period meter should be reversed for this calibration.

SECTION 5. REPLACEABLE PARTS

5-1. REPLACEABLE PARTS LIST.

a. The Replaceable Parts List describes the components of the Model 421 Log n Period Amplifier. The List gives the circuit designation, the part description, a suggested manufacturer and the Keithley Part Number. The name and address of the manufacturers listed in the "Mfg. Code" column is contained in Table 3.

b. In some instances, it is necessary to substitute parts in the instrument you receive. These substitutions do not impair the performance of the instrument. Either the substitute part or the part specified in the Replaceable Parts List may be used for replacement purposes.

5-2. HOW TO ORDER PARTS.

a. For parts orders, include the instrument's model and serial numbers, the Keithley Part Number, the circuit designation and a description of the part. All structural parts and those parts coded for Keithley manufacture (80164) must be ordered from Keithley Instruments, Inc. In ordering a part not listed in the Replaceable Parts List, completely describe the part, its function and its location.

b. If any part ordered has been replaced by a new or improved part, the new part will be shipped.

c. Order parts through:

Sales Service Department
Keithley Instruments, Inc.
12415 Euclid Avenue
Cleveland 6, Ohio
Telephone 795-2666, Area Code 216

amp	ampere	Mil No.	Military Type Number
		μ	micro (10^{-6})
CbVar	Carbon Variable	My	Mylar
CerD	Ceramic, Disc		
Comp	Composition	Ω	ohm
DCb	Deposited Carbon	Poly	Polystyrene
		p	pico (10^{-12})
EMC	Electrolytic, metal cased		
		v	volt
f	farad	Var	Variable
k	kilo (10^{3})	w	watt
		WW	Wirewound
M or meg	mega (10^{6}) or megohms	WWVar	Wirewound Variable
m	milli (10^{-3})		
Mfg	Manufacturer		

TABLE 2 Abbreviations and Symbols.

MODEL 421 REPLACEABLE PARTS LIST
(Refer to Schematic Diagram 16298D for circuit designations)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
C101	150 pf	500 v	Poly	71590	C138-150P
C102	*.0001 µf	600 v	CerD	01121	C22-100P
C103	50 µf	6 v	EMC	83125	C17-50M
C104	0.02 µf	600 v	CerD	72982	C22-.02M
C105	.0001 µf	600 v	CerD	01121	C22-100P
C106	0.001 µf	600 v	CerD	72982	C22-.001M
C201	1.0 µf	400 v	My	00686	C37-1.0M
C202	*.0001 µf	600 v	CerD	01121	C22-100P
C203	50 µf	6 v	EMC	83125	C17-50M
C204	0.1 µf	400 v	My	00656	C30-0.1M
C301	16 µf	600 v	EMC	14655	C34-16M
C302	16 µf	600 v	EMC	14655	C34-16M
C303	20 µf	450 v	EMC	37942	C7-20M
C304	20 µf	450 v	EMC	37942	C7-20M
C305	0.02 µf	600 v	CerD	72982	C22-.02M
C306	0.02 µf	600 v	CerD	72982	C22-.02M
C307	0.1 µf	400 v	My	00656	C30-0.1M
C308	20 µf	450 v	EMC	37942	C7-20M
C401	500 µf	50 v	EMC	14655	C57-500
C402	500 µf	50 v	EMC	14655	C57-500
C403	0.01 µf	600 v	CerD	01121	C22-.01M
C404	500 µf	25 v	EMC	14655	C58-500

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.
D201	Zener	1N706	12954	DZ-1
D202	Zener	1N706	12954	DZ-1
D301	Selenium	PT065	81483	RF-18
D302	Selenium	PT065	81483	RF-18
D303	Selenium	PT065	81483	RF-18
D304	Selenium	PT065	81483	RF-18
D305	Silicon	1N3253	02735	RF-20
D306	Silicon	1N3253	02735	RF-20

*Component in Model 4102 Input Assembly

DIODES (Cont'd)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.
D401	Zener	1N706	12954	DZ-1
D402	Silicon	1N482	12065	RF-14
D403	Zener	1N715	12954	DZ-22

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.
B1	Battery, 1.34 v Mercury (Mfg. No. RM401R)	37942	BA-8
F1 (117 v)	Fuse, 3 amp, 3 AG	75915	FU-2
F1 (234 v)	Fuse, 1.5 amp, 3 AG	75915	FU-8
---	Fuse holder	75915	FH-3
J1	Receptacle, HN Series, INPUT, Mil No. UG-560/U (Mfg. No. 82-805) (Mating plug is Keithley part CS-31)	02660	CS-30
J2	Receptacle, Microphone, +225 (Mfg. No. 80 C)	02660	CS-34
---	Plug, Microphone, Mate of J2 (Mfg. No. 80 M)	02660	CS-35
J3	Receptacle, Microphone, 50 MV LOG N OUTPUT (Mfg. No. 80 PC2F) (Mating plug is Keithley part CS-33)	02660	CS-32
J4	Receptacle, Microphone, 75 V LOG N OUTPUT (Mfg. No. 80 PC2F) (Mating plug is Keithley part CS-33)	02660	CS-32
J5	Receptacle, Microphone, 50 MV PERIOD OUTPUT (Mfg. No. 80 PC2F) (Mating plug is Keithley part CS-33)	02660	CS-32
J6	Receptacle, Microphone, 10 V PERIOD OUTPUT (Mfg. No. 80 PC2F) (Mating plug is Keithley part CS-33)	02660	CS-32
M1	Meter, Log n	80164	ME-28
M2	Meter, Period	80164	ME-4
---	Pilot Light Assembly	80164	PL-9
---	Bulb, Miniature bayonet base, (Mfg. No. 51)	08804	PL-8
P1	Plug, HN Series (Mfg. No. 82-816)	02660	CS-31
P2	Line Cord	80164	CO-2
---	Cable Clamp	80164	CC-7
P3 to P6	Plug, Microphone (Mfg. No. 80 MC2M)	02660	CS-33
S1	Rotary Switch less components, OPERATE	80164	SW-38
---	Switch Assembly with components, Operate	80164	16301B
---	Skirted Knob Assembly, Operate Switch	80164	15459A
S2	Push Button Switch Assembly, RECOVER	80164	14130B

MISCELLANEOUS PARTS (Cont'd)

Circuit Desig.	Description	Mfg. Code	Keithley Part No.
S3	Toggle Switch, SPDT, OPERATE - CHECK 00	04009	SW-5
S4	Toggle Switch, SPST, ON-OFF	04009	SW-4
T1	Transformer	80164	TR-60

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R101	34 kΩ	1%, 1/2 w	DCb	00327	R12-34K
R102	100_{11} kΩ	1%, 1/2 w	DCb	01661	R12-100K
R103	10^{11} Ω	+3%, -0%	Himeg	63060	R20-10^{11}
R104	75 kΩ	1%, 1/2 w	DCb	01661	R12-75K
R105	27.3 kΩ	1%, ½ w	DCb	01661	R12-27.3K
R106	200 Ω	10%, 2 w	WWVar	71450	RP3-200
R107	500 Ω	1%, ½ w	DCb	00327	R12-500
R108	300 kΩ	1%, ½ w	DCb	00327	R12-300K
R109	3 kΩ	10%, 2 w	WWVar	71450	RP3-3K
R110	10 kΩ	10%, ½ w	Comp	01121	R1-10K
R111	50 kΩ	5%, 5 w	WWVar	73138	RP4-50K
R112	50 kΩ	1%, ½ w	DCb	00327	R12-50K
R113	*22 MΩ	10%, ½ w	Comp	44655	R1-22M
R114	*10 MΩ	1%, 1/2 w	DCb	00327	R12-10M
R115	*10 MΩ	1%, 1/2 w	DCb	00327	R12-10M
R116	200 Ω	3%, 3 w	WWVar	02111	RP23-200
R117	150 Ω	1%, ½ w	WW Special	80164	R65-150
R118	250 Ω	1%, ½ w	WW Special	80164	R65-250
R119	22.5 kΩ	5%, 10 w	WW	63743	R5-22.5K
R120	6 MΩ	1%, 1 w	DCb	01661	R13-6M
R121	22.5 kΩ	5%, 10 w	WW	63743	R5-22.5K
R122	220 kΩ	1%, ½ w	DCb	00327	R12-220K
R123	470 kΩ	1%, ½ w	DCb	01661	R12-470K
R124	1.14 MΩ	1%, ½ w	DCb	00327	R12-1.14M
R125	10 kΩ	1%, ½ w	DCb	01661	R12-10K
R126	10 kΩ	10%, ½ w	Comp	01121	R1-10K
R127	600 kΩ	1%, ½ w	DCb	00327	R12-600K
R128	60 kΩ	1%, 1/2 w	DCb	00327	R12-60K
R129	1.4 MΩ	1%, ½ w	DCb	01661	R12-1.4M
R130	100 kΩ	10%, 1 w	Comp	44655	R2-100K

*Component in Model 4102 Input Assembly

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R131	1.5 MΩ	1%, ½ w	DCb	01661	R12-1.5M
R132	22.5 kΩ	5%, 10 w	WW	63743	R5-22.5K
R133	50 kΩ	1%, ½ w	DCb	00327	R12-50K
R134	250 kΩ	1%, ½ w	DCb	01661	R12-250K
R135	500 kΩ	20%, ¼ w	CbVar	71450	RP7-500K
R136	50 Ω	1%, ½ w	DCb	01661	R12-50
R137	400 kΩ	1%, ½ w	DCb	00327	R12-400K
R138	75 kΩ	1%, ½ w	DCb	01661	R12-75K
R201	600 kΩ	1%, 1/2 w	DCb	00327	R12-600K
R202	47 kΩ	10%, ½ w	Comp	44655	R1-47K
R203	*22 MΩ	10%, ½ w	Comp	44655	R1-22M
R204	*10 MΩ	1%, 1/2 w	DCb	00327	R12-10M
R205	*10 MΩ	1%, 1/2 w	DCb	00327	R12-10M
R206	200 Ω	10%, 2 w	WWVar	71450	RP3-200
R207	150 Ω	1%, ½ w	WW Special	80164	R65-150
R208	250 Ω	1%, ½ w	WW Special	80164	R65-250
R209	22.5 kΩ	5%, 10 w	WW	63743	R5-22.5K
R210	6 MΩ	1%, 1 w	DCb	01661	R13-6M
R211	5.25 MΩ	1%, 1 w	DCb	00327	R13-5.25M
R212	22.5 kΩ	5%, 10 w	WW	63743	R5-22.5K
R213	100 kΩ	1%, 1/2 w	DCb	01661	R12-100K
R214	100 kΩ	1%, 1/2 w	DCb	01661	R12-100K
R215	1 MΩ	1%, 1/2 w	DCb	00327	R12-1M
R216	3.4 kΩ	1%, 1/2 w	DCb	00327	R12-3.4K
R217	60 kΩ	1%, ½ w	DCb	00327	R12-60K
R218	1.5 MΩ	1%, 1/2 w	DCb	01661	R12-1.5M
R219	22.5 kΩ	5%, 10 w	WW	63743	R5-22.5K
R220	1 kΩ	1%, 1/2 w	DCb	00327	R12-1K
R221	3 kΩ	10%, 2 w	WWVar	71450	RP3-3K
R222	6 kΩ	1%, 1/2 w	DCb	01661	R12-6K
R223	10 kΩ	1%, ½ w	DCb	01661	R12-10K
R224	50 Ω	1%, ½ w	DCb	01661	R12-50
R225	55 kΩ	1%, 1/2 w	DCb	01661	R12-55K
R301	100 Ω	5%, 5 w	WW	44655	R4-100
R302	100 Ω	10%, ½ w	Comp	01121	R1-100
R303	3.3 MΩ	10%, ½ w	Comp	44655	R1-3.3M
R304	1250 Ω	5%, 10 w	WW	44655	R5-1250
R305	1250 Ω	5%, 5 w	WW	63743	R4-1250

*Component in Model 4102 Input Assembly

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Keithley Part No.
R306	1250 Ω	5%, 5 w	WW	63743	R4-1250
R307	5 kΩ	5%, 5 w	WW	44655	R4-5K
R308	1 MΩ	1%, ½ w	DCb	44655	R1-1M
R309	68 kΩ	10%, 1 w	Comp	01121	R2-68K
R310	2.2 MΩ	1%, ½ w	Comp	00327	R12-2.2M
R311	2.2 MΩ	1%, ½ w	DCb	00327	R12-2.2M
R312	1 MΩ	1%, ½ w	DCb	00327	R12-1M
R313	1.3 MΩ	1%, ½ w	DCb	01661	R12-1.3M
R314	600 kΩ	1%, ½ w	DCb	00327	R12-600K
R401	5 Ω	3%, 5 w	WW	91637	R6-5
R402	560 Ω	10%, ½ w	Comp	44655	R1-560
R403	10 kΩ	10%, ½ w	Comp	01121	R1-10K
R404	10 kΩ	10%, ½ w	Comp	01121	R1-10K
R405	150 kΩ	10%, ½ w	Comp	01121	R1-150K
R406	680 Ω	10%, ½ w	Comp	44655	R1-680
R407	10 kΩ	10%, ½ w	Comp	01121	R1-10K
R408	4.7 kΩ	10%, ½ w	Comp	01121	R1-4.7K
R409	**500 Ω	1%, ½ w	DCb	00327	R12-500
R410	**500 Ω	1%, ½ w	DCb	00327	R12-500
R411	47 Ω	10%, 5 w	WW	91637	R4A-47

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.
Q1	2N1183	02735	TG-11
Q2	2N1381	01295	TG-8
Q3	2N1381	01295	TG-8
Q4	2N1381	01295	TG-8
Q5	2N1381	01295	TG-8
Q6	2N1535	80211	TG-7

VACUUM TUBES

Circuit Desig.	Number	Mfg. Code	Keithley Part No.
V1	EA52	80164	EV-EA52
V2	*5886	80164	EV-5886-5P
V3	*5886	80164	EV-5886-5P
V4	6CB6	94154	EV-6CB6
V5	6CB6	94154	EV-6CB6

*Component in Model 4102 Input Assembly.
**Nominal value, factory selected.

VACUUM TUBES (Cont'd)

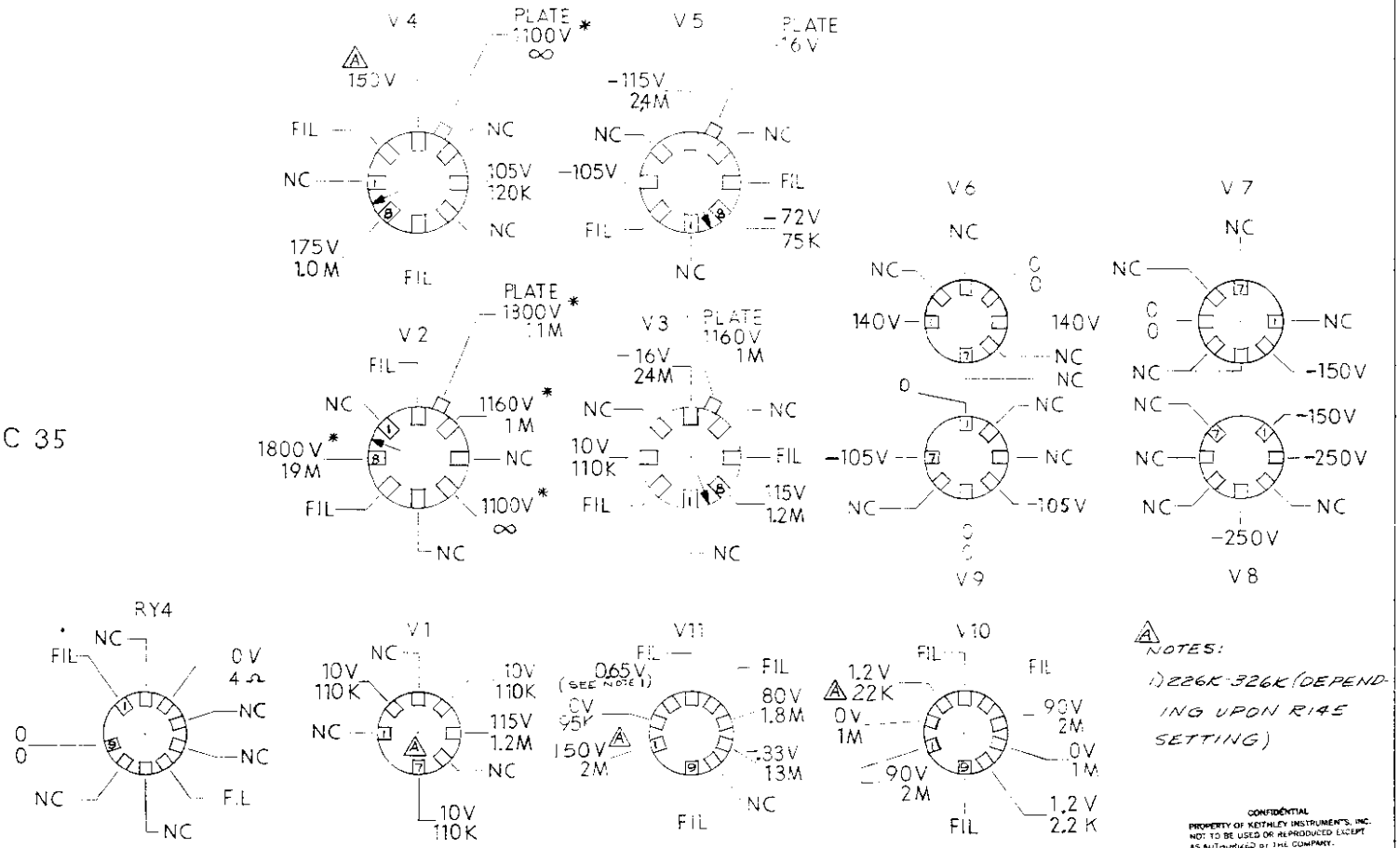
Circuit Desig.	Number	Mfg. Code	Keithley Part No.
V6	12BH7	86684	EV-12BH7
V7	6AV6	85599	EV-6AV6
V8	*5886	80164	EV-5886-5P
V9	*5886	80164	EV-5886-5P
V10	12AU7	73445	EV-12AU7
V11	6C4	86684	EV-6C4
V12	6BW4	00011	EV-6BW4
V13	6Y6GA	00011	EV-6Y6GA
V14	7025	73445	EV-7025
V15	0A2	85599	EV-0A2
V16	0G3	73445	EV-0G3
V17	7025	73445	EV-7025

*Component in Model 4102 Input Assembly

00011	Sylvania Electric Products, Inc. Electronic Tubes Div. Buffalo, N. Y.
00327	Welwyn International, Inc. Cleveland, Ohio
00656	Aerovox Corp. New Bedford, Mass.
00686	Film Capacitors, Inc. New York, N. Y.
01121	Allen-Bradley Corp. Milwaukee, Wis.
01295	Texas Instruments, Inc. Semi-Conductor Products Div. Dallas, Texas
01661	Wilrite Products, Inc. Cleveland, Ohio
02111	Spectrol Electronics Corp. San Gabriel, Calif.
02660	Amphenol Connector Division Amphenol-Borg Electronics Corp. Chicago, Illinois
02735	Radio Corp. of America RCA Semiconductor & Materials Div. Somerville, N. J.
04009	Arrow-Hart & Hageman Electric Co. Hartford, Conn.
08804	General Electric Co. Lamp Division Cleveland, Ohio
12065	Transitron Electronic Corp. Wakefield, Mass.
12954	Dickson Electronics Corp. Scottsdale, Ariz.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co. Newark, N. J.
37942	Mallory, P. R., and Co., Inc. Indianapolis, Ind.
44655	Ohmite Mfg. Co. Skokie, Ill.
56289	Sprague Electric Co. North Adams, Mass.
63060	Victoreen Instrument Co. Cleveland, Ohio
63743	Ward Leonard Electric Co. Mount Vernon, N. Y.
71450	CTS Corp. Elkhart, Ind.
72982	Erie Resistor Corp. Erie, Pa.
73138	Helipot Division Beckman Instruments, Inc. Fullerton, Calif.
73445	Amperex Electronic Corp. Hicksville, N. Y.
75915	Littelfuse, Inc. Des Plaines, Ill.
80164	Keithley Instruments, Inc. Cleveland, Ohio
80211	Motorola, Inc. Chicago, Illinois
81483	International Rectifier Corp. El Segundo, Calif.
83125	General Instrument Corp. Capacitor Division Newark, N. J.
85599	General Electric Co. Schenectady, New York
86684	Radio Corp. of America RCA Electron Tube Div. Harrison, N. J.
91637	Dale Electronics, Inc. Columbus, Nebr.
99942	Hoffman Electronics Corp. Semiconductor Division El Monte, Calif.

TABLE 3. Code List of Suggested Manufacturers.

REVISIONS		
LTR	E.C.O. NO.	DATE
A	2166	8-3-60



NOTES:

1) 226K-326K (DEPENDING UPON R145 SETTING)

MEASUREMENTS MADE FROM TUBE PIN TO CHASSIS GROUND WITH CONTROLS SET AS FOLLOWS:
OUTPUT VOLTS ON ZERO
TRIM ON ZERO
GROUNDING CAP ON MINUS OUTPUT CONNECTOR
STANDBY, IN "READY" POSITION

VOLTAGES INDICATED WITH AN ASTERISK ARE MEASURED WITH A 50,000 OHM / VOLT D.C. VOLTMETER
ALL OTHER VOLTAGES ARE MEASURED WITH AN 11 MEGOHM (INPUT) V.T.V.M.

ATTENTION: THE FILAMENTS OF V2 AN V3 ARE CONNECTED TO THEIR CATHODES. WITH OUTPUT VOLTS ON ZERO, ONLY V2 IS AT HIGH D.C. VOLTAGE POTENTIAL. INSULATE THE VOLTMETER FROM GROUND WHEN MEASURING FIL-AC VOLTAGES

V&R CHART
MODEL 241
KEITHLEY INSTRUMENTS
CLEVELAND, OHIO

DRAWN	DATE	CH	DATE
par	5-10-60		

DR 13419 C