RFL Industries 829G AC/DC calibration standard. S.N. 2064.
Picked up from Charlie 9 Apr 2024
Condition was poor with no front panel meter (Data Tech 4212-02), no safety guard cover, some top panel screws missing, and some front panel labelling worn off. Labelled as Army Design Establishment TA 9/1. Internals look original, except for missing meter (only internal two connectors/harnesses remain).

Mains cord wiring goes close to other wiring. CB in neutral line (not active) using blk wiring; active using brn wiring; both lines switched by front panel; brn to T1 terminal 4. Fan 110V - rotor feels stiff, and oil residue on nearby surfaces. Fan and 110V mains feed to front panel meter M1 off terminals 1,2 of T1. T1 terminal 3 (grey). Underneath terminal strip marked 1-5: #2-#3 link: #3 from T1 terminal 3 (grey); #2 from T1 terminal 2 (tan); #4 linking isolate switch to T1 - brn; #5 linking isolate switch to T1 - blk.

Reconfigured active to go to CB (rather than neutral). If the cb opens, then fan and meter module connect to neutral. Also seperated main incoming, and mains switched wiring from other wiring in looms. CB housing loose - replaced with temporary 3A 3AG fuse/holder (so lower than rated 5A CB, but could be reduced to 1.6 or 2A T). Megger test mains primary to >2Gohm at 1kVdc (fan disconnected). 2.0R mains DCR.

Rear heatsinks are floating. Heatsink T03 device cans are not shrounded. Outputs and +/-50V are floating unless linked to front chassis terminal.

Some parts don't have labelled designators.

+/-50V unreg uses 2x 5,900uF 75V ecaps for C1, C2.
C1/pos connects to red to rectifiers; yel to relay; wh/or/wh to amp.
C1/neg connects to Measurement Module loom; blk in large loom aperture; double to preamp pcb connector; triple to ?

C2/pos connects to T1/8 and C1/neg
C2/neg connects to small terminal board R4-R61-R64 and pcb assembly connector; seperate wire to CR2-CR4 on large terminal board

C1, C2 Cornell Dubilier FAH 6,500-75-B3
C1 <100uA at 72V, ESR ~9 milliohm Signs of slight leakage on perimeter and vent
C2 ~220uA at 75V, ESR <10milliohm
C9 18,000uF 25V: <60uA at 25V, ESR <10 milliohm.
C10 18,000uF 25V: <65uA at 25V, ESR <10 milliohm.
C7 240uF 300V, but marked 425uF 300V: leakage current jittery around 150uA at 300V; abt 70mohm ESR 450uF.
C8 95uF 350V: <100uA but jittery at 350V; abt 250mohm ESR; 121uF

Energised C1 and C2 ok (loads disconnected). Added 4k4 4W bleeds from +50Vunreg to '3' gnd to -50Vunreg on parts pcb at CR1-4. 230Vac is 'nominal'.
220Vac 0.18A 60.5Vdc (discharged to 20V after 60 secs).
240Vac 0.27A 67Vdc (discharged to 22V after 60 secs, and to 8V after 2 mins).

PRE AMPLIFIER Pcb assembly HC-31051 CSW-3
Input signal derived from oscillator output with amplitude derived from coarse/fine kelvin-varley divider (in enclosed case). Range switched from 0.1 to 1kV, with 40% margin. Preamp input is filtered and diode limited to LM301A (+/-15V), then to driver, and out to Power amp. C103 is 1000pF (not uF). Two 100uF 25V ecaps back-to-back marked C101-C102 going to R101-R102 junction - this is shown in extra dashed box for I-FDBK - both caps <5uA at 25V, and ~110uF. R117 is 1k (not 100). Connector pin 15 is to "3" triangle ground. Q105 is over-current protection (0.6/0.075=8A). With voltage feedback at 0V, the LM301A output would just bias Q104 and Q103 for 0V at pin 6 (driver mid-point). Powered up +/-15V and opamp railed to +14V. If preamp pcb is not fitted then amp output stage transistors should all be off, with no idle current and mid-point at 0V gnd through primary.

Relays:
K1 2PDT HA-18574 2kohm coil DCR Artisan Engineering:
Oscillator 4k7 & Coarse to K1/1 (NC); K1/5 (com) to gnd; K1/8 (NO) not connected.
+50V to K1/6 (com); R77 and Reset Indicator to K1/4 (NC); R53/4k7 to K1/7 (NO).
Coil K1/2 wh connected to 0V via protection contacts (schematic error shows K1/3 doing this)
Coil K1/3 pur to R53 and S6 (Reset) and Coarse 0 position (schematic error shows K1/2 doing this)
Schematic error - no R80, C16 snubber across coil.

K2 coil (~106R but lots of inductance) energised at 32V via NC K1/4, which then shorts any voltage on the 10V,100V,1kV outputs. Schematic error.
K3 2PDT HA-18574 2kohm coil DCR Artisan Engineering.

Magnetics:
T1
T2
L1 : wh-or and wh-yel
T3 : small toroid on large board

AC MAINS switch S1
RANGE switch S2 in measurement module (100mV,1V,10V,100V,1kV,*).
FUNCTION switch S3 (Volts, Resistors hi, Resistors lo, ohms measure hi, ohms measure lo, Amps).
MODE switch S4 (AC supply, - supply, off, + supply, DC measure, AC measure).
Normal/Run-up S5
COARSE S6 (not identified on schematic) - works with Med/Fine adjust.
RESET switch S7 - part of RESET indictor - Coarse S6 position 0 shorts S7
READOUT S8
DISPLAY S9 (STD CELL, Zero, Ohms Cal, Read)
Terminal cover interlock S10

M1 Digital Readout has inputs for decimal point/range, and mains 110Vac (connector 1/15 and /S). Generates a floating +/-12V-gnd output for powering the measurement module. RFL chose a meter variant (Data Tech 4212-02) that has an extra internal pcb and rear connector than the base model. The increased functionality appears to include an over-voltage/range signal to then trip the unit; a HOLD signal to retain the displayed value; what appears to be a parallel printer port; and decimal point inputs â€“ so the OVP trip is the important function, and otherwise just a 4.5D meter. Previous variant Data Tech 344-2, and later variant Weston Model 2471.

The M1 J1 connector pins do not align with the schematic, except for J1-15 and J1-S for AC line. J1-5,10,F are not wired, but +/-12V for Measurement module goes via its 56-way socket: 's' (R323/+12V) to wiring loom marked '6' going to M1 J1/p red ; 'w' (R324/-12V) to M1 J/1 blk; 'r' (com 0V) to M1 J1/n with 2 other wires - blk and gry; with s,w,r contacts at rotary switch end of 56-way ELCO 8016 socket. Also see WESTON Model 2471/2472 instruction manual for connector listing.

There is no over-range trip external module (94430, series 400) and no connection to CR15 and L2 node.

High voltage indicator lit for 100V and 1kV ranges for Volts function using +50V - this also energises reed relay in Measurement module.

The RESET pushbutton momentarily connects +50V (via R52&53) to K1 coil, which is energised if the terminal cover interlock and heatsink 125C thermostat contacts are closed, and for any mode except off. When K1 is energised, the RESET indicator is lit, and K3 is energised. When the RESET pushbutton is released, K1 de-energises and the RESET indicator goes out and K2 coil is energised (to unclamp the 10V,100V,1kV outputs). The RESET function is also active when the COARSE amplitude switch is set at 0.

Oscillator Board/Box - located in metal box behind front panel Frequency selector. Output to rear J2 and via J1 to K1

NO contact, and then to top of Coarse Amplitude setting, and then through to preamp input. PCB - HC-31076. LM301A and 3N153 FET identifiable, so circuit is not the same as the schematic! Screened loom from oscillator goes to rear small board area - wh/blk to main e-cap common doesn't extend to oscillator board, so likely a loom shield. Blu/Grn/Brn are +/-15V and 0V com supply from parts CR5-CR6 on parts pcb. BLU-Wh 0V to pre-amp pcb pin 14. Yel-wh signal output to parts pcb and then through screened cable to oscillator output sockets. Blk/wh and Brn/wh from isolated 47k on fequency switch wafers - to parts pcb, with blk/wh then to screened cable to K1/8-NO. Brn-wh and yel-wh go to shield ed cable to rear panel J1-Amp in socket. Oscillator boad powered up with +/-15V and was ok with frequencies at 52.7Hz, 57.4Hz, 373Hz, and 930Hz - with low 2HD of 0.038%, 0.026%, 0.030% and 0.027%, with 3HD lower. Noticeable sidelobes of 50 and 60Hz. 400 and 1k can take a few seconds to start. 1.99Vrms when power is on, and 2.00Vrms when connected to Coarse (and not shorted to gnd by K1).

Amplifier output
Output transformer T2 primary winding extended to rear panel terminals with links - removing one link would disconnect primary from gnd. Primary orange & red linked to wh/or and wh/rd. R7 trim is a ww 5W under rear cover next to heatsink.
T2 output winding from 5 to 11 is monitored by T3 with three series 850V spark-gaps. If a spark-gap shorts then the applied voltage to the winding couples to the SCR CR15 gate trigger circuitry to enable the over-range trip function - trips K1 off and RESET indicator is lit and oscillator output shorted into Coarse and K2 is de-energised (to short 10V,100V,1kV feeds to gnd) and K3 is de-energised (to short DMM input) - unsure how resistance measurement path is opened?

Measurement Module HB-31060 marked TA9/1 Serial No 736
Removal of module requires rear slotted rod to be unscrewed to slowly disconnect module from internal connector. The +/-12V supply feed from M1 is used to power the AD146J (FET low drift opamp module). The +/-6V feeds the AC feedback circuitry, and bias trimpots for 146J (via 56-way y,m,t,x to enclosure behind front panel DISPLAY switch with 3 holes for trimpot adjust).

STD CELL EPLAB 0.1% accurate, 1.0193V, M165452, Miniature unsaturated cell, likely model "MIN 1". 20degC, 34401A Hi-Z, started at 1.01808, then rose and stabilised at 1.01812V, so past its life limit. After about 4 days the OCV has slowly trended down to 1.018095.
"The docs for M165452 are attached. In summary, this cell came from a build of 44 cells with construction and inspection completed on 9/27/1974. The voltage readpoints were made on Oct 4 and 23, 1974, at 28C with a final voltage at shipment of 1.01932. They were shipped per RFI sales order 31266 on Nov 13, 1974. Other units of that same lot build were shipped to Leeds and Northrup (Italy) and â€œElectrical Instrument Serviceâ€ ."
Schematic incorrect, as cell connected to pole.
Ensure that switch is set to external to unload cell.

Reverse/Normal switch on rear panel had bad contact - recovered by repeated switching.

Trimpots are for AC voltage and current trim. K301 is not marked on schematic, and associated with 5M parallel cap.

CTG - Crestwood Technology Group
Amb=23C, 34401A, 100 NPLC, 4W, switch changed to suit resistor 34401A 8588A transfer
4W L&N 4288 & AN8009 uV to front terminals

R301 -.02% +/-0.01% 5M	= 4M99855	K197 4W 4M9980	-0.029%	
R313 -.02% +/-0.01% 5M	= 4M99858	4M9980		
R302 -.02% +/-0.01% 1M	= 999k994	K197 4W 999k75		
R303 -.02% +/-0.01% 100k	= 99k992	99k981	-0.008%	-0.016%
R304 -.02% +/-0.01% 10k	= 9k999.42	9k9989	-0.0058%	-0.0006%
R305 -.02% +/-0.01% 1k	= 999.4195	999.06	-0.094%	
R342 +.02% +/-.01% 1k1111	= 1k11149			
R311 .02% +/-0.01% 1k	= 1k00033			
R310 .02% +/-0.01% 100	= 100.0377	+0.0377%		
R309 +.1% 10	= 10.012		10.00 @10mA	

R308 .01% 1 = 0.9978 99.9735mV @0.1A CCS 100mV burdon. 1.000 @100mA
R307 .01% 0.1 = 0.0976 9.99675mV @0.1A CCS 119mV burdon. 103.19mV @1A CCS low burdon. 0.0999
10.027mV @0.1A CCS 54mV burdon. 100.0025mV @1A CCS 0.546V burdon
9.9968mV @0.1A CCS 21mV burdon. 101.81mV @1A CCS 0.21V burdon
R306 .01% 0.01 = 0.0095 0.9985mV @0.1A CCS 5mV burdon. 10.5097mV @1A CCS. 0.00999 (with x6 gain)

0.01% of 1000k is 100R, so -0.03 to 0.01% span is -300 to -100R, indicating 34401A may be out of tolerance, and K197 is within the resistor tolerance for 20k and 2Meg range and for 200k.

Front terminal 2W resistance measurement (standard resistor value includes any factory series/parallel trimming) using SEI 230B at 15C, with AN8009 +6x gain detector

15C note low temp, and 2W measurement (even with shorted lead adjustment) - need to repeat at say 23C.

Shorted leads	0.0073
1	1.1351
10	10.1575
100	100.169
1k	999.40
10k	9,998.09
100k	99,970.9
1M	999,830
10M	9,998,270

Testing:
Raised +/-50V with variac, but disconnected all other circuitry from ecap terminals (amp primary side; reset circuitry; function switching; trip module), and removed K1, set S5 to run-up to ground preamp input.
C1 pos: red to parts board CR1-3; yel to K3 ; wh/red to preamp connector pin 7; orange to parts board R3-zener; wh/red to amp heatsink assembly.
C2 neg: blk to parts board CR2-4; blk to parts board R4-15V zener and preamp pcb pin 2 and current sense R51-R64.
C1 and C2 fitted with bleeds - see above for measurements.

Removed preamp board, and fitted all feeds for C2 neg and C1 pos, and set Amplitude Coarse switch to 0. Raised +/-50V. Amp output stage mid-point sat at 0V (no current through R18+R79, or voltage across emitter ballast resistors). 15V zeners regulate to +14.4V and -14.1V. K2 energises at +32V (via K1/4 NC), RESET indicator on (visible above about 30V). K3 energises at +36V. Oscillator works. Hi Voltage indicator lit for 100V and 1kV Range settings. K1 energises when RESET pushbutton is lit and then pressed (interlocks are ok and Coarse at 0), or Coarse returned to 0 setting, using assistance from charged C3. K1 is de-energised if CR15 scr is fired from protection - confirmed with 1.5V battery trip, and later when raising Coarse setting well above FS output setting.

With S2 RANGE/1=100mV and S3 FUNCTION/1=Volts, and S4 MODE/1=AC supply, T2/6 connected to + O/P, and T2/5 connected to - O/P terminals.
With S2 RANGE=1V then T2/7 connected to + O/P.
With S2 RANGE=10V then T2/9 connected to + O/P.
With S2 RANGE=100V then T2/10 connected to + O/P.
With S2 RANGE=1000V then T2/12 connected to + O/P.

With S2 RANGE=100mV and S3 FUNCTION=Volts, and S4 MODE/4=+DC supply, T2/9 connected to CR10 and filter, and dc rail is divided by R31/30/32 and then connected to + O/P terminal. T2/5 connected to - O/P terminal, and to CR12. Similar for 1V and 10V except R30/31/32 divider.
With S2 RANGE=100V then T2/10 connected to CR9 and filter then connected to + O/P terminal.
With S2 RANGE=1000V then T2/12 connected to CR8 and filter then connected to + O/P terminal.

Regulation of DCV via the sense terminals. Volts neg to opamp + input, and meter i/p.

Without +/-12V from meter module, the opamp isn't functional, and so the voltage presented to the display meter is not valid, but the voltage applied to the output terminals should be correct.

Coarse setting shows nominal steps in dc output voltage, along with nominal steps in AC voltage at output of amplifier. Med/Fine adjust pot (Deyoung 23A-10K) is inside a shield enclosure behind switch assemblies and difficult to access. Pot incorporates two adjustment elements - a fine vernier which then changes to a medium vernier at the end of the fine vernier rotation.

Preferably operate at 220-230Vac mains.

Only tested to 100mA current, and about 700V. Resistance measurement not operational. No testing of 'STD CELL; ZERO; OHMS CAL; READ" settings and operation as they relate to Display meter.

Always start with Coarse at min, and check measured output as increased. Output will likely reach FS level for Coarse set to about 5 (of 15), and unit will trip off when output >140% of FS level (so requiring a reset - push in indicator switch).

---------- Forum info
I'm progressing through the restoration of an RFL Industries AC/DC Calibration Standard model 829G from the mid 1970's. Unfortunately this unit is missing its Digital Panel Meter.
Luckily the 829G manual was on-line here: https://www.davmar.org/pdf/RFL829G.pdf, and an advert is shown here: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5213241. But the manual is a little short on details.

This equipment either used a Data Tech 344-2, a Data Tech 4212-02, or the Weston Model 2471 DPM. I can't really locate any relevant catalogs or adverts for Data Tech or Weston's ranges of DPM's, or a manual for those specific models. The attached photo of a Data Tech below would be similar, as it uses two separate rear connectors, with one connector related to options. The optional functionality in my missing 4212-02 model appears to include an over-voltage/range signal to then trip the unit; a HOLD signal to retain the displayed value; what appears to be a parallel printer port; decimal point inputs; and a front panel full scale adjustment.

From the fault-finding notes, the 4.5 digit meter appears to have a high input impedance and 1.4V max input, which relates directly to an optional Standard Cell used for self-calibration of the equipment's ranges. The 829G manual only makes passing reference to a separately provided DPM manual.

If anyone has any manuals etc on these DPM's I'd appreciate a post/PM.

The restoration doesn't pedantically need the panel meter, as a modern meter and some simple form of decimal range display, and perhaps an over-voltage detector, should be fine, but always worth chasing up details if they still exist.
This calibrator seems to have been mainly sold into the defence force establishments, so perhaps uncommon to see in a cal lab.

Just located a Weston Model 2471/2472 manual at https://www.surplussales.com/items/115388/weston-digit-display/.

Relative to the internal Weston Cell measurement, the 1.9999V FS meter range has a 1,000Megohm input resistance, and uses a LM399H and ICL7103 based ADC, so appears to be the dominant limiting aspect of the calibrator accuracy.

I've confirmed that although the meter could provide an over-range control line, the 829G doesn't include a trip interface to use any such line. So the only other function needed from this meter is an isolated +/-12Vdc to power a vintage AD146J opamp, which I can easily work around.

The RFL 829G calibrator has a 'front end' source that generates a DC or AC output level, and effectively a separate

'back end' that displays the output level being used as the calibration standard. So the panel meter is per se just acting as an accurate display of the chosen output standard. As such, a suitably specced, modern auto-ranging 5-6 digit DMM can simply be used to make the 829G functional again for voltage, and for current with the DMM inserted in the current path. Given the stability of the source, and AC settings of 50, 60, 400 and 1kHz, and the ability for fine adjustment within each decade range setting (0.1V to 1kV, or 0.1mA to 10A), this beast is quite versatile for calibration services, and as accurate as the available DMM.

Using the 829G for resistance measurement is at the moment a little more onerous, as the internal AD 146J fet opamp needs a power supply retrofitted, and the input to the missing panel meter needs to be measured by a DMM, and accuracy will be dependent on the internal precision resistors.

Interestingly, the manually set output level (voltage or current) is made using the decade range setting, along with a 15 step coarse adjust setting followed by a single DeYoung pot (23A-10k) providing both medium and fine level adjustment using a neat internal double element pot resistor configuration. The pot is based on US380010 (https://patentimages.storage.googleapis.com/d6/aa/06/f448d371fb6686/US3380010.pdf), and Greg Christenson (@Barbouri) describes it in his blog on a HP 3551A restoration (https://www.barbouri.com/2022/05/27/hewlett-packard-3551a-transmission-test-set/). Initial testing made me think naively that the pot had a bad wiper contact - and even knowing how it adjusts it still takes a bit of getting used to!

Theory of Operation

Specifications

Initial Check-out

Calibration Source Operation

Instruction Manual and Operational Procedure

for

Model 829G Calibration Standard

Amperes D C

Volts D C

Standard Resistances

Measurement Standard Operation

Serial No. 2789

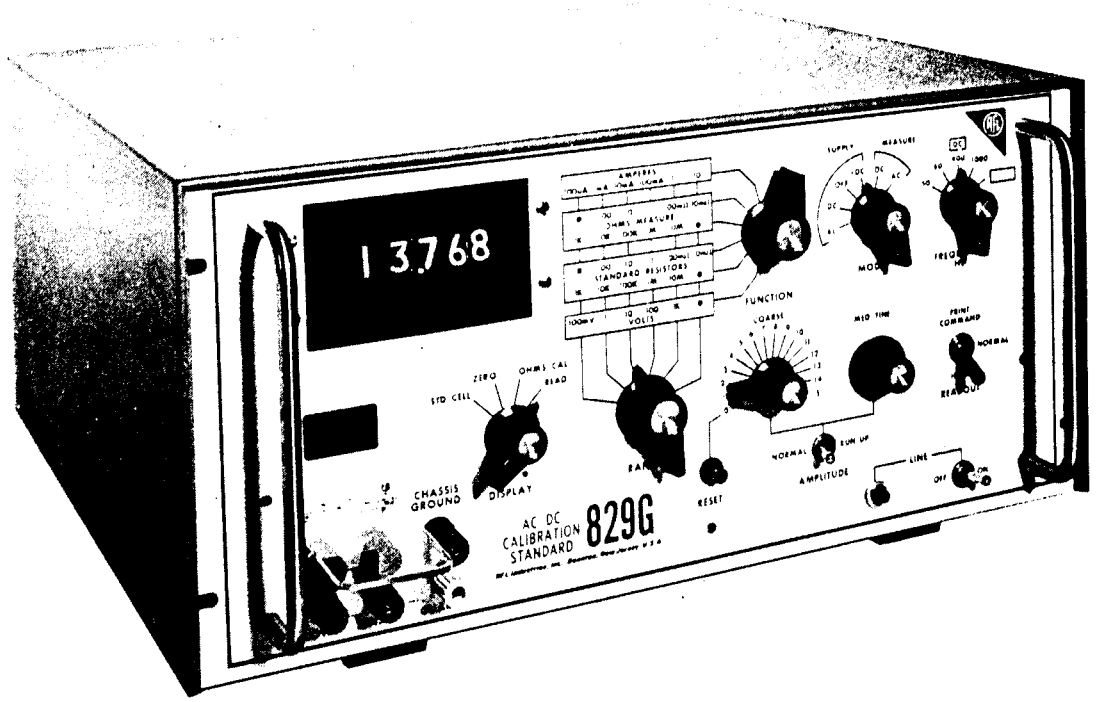
Amperes D C

Volts D C

Ohms D C

RFL Industries, Inc.

Boonton, New Jersey, U. S. A.



Model 829G AC-DC Calibration Standard.

THEORY OF OPERATION

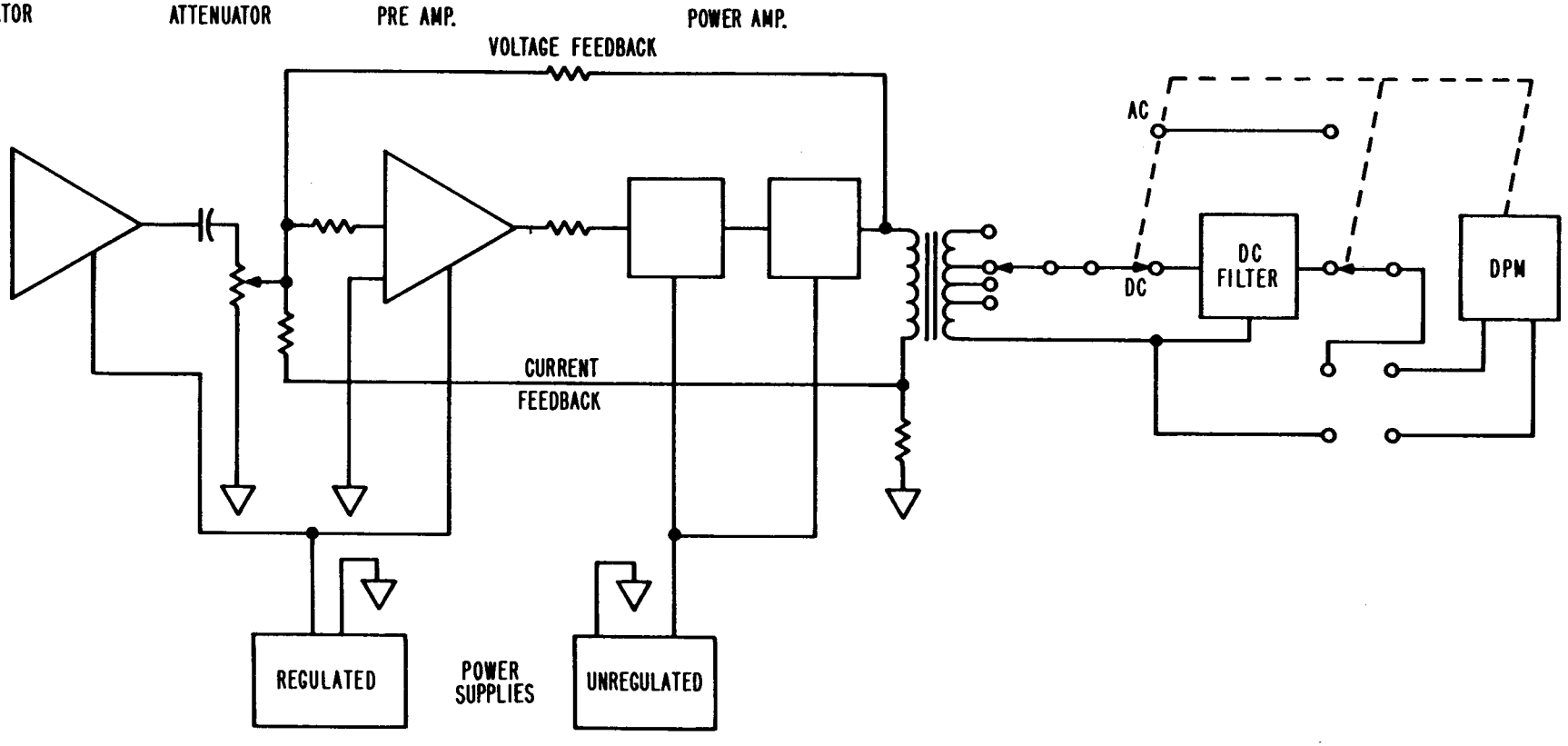
The Model 829G Calibration Standard is a highly and precise instrument capable of two distinct modes of operation; supplying a wide range of AC-DC voltage and current and preset resistance values; measuring AC-DC voltage and current of the same parameters which it can supply, plus the ability to measure a broad range of resistance values. In its source mode, the instrument uses a state-variable oscillator, the amplitude of which is controlled with an optically isolated regulator. Output-signal frequencies of 50, 60, 400, and 1000 Hz are selected with a front-panel control. 400 Hz is used as the signal source when the Standard is used in the dc mode, so that ripple in the output is minimized.

The oscillator output is applied to a preamplifier/power amplifier through a three-stage Kelvin-Varley attenuator (Amplitude controls). Over-all voltage and current feedback is designed into the amplifier sections and roll-off control is incorporated to prevent high frequency bursts from occurring in the output waveform. The amplifier output is applied to a transformer which is capable of handling all output voltage and current, both AC and DC (the latter in conjunction with the appropriate rectifier circuits).

The precise value of output voltage or current is measured at the output terminals by means of the Mod I 829G digital readout instrumentation. Appropriate voltage dividers and four-terminal shunts are incorporated to enable accurate sensing of the voltage and current. Current and voltage limiting components, where necessary, are incorporated into the Model 829G Range and Function switching circuits. The output of the oscillator and the input circuit of the preamplifier are accessible through rear panel connections on the Model 829G. These provide necessary synchronization points when two Model 829G's (or an 829G plus an auxiliary AC source) are used for wattmeter calibration.

The Model 829G incorporates internal protective circuitry to provide protection for the operator, the Model 829G and the instrument under test. The output terminals of the Model 829G are covered by a plexiglass shield which must be lowered over the terminals before the instrument can be energized. Raising this shield while the Model 829G is energized will result in de-energization; the shield must be lowered and the RESET button pressed in order to reactivate the voltage or current.

The possibility of damaging an instrument under test is minimized by interlock circuitry associated with the RANGE and FUNCTION selectors. The Model 829G is protected by spark-gap/SCR circuitry which is energized in the event of excessive voltage (transient or constant) in critical circuits when operated by its internal oscillator/amplifier. The SCR trip circuit is also associated with the Sense to Chassis Ground terminals to protect against excessive EMF levels at these points. Overheating of the Model 829G can occur if the instrument is operated in

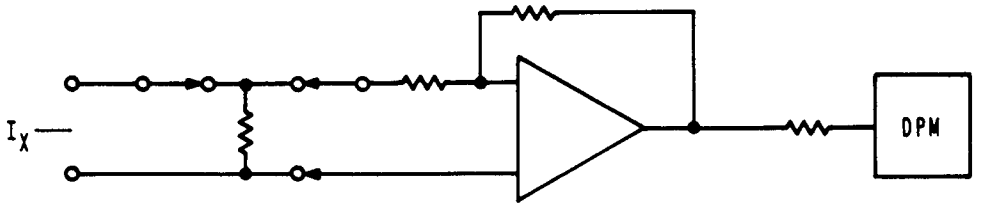


A. Block Diagram: Model 829G AC-DC Current/Voltage Supply Mode.

excessively high ambient temperature environments or if an attempt is made to work at overloaded output conditions for any length of time. A snap action temperature sensor initiates if the Model 829G heat sinks exceed 125°C. Once tripped, the self-restoring sensor prevents operation of the instrument until the heat sinks return to normal temperature.

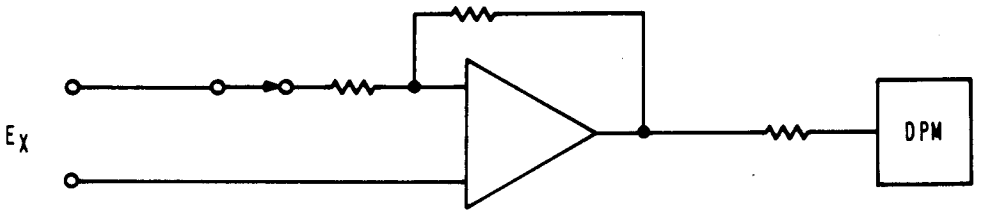
In the Measurement mode the Model 829G utilizes its switching circuitry and precision measurement section consisting of the digital panel meter, precision shunts and multipliers, operation amplifier for DC functions and an operational rectifier for AC functions.

When measuring DC current, the effective circuit is that shown in block diagram (B). The input circuits of the operational amplifier are connected across a precision resistor having a value that will develop a precise 100 mV at an applied full-scale range value. The voltage from the precision resistor is applied to the operational amplifier circuit which has its negative input at a summing point held to zero voltage. The developed EMF is of opposing polarity and equal in magnitude (at full-scale) to the EMF of the precision feedback circuit; therefore, the EMF at the operational amplifier output is precisely related to the current applied to the Model 829G terminals.



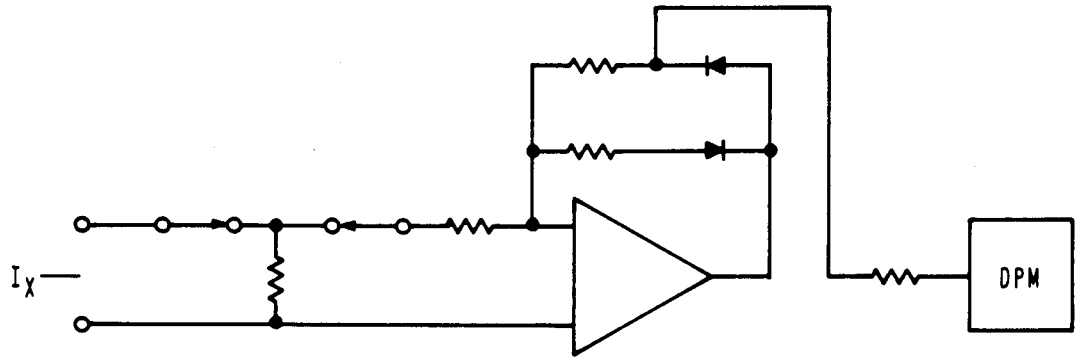
B. Direct Current.

DC voltage measurement, block diagram (C) is similar to DC current measurement. The negative input of the operational amplifier is a current summing point held at zero voltage. The 0.1 mA current through the precision input divider must be equal and opposite to the current from the precision feedback circuit. The EMF developed at the operational amplifier output is directly related to the voltage applied to the Model 829G input terminals.



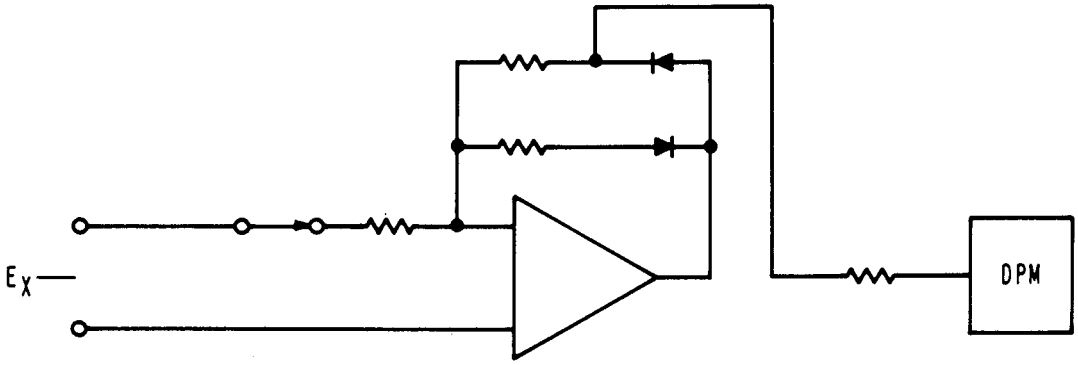
C. DC EMF.

In the Alternating Current mode of operation, the operational amplifier and two feedback paths with series rectifiers form an operational rectifier. The operational amplifier generates EMF as required to compensate for diode EMF drop. Since one end of the feedback resistor is at zero potential, the current through the feedback resistor, R_f causes a precision voltage to be developed at the DPM input. The same four-terminal resistors used in the Direct Current mode are used as input sensing elements, see block diagram (D).



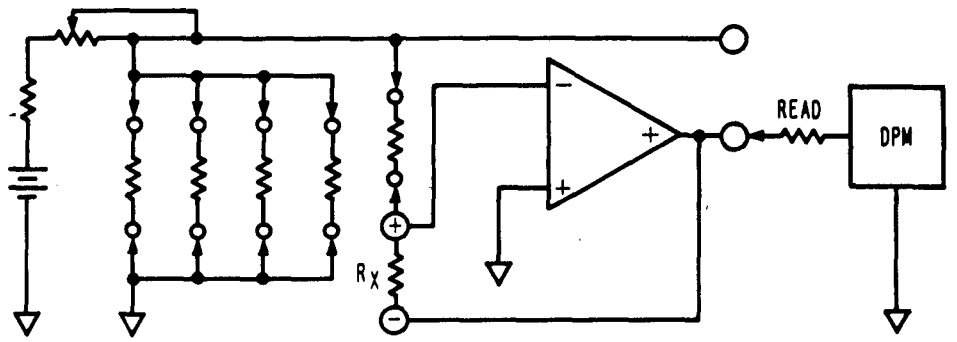
D. Alternating Current.

The AC Voltage mode utilizes the same operational rectifier circuitry described above and also uses the precision voltage divider arrangement used in measuring DC voltage, see block diagram (E). The current developed in the divider circuit is applied to the operational rectifier circuit summing junction.



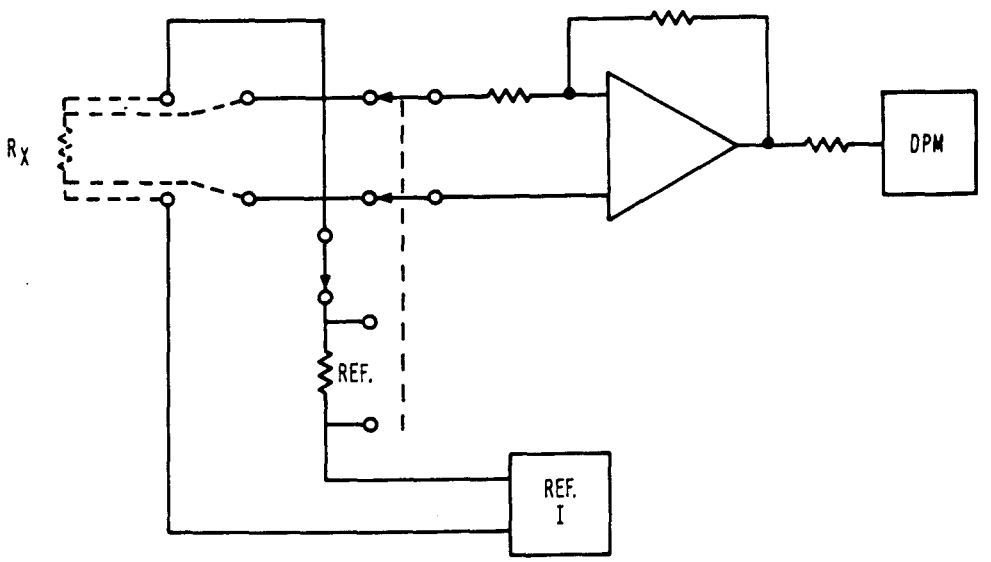
E. AC EMF.

In the High Resistance Measurement mode (1K to 10M ohms) a precise EMF (1 Volt) is applied to a precision range resistor. The current through the range circuit is applied to the summing point and is exactly balanced by the feedback current fed through the unknown resistor. For a precision current driven through the unknown resistor, a voltage proportional to the unknown resistance is developed and read by the DPM.



F. Ohms Measurement.

Low resistance measurements utilize four-terminal resistance techniques. Selection of the Model 829G range automatically switches an appropriate four-terminal precision resistor into the measurement circuit. The external four-terminal resistance which is to be measured is connected as a series extension to the Model 829G four-terminal standard resistor. A full-scale range current (i.e. 10 mA, 100 mA, etc.) is applied through the series circuit and held constant. The measurement circuit is then switched to read the EMF developed across the unknown resistor. This EMF is applied to the summing point in the operational circuit which is held at zero, and the precision voltage across the feedback resistor is measured by the DPM. The EMF is directly proportional to the voltage developed across the unknown resistor.



G. Low Ohms Measurement.

The internal precision Range resistors are connected to the Model 829G front panel terminals when the FUNCTION selector is placed in STANDARD RESISTORS position. This enables precise two and four-terminal resistances to be used as selected resistance references.

CAUTION

When measuring current, voltage or selected resistance values, care must be exercised not to exceed the current or voltage specified for the range in use. Excessive input can damage these precision components.

An internal (or external) standard cell should be used to check the full scale accuracy of the Model 829G DPM. This check may be performed on a daily or weekly basis, depending on the accuracy required of the over-all calibration system.

If it is desired to measure the resistance of a galvanometer, switch to the appropriate RANGE and FUNCTION before connecting meter.

Do not connect meter prior to selecting FUNCTION and RANGE, as it is possible to damage a galvanometer by switching through an inappropriate resistance measure range.

SPECIFICATIONS

CALIBRATION SOURCE

FULL-SCALE RANGES:

AC-DC Voltage: 0.1, 1, 10, 100, 1000 Volts (plus 40% overrange)

Max. Burden: 0.03A @ 1000V AC-DC
0.2A @ 100V AC-DC
2.0A @ 10V AC-DC
5A @ 1V AC
1A @ 1V DC
0.5A @ 0.1V AC-DC

AC-DC Current: 100μA, 1 mA, 10 mA, 100 mA, 1A, 10A (plus 40% overrange)

Max. Compliance: 2 Volts @ 10 Amperes

Ohms: (cardinal values only) 0.01, 0.1, 1, 10, 100, 1k, 10k, 100k, 1M and 10M

ACCURACY: (for 100% to 10% of full-scale range)

DC Volts: ±(0.02% of range +0.03% of reading) +0.2 mV

AC Volts: ±(0.03% of range +0.05% of reading) +0.5 mV

DC Amperes: ±(0.02% of range +0.03% of reading) +0.2μA (to 1A)
±(0.02% of range +0.1% of reading) (to 10A)

AC Amperes: ±(0.03% of range +0.05% of reading) +0.5μA (to 1A)
±(0.03% of range +0.2% of reading) (to 10A)

Ohms: ±0.06% of value (4 terminal configuration) to 100k
±0.1%, 1 and 10 Megohms

RESOLUTION: 0.01% of range

FREQUENCY: (internally generated) 50, 60, 400, 1 kHz

OUTPUT REGULATION: Better than 0.05% for 10% line variation.

OUTPUT TERMINALS: Two or four-terminal arrangement, at operator's discretion. High and Low Output, High and Low Sensing, Circuit and Chassis Ground.

MEASUREMENT STANDARD

FULL-SCALE RANGES: (plus 40% overrange)

AC-DC Voltage: 0.1, 1, 10, 100, 1000 Volts (input impedance: 10k ohms/volt)

AC-DC Current: 100μA, 1 mA, 10 mA, 100 mA, 1A, 10A (input impedance varies with range: 0.1 to 20k ohms)

Ohms Range: Low: 0.01, 0.1, 1, 10, 100 ohms (AC & DC)
High: 1k, 10k, 100k, 1M, 10M ohms (DC only)

Frequency Response: 50 Hz to 1 kHz

ACCURACY: (for 100% to 10% of full-scale range)

DC Volts: ±(0.02% of range +0.03% of reading) +0.2 mV

AC Volts: ±(0.03% of range +0.05% of reading) +0.5 mV

DC Amperes: ±(0.02% of range +0.03% of reading) +0.2μA (to 1A)
±(0.02% of range +0.1% of reading) (to 10A)

AC Amperes: ±(0.03% of range +0.05% of reading) +0.5μA (to 1A)
±(0.03% of range +0.2% of reading) (to 10A)

AC Ohms: (Low Range Only) ±(0.05% of range +0.05% of reading) +100μ ohms

DC Ohms - Low Range: ±(0.02% of range +0.03% of reading) +100μ ohms

DC Ohms - High Ranges: ±(0.02% of range +0.03% of reading) +0.1 ohm (to 100k)
±(0.02% of range +0.1% of reading) (to 1 Meg)
±(0.02% of range +0.2% of reading) (to 10 Meg)

SIZE: 19" W x 8¾" H x 23" D (48.3 x 22.2 x 58 cm)

WEIGHT: 98 pounds (44.5 kilograms)

POWER LINE REQUIREMENTS: 115 or 230 Volts, 50/60 Hz

Maximum Demand: 250 watts @ 60 Hz

NOTE

For optimum accuracy in all modes of operation, it is advised that the DPM zero "toggle" be checked and reset (if necessary) periodically, i.e. daily. Refer to Calibration paragraphs 1 and 4.

INITIAL CHECK-OUT

1. Unless tagged otherwise, the Model 829G is internally connected for 115 volt line operation

2. Before plugging the line cord into power receptacle, set the Model 829G controls as follows: LINE switch to OFF, READOUT switch to NORMAL, FREQUENCY selector to 400 Hz, MODE selector to OFF, AMPLITUDE switch to NORMAL, COARSE and MED/FINE controls full counterclockwise, FUNCTION selector to VOLTS, RANGE selector to the 100 mV position, DISPLAY selector to READ, and plexiglass safety shield into its lowered position. Plug line cord into appropriate power receptacle and place LINE switch in ON position. Allow approximately one-half hour warm-up prior to operation for maximum stability.

3. Place DISPLAY selector to ZERO position and check for zero (±3 last place digit) readout of digital display.

4. Place DISPLAY selector in STD CELL position (if standard cell check is desired). If Model 829G is equipped with an internal cell, the digital display should indicate the appropriate EMF (the EMF of a cell furnished with the Model 829G will be found on the Certificate inside this manual). If an external standard cell is used for calibration check, see procedure under CALIBRATION in this manual.

5. Strap HIGH OUTPUT to HIGH SENSE and LOW OUTPUT to LOW SENSE and connect a shorting strap from HIGH to LOW OUTPUT. Set COARSE AMPLITUDE control to zero. Set MODE selector to +DC (SUPPLY). Set DISPLAY selector to READ position. Lower plexiglass shield until it engages its associated interlocking switch. Check for digital readout of .0000 ±3 last place digit.* Remove shorting strap from HIGH to LOW OUTPUT.

6. If any of the initial checks performed above fail to fall within the specified readings, adjust appropriate controls as described under CALIBRATION in this manual.

See "Interlock Reset Operation," page 10 for details of Reset Operation.

CAUTION

HIGH VOLTAGE

The Model 829G AC-DC Calibration Standard can generate voltages of a hazardous and/or lethal nature. A protective, electrically interlocked plexiglass shield is provided over the Voltage/Current Output terminals. Lowering the shield to its maximum "down" position allows the output circuit to be energized. When the shield is raised, even slightly, from its full "down" position, a drop-out relay automatically disconnects voltage or current from the output terminals. Do not attempt to defeat the purpose of this protective interlock.

GUARD CIRCUIT OPERATION

NOTE: The following precautions may be disregarded when operating the Model 829G as a normal circuit grounded instrument, i.e. when the CHASSIS GROUND, GUARD, LOW SENSE and LOW OUTPUT are strapped together.

The LOW SENSE circuit and the GUARD circuit are internally connected by back to back diodes. Potential difference between these two terminals should never exceed ±0.75 volt. The LOW SENSE circuit is connected to CHASSIS by a solid-state trigger circuit. Potential difference between these two terminals must never exceed ±40 volts. If the GUARD to CHASSIS potential is excessive, EXTENSIVE DAMAGE TO THE DIGITAL READOUT AND/OR CONVERTER CIRCUITRY CAN RESULT.

INTERLOCK RESET OPERATION

If the RANGE, FUNCTION or MODE selector position is changed while the Model 829G is energized (COARSE AMPLITUDE control run-up to any position above zero) the Model 829G will immediately become de-energized and the RESET push button will become illuminated. Under these conditions, output voltage or current will drop to zero. The same condition will automatically occur if the output voltage exceeds its 40% overrange to any great extent, but never greater than the DPM range or if extensive transient pulses cause momentary peak EMF beyond the 40% region.

Re-energization of the instrument may be accomplished in either of two ways. The RESET button may be pressed, all controls remaining in their previously established positions, and the voltage or current will be re-established to the previous levels. Or, the COARSE AMPLITUDE control may be returned to its zero position, in which case the interlock circuit will immediately re-engage. NOTE: If the COARSE AMPLITUDE control is at zero and the FUNCTION, RANGE or MODE selector position is changed, the interlock will operate, turning off the amplifier input. In this case pressing the RESET button will NOT re-engage the interlock. It is necessary to either rotate the COARSE AMPLITUDE control up one step and then back to zero, at which time the circuit will automatically become engaged, or the COARSE AMPLITUDE control may be advanced any number of positions from zero and pressing the RESET button will result in re-establishment of voltage or current output.

CALIBRATION SOURCE OPERATION

AMPERES AC

Ranges: 0 to 100μA, 1 mA, 10 mA, 100 mA, 1A, 10A (plus 40% overrange)

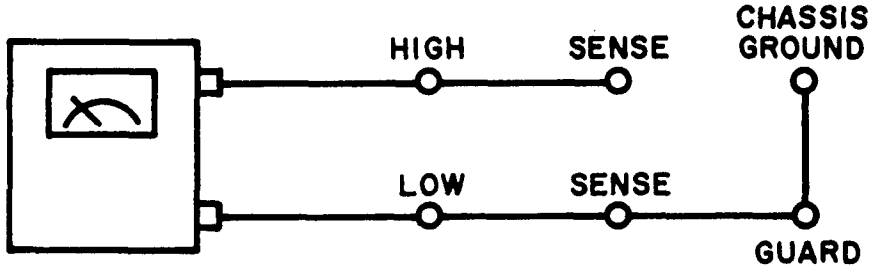
Maximum Compliance: 2 volts

Accuracy: **(for 100% to 10% of full-scale range)**

(up to 1A) ±(0.03% of range +0.05% of reading) +0.5μA

(up to 10A) ±(0.03% of range +0.2% of reading)

TERMINAL CONNECTIONS



OPERATION PROCEDURE

1. Set MODE selector to OFF, FUNCTION selector to AMPERES, DISPLAY selector to READ, RANGE selector to full-scale current range desired, READ-OUT switch to NORMAL, AMPLITUDE switch to NORMAL with COARSE and MED/FINE controls full counterclockwise, and FREQUENCY selector to desired frequency setting.

2. Raise protective plexiglass shield and connect instrument which is to be tested to appropriate terminals (see illustration above). After completing connections, lower plexiglass shield until its associated interlocking switch engages.

3. Place MODE selector to AC (SUPPLY) position.

   Calibration of the instrument under test may be accomplished in either of two ways: The Model 829G may be adjusted to provide a desired output as indicated by the digital display and the indication of the instrument under test noted, or, the output amplitude of the Model 829G may be adjusted until the instrument under test indicates the desired value and the applied current is noted on the Model 829G readout display.

4. Advance COARSE AMPLITUDE control one step and then return it to zero to engage interlock circuitry. Advance MED/FINE control approximately half its rotation. Advance COARSE AMPLITUDE control while observing indication of the instrument under test (or the Model 829G readout). Adjust both COARSE and MED/FINE AMPLITUDE controls until desired indication is achieved. The Model 829G display indicates directly the value of current applied through the output terminals. It should be noted that the display indication lags a change in amplitude adjustment by a second or two.

5. In some instances it may be desirable to retain the Model 829G readout while its indication is noted and manually recorded. This may be accomplished by placing the READOUT switch in HOLD position. This retains the readout which is present at the instant the switch is placed in HOLD; however, it does not lock the output amplitude of the Model 829G. Return READOUT switch to NORMAL after completing the test.

6. When testing analog meters, it is generally advisable to check the movement for friction or bearing sticks. This may be accomplished with the Model 829G in the following manner:

   Adjust COARSE and MED/FINE AMPLITUDE controls for full-scale indication of meter under test. Place AMPLITUDE switch in RUN-UP position. The MED/FINE control may now be used to continuously adjust meter deflection from zero to full-scale or conversely from full-scale to zero. In some cases it may be necessary to advance COARSE control.

   Return AMPLITUDE control switch to NORMAL after completion of run-up tests.

7. Upon completion of calibration operations, return AMPLITUDE controls to full counterclockwise positions, place MODE selector in OFF, raise protective plexiglass shield and disconnect tested instrument.

PRECAUTIONARY NOTES

Interlock Operation

If the RANGE, FUNCTION or MODE selector position is changed, or if the plexiglass shield is raised while the Model 829G is energized, the instrument will immediately become de-energized and output will drop to zero. Re-energization may be accomplished by pressing the RESET button, in which case full energization will be realized, or the COARSE AMPLITUDE control may be returned to zero position and again advanced. In the case of the shield causing interlock cutout, the shield must be lowered until its interlocking switch engages, following which the RESET button must be pressed or the COARSE control returned to zero position.

VOLTS AC

Ranges: 0 to 0.1V, 1V, 10V, 100V, 1000V (plus 40% overrange)

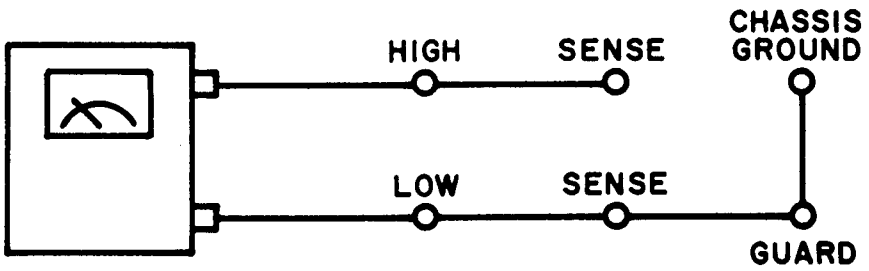
Maximum Burden:

0.03A	@	1000 volts
0.2A	@	100 volts
2.0A	@	10 volts
5.0A	@	1 volt
0.5A	@	0.1 volt

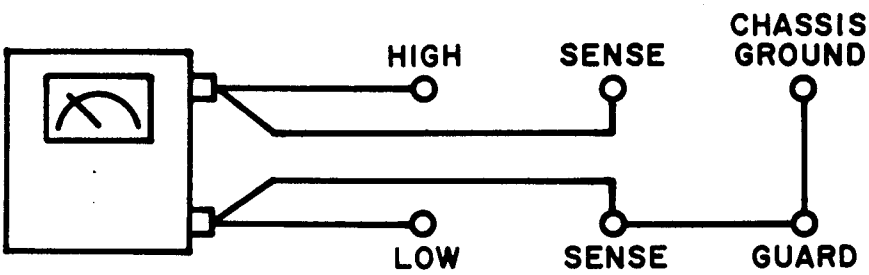
Accuracy: (for 100% to 10% of full-scale range)

±(0.03% of range +0.05% of reading) +0.5mV

TERMINAL CONNECTIONS



Two-Terminal Configuration (for low burden instruments).



Four-Terminal Configuration (remote sensing).

OPERATIONAL PROCEDURE

1. Set MODE selector to OFF, FUNCTION selector to VOLTS, DISPLAY selector to READ, RANGE selector to full-scale range desired, READOUT switch to NORMAL, AMPLITUDE switch to NORMAL, COARSE and MED/FINE controls full counterclockwise, and FREQUENCY selector to desired frequency.

2. Raise protective plexiglass shield and connect instrument which is to be tested to appropriate terminals. After completing connections, lower plexiglass shield until its associated interlocking switch engages.

3. Place MODE selector in AC (SUPPLY) position.

   Calibration of the instrument under test may be accomplished in either of two ways: The Model 829G may be adjusted to provide a desired output as indicated by the digital display and the indication of the instrument under test noted, or, the output amplitude of the Model 829G may be adjusted until the instrument under test indicates the desired value and the applied voltage is noted on the Model 829G digital display.

4. Advance COARSE AMPLITUDE control one step and then return it to zero to engage interlock circuitry. Advance MED/FINE control approximately half of its rotation. Advance COARSE AMPLITUDE control while observing indication of instrument under test (or Model 829G readout). Adjust both COARSE and MED/FINE controls until desired indication is achieved. The Model 829G display indicates directly the value of voltage applied to the output terminals. It should be noted that the display indication lags a change in amplitude adjustment by a second or two.

5. In some instances it may be desirable to retain the Model 829G readout while its indication is noted and manually recorded. This may be accomplished by placing the READOUT switch in HOLD position. This retains the readout which is present at the instant the switch is placed in HOLD; however, it does not lock the output amplitude of the Model 829G. Return READOUT switch to NORMAL after completing the test.

6. When testing analog meters, it is generally advisable to check the movement for friction or bearing sticks. This may be accomplished by the Model 829G in the following manner:

   Adjust COARSE and MED/FINE AMPLITUDE controls for full-scale indication of meter under test. Place AMPLITUDE switch in RUN-UP position. The MED/FINE control may now be used to continuously adjust meter deflection from zero to full-scale or conversely from full-scale to zero. In some cases it may be necessary to advance COARSE control.

   Return AMPLITUDE control switch to NORMAL after completion of run-up tests.

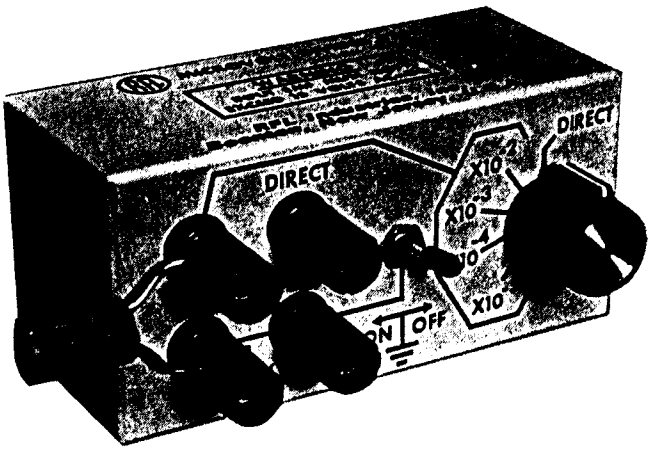
7. Upon completion of calibration operations, return AMPLITUDE controls to full counterclockwise positions, place MODE selector to OFF, raise protective plexiglass shield and disconnect tested instrument.

PRECAUTIONARY NOTES

Interlock Operation

If the RANGE, FUNCTION or MODE selector position is changed, or if the plexiglass shield is raised while the Model 829G is energized, the instrument will immediately become de-energized and output will drop to zero. Re-energization may be accomplished by pressing the RESET button, in which case full energization will be realized, or the COARSE AMPLITUDE control may be returned to zero position and again advanced. Where raising the shield causes interlock cutout, the shield must first be lowered and the RESET button pressed or the COARSE control returned to zero position.

MODEL 8390
MICROVOLT DIVIDER



The Model 8390 Microvolt Divider is an accurate attenuator designed to complement RFL voltage and current standards. It plugs directly into the output binding posts of the Model 829-G, and it may be used within its maximum input-voltage limit of 15 volts.

The five positions of the range switch provide for multiplying the input signal by factors of 10^0, 10^{-2}, 10^{-3}, 10^{-4}, and 10^{-5} when the load imposed on the divider is precisely 50 ohms. The DIRECT position (10^0) enables the user to read the input voltage without disconnecting the Divider from the source. The 50-ohm load may be either the device under test or the 50-ohm terminating resistor supplied with the Model 8390.

Contact RFL for complete data and specifications.

AMPERES DC

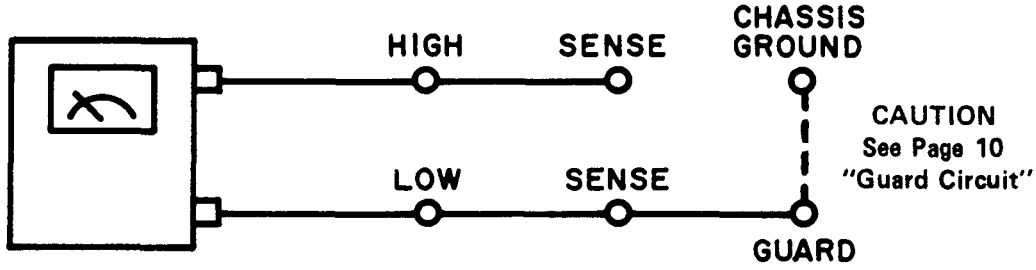
Ranges: 0 to 100μA, 1mA, 10mA, 100mA, 1A, 10A (plus 40% overrange)

Maximum Compliance: 2 volts

Accuracy: (for 100% to 10% of full-scale range)

(to 1A) ±(0.02% of range +0.03% of reading) +0.2μA
(to 10A) ±(0.02% of range +0.1% of reading)

TERMINAL CONNECTIONS



OPERATIONAL PROCEDURE

1. Set MODE selector to OFF, FUNCTION selector to AMPERES, DISPLAY selector to READ, RANGE selector to full-scale current range desired, READ-OUT switch to NORMAL, AMPLITUDE switch to NORMAL, COARSE and MED/FINE AMPLITUDE controls full counterclockwise, and FREQUENCY selector to 400 Hz.

2. Raise protective plexiglass shield and connect instrument which is to be tested to appropriate terminals (see illustration above). After completing connections lower plexiglass shield until its associated interlocking switch engages.

3. Place MODE selector to appropriate DC (SUPPLY) position.

   Calibration of the instrument under test may be accomplished in either of two ways: The Model 829G may be adjusted to provide a desired output as indicated by the digital display and the indication of the instrument under test noted, or, the output amplitude of the Model 829G may be adjusted until the instrument under test indicates the desired value and the applied current is noted on the Model 829G readout display.

4. Advance COARSE AMPLITUDE control one step and then return it to zero to engage interlock circuitry. Advance MED/FINE control approximately half of its rotation. Advance COARSE AMPLITUDE control while observing indication of instrument under test (or Model 829G readout). Adjust both COARSE and MED/FINE controls until desired indication is achieved. The Model 829G

display indicates directly the value of current applied through the output terminals. It should be noted that the display indication lags a change in amplitude adjustment by a second or two.

5. In some instances it may be desirable to retain the Model 829G readout while its indication is noted and manually recorded. This may be accomplished by placing the READOUT switch in HOLD position. This retains the readout which is present at the instant the switch is placed in HOLD; however, it does not lock the output amplitude of the Model 829G. Return READOUT switch to NORMAL after completion of this test.

6. When testing analog meters, it is generally advisable to check the movement for friction or bearing stick. This may be accomplished by the Model 829G in the following manner:

   Adjust COARSE and MED/FINE AMPLITUDE controls for full-scale indication of meter under test. Place AMPLITUDE switch in RUN-UP position. The MED/FINE control may now be used to continuously adjust meter deflection from zero to full-scale or conversely from full-scale to zero. In some cases it may be necessary to advance COARSE control.

   Return AMPLITUDE control switch to NORMAL after completion of RUN-UP tests.

7. Upon completion of calibration operations, return AMPLITUDE controls to full counterclockwise positions, place MODE selector to OFF, raise protective plexiglass shield and disconnect tested instrument.

PRECAUTIONARY NOTES

Interlock Operation

If the RANGE, FUNCTION or MODE selector position is changed, or if the plexiglass shield is raised while the Model 829G is energized, the instrument will immediately become de-energized and output will drop to zero. Re-energization may be accomplished by pressing the RESET button, in which case full energization will be realized, or the COARSE AMPLITUDE control may be returned to zero position and again advanced. Where raising the protective shield causes interlock cutout, the shield must be returned to its lowered position before reset of the interlock circuit can be accomplished.

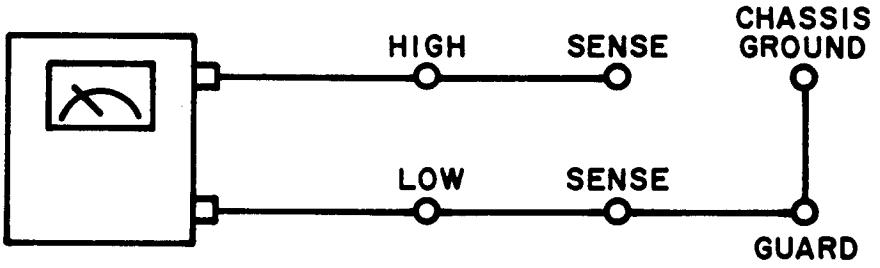
VOLTS DC

Ranges: 0 to 0.1V, 1V, 10V, 100V, 1000V

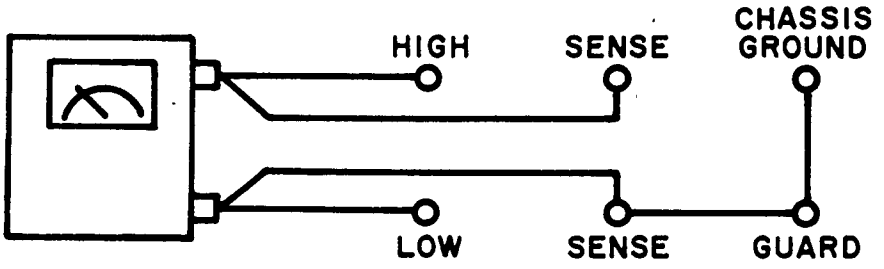
Maximum Burden: 0.03A @ 1000V
0.2A @ 100V
2.0A @ 10V
1.0A @ 1V
0.5A @ 0.1V

Accuracy: (for 100% to 10% of full-scale range)
±(0.02% of range +0.03% of reading) +0.2mV

TERMINAL CONNECTIONS



Two-Terminal Configuration (for low burden instruments).



Four-Terminal Configuration (remote sensing).

OPERATIONAL PROCEDURE

1. Set MODE selector to OFF, FUNCTION selector to VOLTS, DISPLAY selector to READ, RANGE selector to full-scale voltage range desired, READ-OUT switch to NORMAL, AMPLITUDE switch to NORMAL, COARSE and MED/FINE AMPLITUDE controls full counterclockwise, and FREQUENCY selector to DC position.

2. Raise protective plexiglass shield and connect instrument which is to be tested to appropriate terminals (see illustration, page 19). After completing connections, lower plexiglass shield until its associated interlocking switch engages.

3. Place MODE selector to + or – DC (SUPPLY) position.

   Calibration of the instrument under test may be accomplished in either of two ways: The Model 829G may be adjusted to provide a desired output as indicated by the digital display and the indication of the instrument under test noted, or, the output amplitude of the Model 829G may be adjusted until the instrument under test indicates the desired value and the applied voltage is then noted on the Model 829G readout display.

4. Advance COARSE AMPLITUDE control one step and then return it to zero to engage interlock circuitry. Advance MED/FINE control approximately half its rotation. Advance COARSE AMPLITUDE control while observing indication of the instrument under test (or the Model 829G readout). Adjust both COARSE and MED/FINE AMPLITUDE controls until desired indication is achieved. The Model 829G display indicates directly the value of EMF applied to the panel output terminals. It should be noted that the display indication lags a change in amplitude adjustment by a second or two.

5. In some instances it may be desirable to retain the Model 829G readout while its indication is noted and manually recorded. This may be accomplished by placing the READOUT switch in HOLD position. This retains the readout which is present at the instant the switch is placed in HOLD; however, it does not lock the output amplitude of the Model 829G. Return READOUT switch to NORMAL after completing the test.

6. When testing analog meters, it is generally advisable to check the movement for friction or bearing sticks. This may be accomplished by the Model 829G in the following manner:

   Adjust COARSE and MED/FINE AMPLITUDE controls for full-scale indication of meter under test. Place AMPLITUDE switch in RUN-UP position. The MED/FINE control may now be used to continuously adjust meter deflection from zero to full-scale or conversely from full-scale to zero. In some cases it may be necessary to advance COARSE control.

   Return AMPLITUDE control switch to NORMAL after completion of RUN-UP tests.

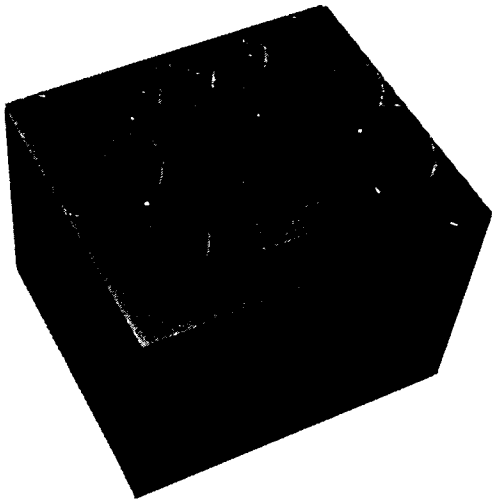
7. Upon completion of calibration operations, return AMPLITUDE controls to full counterclockwise positions, place MODE selector to OFF, raise protective plexiglass shield and disconnect tested instrument.

PRECAUTIONARY NOTES

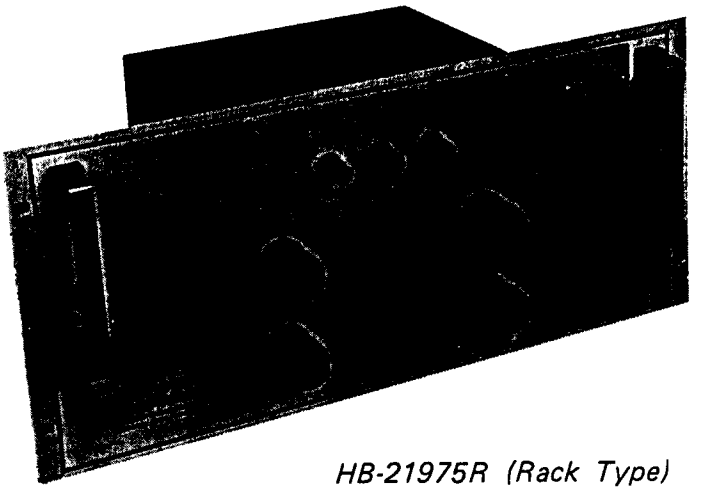
Interlock Operation

If the RANGE, FUNCTION or MODE selector position is changed, or if the plexiglass shield is raised while the Model 829G is energized, the instrument will immediately become de-energized and output will drop to zero. Re-energization may be accomplished by pressing the RESET button, in which case full energization will be realized, or the COARSE AMPLITUDE control may be returned to zero position and again advanced. Where raising the protective shield causes interlock cutout, the shield must be returned to its lowered position before reset of interlock circuit can be accomplished.

CURRENT TRANSFORMER HB-21975



HB-21975 (Bench Type)



HB-21975R (Rack Type)

This current transformer, an accessory available for use with the Model 829G, is used increasing its standardized ac current source of 0-5 or 0-10 amperes, to selectable ranges of 0-20, -50, and -100 amperes. It operates over a frequency range of 50 to 1000 Hz. The transformer is connected to the output of the calibration standard, and a choice of output currents is provided both by changing input current and by choosing taps on the transformer's secondary.

Contact RFL for complete data and specifications.

STANDARD RESISTANCES

Fixed Values:

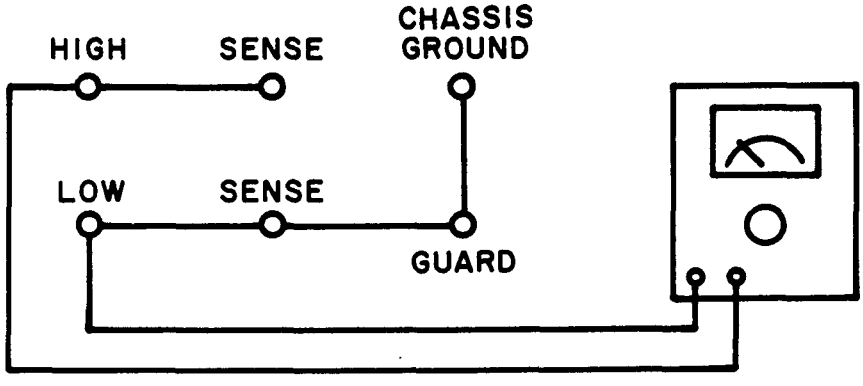
Low Range: 0.01, 0.1, 1, 10 and 100 ohms
High Range: 1k, 10k, 100k, 1M and 10M ohms
Accuracy: ±0.06% of value (based on 4-terminal measurement for values of 0.01 through 100 ohms)

Maximum Power Dissipation:

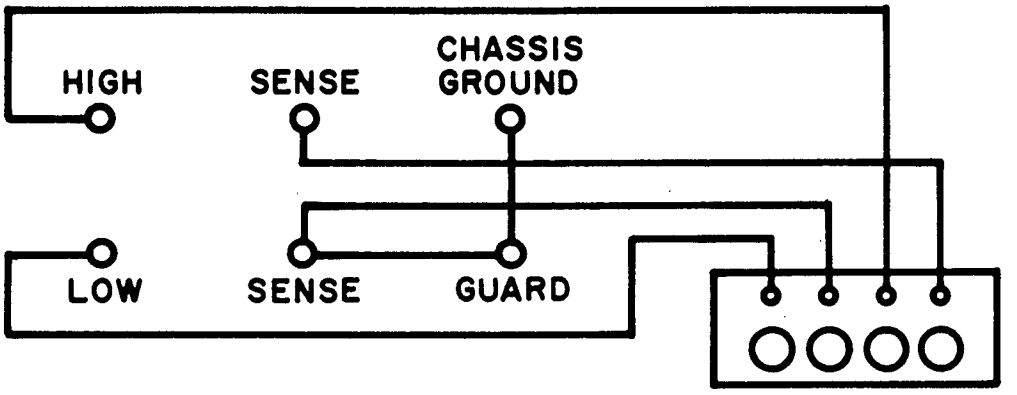
Value	Voltage	Current	Watts
0.01 ohm	0.14V	14.0A	1.96
0.1 ohm	0.14V	1.4A	0.19
1.0 ohm	0.316V	0.316A	0.10
10 ohms	1.0V	0.1A	0.10
100 ohms	3.16V	0.032A	0.10
1k ohms	10V	0.01A	0.10
10k ohms	31.6V	0.003A	0.10
100k ohms	100V	0.001A	0.10
1M ohms	316V	0.3 mA	0.10
10M ohms	1.4 kV	0.1 mA	0.10

NOTE: When operating in STANDARD RESISTANCES the DPM has no function in relation to the STANDARD RESISTANCE.

TERMINAL CONNECTIONS



Two-Terminal Configuration: Ohmmeter Being Calibrated.



Four-Terminal Configuration: Resistance Bridge Being Calibrated.

OPERATIONAL PROCEDURE

Low Value Ranges:

For values of 0.01 ohm to 100 ohms where the maximum accuracy of +0.06% is required, a four-terminal measurement technique should be used. An exception to this is where a relatively low accuracy instrument (such as a 3% multirange VOM) is to be calibrated. In the latter case, a two-terminal configuration should be used.

1. Place MODE selector in OFF position, AMPLITUDE controls full counter-clockwise, FUNCTION selector to low-value ohm designation in STANDARD RESISTORS range, and RANGE selector to desired ohmic value.

2. Raise plexiglass protective shield and connect resistance measuring instrument to Model 829G terminals (see illustration above, Four-Terminal Configuration). Model 829G need not be plugged into power line for operation as a resistance standard.

3. Operate the resistance measuring instrument in its normal manner to verify its accuracy relative to the values and accuracy of the Model 829G standard resistors.

High Value Ranges:

1. Place MODE selector to OFF, AMPLITUDE controls full counterclockwise, FUNCTION selector to high-value ohms designations in STANDARD RESISTORS range, and RANGE selector to desired ohmic value.

2. Raise plexiglass protective shield and connect the resistance measurement instrument which is to be tested to the Model 829G terminals (see illustration, page 23, under Two-Terminal Configuration).

3. Operate the resistance measurement instrument in its normal manner to verify its accuracy relative to the value and accuracy of the resistance standards incorporated in the 829G.

4. NOTE: When using a line operated bridge, disconnect Model 829G from AC line supply.

MEASUREMENT STANDARD OPERATION

AMPERES AC

Full-Scale Ranges: (plus 40% overrange)

0 to 100μA, 1 mA, 10 mA, 100 mA, 1A, 10A

Range Burdens: (excluding connecting leads)

Full-Scale Range	Ohms	Burden Volts*	VA*
100μA	21k	2.1	0.00021
1 mA	2.1k	2.1	0.0021
10 mA	210	2.1	0.021
100 mA	21.2	2.1	0.21
1A	2.13	2.13	2.13
10A	0.2	2.13	21.3

* *Indicates load at full-scale range (not at overrange conditions). Do not exceed full-scale range value by more than 40%. Excess current can result in damage to precision shunts.*

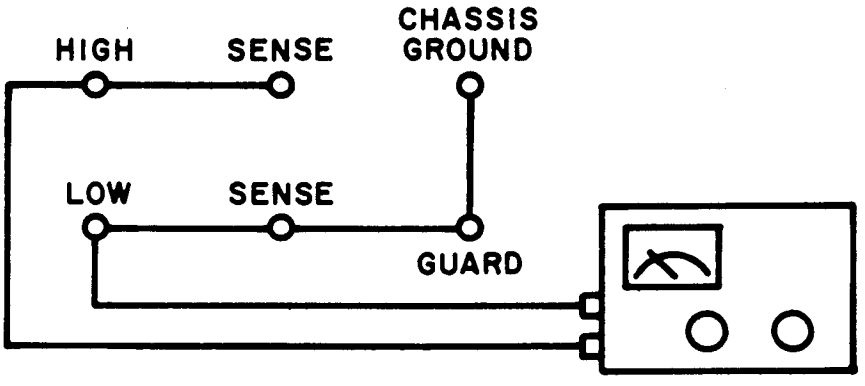
Accuracy: (for 100% to 10% of full-scale range)

(To 1A) ±(0.03% of range +0.05% of reading) +0.5μA

(To 10A) ±(0.03% of range +0.2% of reading)

Frequency Response: 50 - 1000 Hz

TERMINAL CONNECTIONS



Current Source Being Calibrated.

OPERATIONAL PROCEDURE

1. Place READOUT switch in NORMAL position, MODE selector to OFF, AMPLITUDE controls full counterclockwise, FUNCTION selector to AMPERES, RANGE selector to desired range and DISPLAY selector to READ, FREQUENCY selector is not used in this mode of operation.

2. Connect the de-energized source which is to be calibrated to the Model 829G terminals (see illustration, page 25). Raise protective plexiglass shield to facilitate connecting leads. Shield must be lowered until its associated interlocking switch engages before measurement operate can be continued.

3. Place MODE selector to AC (MEASURE). If interlock circuit is activated (RESET push button lighted) it will be necessary to either press the RESET button or advance the COARSE AMPLITUDE control one step and then return it to zero in order to deactivate the circuit.

4. Energize the current source which is to be calibrated. Measurement may be performed in either of two ways: The source may be adjusted to a desired level and the resultant current read from the Model 829G readout, or the source may be adjusted until the Model 829G display indicates a desired value and then the current indication at the source noted. Note: The Model 829G readout display may lag a change in amplitude adjustment of the source by a second or two. In some instances it may be desirable to hold the readout display while the indication is noted and manually recorded. This can be achieved by placing the READOUT switch in HOLD at which time the readout present at the instant the switch is closed will be retained. Return the READOUT switch to NORMAL after completion of observations.

PRECAUTIONARY NOTE

Overrange

Do not exceed rated full-scale range current by more than 40%. Failure to observe this precaution can result in damage to the Model 829G components.

VOLTS AC

Full-Scale Ranges: 0 to 0.1, 1, 10, 100, 1000 Volts (plus 40% overrange)

Input Impedance: 10k ohms/volt

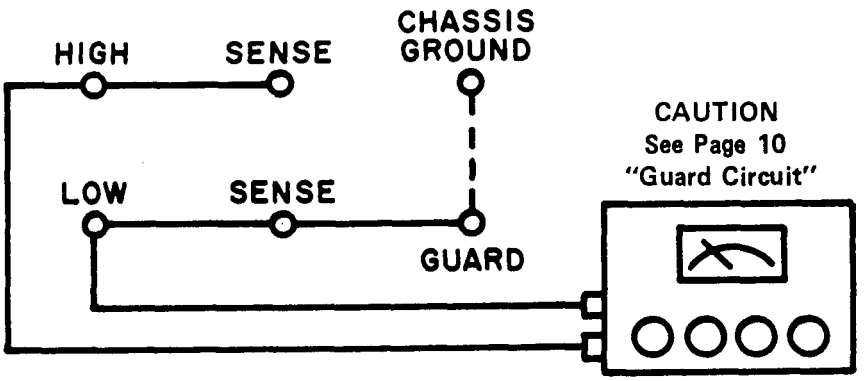
Accuracy: (for 100% to 10% of full-scale range)

±(0.03% of range +0.05% of reading) +0.5 mV

Frequency Response: 50 Hz to 1 kHz

TERMINAL CONNECTIONS

Dashed lines indicate optional connections.
Solid lines indicate mandatory connections.



Voltage Source Being Calibrated.

OPERATIONAL PROCEDURE

1. Place READOUT switch in NORMAL position, MODE selector to OFF, AMPLITUDE controls full counterclockwise, AMPLITUDE switch to NORMAL, FUNCTION selector to VOLTS, RANGE selector to desired range and DISPLAY selector to READ. The FREQUENCY selector is not used in this mode of operation.

2. Connect the de-energized source which is to be measured to the Model 829G terminals (see illustration above). Raise protective plexiglass shield to facilitate connecting leads. Shield must be lowered until its associated interlocking switch engages before measurement operation can continue.

3. Place MODE selector to AC (MEASURE). If interlock circuit is activated (RESET push button lighted) it will be necessary to either press the RESET button or advance the COARSE AMPLITUDE control one step and then return it to zero in order to deactivate the circuit.

4. Energize the voltage source which is to be calibrated. Measurement may be performed in either one or two ways: The source may be adjusted to a desired level and the resultant voltage read from the Model 829G display, or the source may be adjusted until the Model 829G display indicates a desired value and then the voltage indication of the source noted. NOTE: The Model 829G readout may lag a change of amplitude adjustment of the source by a second or two. In some instances it may be desirable to retain the Model 829G display while the indication is noted and manually recorded. This can be achieved by placing the READOUT switch in HOLD position, at which time the indication present at the instant the switch is closed will be retained. Return the READOUT switch to NORMAL after completion of observations.

PRECAUTIONARY NOTE

Overrange

Do not exceed the rated full-scale range voltage by more than 40%. Failure to observe this precaution can result in damage to the Model 829G components.

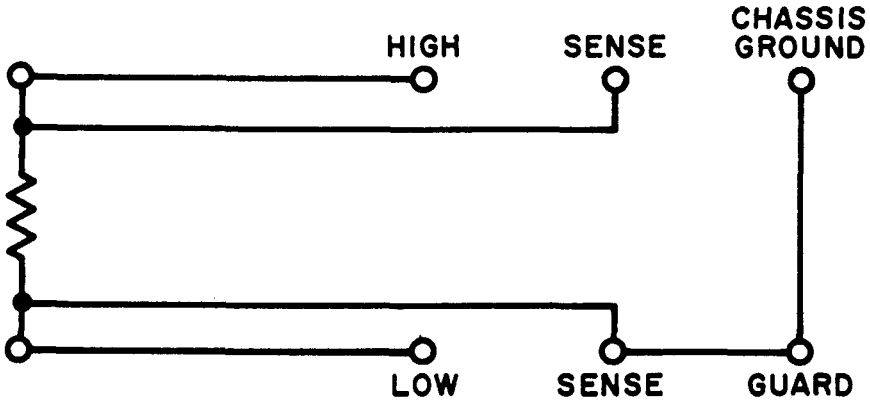
OHMS AC

Full-Scale Ranges: 0 to 0.01, 0.1, 1, 10, 100 ohms (plus 40% overrange)

Accuracy: (for 100% to 10% of full-scale range)

±(0.05% of range +0.05% of reading) +100μ ohms

Terminal Connections:



OPERATIONAL PROCEDURE

1. Set DISPLAY selector to ZERO, FUNCTION selector to OHMS MEASURE (low range), RANGE selector to range commensurate with resistance which is to be measured, MODE selector to OFF, READOUT switch to NORMAL, AMPLITUDE SWITCH to NORMAL, AMPLITUDE controls full counter-clockwise and frequency selector to desired frequency.

2. Connect resistor which is to be measured to the Model 829G terminals as shown in illustration above. Lower protective plexiglass shield until its associated interlocking switch engages. Place MODE selector in AC (SUPPLY) position. Press RESET button or advance COARSE AMPLITUDE control one step and then return it to zero to de-activate interlock circuit. Model 829G display should indicate zero. Set DISPLAY switch to READ. Set FUNCTION selector to AMPERES, advance COARSE AMPLITUDE control one step and return to zero, and adjust COARSE and MED/FINE AMPLITUDE controls until Model 829G display indicates full-scale value of current range. For example, if the RANGE selector is in the 10 ohms position, the applied current through the resistor will be 10.000 milliamperes. Return FUNCTION selector to OHMS MEASURE (low range), press RESET and read resistance value directly from Model 829G display. NOTE: Do not readjust the AMPLITUDE controls after switching the FUNCTION selector from AMPERES to OHMS MEASURE. Each time the FUNCTION selector position is changed it will be necessary to press the RESET button to de-activate the interlock circuit.

NOTES

If Model 829G display does not indicate zero (±3 counts) in Step 2 with DISPLAY selector in ZERO position, it will be necessary to reset the electrical zero of the digital display. See Calibration Procedure section of this manual for adjustment technique.

The current applied through the resistor being measured will be that value adjacent to the range noted on the panel, i.e. 10M ohms - 10A; 100M ohms- 1A; 1 ohm - 100 mA; 10 ohms - 10 mA; and 100 ohms - 1 mA.

AMPERES DC

Full-Scale Ranges: 0 to 100μA, 1 mA, 10 mA, 100 mA, 1A, 10A (plus 40% overrange)

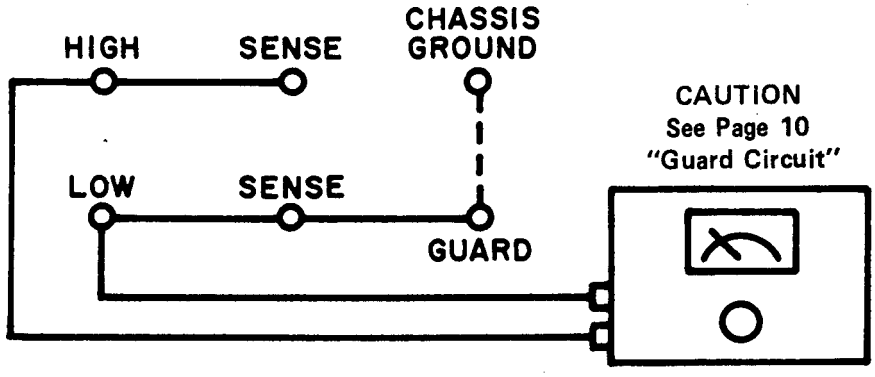
Range Burdens: (excluding connecting leads)

Full-Scale Range	Ohms	Burden Volts*	VA*
100μA	21k	2.1	0.00021
1 mA	2.1k	2.1	0.0021
10 mA	210	2.1	0.021
100 mA	21.2	2.1	0.21
1A	2.13	2.13	2.13
10A	0.2	2.13	21.3

** Indicates load at full-scale range (not at overrange conditions). Do not exceed full-scale range value by more than 40%. Excess current can result in damage to precision shunts.*

TERMINAL CONNECTIONS

Dashed lines indicate optional connections
Solid lines indicate mandatory connections



Current Source Being Calibrated.

OPERATIONAL PROCEDURE

1. Place READOUT switch in NORMAL position, MODE selector to OFF, AMPLITUDE controls full counterclockwise, AMPLITUDE switch in NORMAL, FUNCTION selector to AMPERES, RANGE selector to desired range, and DISPLAY selector to READ position. FREQUENCY selector is not used in this mode of operation.

2. Connect the de-energized source which is to be calibrated to the Model 829G terminals (see illustration, page 31). Raise protective plexiglass shield to facilitate connecting leads. Shield must be lowered until its associated interlocking switch engages before measurement operation can continue.

3. Place MODE selector to DC (MEASURE). If interlock circuit is activated (RESET push button lighted) it will be necessary to either press the RESET button on advance COARSE AMPLITUDE control one step and then return it to zero in order to de-activate the circuit.

4. Energize the current source which is to be calibrated. Measurement may be performed in either one of two ways: The source may be adjusted to a desired level and the resultant current read from the Model 829G display, or the source may be adjusted until the Model 829G display indicates a desired value and then the current indication at the source noted. NOTE: The Model 829G readout display may lag an amplitude change in the source by a second or two. In some instances it may be desirable to retain the Model 829G display reading while the indication is noted and manually recorded. This can be achieved by placing the READOUT switch in HOLD position at which time the readout present at the instant the switch is closed will be retained. Return the READOUT switch to NORMAL after completion of observations.

PRECAUTIONARY NOTE

Overrange

Do not exceed full-scale rated current by an amount greater than 40% of full-scale range. Failure to observe this precaution can cause damage to the Model 829G circuitry.

VOLTS DC

Full-Scale Ranges: 0 to 0.1, 1, 10, 100, 1000 volts (plus 40% overrange)

Input Impedance: 10k ohms/volt

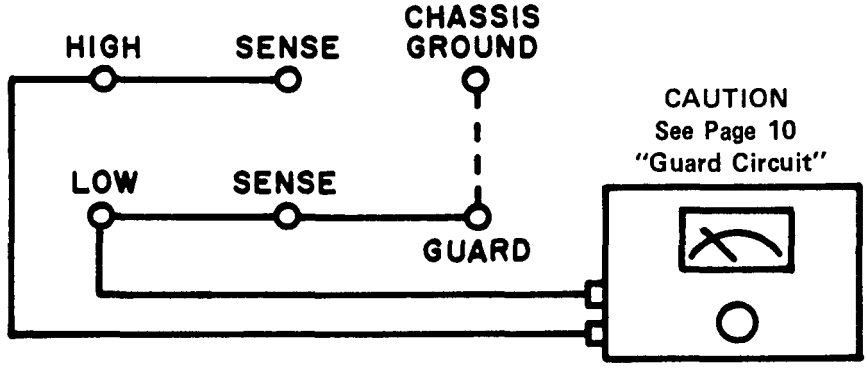
Accuracy: (for 100% to 10% of full-scale)

±(0.02% of range +0.03% of reading) +0.1mV

Caution: Do not exceed full-scale rated input by more than 40%. Failure to observe this precaution can result in damage to the Model 829G.

TERMINAL CONNECTIONS

Dashed lines indicate optional connections.
Solid lines indicate mandatory connections.



Voltage Source Being Calibrated.

OPERATIONAL PROCEDURE

1. Place READOUT switch in NORMAL position, MODE selector to OFF, AMPLITUDE controls full counterclockwise, AMPLITUDE switch to NORMAL, FUNCTION selector to VOLTS, RANGE selector to desired range and DISPLAY selector to READ position. The FREQUENCY selector is not used for this mode of operation.

2. Connect the de-energized source which is to be measured to the Model 829G terminals (see illustration above). Raise protective shield to facilitate connecting leads. The shield must be lowered until its associated interlocking switch engages before measurement operation can continue.

3. Place MODE selector to DC (MEASURE). If interlock circuit is activated (RESET push button lighted) it will be necessary to either press the RESET button or advance COARSE AMPLITUDE control one step and then return it to zero in order to de-activate the circuit.

4. Energize the voltage source which is to be calibrated. Measurement may be performed in either one of two ways: The source may be adjusted to a desired level as indicated by its readout and the resulting voltage read on the Model 829G display, or the source may be adjusted until the Model 829G display indicates a desired value and the source indicator then noted for indication. NOTE: The Model 829G display may lag a change in amplitude adjustment of the source by a second or two. In some instances it may be desirable to retain the Model 829G reading while the indication is noted and manually recorded. This can be achieved by placing the READOUT switch in HOLD position at which time the readout present at the instant the switch is closed will be retained. Return READOUT switch to NORMAL at completion of observations.

PRECAUTIONARY NOTE

Overrange

Do not exceed full-scale rated voltage by more than 40%. Failure to observe this precaution can cause damage to the Model 829G circuitry.

OHMS DC

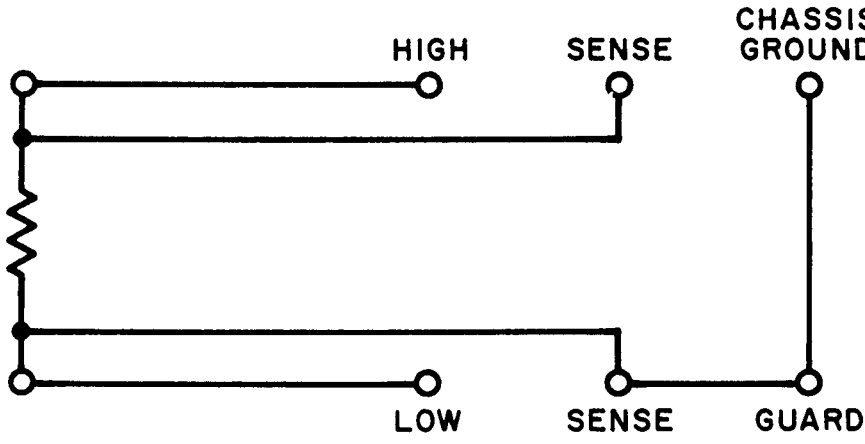
Low Ranges

Full-Scale Ranges: 0 to 0.01, 0.1, 1, 10, 100 ohms (plus 40% overrange)

Accuracy: (for 100% to 10% of full-scale range)

±(0.02% of range +0.03% of reading) +100μ ohms

TERMINAL CONNECTIONS



OPERATIONAL PROCEDURE

1. Set DISPLAY selector to ZERO, FUNCTION selector to OHMS MEASURE (low ranges), RANGE selector to range commensurate with resistance which is to be measured. MODE selector to OFF, READOUT switch to NORMAL, AMPLITUDE SWITCH to NORMAL, AMPLITUDE controls full counter-clockwise and FREQUENCY selector to 400 Hz.
2. Connect resistor which is to be measured to the Model 829G terminals as shown in illustration above. Place MODE selector to +DC (SUPPLY) position. Press RESET button or advance COARSE AMPLITUDE control one step and then return it to zero to de-activate the interlock circuit. Model 829G display should indicate zero (±3 counts). Set FUNCTION selector to AMPERES and advance COARSE AMPLITUDE control one step and return to zero. Set DISPLAY selector to READ position. Adjust COARSE and MED/FINE controls until Model 829G display indicates full-scale. For example, if RANGE selector is set to 10 ohms range, full-scale current will be 10.000 milliamperes. Return FUNCTION selector to OHMS MEASURE (low ranges), press RESET and read resistance value directly from Model 829G display. NOTE: Do not readjust Model 829G AMPLITUDE controls after switching FUNCTION selector from AMPERES to OHMS MEASURE. Each time FUNCTION selector position is changed it will be necessary to press RESET button in order to re-activate the interlock circuit.

NOTES

If Model 829G display does not indicate zero (±3 counts) in Step 2 with DISPLAY selector in ZERO position, it will be necessary to reset the electrical zero of the digital display. See Calibration section of this manual for adjustment procedure.

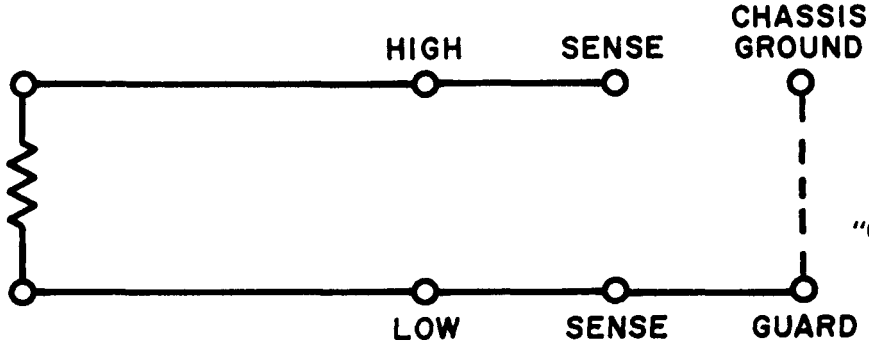
The current applied through the resistor being measured will be that value adjacent to the range noted on the panel; i.e. 10M ohms - 10A; 100M ohms - 1A; 1 ohm - 100 mA; 10 ohms - 10 mA; and 100 ohms - 1 mA.

OHMS DC
High Ranges

Full-Scale Ranges: 0 to 1k, 10k, 100k, 1M, 10M

Accuracy: ±(0.02% of range +0.03% of reading) +0.1 ohm (to 100k)
±(0.02% of range +0.1% of reading) (to 1 Megohm)
±(0.02% of range +0.2% of reading) (to 10 Megohms)

TERMINAL CONNECTIONS



CAUTION
See Page 10
"Guard Circuit"

OPERATIONAL PROCEDURE

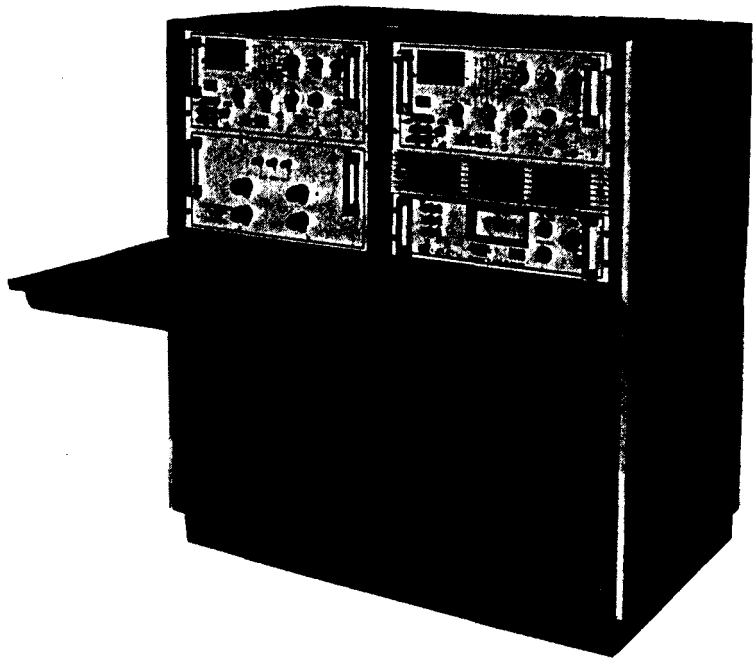
1. Place MODE selector to OFF, FUNCTION selector to OHMS MEASURE (high ranges), RANGE selector to range commensurate of resistance which is to be measured, READOUT switch to NORMAL, AMPLITUDE controls full counterclockwise, AMPLITUDE switch to NORMAL, FREQUENCY selector to 400 Hz (DC) and DISPLAY selector to zero.

2. Connect resistor which is to be measured to Model 829G terminals as shown in illustration above. Place MODE selector to DC (MEASURE) position. Model 829G readout should indicate zero (±3 counts), if zero ±3 last place digit is not indicated, see Calibration section of this manual for adjustment procedure.

3. Place DISPLAY selector in OHMS CAL position. Model 829G display should indicate full-scale, i.e. 10.000 or 1.000, etc. (If full-scale reading is not evident, see Calibration section of this manual for adjustment procedure.)

4. Place DISPLAY selector to READ position. Model 829G display will indicate value of resistance.

MODEL 5058A
WATTMETER CALIBRATION MODULE

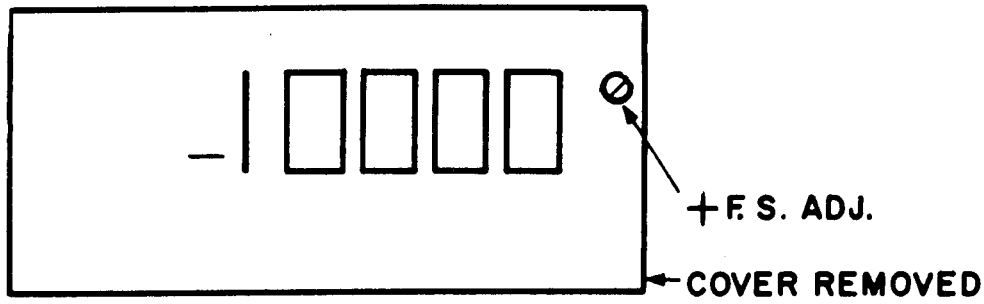


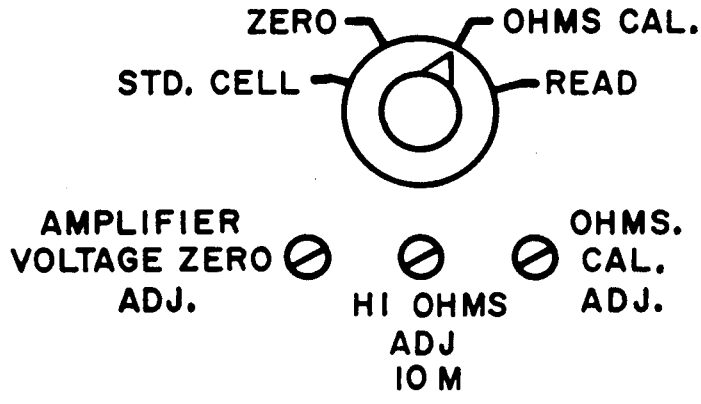
The Model 5058A Wattmeter Calibration Module is an accessory unit, for use with two Model 829G Calibration Standards, which enables calibration of four-terminal wattmeters. Range is from 0.05 watt to 14,000 watts, at frequencies of 50, 60, 400, and 1000 Hz. Power factor is adjustable from unity to zero, or 0 to 90° phase angle. The module includes all necessary shunts and multipliers, phase-shifting networks and controls, and also a direct-reading phase-angle/power-factor meter.

A complete system for measuring voltage, current, and power can be obtained with individual purchases of Model 829G Standards and the wattmeter calibration module. The complete system is also available in an attractive customized enclosure, with work table, as shown.

Contact RFL for complete data and specifications.

CALIBRATION





DISPLAY

MODEL 829G SELF CALIBRATION

Allow equipment to warm-up at least one-half hour prior to making any calibration checks.

1. Set DISPLAY to READ, FUNCTION to VOLTS, RANGE to 100 mV, and set COARSE and FINE AMPLITUDE controls fully counterclockwise. Short across high and low output terminals. Adjust amplifier voltage zero control, identified above, until the blank and – indicators reach the toggle point. This is the point at which the blank and – indicators appear alternately in a random manner. Disregard any reading on the DPM. Note there will be a two-digit reading if the controls should be set to AC volts. This threshold noise will not affect accuracy of output or indication at either full scale or down scale.

   When the Model 829-G has an internal standard cell, the instrument is self calibratable, excepting for the 10-megohm range.

   When the instrument is not furnished with an internal standard cell, an external cell or solid-state reference may be used. It is connected to the pins

marked STD CELL, located on the panel of the measurement module at the center of the rear panel. Note polarity and connect the reference accordingly. The emf of the reference should be known to within ±0.01%. Place the STD CELL switch to EXT or to INT as appropriate.

2. Place REVERSE-NORMAL switch, located at the back of the instrument on the measurement module, to REVERSE, and set DISPLAY to STD CELL. Record the negative (—) full-scale reading of the DPM as well as the known value of the reference.

   Next set REVERSE-NORMAL switch to NORMAL and adjust +FS control, identified on page 39, until the same known emf is indicated.

   Repeat these steps alternately until both + and — readings of the DPM are equal to the certified potential of the standard cell.

3. Set DISPLAY switch to OHMS CAL. and FUNCTION selector to HI OHMS MEASURE. Short the HIGH output terminal to the LOW terminal. Adjust the CAL. ADJ. control until the DPM indicates 1.0000. Place DISPLAY switch in READ position. Remove short from the output terminals. Connect a precision 10 megohm resistor (±0.03%) across the output terminals and adjust HI OHMS Adj. 10M control until DPM indicates 10.000.

MAINTENANCE

The Model 829G is basically a combination of four major circuit sections: Power Supply, Digital Panel Meter, Measurement Module, and Oscillator. If a problem exists, it is suggested that a preliminary check of the power supplies be taken. The following voltages apply.

REFERENCE — Negative side of C1 – Common
Positive side of C1 – Approx. +70V DC unreg.
Negative side of C2 – Approx. -70V DC unreg.
Cathode of CR5 – Approx. +15V DC
Anode of CR6 – Approx. -15V DC

The following chart should be useful for locating a problem but does not exclude other circuitry which might be the cause of a particular problem.

Troubleshooting Guide

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
RESET indicator remains lighted continuously or its operation appears erratic.	MODE selector in OFF position.		Place MODE selector to one of its operational positions.
	RANGE, FUNCTION or MODE selectors not in their detented positions.		Rotate selector knobs to be certain switches are seated in detent positions.
	Defective over-range trip board	Voltage not zero at CR15 anode	IC401, Q401, or Q402

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
RESET indicator remains lighted continuously or its operation appears erratic.	COARSE AMPLITUDE control in zero position.		Rotate control several steps clockwise and return to zero.
	Plexiglass terminal shield not activating its associated switch S10.	Audible click should be heard as shield is raised or lowered.	Switch push rod may be binding against panel. S10 may be defective. Adjust or replace as required.
	Heat sink temperature thermostat open due to prolonged overload conditions or defective thermostat.	S11	Allow instrument to cool for several minutes until thermostat automatically resets. Replace if defective.
	Overvoltage sensor shorted. Capacitor C14 defective.	SCR (CR-15) on circuit board located on underside of instrument.	Replace if defective.
	Relay K1 not operating or operating erratically.	Relay K1 coil and supply current.	Pull-in current 8 mA, drop-out current 3.5 mA. Nominal operating current approx. 5.5 mA. Resistor R53 is current limiting component for this relay.
	Spurious oscillation in power amplifier/preamplifier.	Connect oscilloscope to front panel LOW terminal and terminals 1 - 2 on TB2 (rear of instrument). Check for r.f. oscillation.	Roll-off capacitor C110. May require selected value to cancel spurious oscillation.

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
Front panel thermal circuit breaker releases repeatedly with 829G operating below its rated output.	Defective breaker.	CB1	Replace
	Change of breaker sensitivity.	CB1	Adjust set screw on rear of breaker for lower sensitivity (CCW rotation raises current rating).
	Excessive idle current through power amplifier.	Voltage drop across each 5 ohm resistor R12 thru R17 not to exceed 2V DC.	Adjust current limiting resistor R7 until drop across each of the 5 ohm resistors is approx. 2V DC.
	Preamplifier roll-off shift causing spurious oscillation.	Remove shorting strap from pins 1 - 2 on TB2 (rear panel of instrument). If circuit breaker can then be reset, preamplifier or power amplifier is suspect.	Shorted or leaky transistors Q1 thru Q8. Replace if necessary. Adjust value of C110 or R119 on preamplifier board or check for and replace any defective components on preamplifier board.
Reset circuit does not operate (i.e. RESET lamp does not glow and relay K1 does not drop out) when AMPLITUDE controls are run to full maximum in any voltage range with output terminals open-circuited.	CR15 and associated circuitry.	Check CR15 and visual indication of operation on vacuum spark gaps E1, E2, or E3.	Replace defective component.

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
Panel meter reading indicates 14000, regardless of AMPLITUDE control adjustment.	READOUT switch locked in HOLD or PRINT COMMAND position.	READOUT switch.	Place switch to NORMAL.
	Measurement Module not fully seated in its associated socket.		Tighten Module slotted head seating shaft located on Module panel.
	Loose plug-in board in DPM unit.	DPM.	Remove DPM cover and seat all boards and I.C.'s.
	Defective DPM.		Replace DPM or service per DPM manual supplied with instrument.
DPM zero adjustment does not allow DPM to be set to zero with DISPLAY selector in ZERO position.	Excessive heat rise in DPM.	Model 829G circulation fan or associated plug.	Loose or defective plug or defective fan. Tighten or replace as necessary.
	Defect in DPM.		See DPM Instruction Manual supplied with instrument.
AMPLIFIER VOLTAGE ZERO adjustment fails to achieve zero DPM indication when following procedure described under (4) of Calibration Procedure.	Defective Operational Ampli-	Op-Amp. IC301.	Replace if defective.
	Operational Amplifier IC301 characteristics change.		Adjust R344. Trim resistor value by replacing resistor with units having adjacent values (i.e. 510 ohms or 420 ohms).

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
Insufficient output.	Defective transistors in power amplifier.	Check for peak-to-peak signal level of not less than 60V on pins 1-2 of TP2.	Replace transistors.
	Low DC voltages to amplifiers.	EMF levels from DC power supplies as noted in initial steps of this maintenance section.	Locate faulty component and replace as necessary.
	Defective signal transformer or its associated circuitry.	Transformer T2 and associated wiring and components.	Repair or replace as required.
All DC and AC voltage ranges out of tolerance.	Defective voltage sense resistor.	Value of R339 plus associated trimming resistor should be 10K ohms ±0.01%.	Replace as required.
All DC and AC current ranges out of tolerance.	Defective current sense resistor.	Value of R342 plus associated trimming resistor should be 1111.1 ohms ±0.01%.	Replace as required.
All AC current ranges out of tolerance.	Resistor R348 requires adjustment.	Adjustment of R348.	Remove top cover of 829G. With instrument adjusted for 1.0000 ampere output on 1 ampere range adjust R348 for DPM indication of 1.0000 (400 Hz frequency).

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
All AC voltage ranges out of tolerance.	Resistor R347 requires adjustment.	Adjustment of R347.	Remove top cover of 829G. With instrument adjusted for 100.00 volt output on 100 volt range, adjust R347 for DPM indication of 100.00 volts (400 Hz freq.).
Output voltage correct when MODE selector set to +DC but erroneous when set to -DC.	Insulation breakdown between low side of circuitry and ground.	C7 - C10, CR11 & CR12 and associated wiring and switches for short.	Repair shorted condition or replace defective component.
Calibration out of tolerance but standard resistors measure correctly.	Meter + and -.	Standard cell + and -.	Adjust meter. See DPM Manual.
	Defective Operational Amplifier or associated component.	IC301. Check for spurious oscillation at terminals 1 & 3 on Measurement Module panel.	Replace IC301 if found defective. If oscillation is apparent on both upper and lower portions of waveform select appropriate value of capacitor for C309. If oscillation appears only on upper portion of waveform select appropriate value for C305. If oscillation is apparent only on lower half of waveform select an appropriate value of capacitance for C306..
	Defective preamplifier.	Check TB2 terminals 1 & 2 to chassis (rear of instrument) for spurious oscillations.	If oscillation is apparent on upper half of waveform, increase C111. If oscillation is apparent on lower half of waveform, check C105, C106, C109 & R116 on preamplifier.

SYMPTOM	PROBABLE CAUSE	CHECK	POSSIBLE CORRECTION
One particular range out of tolerance.	Defective resistive component caused by over dissipation when operating instrument in its MEASURE mode (i.e. excessive current or voltage applied).	Appropriate precision resistor. See procedure under Precision Resistors, page 23 of this manual.	Replace as required.
Output value of voltage current or resistance differs from selected range by a factor of 10.	Misalignment between front section of RANGE selector rear section.	Coupler between front (panel) section and rear (Measurement Module) section.	Remove Model 829G top cover. Remove Measurement Module from instrument. Rotate RANGE selector full CCW (100 mV) position). Rotate switch shaft on front of Measurement Module fully CCW. Replace Measurement Module into Model 829G and observe alignment of coupler. Loosen and reset set screws if necessary.
Output appears on front panel terminals but Model 829G DPM does not indicate.	Loose binding post on front panel or link not in position.	Tightness of terminals and presence of links.	
	READOUT or DISPLAY switch in other than NORMAL position.	READOUT & DISPLAY switch.	Place switch in NORMAL position.
	DPM.	If instrument incorporates internal standard cell, place DISPLAY switch to STD. CELL position. Correct reading indicates DPM satisfactory. An external EMF of approx. 1 volt may also be used.	DPM failure may indicate excessive EMF has been applied. Check EMF applied to DPM by means of a high impedance voltmeter connected in place of DPM input. EMF applied to DPM at full-scale range value is 1 volt.

Table of Recommended Spare Parts

SYMBOL DESIGNATION	RFL P/N	RECOMMENDED QUANTITY	DESIGNATION
C4, C5, C6	HA-7710	1	Filter Capacitor: 0.5μF, 2000 volts
CB1	HB-11663	1	Line Circuit Breaker: 5A for 115 volt line
	HA-17310	1	Line Circuit Breaker: 3A for 220 volt line
CR15	HA-26927	1	C106B-2 Silicon Controlled Rectifier
CR103, CR104, CR215, CR216 CR303, CR304, CR313, CR314 CR315, CR316, CR319, CR320	HA-29074	2	Diode: Type 1N4448
CR317, CR318	HA-31025	1	Hot Carrier Diode
IC101	H-0620-27	1	Operational Amplifier:(pre-amp) LM-301-A
IC201	H-0620-7	1	Operational Amplifier:(oscillator) u709G
R106	H-1100-393	1	Parasitic Suppressor Resistor: 10 ohms, 5 W
S7	HA-38512	1	Reset Indicator and Switch
S11	HA-31759	1	Heat Sink Thermostat: 227°F. operating point

TABLE OF REPLACEABLE PARTS

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
B1	Fan assembly	HA-20299
C1, 2	Capacitor, electrolytic, 5900 μF, −10 +75%, 75 V	HA-31026
C3	Capacitor, electrolytic, 2 μF, −10 +50%, 100 V	H-1007-870
C4, 5, 6	Capacitor, paper, 0.5 μF, 10%, 3000 V	HA-7710
C7	Capacitor, electrolytic, 240 pF, −10 +50%, 300 V	HA-28469
C8	Capacitor, electrolytic, 95 μF, −10 +50%, 350 V	HA-28468
C9, 10	Capacitor, electrolytic, 18000 μF, −10 +75%, 25 V	HA-31028
C11	Capacitor, metallized mylar, 1 μF, 2%, 200 V	H-1007-482
C12	Capacitor, mylar, 0.1 μF, 10%, 200 V	H-1007-622
C13	Capacitor, mylar, 1 μF, 10%, 100 V	H-1080-350
C14, 15	Capacitor, ceramic, 0.47 μF, −20 +80%, 50 V	H-1007-939
C16	Capacitor, mylar, 0.47 μF, 2%, 200 V	H-1007-1138
C17	Capacitor, mylar, 0.47 μF, 2%, 100 V	H-1007-448
C101, 102	Capacitor, electrolytic, 100 μF, −10 +75%, 25 V	H-1007-882
C103	Capacitor, mica, 0.001 μF, 5%, 500V	H-1080-245
C104, 107	Capacitor, ceramic disc, 0.01 μF, 20%, 500 V	H-1007-83
C105	Capacitor, mica, 15 pF, 5%, 500 V	HA-16506
C106	Capacitor, mica, 30 pF, 5%, 500 V	HA-16510
C108	Capacitor, metallized mylar, 1 μF, 2%, 200 V	H-1007-482
C109	Capacitor, mica, 47 pF, 5%, 500 V	HA-16515
C110	Capacitor, mylar, 0.02 μF, 2%, 100 V	H-1007-669
C111	Capacitor, mica, 68 pF, 5%, 500 V	HA-16518
C200-234	Not used	
C235	Capacitor, mica, 10 pF, 5%, 500 V	HA-16504
C236	Capacitor, tantalum, 22 μF, 20%, 15 V	H-1007-656
C237, 238	Capacitor, poly., 0.00315 μF, 2%, 100 V	H-5515-10
C239, 240	Capacitor, tantalum, 10 μF, 10%, 20 V	H-1007-955
C241, 242	Capacitor, tantalum, 33 μF, 20%, 20 V	H-1007-1161
C243	Capacitor, tantalum, 6.8 μF, 20%, 15 V	H-1007-916
C301, 302	Capacitor, ceramic disc, 0.1 μF, −20 +80%, 500 V	H-1007-201
C303	Not used	
C304	Capacitor, mylar, 1.0 μF, 10%, 100 V	H-1080-350

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
C305, 306	Capacitor, mica, 20 pF, 5%, 500 V	HA-16507
C307	Capacitor, mica, 0.0012 μF, 2%, 500 V	HA-16212
C308	Not used	
C309	Capacitor, mica, 27 pF, 5%, 500 V	HA-16509
C310	Not used	
C311	Capacitor, factory-adjusted	HA-33324
CB1	Circuit breaker, 5 amp	HB-11663
CR1-4, 7	Diode, silicon, 5 amp., 400 V	HA-31024
CR5, 6	Diode, zener, 15 V, 5%, 1 W, Type 1N4744A	HA-29756
CR8	Diode, silicon, 8 kV, PIV	HA-31769
CR9	Diode, silicon, 3 amp., 600 V	HA-31092
CR10, 11, 12, 13	Diode silicon, 20 amp., Type 1N248C	HA-18612
CR14, 24	Diode, zener, 39 V, 10%, 1 W, Type 1N4754	HA-31758
CR15	Silicon-controlled rectifier, 2 amp., 200 V	HA-26927
CR16, 17	Not used	
CR18-23, 25, 26	Diode, silicon, 1 amp., Type 1N4003	HA-30769
CR101, 102	Diode, silicon, 5 amp, 400 V	HA-31024
CR103, 104	Diode, silicon, Type 1N914B/1N4448	HA-26482
CR200-219	Not used	
CR220	Diode, zener, 6.2 V, 400 mW, Type 1N821A	HA-31033
CR221-223	Diode, silicon, Type 1N914B/1N4448	HA-26482
CRZ224	Rectifier bridge, 50 V, 1 A	HA-46371
CR225	Diode, zener, 6.8 V, 5%, 1 W, Type 1N4736A	HA-29752
CR301, 302	Diode, Type 1N965B, See Note 2	HA-31091
CR303, 304, 313-316, 319, 320	Diode, silicon, Type 1N914B/1N4448	HA-26482
CR305, 306	Not used	
CR307, 308, 311, 312	Diode, planar, WIV 125 V, FD333	HA-31049
CR309, 310	Diode, zener, 6.2 V, 5%, 1 W, Type 1N4735A	HA-29751
CR317, 318	Diode, hot-carrier, HP50822900, or eq.	HA-31025
E1, 2	Surge suppressor	HA-31754

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
E3	Surge suppressor	HA-34119
I1	Lamp, incandescent, 28V, 0.04A	HA-39396
I2	Lamp, incandescent, 28V, 0.04A	HA-34143
IC101	Linear opamp., Analog Devices AD301ALH, or eq.	H-0620-86
IC102	Not used	
IC202	Linear opamp, Texas Inst. TL-4300LP, or eq.	H-0620-151
IC203	Linear opamp., National LF355N, or eq.	H-0620-139
IC204	Photo-coupled resistor CLM-8200	HA-46545
IC301	Linear opamp., Analog Devices 146J, or eq.	HA-31767
J1	Jack, telephone, 3-conductor	HA-27142
J2	Connector, coaxial, BNC	HA-47568
J3	Connector, plug, female	HA-33369
J4	Connector, edge, 15-term, for use with BCD option	HA-25474
J5	Not used	
J6	Connector housing, molded	HA-31021
K1, 3	Relay, DPDT, 2K ohm resistance	HA-18574
K2	Relay, 4PDT, 24-Vdc coil	HA-31075
K301	Not used	
K302	Relay, 4PDT 2500 ohms, 8.4 mA	HA-26510
L1	Choke, swinging, 0.01 H @ 10A	HB-18459
L2	Choke	HB-31977
M1	Meter, panel, digital	HC-90301
P1	Card, power, with molded plug, 9-ft.	HA-29672
P2	Connector, plug, male	HA-33368
P301	Connector, shell plug	HA-31020
Q1, 2	Transistor, silicon, NPN, Type 2N4347	HA-21544
Q3-8	Transistor, selected, Type 2N3773	HA-49508
Q101-102, 103, 105	Transistor, silicon, NPN, Type 2N2102	HA-22678
Q104	Transistor, silicon, PNP, Type 2N4036	HA-24003
R1, 2, 5, 6, 28, 29, 51, 64, 71, 72	Resistor, wirewound, 0.15 ohms, 5%, 3W	H-1100-592
R3, 4	Resistor, wirewound, 1K, 5%, 3.25W	H-1220-24
R7	Resistor, wirewound, adjustable, 2 ohms, 10%, 25W	H-1100-44

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
R8, 10	Resistor, wirewound, 10 ohms, 5%, 5W	H-1100-393
R9, 11	Resistor, wirewound, 100 ohms, 5%, 3.25W	H-1220-33
R12-17	Resistor, wirewound, 5 ohms, 5%, 25W	H-1100-607
R18, 79	Resistor, wirewound, 0.1 ohm, 5%, 3W	H-1100-606
R19, 20, 22	Resistor, wirewound, 3.5K, 5%, 12W	H-1100-404
R21, 56	Resistor, metal-film, 390K, 5%, 2W	H-1510-1076
R23	Resistor, wirewound, 7K, 5%, 20W	H-1100-624
R24	Resistor, wirewound, 5 ohms, 5%, 3.25W	H-1100-449
R25	Resistor, wirewound, 2.7K, 5%, 11W	H-1100-600
R26, 58	Resistor, wirewound, 200 ohms, 5%, 25W	H-1100-608
R27	Resistor, wirewound, 2 ohms, 5%, 11W	H-1100-548
R30	Resistor, wirewound, 5 ohms, 5%, 50W	H-1100-695
R31	Resistor, wirewound, 1 ohm, 5%, 12W	H-1100-260
R32	Resistor, wirewound, 0.1 ohm, 3%, 25W	H-1780-45
R33	Not used	
R34-48, 61, 68	Resistor, fixed, composition, 1K, 5%, 0.25W	H-1009-612
R49	Resistor, fixed, composition, 2.7K, 5%, 0.25W	H-1009-762
R50	Resistor, variable, wirewound, 10K, 3%, 3W	HA-31036
R51	Not used	
R52	Resistor, fixed, composition, 47K, 5%, 0.5W	H-1009-517
R53	Resistor, fixed, composition, 4.7K, 10%, 1W	H-1009-428
R54	Resistor, wirewound, 150 ohms, 5%, 11W	H-1100-599
R55	Resistor, wirewound, 1.8K, 5%, 3.25W	H-1100-620
R57	Resistor, wirewound, 500 ohms, 5%, 12W	H-1100-208
R59	Not used	
R60	Resistor, metal-film, 220K, 5%, 2W	H-1510-1184
R62	Resistor, metal-film, 220 ohms, 5%, 2W	H-1510-1083
R63	Resistor, variable, metal-film, 100 ohms, 20%, 0.75W	HA-31040
R65	Resistor, variable, metal-film, 200 ohms, 20%, 0.75W	HA-34610
R66	Resistor, variable, metal-film, 100K, 20%, 0.75W	HA-31791
R67	Resistor, metal-film, 100K, 5%, 1/4W	H-1510-1069
R69	Not used	
R70	Resistor, metal-film, 1K, 5%, 2W	H-1510-786

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
R73	Resistor, fixed, composition, 1.5 mg., 10%, 0.5W	H-1009-488
R74	Not used	
R75, 76	Resistor, fixed composition, 3.3 meg., 10%, 0.5W	H-1009-406
R77	Resistor, fixed, composition, 2.7K, 5%, 0.5W	H-1009-964
R78	Resistor, adjustable, wirewound, 1 ohm, 10%, 50W	H-1100-337
R79	Not used	
R80	Resistor, fixed, composition, 27 ohms, 5%, 0.5W	H-1009-933
R101, 102, 103	Resistor, metal-film, 100K, 5%, 0.25W	H-1510-1069
R104	Resistor, metal-film, 10K, 5%, 0.25W	H-1510-1067
R105	Resistor, metal-film, 33K, 5%, 0.25W	H-1510-1068
R106	Resistor, wirewound, 10 ohms, 5%, 5W	H-1100-393
R107	Resistor, metal-film, 1K, 5%, 0.25W	H-1510-1066
R108	Resistor, fixed, composition, 100K, 5%, 0.25W	H-1009-795
R109, 113, 116	Resistor, fixed, composition, 1K, 5%, 0.5W	H-1009-77
R110	Resistor, fixed, composition, 10K, 5%, 0.25W	H-1009-742
R111	Resistor, metal-film, 4.7K, 5%, 2W	H-1510-1077
R112, 115	Resistor, metal-film, 220 ohms, 5%, 2W	H-1510-1083
R114, 117	Resistor, fixed, composition, 100 ohms, 5%, 0.5W	H-1009-149
R118	Resistor, fixed, composition, 2K, 5%, 0.25W	H-1009-760
R119	Resistor, fixed, composition, 470 ohms, 5%, 0.25W	H-1009-751
R120	Resistor, fixed, composition, 470K, 5%, 0.25W	H-1009-797
R121	Resistor, fixed, composition, 43K, 5%, 0.25W	H-1009-882
R200-249	Not used	
R250	Resistor, metal-film, 3.65K, 1%, 0.125W	H-1510-1527
R251	Resistor, variable, metal-film, 10K, 10%, 0.5W	HA-47147
R252	Resistor, metal-film, 23.7K, 1%, 0.125W	H-1510-1278
R253-256, 267, 268	Resistor, metal-film, 20K, 1%, 0.125W	H-1510-1149
R257, 258, 259, 271, 272	Resistor, metal-film, 10K, 1%, 0.125W	H-1510-775
R260	Resistor, fixed, composition, 3.3K, 5%, 0.25W	H-1009-729
R261	Resistor, metal-film, 1.30K, 1%, 0.125W	H-1510-1517
R262	Resistor, metal-film, 150K, 1%, 0.125W	H-1510-1585

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
R263	Resistor, metal-film, 48.7K, 1%, 0.125W	H-1510-1559
R264	Resistor, metal-film, 4.42K, 1%, 0.125W	H-1510-1529
R265	Resistor, metal-film, 301K, 1%, 0.125W	H-1510-1576
R266	Resistor, variable, metal-film, 5K, 10%, 0.5W	HA-49462
R269, 270	Resistor, metal-film, 1000K, 1%, 0.25W	H-1510-508
R273, 276	Resistor, metal-film, 5.11 meg., 1%, 0.25W	H-1510-2024
R274, 277	Resistor, metal-film, 150K, 1%, 0.125W	H-1510-1585
R275, 278, 283, 284	Resistor, metal-film, 54.9K, 1%, 0.125W	H-1510-1561
R280	Resistor, metal-film, 3.01K, 1%, 0.125W	H-1510-711
R281	Resistor, metal-film, 2K, 1%, 0.125W	H-1510-1096
R282	Resistor, fixed, composition, 4.7K, 5%, 0.25W	H-1009-787
R301	Resistor, wirewound, 5 meg., 2.5W	HA-28458
R302	Resistor, wirewound, 1 meg., 1W	HA-31797
R303	Resistor, wirewound, 100K, 1W	HA-31798
R304, 339	Resistor, wirewound, 10K, 1W	HA-31840
R305, 311	Resistor, wirewound, 1K, 1W	HA-31841
R306	Resistor, assembly, 0.01 ohm, ±0.01%	HB-24220
R307	Resistor, assembly, 0.1 ohm, 0.01%	HB-24219
R308	Resistor, assembly, 1 ohm, 0.1%	HB-34113
R309	Resistor, wirewound, 10 ohms, ±0.1%	HA-31799
R310	Resistor, wirewound, 100 ohms, 1W	HA-31842
R312, 314-317, & 352	Resistor, fixed, composition, factory-selected value	H-1009-(xxx)
R313	Resistor, wirewound, 5 meg., 2.5W	HA-31796
R318	Resistor, wirewound, 2 ohms, 5%, 30W	H-1100-236
R319	Resistor, wirewound, 20 ohms, 5%, 5W	H-1100-324
R320	Resistor, metal-film, 200 ohms, 5%, 2W	H-1510-1064
R321	Resistor, metal-film, 2K, 5%, 2W	H-1510-780
R322	Resistor, metal-film, 20K, 5%, 2W	H-1510-1065
R323, 324	Resistor, fixed, composition, 1K, 5%, 0.25W, See Note 2 at end of parts list	HA-1009-77
R325	Not used	
R326	Resistor, metal-film, 1K, 5%, 0.25W	H-1510-1066
R327, 329	Resistor, fixed, composition, 2.2K, 5%, 0.25W	H-1009-767

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
R328	Resistor, metal-film, 100 ohms, 5%, 0.25W	H-1510-1078
R330, 331	Resistor, metal-film, 10K, 5%, 0.25W	H-1510-1067
R332	Resistor, ink-path, 1000 megohm, 20%, 1W	HA-31752
R333, 336	Resistor, metal-film, 2K, 5%, 0.25W	H-1510-1079
R334	Resistor, metal-film, 100K, 5%, 0.25W	H-1510-1069
R335	Resistor, wirewound, 22K, 1W	HA-31844
R336	Not used	
R337	Resistor, wirewound, 14K, 1W	HA-31845
R338	Resistor, metal-film, 30K, 5%, 0.25W	H-1510-1082
R339, 340, 341	Not used	
R342	Resistor, wirewound, 1.1111K, 1W	HA-31843
R343	Resistor, wirewound, 5K, 1%, 0.25W	H-1770-100
R344	Resistor, fixed, composition, 470 ohms, 5%, 0.25 watt	H-1009-751
R345, 346	Not used	
R347	Resistor, variable, metal-film, 100 ohms, 20%, 0.75W	HA-31040
R348	Resistor, variable, metal-film, 2K, 20%, 0.75W	HA-31854
R349	Resistor, fixed, composition, 100K, 5%, 0.25W	H-1009-795
R350	Resistor, fixed, composition, 22 meg., 5%, 0.25W	H-1009-880
R351	Resistor, fixed, composition	H-1009-248
S1	Switch, toggle, DPDT	HA-7036
S2	Switch, rotary, six-position, 6-deck, two poles per deck	HC-31043
S3	Switch, rotary, six-position, 12-deck, two poles per deck	HC-31045
S4	Switch, rotary, six-position, 8-deck, two poles per deck	HC-31046
S5	Switch, toggle, DPDT	HA-7036
S6	Switch, assembly, amplitude	HA-31792
S7	Switch, pushbutton, illuminated, SPST momentary, normally open	HA-38512
S8	Switch, lever, 3-position	HA-36822
S9	Switch, rotary, four-positions, one deck, two poles per deck	HC-31771
S10	Switch, sensitive, panel interlock	HA-6429
S11	Switch, thermostat	HA-31759
S201	Not used	
S202	Switch, rotary, five-position, one deck, two poles per deck	HB-90312
S301	Switch, rotary, six-position, four decks, four poles per deck	HC-31044

Continued

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
S302, 303	Switch, toggle, DPDT	HA-25402
SC301	Standard cell, optional	HA-31034
T1	Transformer, power	HB-31042
T2	Transformer, signal	HB-31762
T3	Transformer, pulse	HB-31784
	Schematic, oscillator board	HC-47437
	Schematic, basic instrument	HE-28599

NOTES

1. This note used only in instruction manuals of Issue E, or earlier. See bottom-right corner of page 1.

2. Digital Panel Meters:

   (a) On units with serial numbers below 1933, the digital panel meter is Data Tech 344-2, RFL Part HD-31850, which requires the use of CR301, CR302, R323, and R324.

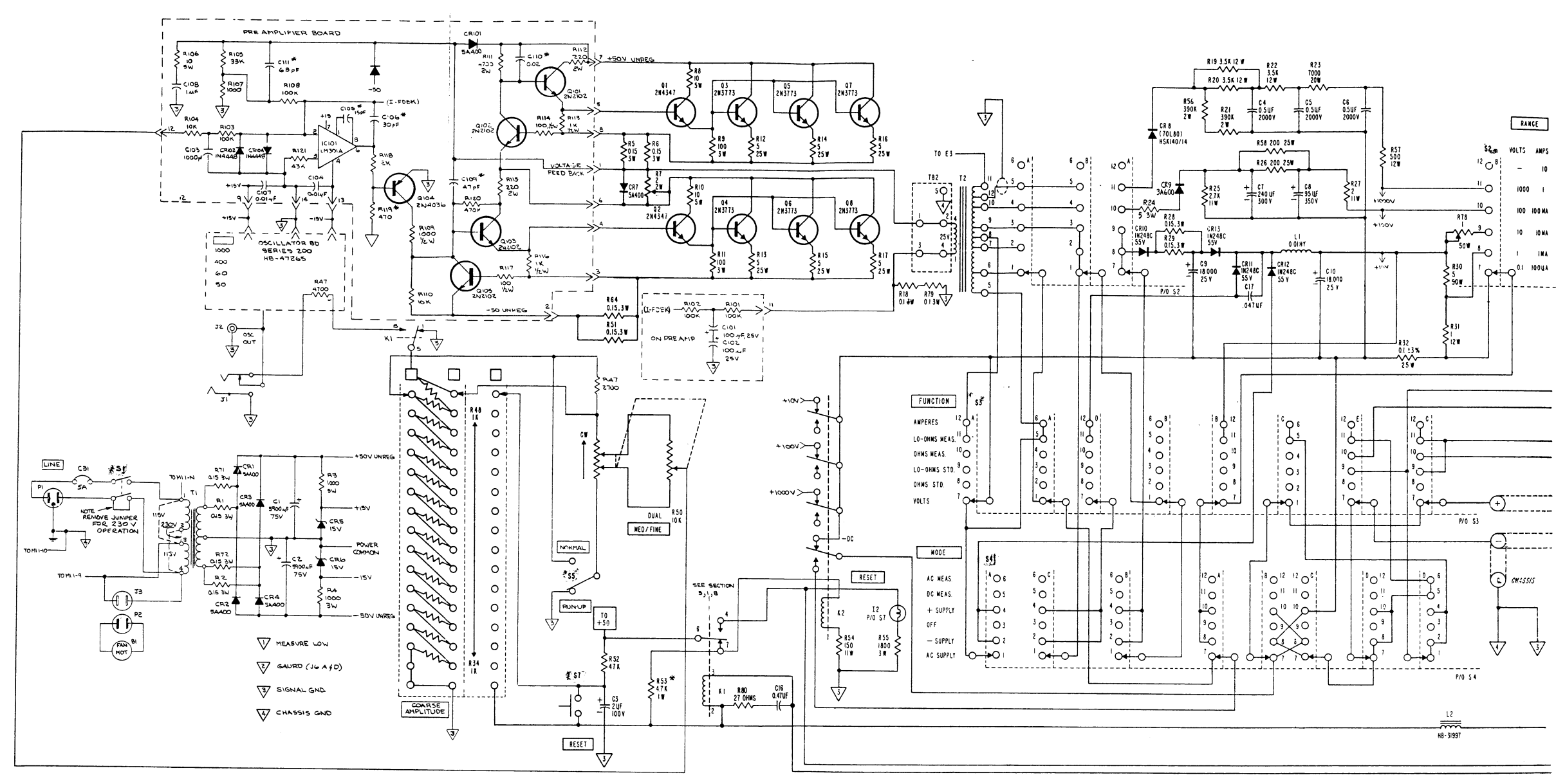
   (b) On units with serial numbers 1933 through 2456 the digital panel meter is Data Tech 4212-02, RFL Part HB-40499.

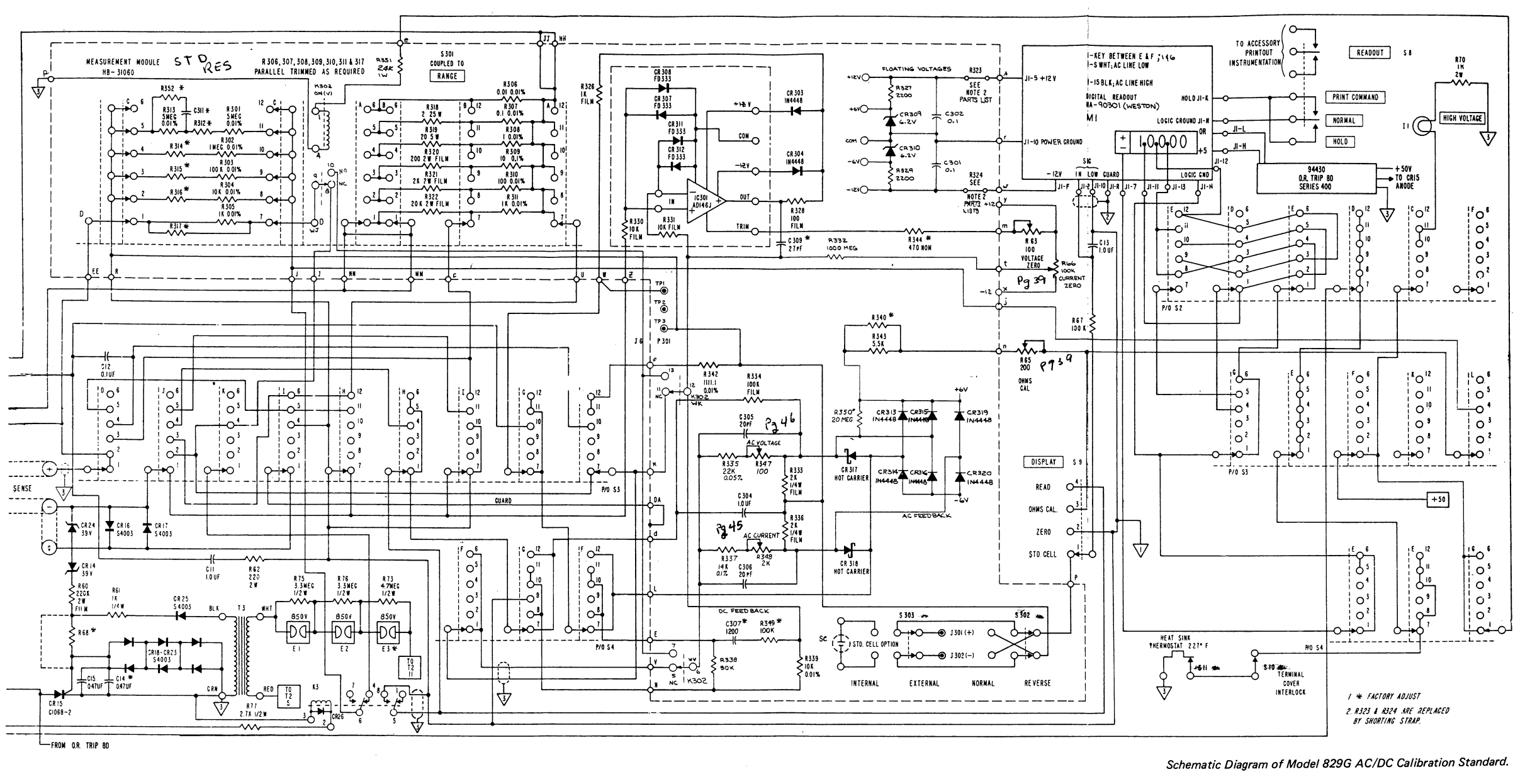
   (c) On units with serial numbers 2457 and above the digital panel meter is Weston Model 2471, RFL Part HB-90301.

OVERRANGE TRIP BOARD

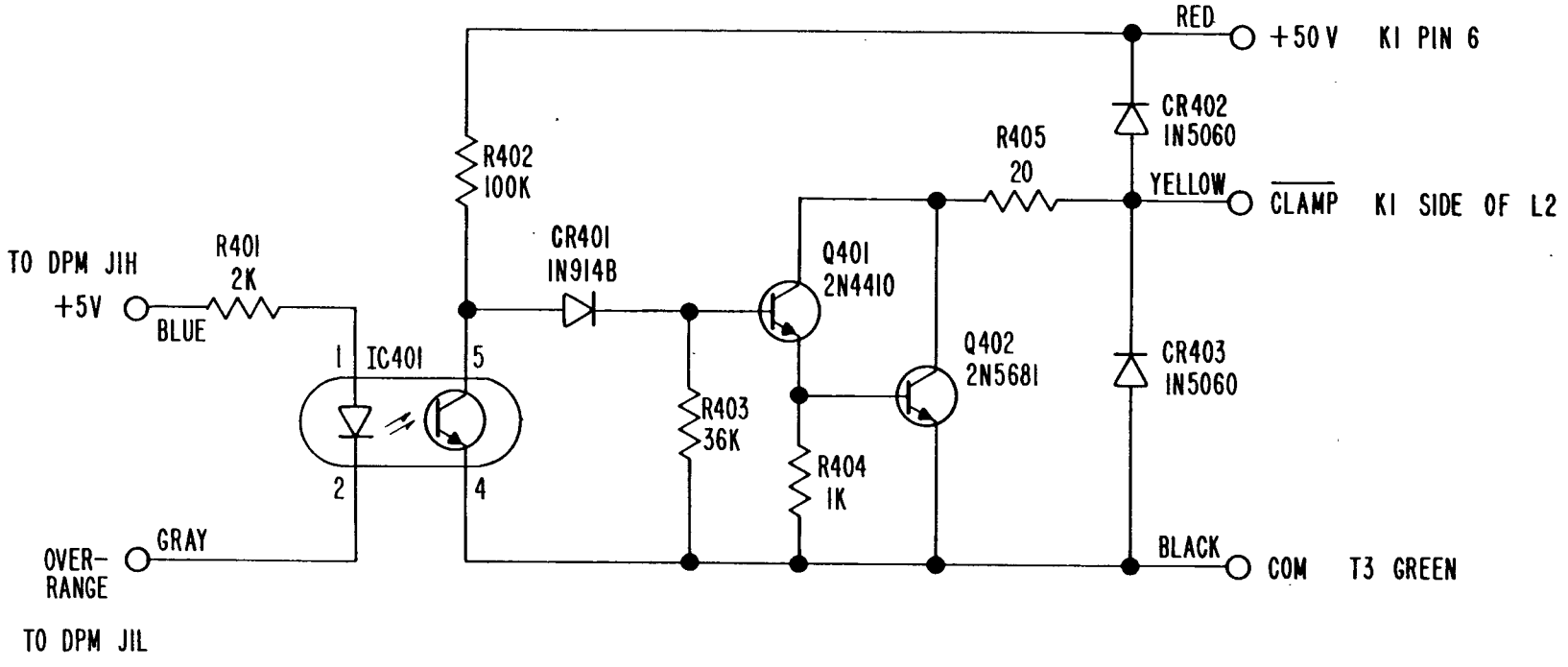
CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
CR401	Diode, silicon, Type 1N914B/1N4448	HA-26482
CR402, 403	Diode, silicon, Type 1N5060	HA-33595
IC401	Optoisolator, Litronix ILCA-2-30	HA-41084
Q401	Transistor, silicon, NPN, Type 2N4410	HA-26584
Q402	Transistor, silicon, NPN, Type 2N5681	HA-34753
R401	Resistor, fixed, composition, 2K, 5%, 0.25W	H-1009-760
R402	Resistor, fixed, composition, 100K, 5%, 0.25W	H-1009-795
R403	Resistor, fixed, composition, 36K, 5%, 0.25W	H-1009-848
R404	Resistor, fixed, composition, 1K, 5%, 0.25W	H-1009-612
R405	Resistor, fixed, composition, 20K, 5%, 0.25W	H-1009-826

S7 = DIALCO 922-1524-525

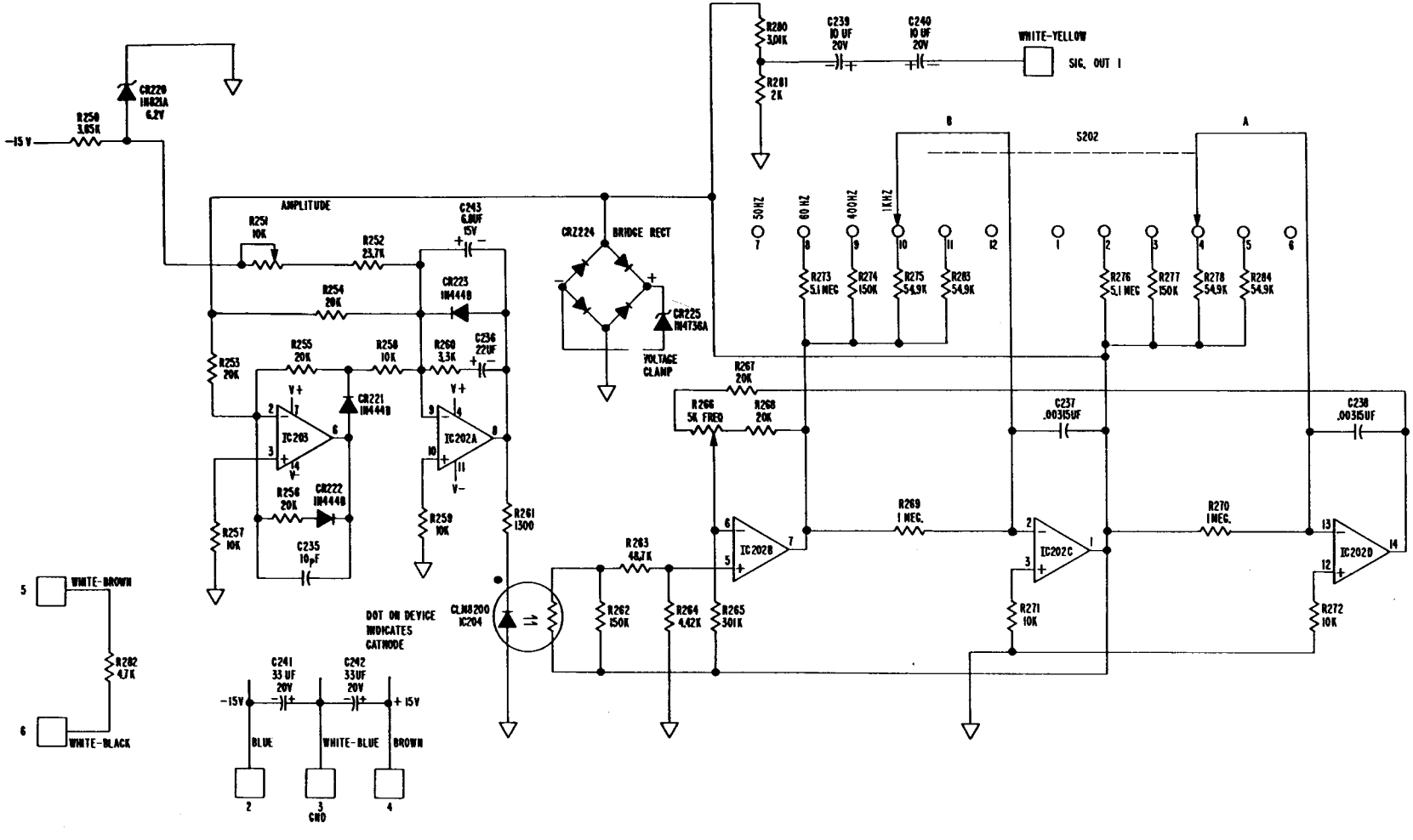

PRE AMPLIFIER BOARD
OSCILLATOR BD SERIES 200 HB-47265
ON PREAMP
VOLTAGE FEED BACK
-50 UNREG
+50V UNREG
(I-FDBK)
OSC OUT
LINE
NOTE REMOVE JUMPER FOR 230 V OPERATION
POWER COMMON
+15V
-15V
MEASURE LOW
GAURD (JG A & D)
SIGNAL GND
CHASSIS GND
COARSE AMPLITUDE
DUAL MED/FINE
NORMAL
RUN-UP
RESET
SEE SECTION B, J, B
FUNCTION
AMPERES
LO-OHMS MEAS.
OHMS MEAS.
LO-OHMS STO.
OHMS STO.
VOLTS
MODE
AC MEAS.
DC MEAS.
+ SUPPLY
OFF
- SUPPLY
AC SUPPLY
RANGE
VOLTS
AMPS
P/O S2
P/O S3
P/O S4
CHASSIS
HB-31997



Schematic Diagram of Model 829G AC/DC Calibration Standard.



Schematic Diagram of Overrange Trip Board.



Schematic Diagram of Model 829G Oscillator.

Warranty

The Model 829G AC-DC Calibration Standard carries a warranty of twelve months from date of delivery for replacement of any part which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f.o.b. Boonton, New Jersey.

RFL Industries, Inc.
Boonton, New Jersey, U. S. A.

Options

- Standard Cell Assembly (HA-31034)
- Wrap-Around Cover For Model 829G Bench Use (HA-31838)
- Accessory Current Transformer HB-21975 (Rack Mount Style HB-21975-R)
- Model 5058A Wattmeter Calibration Module
- Spare Measurement Module (HB-31060) (w/o Std. Cell)
- Custom Enclosure For Wattmeter Calibration System
- Microvolt Divider

CERTIFICATE
FOR
MODEL 829G
AC-DC CALIBRATION STANDARD

Serial Number 2789

The described instrument was calibrated at RFL Industries, Inc., Boonton, N. J. on 8/31/81 at an ambient room temperature of 23 °C. Calibration test covered all ranges provided by the instrument. Instrumentation used in calibration have calibration accuracy traceable to the National Bureau of Standards either directly or indirectly in an unbroken chain.

Calibration performance of the instrument is guaranteed for a period of one year providing interim self-calibration checks are performed in the manner and frequency described in the instruction manual.

*Serial number of standard cell M190225

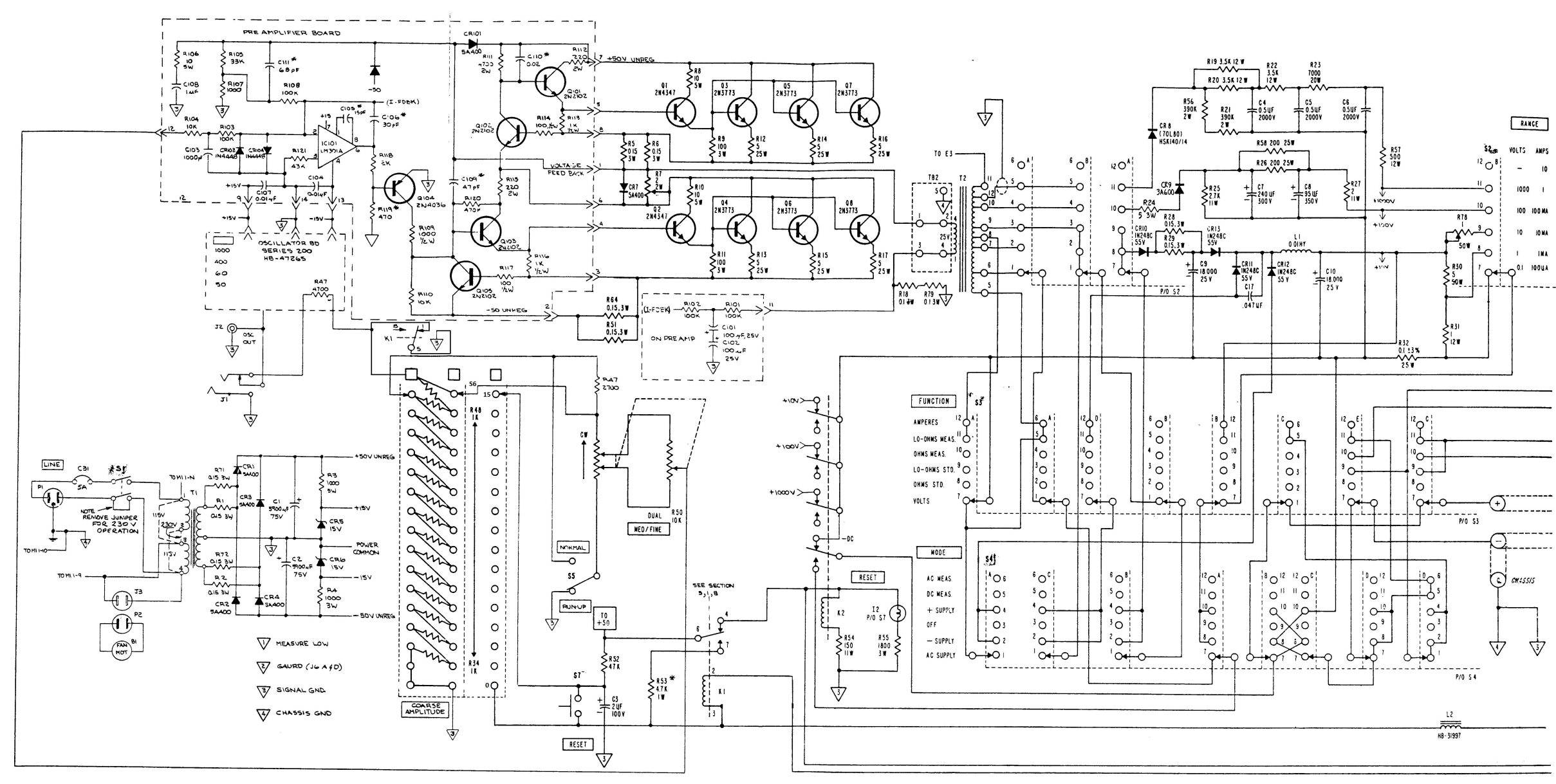
*EMF of standard cell 1.0193 at 23 °C.

It is not expected that the calibration of the instrument will vary more than ±.01 % per °C change in operating environment.

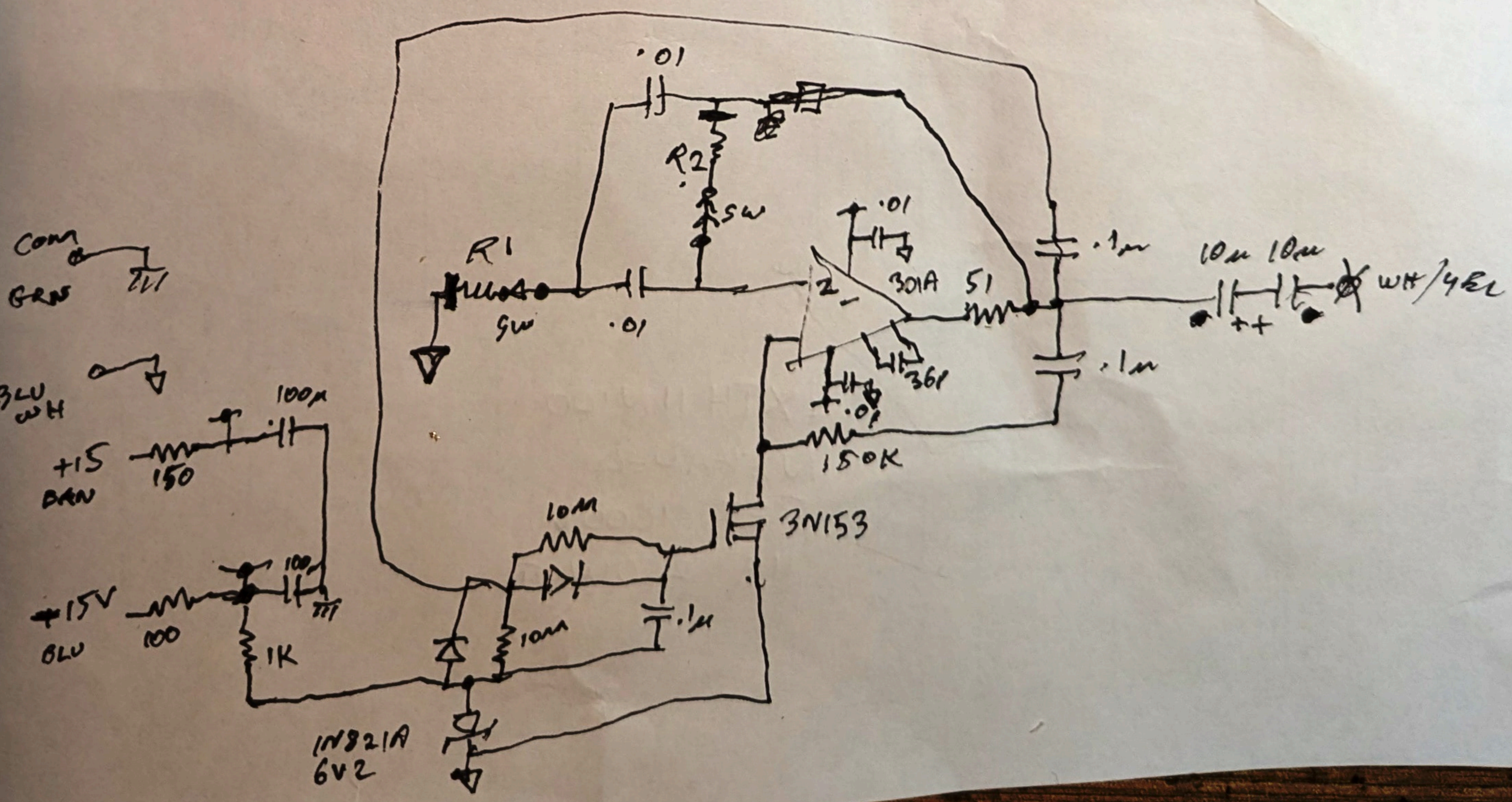
**Standard cell furnished with instrument as an optional accessory.*

Certified by M. Reinhold

Date 4/2/81


PRE AMPLIFIER BOARD
OSCILLATOR BD SERIES 200 HB-47265
VOLTAGE FEED BACK
ON PREAMP
COARSE AMPLITUDE
DUAL MED/FINE
NORMAL
RUN-UP
RESET
LINE
NOTE REMOVE JUMPER FOR 230 V OPERATION
POWER COMMON
SEE SECTION B,J,B
TO E3
RANGE
VOLTS AMPS
FUNCTION
AMPERES
LO-OHMS MEAS.
OHMS MEAS.
LO-OHMS STO.
OHMS STO.
VOLTS
MODE
AC MEAS.
DC MEAS.
+ SUPPLY
OFF
− SUPPLY
AC SUPPLY
+10V
+100V
+1000V
-DC
CHASSIS
P/O S2
P/O S3
P/O S4
HB-31997
1 MEASURE LOW
2 GAURD (J6 A & D)
3 SIGNAL GND.
4 CHASSIS GND

R1	R2	HZ
15K + 1K	1M	50
10K + 820	820K	60
2K + 120	130K	400
680 + 51	51K	1000
	100K	



Instrument Calibrators

THE NECESSITY for accuracy in voltmeters, ammeters, and ohmmeters has been greatly increased by the closer tolerances needed to maintain modern equipment. Since the duties of a PME specialist include the calibration of all types of meters, the calibration standards used to assure meter accuracy will be discussed in this chapter.

3-1. RFL 829 Series Instrument Calibrator

There are several different instrument calibrators available for use in PME laboratories throughout the Air Force. Although they differ in many respects, their principles of voltage and current development are similar. The most common calibrator now in use is the RFL (Radio Frequency Laboratory) 829 series instrument calibrator.

233. Specify the basic capabilities of the RFL 829G, type of oscillator it utilizes, and two safety operating parameters.

Basic Capabilities of the RFL 829G. The Model 829 AC/DC calibration standard is a highly stable and precise instrument. It has the ability to supply a wide range of AC-DC voltage and current and preset resistance values; to measure AC-DC voltage and current of the same parameters which it can supply; and to measure a broad range of resistance value (fig 3-1).

Frequencies of 50, 60, 400, and 1000 Hz may be selected by means of a single front panel control. Overall voltage and current feedback is designed into the amplifier sections and rolloff control is incorporated to prevent high frequency bursts from occurring in the output waveform. The amplifier is applied to a transformer capable of handling all output voltage and current, both AC and DC. Precise value of output voltage or current is measured at the output terminals by means of the digital readout instrumentation. The output of the oscillator and the input circuit of the preamplifier are accessible through rear panel connections. These connections provide necessary synchronization points when two instruments (or one instrument plus an auxiliary AC source) are used for wattmeter calibration. The Model 829G AC/DC calibration standard incorporates internal protective circuitry to provide protection for the operator, the Model 829G, and the instrument under test. The possibility of damaging an instrument under test is minimized by interlock circuitry associated with the range and function selectors. The instrument is protected by sparkgap/SCR circuitry that is energized in the event of excessive voltage (transient or constant) in critical circuits when operated by its internal oscillator/amplifier. The SCR trip circuit is also associated with the sense and chassis group terminals to protect against excessive EMF Levels at these points. In the measurement mode, the Model 829G utilizes its switching circuitry and precision measurement section consisting of the digital panel meter, precision shunts and multipliers, operation amplifier for DC functions, and an operational rectifier for AC functions.

Outputs of AC and DC voltages or currents, or resistances, are obtained from the calibration source portion (fig. 3-2) of the calibration standard. This portion contains an oscillator (bridged T), which can produce an output at any one of four frequencies (50, 60, 400, or 100 Hz). The frequency is selected by use of the frequency front panel control. The 400 Hz frequency is selected when the calibration standard is used to produce a DC output. The oscillator output is applied to a preamplifier/power amplifier circuit through a coarse attenuator, a fine attenuator, and the normal/run-up circuit. The attenuators are manually set by means of the coarse and med/fine front panel amplitude controls to establish the desired calibration standard output signal level. Overall voltage and current feedback is designed into the amplifier circuits. Also, roll-off control is incorporated to prevent high frequency bursts in the output waveform. The power amplifier output, at an amplitude level determined by the settings of the coarse and med/fine controls and at a frequency determined by the frequency control, is transformer coupled to the coupling and filter circuits. The coupling and filter circuits consist of the necessary rectifiers and filters needed to produce DC outputs compatible with the output range, mode (+supply or −supply) and function selected by these three front panel controls. These circuits also contain the necessary coupling paths, less the filters, for AC outputs. Through the sense terminals, which are strapped to the + and − output terminals, respectively, the calibration standard outputs are applied to the measurement section. This section provides a front panel digital indication of the precise value of the output current or voltage. The calibration standard incorporates protection circuits. These circuits protect the operator, the calibration standard, and the instrument under test. The output terminals of the calibration standard are covered by a plexiglas shield. This shield must be lowered over the terminals before the standard can produce an output or display a measurement. While the standard is energized, raising of the shield causes the output to drop to ground potential and the displayed measurement to go to zero. To reenergize the standard, the shield must be in its lowered position and the reset switch depressed or the coarse control placed momentarily in its ZERO position. The possibility of damaging an instrument under test is

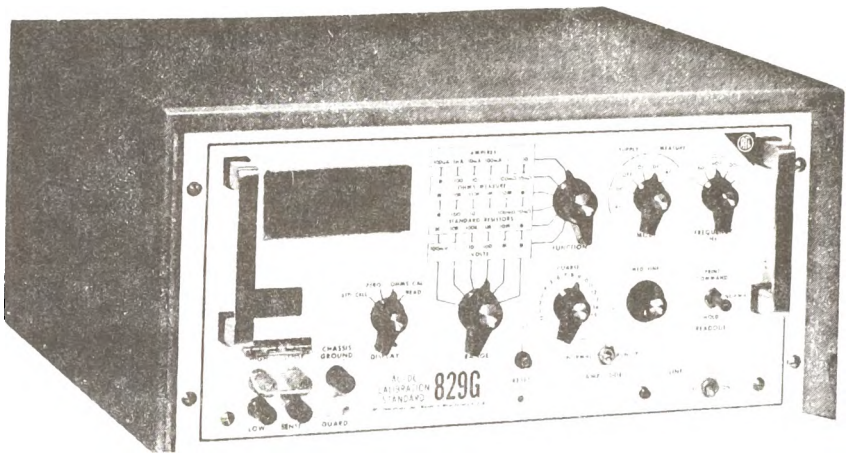


Figure 3–1. 829G front panel.

minimized by wired interlock circuitry associated with the range and function controls. In addition, an overrange detection circuit is incorporated as part of the protection circuits. The overrange detection circuit receives the full transformer coupled output of the power amplifier from the secondary winding of the power amplifier output transformer. Should this output exceed the maximum allowable output level, an SCR is gated on and the following occurs simultaneously:

a. The output terminals are shorted together.
b. The oscillator output is grounded.
c. The input to the digital panel meter is grounded.
d. The DC measurement path during resistance measurements is opened.

The calibration standard is further protected from overheating by use of a heat sink thermostat. Overheating can occur if the calibration standard is operated in excessively high ambient temperature environments or if an attempt is made to work at overloaded output conditions for any length of time. A snap-action thermostat activates, if the calibration standard heat sinks exceed 227°F. (125°C.). Once tripped, the self-restoring thermostat prevents operation until the heat sinks return to normal temperature.

Exercises (233):

1. What type of an oscillator is the 829G?

2. What three things does the RFL 829G supply and measure?

3. In what position must the plexiglas shield be before the 829G will produce an output?

4. (T or F) The 829G operates independently of ambient temperatures.

3-2. Fluke 5100B Calibrator

The Fluke 5100B calibrator is another commonly used instrument calibrator.

234. Specify the basic capabilities of the 5100B and identify the functions of the front panel controls.

Basic Capabilities of the Fluke 5100B. The 5100 Series B calibrator is a microprocessor controlled calibrator. Outputs are programmable from the front panel or through an optional remote interface. A wide range of DC voltages and current, AC voltages and current, and resistance outputs are available. Connections on the front panel include terminals for output, sense, voltage guard, and current guard. A chassis binding post is available on the rear panel. Available on the front panel is a BNC output connector for use with the Wideband Option -03 which extends the frequency range of the instrument. The connector is installed in all instruments, allowing addition of the option at some later date, if desired.

The output can be modified using the front panel error mode controls or through an optional remote interface. This allows the operator, in all outputs except frequency, to modify the output and read the deviation from the base in percentage or digits on the front panel or the remote device.

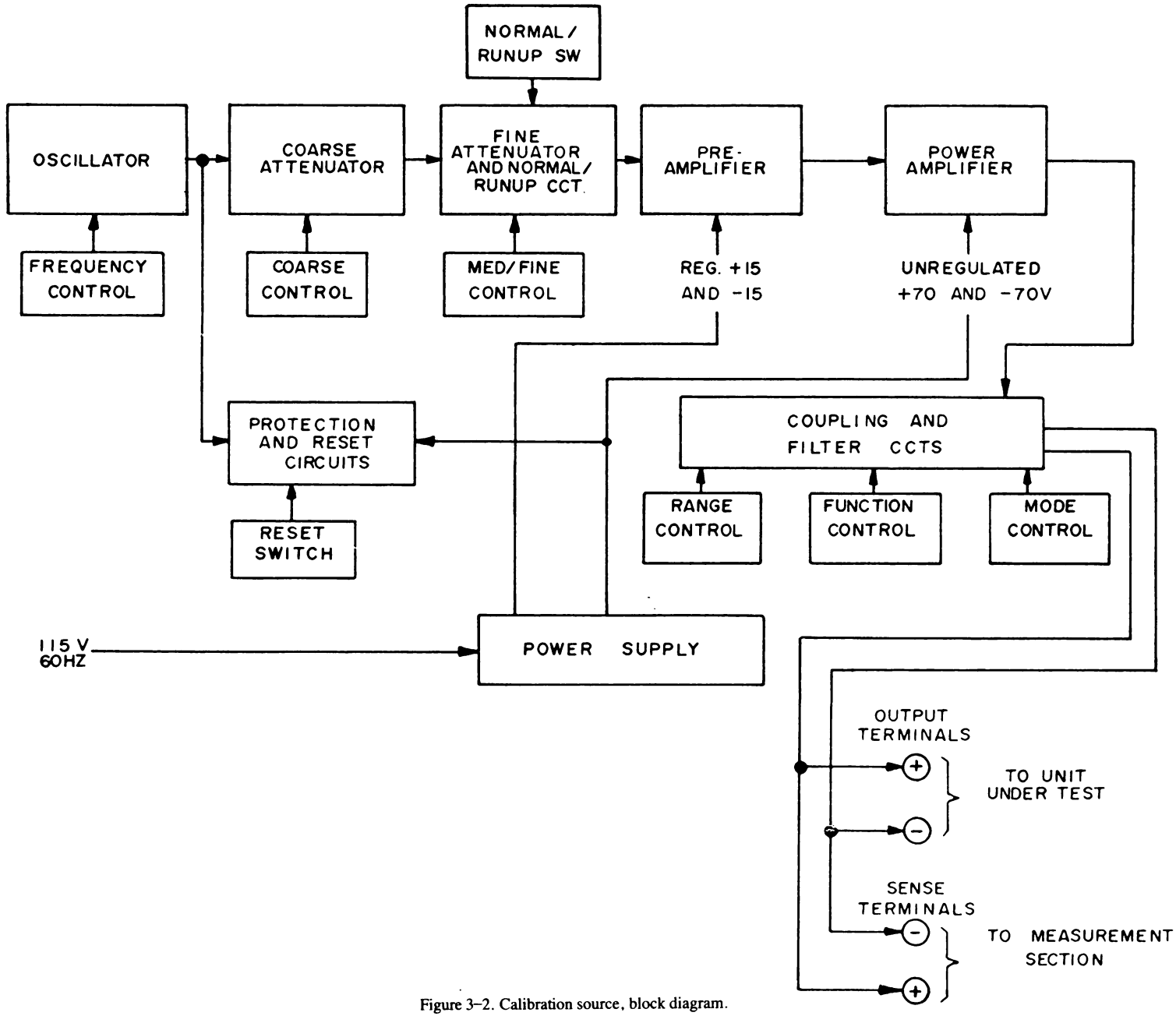
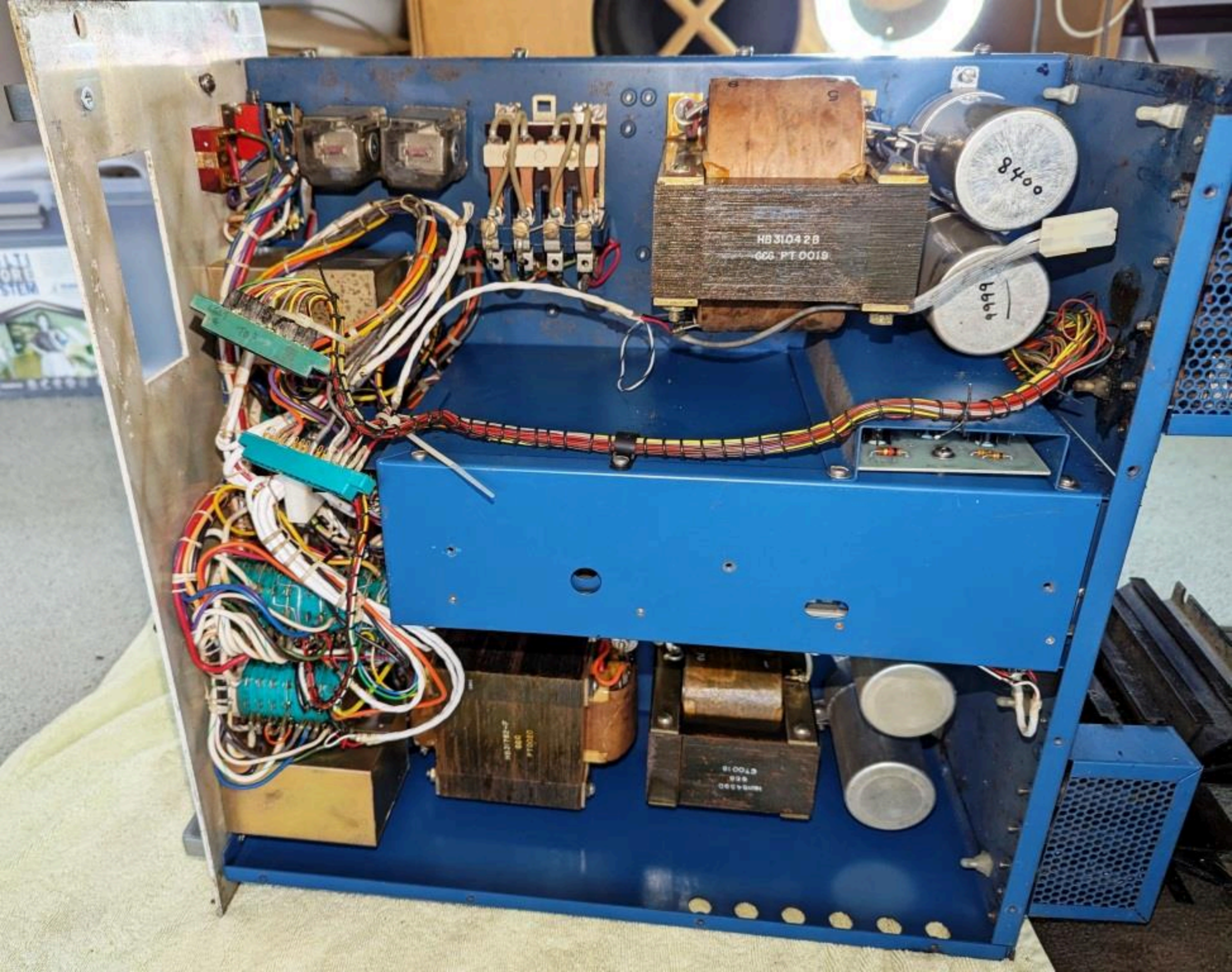
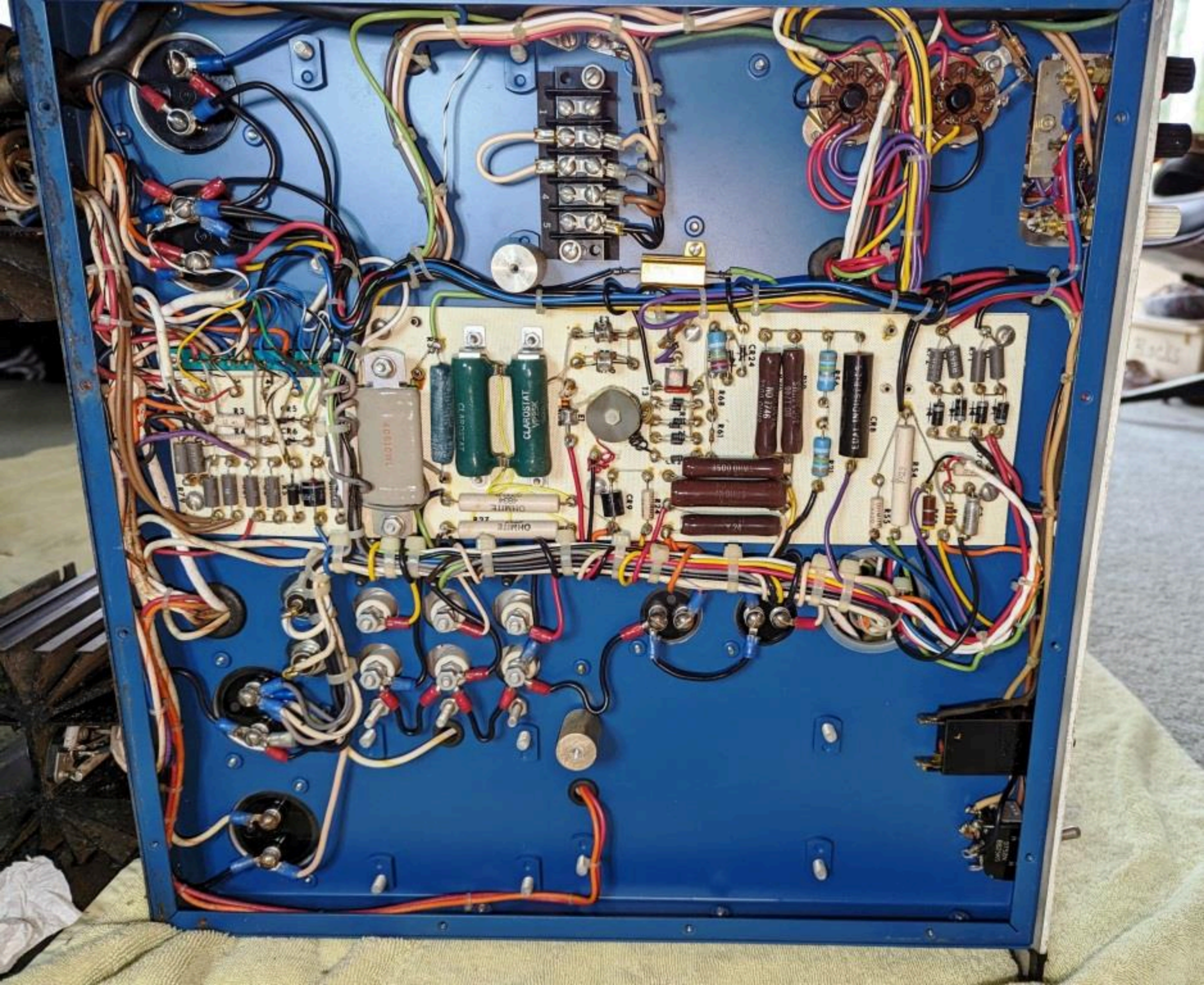
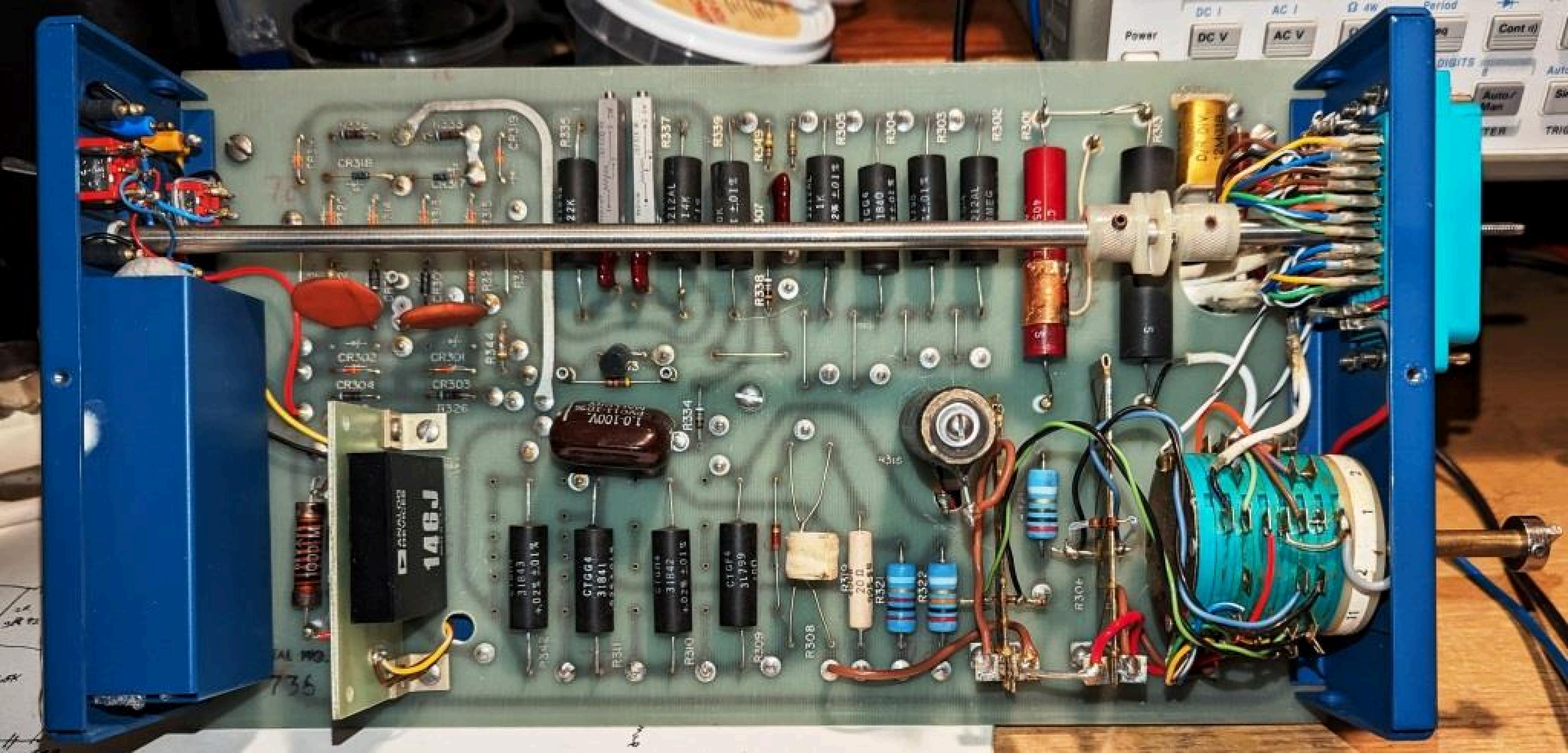


Figure 3–2. Calibration source, block diagram.


8400
HB31042B
GCC PT 0018
1999


CLAROSTAT
CLAROSTAT


AMP IN
OSC. OUT
TP2
1
2
3
4
1
2
3
REVERSE
NORMAL
EXTERNAL
INTERNAL
+
STD CELL
−
RFL
MEASUREMENT MODULE
HB-31060
(DT4212–02)
ARMY DESIGN ESTABLISHMENT
ELECTRICAL ENGINEERING LABORATORIES
TA 9/4
14
2064


Power
DC V
AC V
Cont
CR302
CR301
CR304
CR303
R326
R334
R344
1.0-100V
146J
R338
R321
R322
R308
R309
R310
R311
R304
R305
R303
R302
R337
R339
R336
CR318


EPLAB
RED WIRE POSITIVE
1/10% ACCURACY
ANALOG DEVICES
146J
R326
CR303
CR301
C30
CR30
CR313

.10 -100
7239S
.10 -100
MYRTLE
32P 2%
.10 -100
7236
SPRAGUE
C221
C223
C225
R201
R224
HC-31076 W.W.P.-5


R22