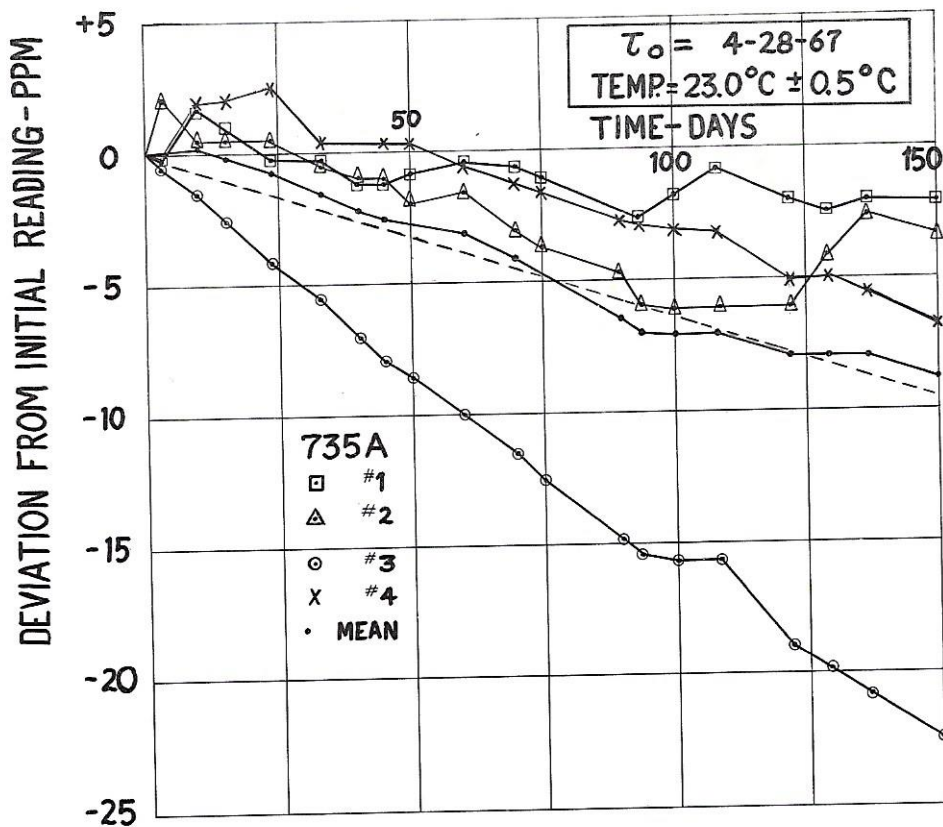


**AC/DC
CALIBRATION
SEMINAR**

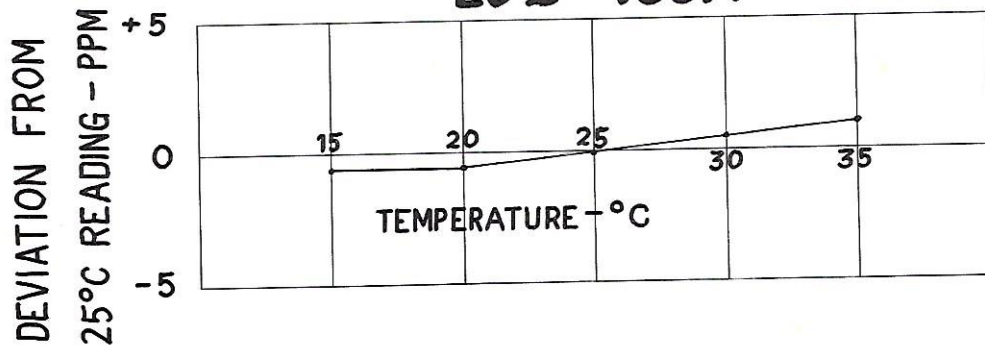
HEWLETT  PACKARD

LOVELAND DIVISON

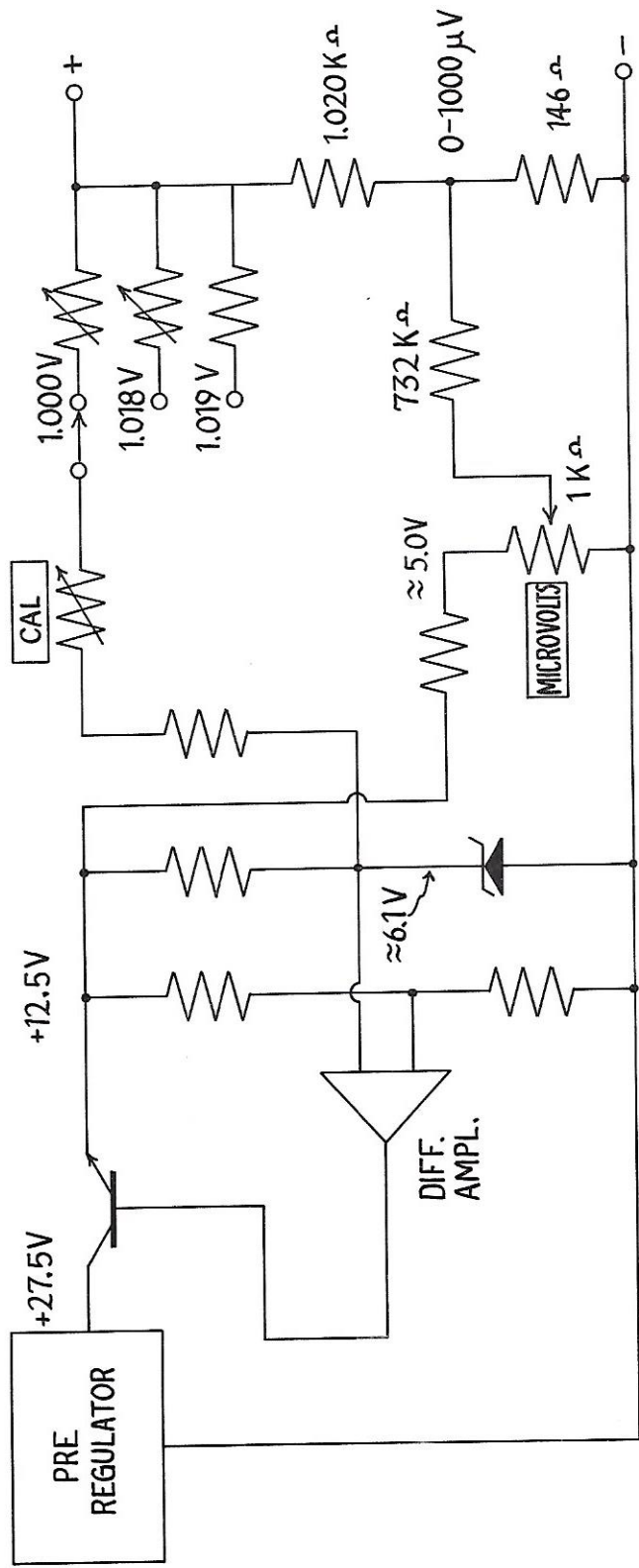
STABILITY WITH TIME E02-735A



STABILITY WITH TEMPERATURE E02-735A



735A DC TRANSFER STANDARD

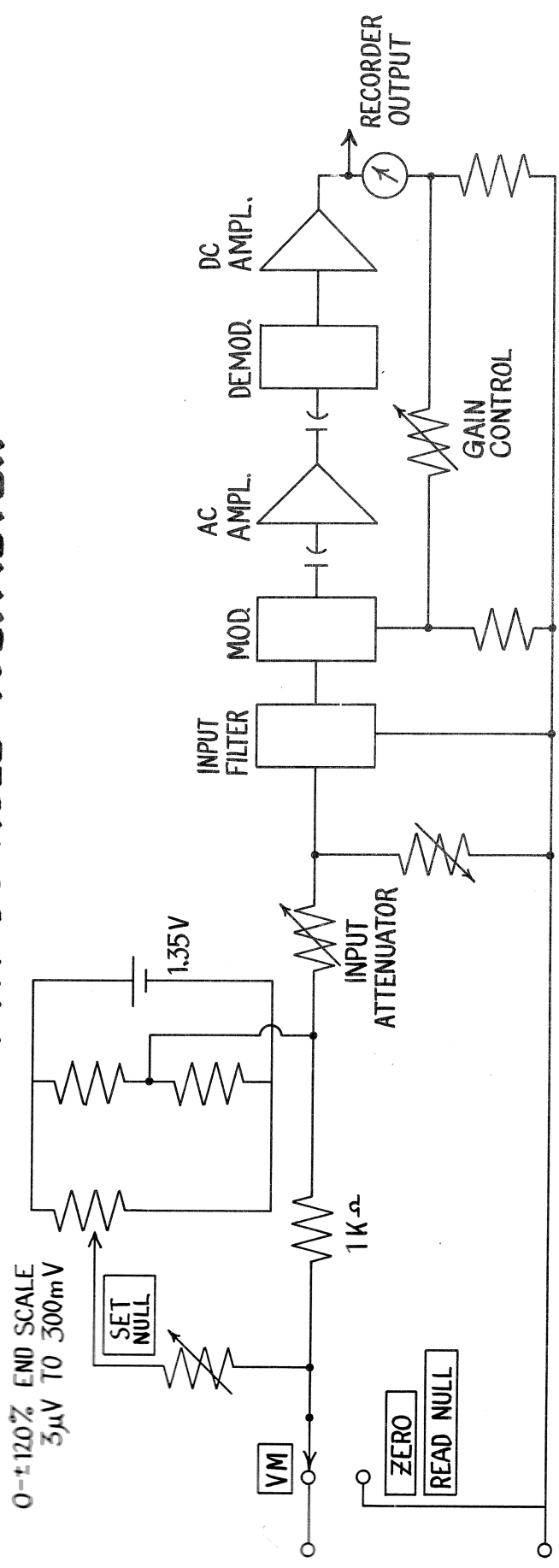


TRANSFER ACCURACY: 2 PPM BETWEEN STANDARD CELLS
10 PPM BETWEEN STANDARD CELLS AND 1.000 VOLT OUTPUT.

STABILITY: $\frac{\text{TIME}}{\text{TEMP}} < 10 \text{ PPM/MO.}$
 $< 1 \text{ PPM/}^\circ\text{C}$

OUTPUT RESISTANCE: $1 \text{ K}\Omega \pm 1\%$

419A DC NULL VOLTMETER



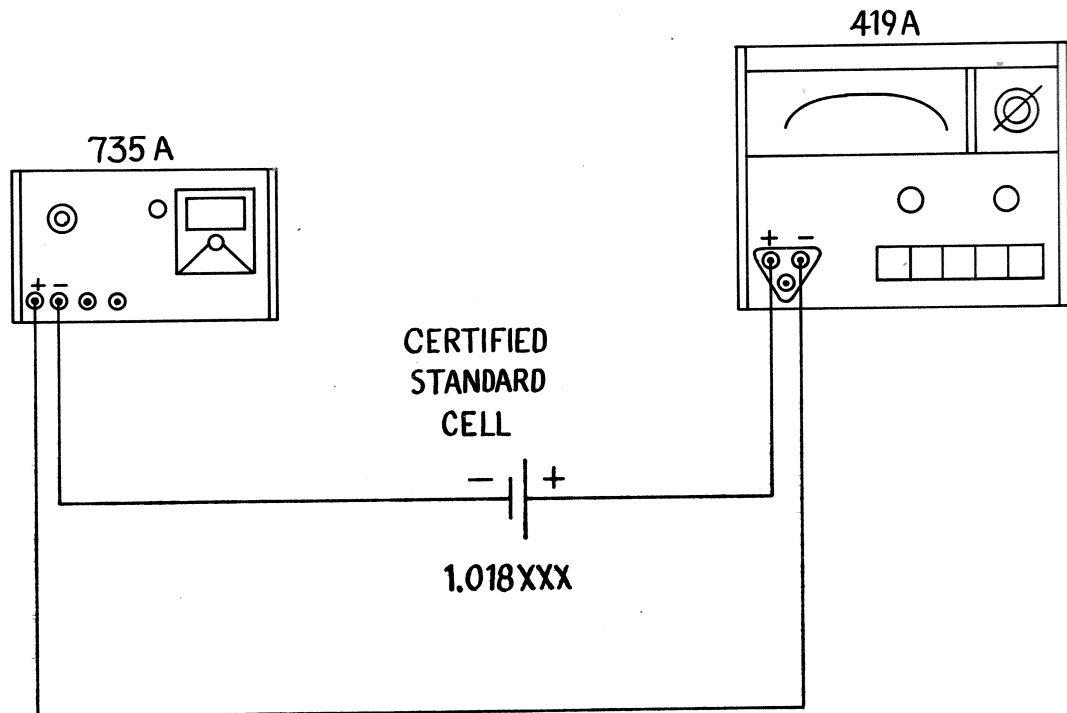
RANGES: ±3μV TO ±1000V END SCALE

ACCURACY: ±(2% END SCALE + 0.1μV)

INPUT RESISTANCE: 3μV TO 3mV - 100KΩ
 10mV TO 30mV - 1MΩ
 100mV TO 300mV-10MΩ
 1V TO 1000V - 100MΩ



735A CALIBRATION



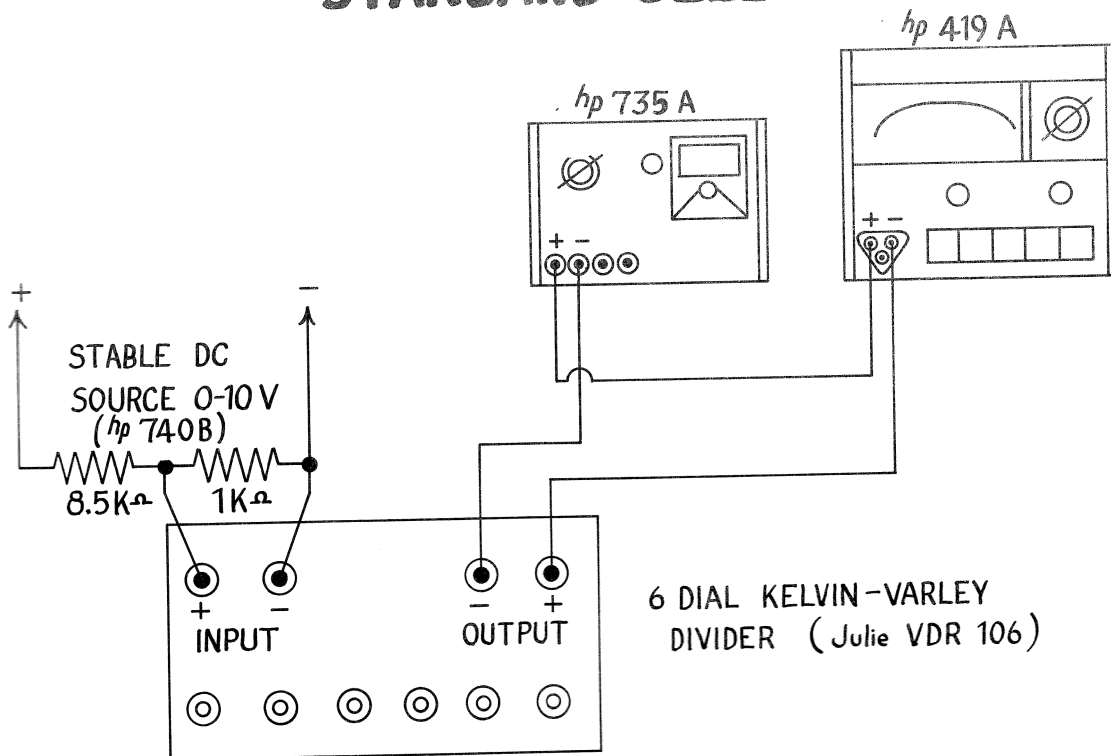
1. BEFORE MAKING ABOVE CONNECTIONS:
 - A. ZERO 419A ON $3\mu\text{V}$ RANGE.
 - B. SET OUTPUT OF 735A TO CERTIFIED VOLTAGE OF STANDARD CELL. LOCK THE KNOB.
2. ADJUST CAL CONTROL OF 735A UNTIL 419A INDICATES A NULL ON THE $3\mu\text{V}$ RANGE.

735A IS NOW CALIBRATED TO STANDARD CELL CERTIFICATION. ANY VOLTAGE 735A GENERATES BETWEEN 1.018000 AND 1.02000 VOLTS IS ACCURATE TO $\pm 2\mu\text{V}$ WITH RESPECT TO STANDARD CELL USED IN CALIBRATION PROCEDURE.

THE 1.000000 V OUTPUT OF THE 735A IS ACCURATE TO WITHIN $\pm 10\mu\text{V}$ WITH RESPECT TO STANDARD CELL USED IN CALIBRATION PROCEDURE. *

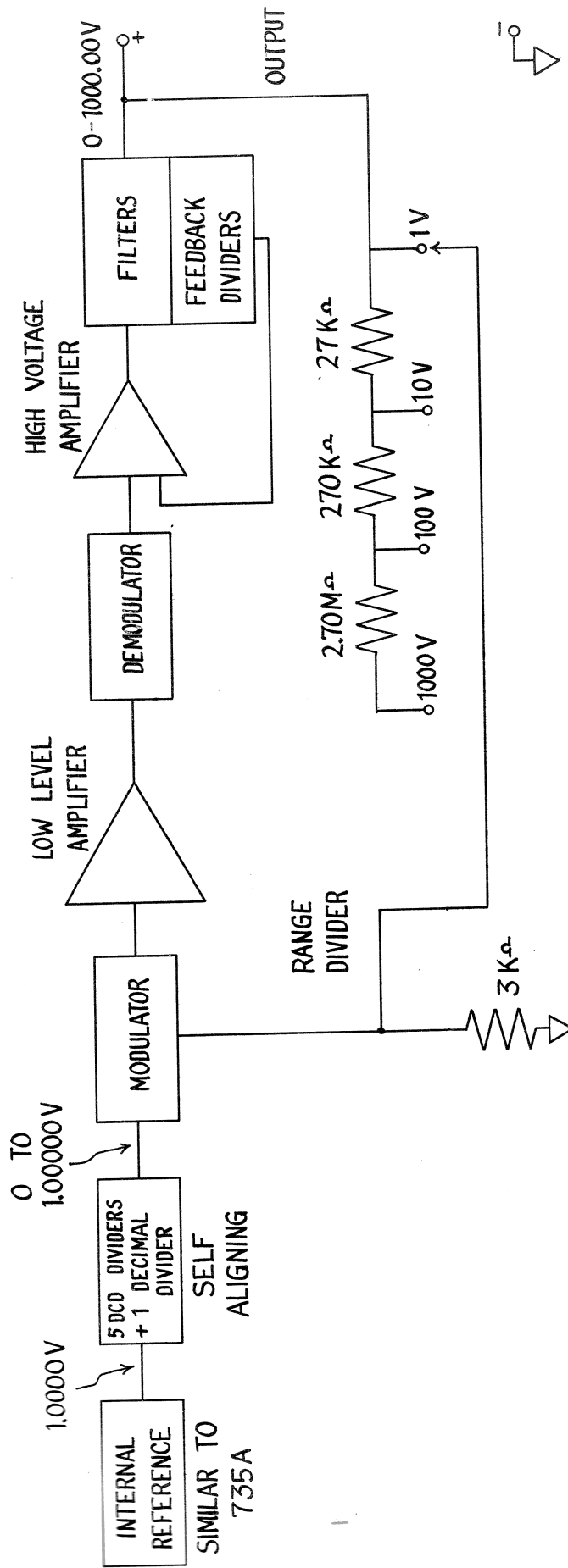
* (NOTE METHOD TO REDUCE 10 PART UNCERTAINTY TO 2 PARTS)

CALIBRATION OF 735A 1.00 VOLT OUTPUT TO WITHIN 2 PARTS OF STANDARD CELL



1. BEFORE MAKING ABOVE CONNECTION :
 - A. ZERO 419A ON 3 μ V RANGE
 - B. CALIBRATE 735A TO CERTIFIED STANDARD CELL (1.018XXX)
 - C. SET VDR 106 TO 1.000000
2. ADJUST STABLE DC SOURCE (≈ 9.6 V) UNTIL 419A INDICATES NULL ON 3 μ V RANGE [OUTPUT OF 735A SHOULD BE THAT OF CERTIFIED STANDARD CELL VOLTAGE (1.018XXX)].
3. SET VDR 106 TO $\frac{1}{1.018XXX}$
4. SET 735A TO 1.000V POSITION AND ADJUST CAL ON 735A FRONT PANEL UNTIL NULL IS ACHIEVED ON 3 μ V RANGE OF 419A.
THE 1.0000 V OUTPUT IS NOW CALIBRATED TO 2.0 PARTS WITH RESPECT TO CERTIFIED STANDARD CELL.

740 B DC STANDARD/DIFFERENTIAL VOLT METER

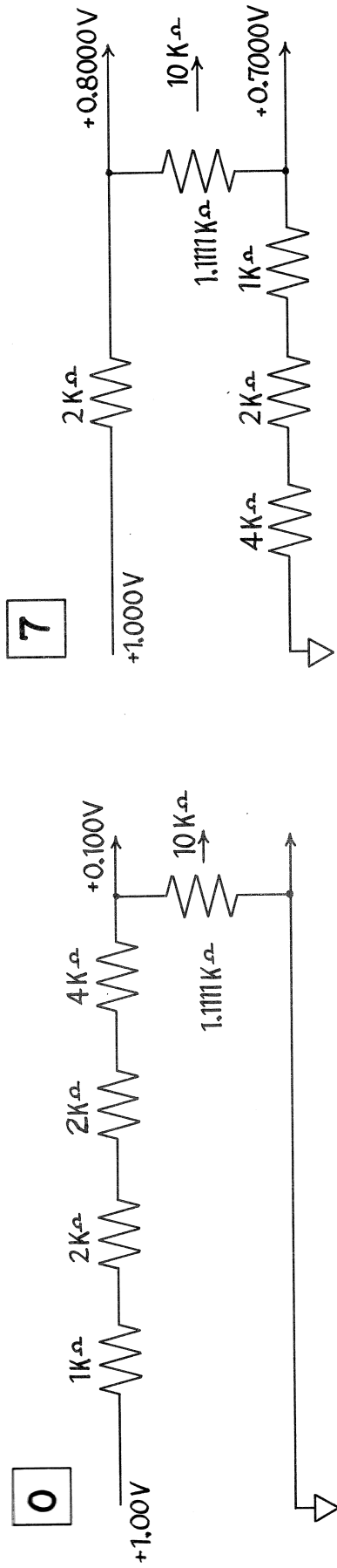


DC STANDARD

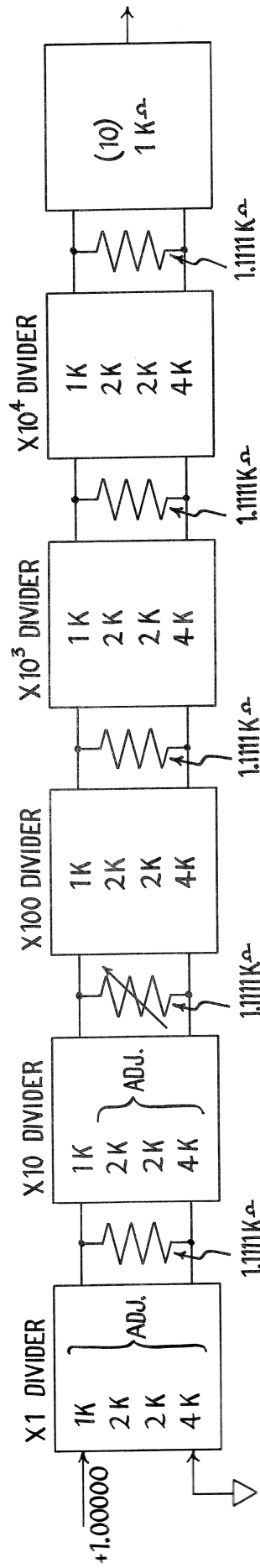
- RANGES:**
 0 TO 1000 V IN 4 DECADE RANGES
 RESOLUTION OF 1 PART IN 10^6 AT FULL SCALE
 MINIMUM RESOLUTION - $1\mu\text{V}$
- ACCURACY:**
 $\pm(0.002\%$ OF SETTING $+0.0004\%$ OF RANGE)
 30 DAY CALIBRATION PERIOD
- STABILITY:**
 TIME - 5 PPM/DAY
 30 PPM/90 DAY
 TEMP - 2 PPM/ $^{\circ}\text{C}$

BINARY CODED DECIMAL DIVIDER 740B

TYPICAL SETTINGS IN INDIVIDUAL BCD DIVIDERS

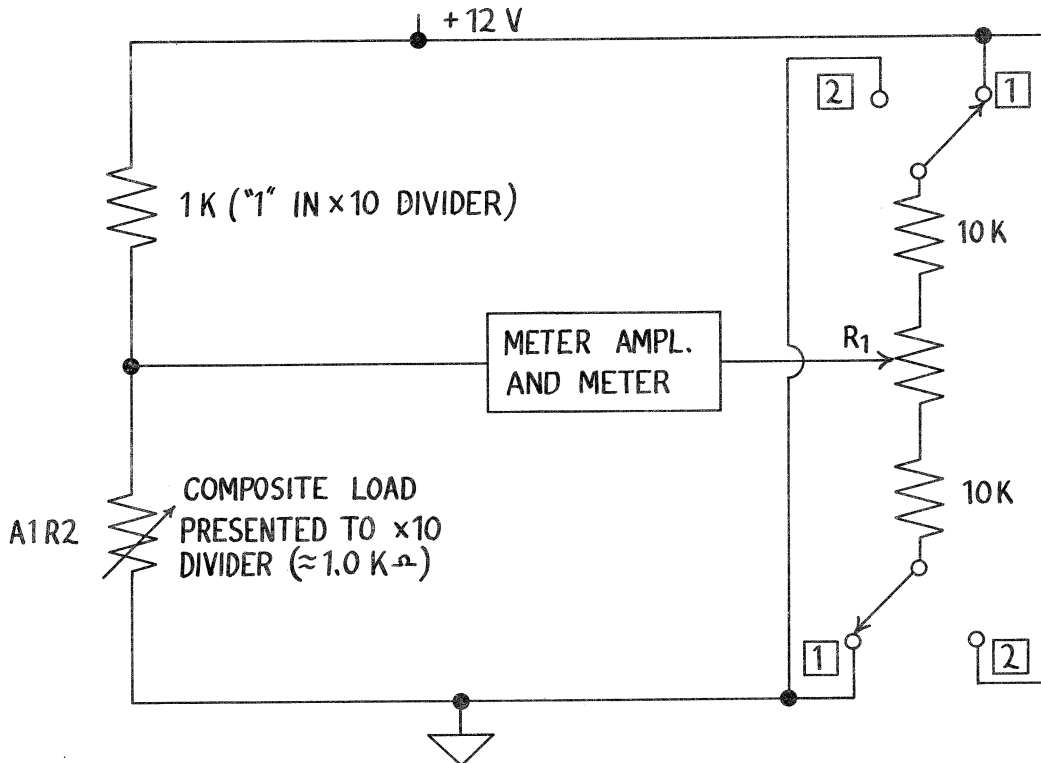


COMPLETE BCD DIVIDER



INTERNAL ALIGNMENT 740B

STEP 1 INTERNAL GENERATION OF EXACT 2:1 RATIO



R_1 IS ADJUSTED UNTIL METER DEFLECTION AND POLARITY ARE EQUAL IN SWITCH POSITIONS **1** AND **2**. AT THIS POINT, THE TAP OF R_1 IS CENTERED IN THE RIGHT HAND SIDE OF THE BRIDGE.

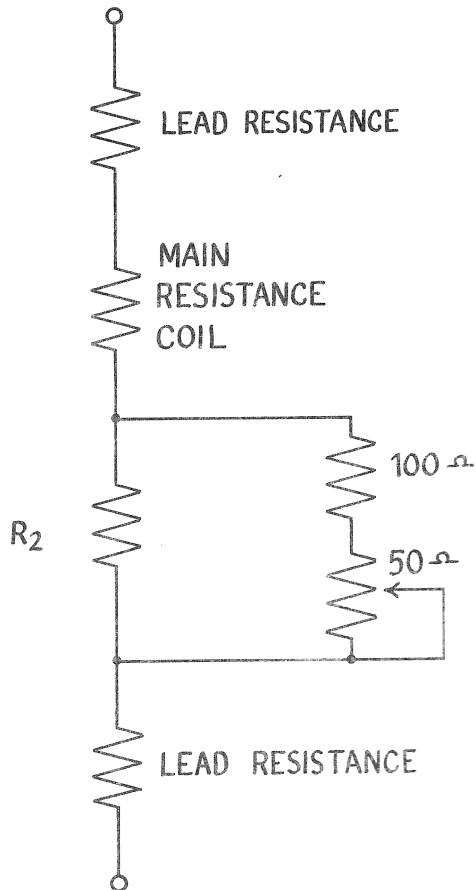
STEP 2 SETTING COMPOSITE LOAD EQUAL TO "1" IN $\times 10$ DIVIDER
A1R2 IS ADJUSTED FOR ZERO DEFLECTION IN SWITCH POSITIONS **1** AND **2**.

FOLLOWING STEPS: THE COMPOSITE LOAD ($1K\Omega$) AND THE "1" IN THE $\times 10$ DIVIDER ($1K\Omega$) ARE NOW SWITCHED IN SERIES AND THE "2" IN THE $\times 10$ DIVIDER ($2K\Omega$) IS SWITCHED INTO THE BRIDGE AND IT IS ADJUSTED FOR NULL.

THIS PROCESS IS CONTINUED UNTIL THE $\times 10$ AND $\times 1$ DIVIDER RESISTORS HAVE ALL BEEN ADJUSTED.

THE RANGE DIVIDER CAN BE CALIBRATED BY A SIMILAR SWITCHING ARRANGEMENT. THIS TOO CAN BE DONE INTERNALLY.

PRECISION ADJUSTABLE RESISTORS



11102 A: 100 Ω

11103 A: 1K Ω

11104 A: 10K Ω

VALUE : ADJUSTED TO WITHIN 6 PPM WITH RESPECT
TO THE LEGAL OHM.

STABILITY:

TIME : < 2 PPM/MO.

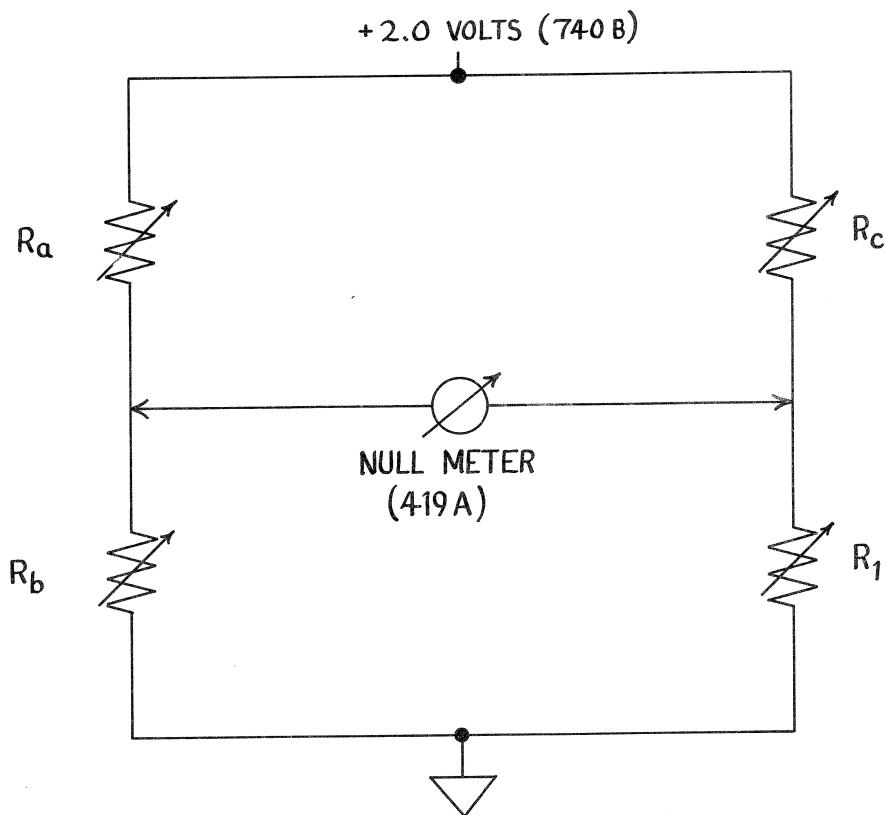
< 24 PPM/YEAR

TEMP < ± 4 PPM/ $^{\circ}$ C

ADJUSTMENT RANGE :

± 100 PPM MINIMUM

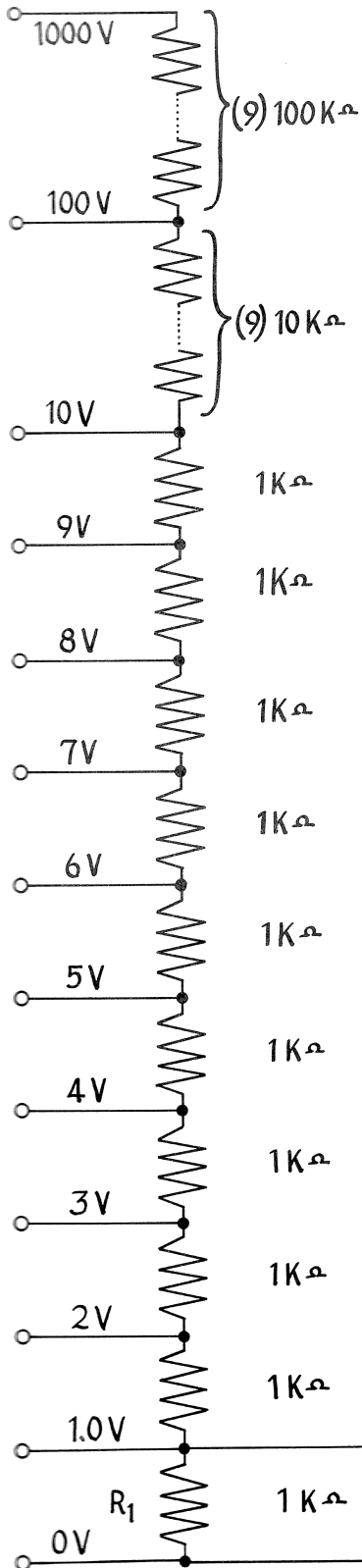
MATCHING $1K\Omega$ PRECISION ADJUSTABLE RESISTORS



1. ASSUME WE START WITH (10) $1K\Omega$ ADJUSTABLE STANDARD RESISTORS (hp 11103A). SET UP THE BRIDGE ABOVE USING 4 OF THESE RESISTORS. R_1 IS GOING TO BE THE REFERENCE RESISTOR.
2. ADJUST ANY OF THE THREE OTHER RESISTORS TO GET A NULL ON THE $3\mu V$ RANGE OF THE 419 A.
3. REPLACE R_1 (ONE AT A TIME) WITH THE SIX OTHER RESISTORS (NOT SHOWN ABOVE) AND ADJUST EACH OF THEM FOR A NULL ON THE 419 A.
4. REBUILD THE BRIDGE SHOWN ABOVE WITH 3 OF THE MATCHED $1K\Omega$ RESISTORS IN PLACE OF $R_{a,b}$ AND R_c . (DO NOT READJUST ANY OF THESE MATCHED RESISTORS)
5. SUBSTITUTE THE REMAINING 3 RESISTORS ($R_{a,b}$ AND R_c) IN PLACE OF R_1 AND ADJUST THESE FOR A NULL ON THE $3\mu V$ RANGE.

ALL $10K\Omega$ RESISTORS ARE NOW EQUAL TO ONE ANOTHER WITHIN 1.0 PART. THESE 10 CAN NOW BE PUT IN A SERIES AND USED AS R_1 IN MATCHING $10K\Omega$ RESISTORS TO THE $1K\Omega$ RESISTORS, ETC;.

GENERATION OF UP TO 1000V DC WITH <5 PART UNCERTAINTY WITH RESPECT TO CERTIFIED STANDARD CELL

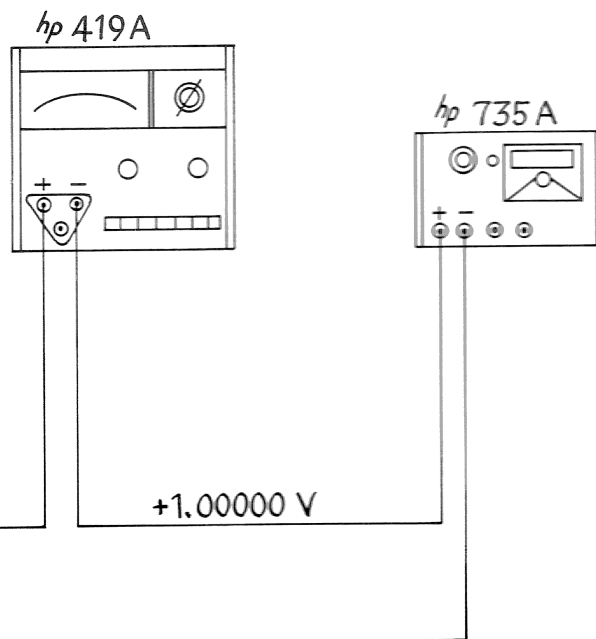


ASSUME:

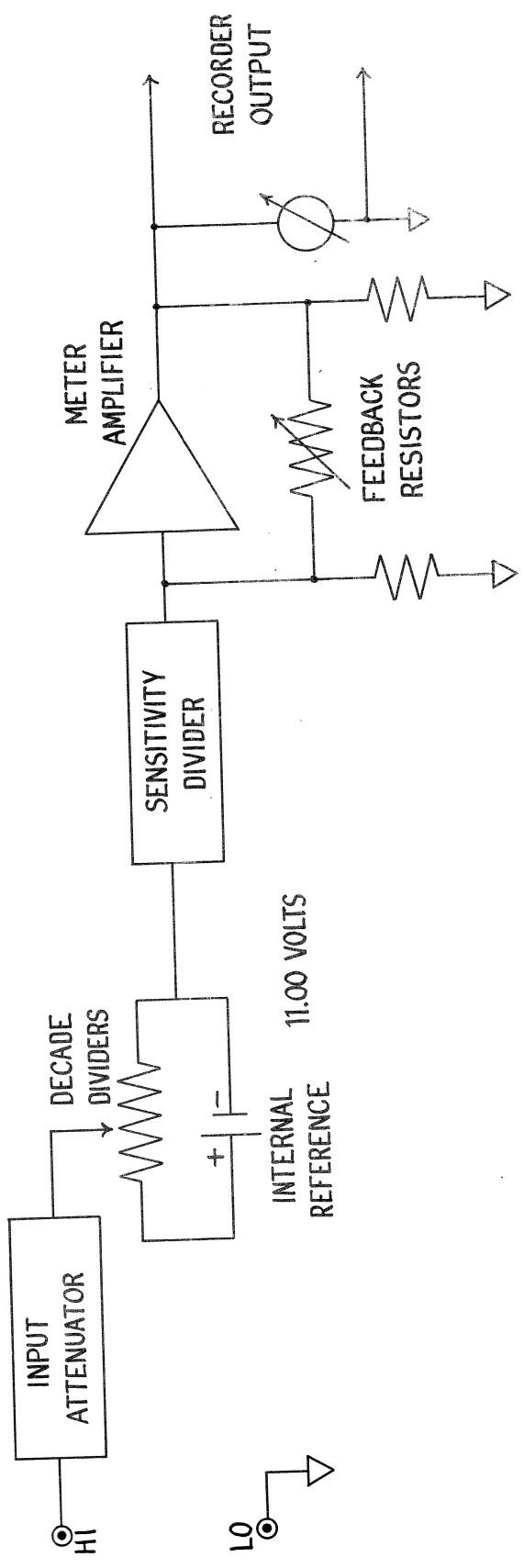
1. ALL RESISTORS HAVE BEEN RATIO MATCHED TO R_1 .
2. 735A 1.000 V OUTPUT HAS BEEN CALIBRATED AGAINST CERTIFIED STANDARD CELL.

THEN

1. IF VOLTAGE APPLIED TO 10 VOLT INPUT IS ADJUSTED FOR NULL ON $3\mu\text{V}$ RANGE OF 419, THIS VOLTAGE IS 10.000 V WITHIN <5 PARTS OF CERTIFIED REFERENCE. (THE SAME CAN BE SAID OF ANY INPUT.)
2. LOAD ON ANY TAP WILL DISTURB ONLY THOSE TAPS AT A HIGHER VOLTAGE.



3420 A/B DC DIFFERENTIAL VOLTMEETER/RATIO METER



DC DIFFERENTIAL VOLTMEETER

RANGES: ±1,000 VOLTS TO ±1,000.0 VOLTS (10% OVERRANGE)

MAXIMUM SENSITIVITY OF 0.2 μV ON 1.0 V RANGE

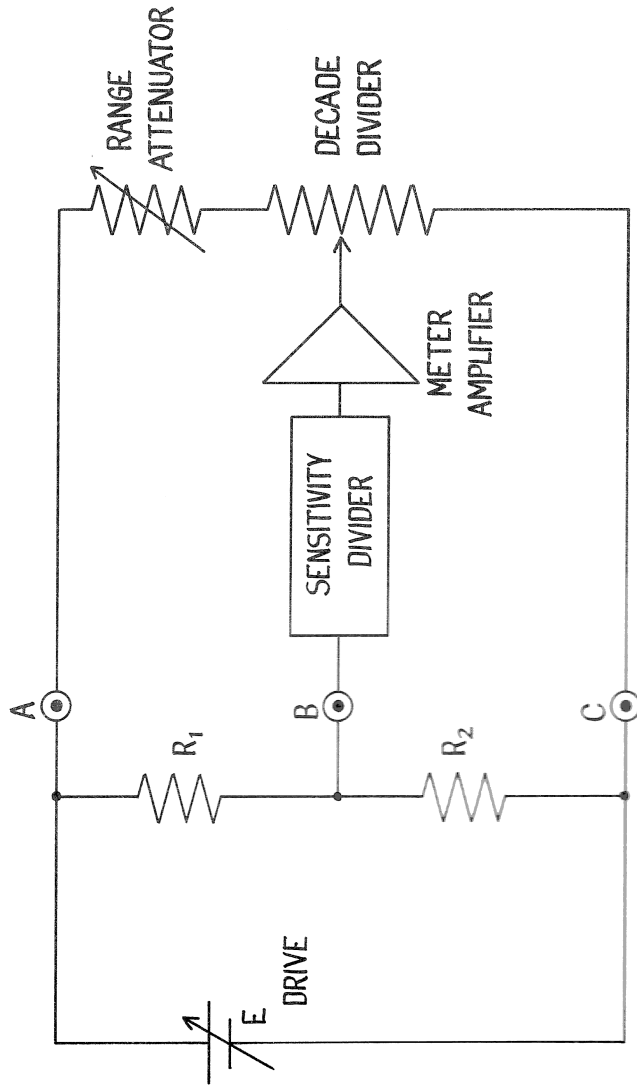
ACCURACY: ±(0.002% OF READING + 0.0002% OF RANGE) FOR A PERIOD OF 30 DAYS

STABILITY:

TIME 1 PPM/HOUR 5 PPM/DAY

TEMPERATURE ± 4 PPM/°C OF READING

3420A/B IN RATIO METER MODE



RANGES:

X1, X.1, X.01 AND X.001

SIX DIGIT READOUT

ACCURACY:

±(0.002% OF READING
+0.0004% OF HIGHEST

DECADE SETTING) FOR 60 DAYS

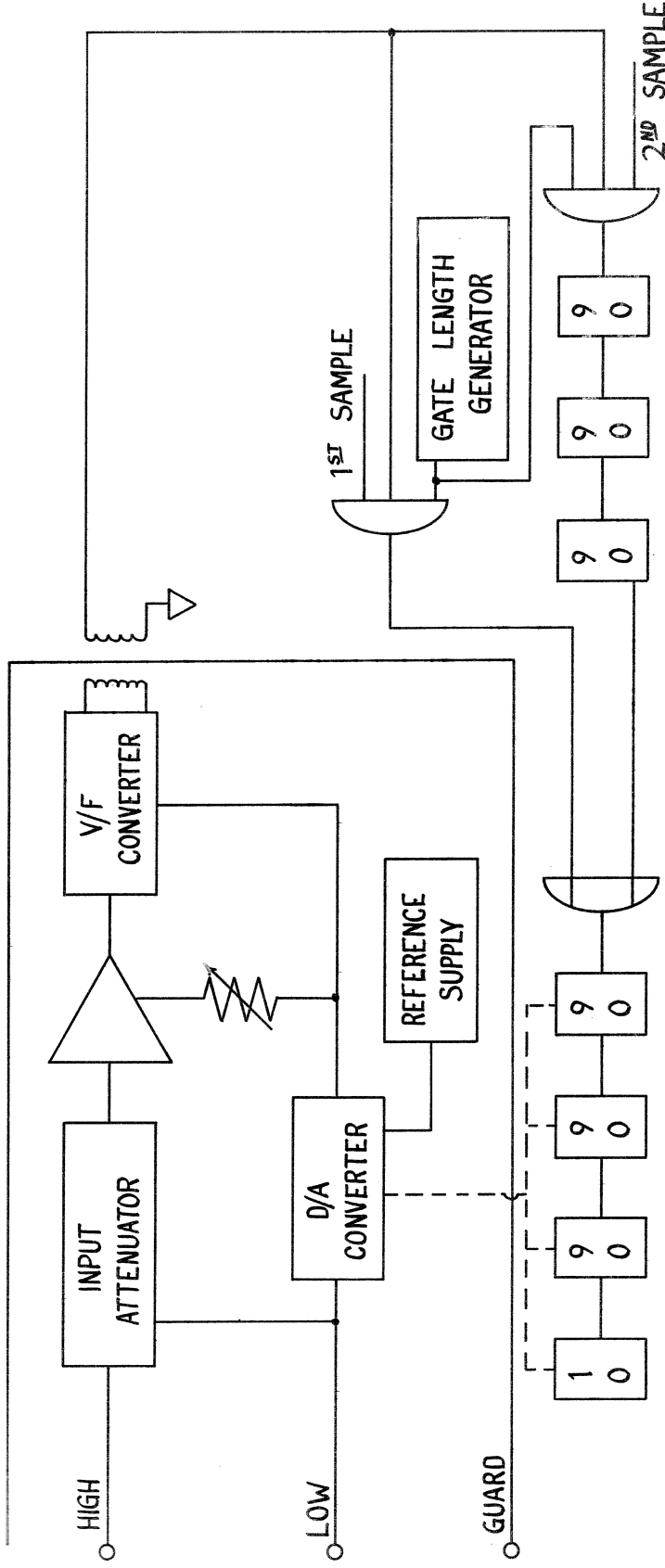
TEMP. COEFFICIENT:

X1 RANGE - 1 PPM/°C

OTHERS - 5 PPM/°C

INDICATOR RATIO: $\frac{R_2}{R_1 + R_2}$

H04-3460 A DIGITAL VOLTMETER



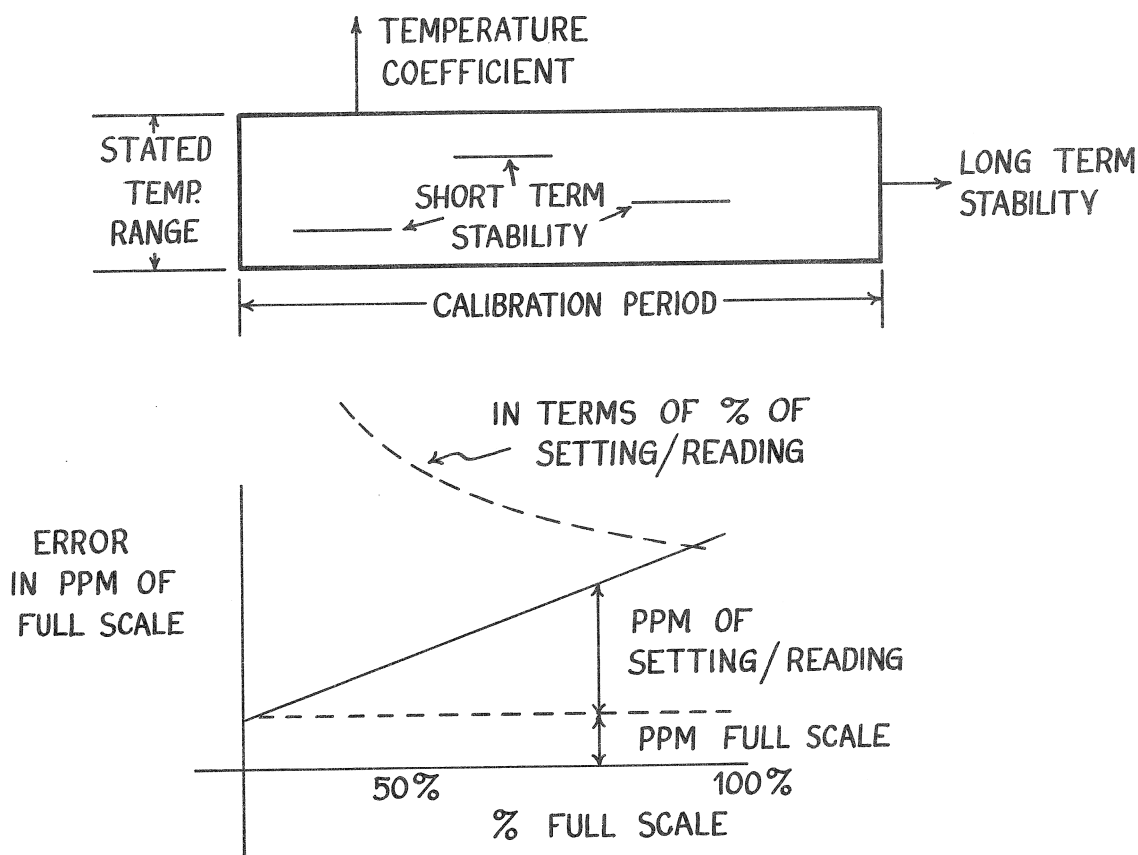
RANGES: $\pm 1V$ TO $\pm 1000 V$
RESOLUTION: 1 PART IN 1.2×10^6 MAX.
SENSITIVITY: $1 \mu V$

ACCURACY: $\pm(0.004\%$ OF READING $+0.002\%$ FULL SCALE) STD
 FOR A 90 DAY PERIOD
 FROM 20° TO $30^\circ C$
 $\pm(0.005\%$ OF READING) OR $\pm(0.0005\%$ FULL SCALE) H04

STABILITY: TIME: 0.008% OF
 READING FOR 6 MOS.
TEMP: 0.0002%/°C

SPECIFICATIONS I

ACCURACY: (ABSOLUTE - RELATIVE TO LEGAL U.S. VOLT)

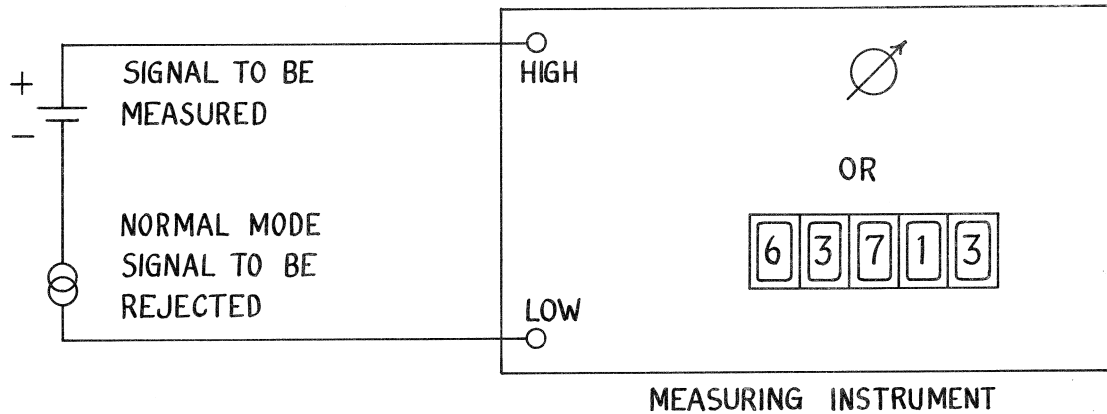


RESOLUTION: NUMBER OF DIGITS READ OR GENERATED.
 740B HAS 6 FULL DIGITS IN ITS GENERATED DC VOLTAGE (1 PART IN 10^6).
 3420 A/B HAS (1 PART IN 5×10^6) RESOLUTION AT FULL SCALE IN ITS READINGS.

SENSITIVITY: SMALLEST INCREMENTAL VOLTAGE READ OR GENERATED ON LOWEST RANGE.
 740B HAS A SENSITIVITY OF $1 \mu\text{V}$ WHEN GENERATING VOLTAGES ON THE 1.00 VOLT RANGE.
 3420 A/B HAS A SENSITIVITY OF $0.2 \mu\text{V}$ WHEN MAKING MEASUREMENTS ON ITS 1.00 VOLT RANGE.

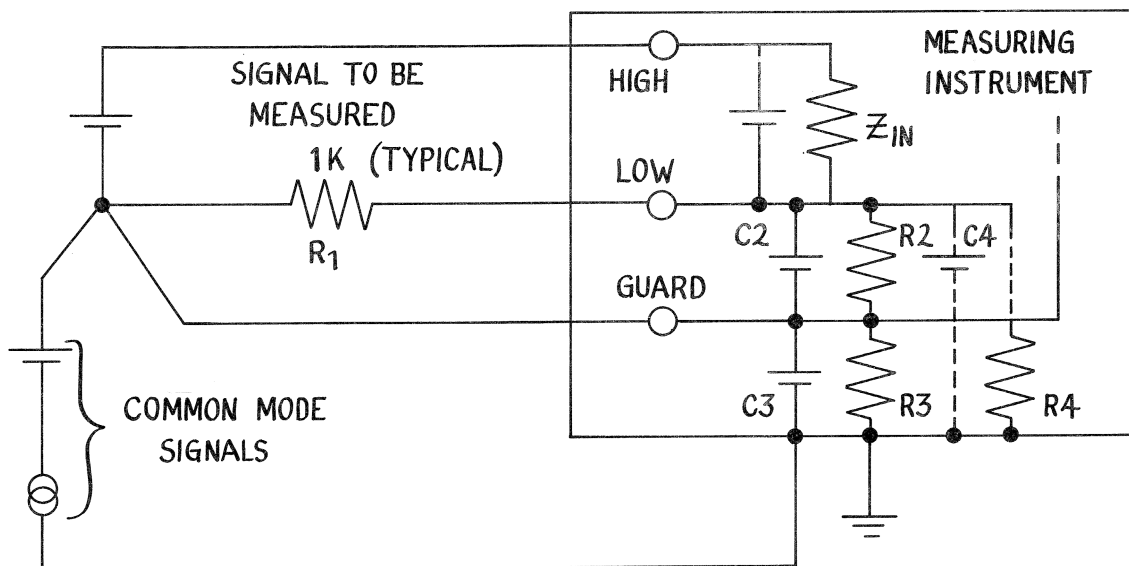
SPECIFICATIONS II

NORMAL MODE REJECTION:



NORMAL MODE REJECTION IS THE AMOUNT OF REDUCTION (BY FILTERING OR BY INTEGRATION) OF THE EFFECT OF NORMAL MODE NOISE ON THE READING.

COMMON MODE REJECTION:

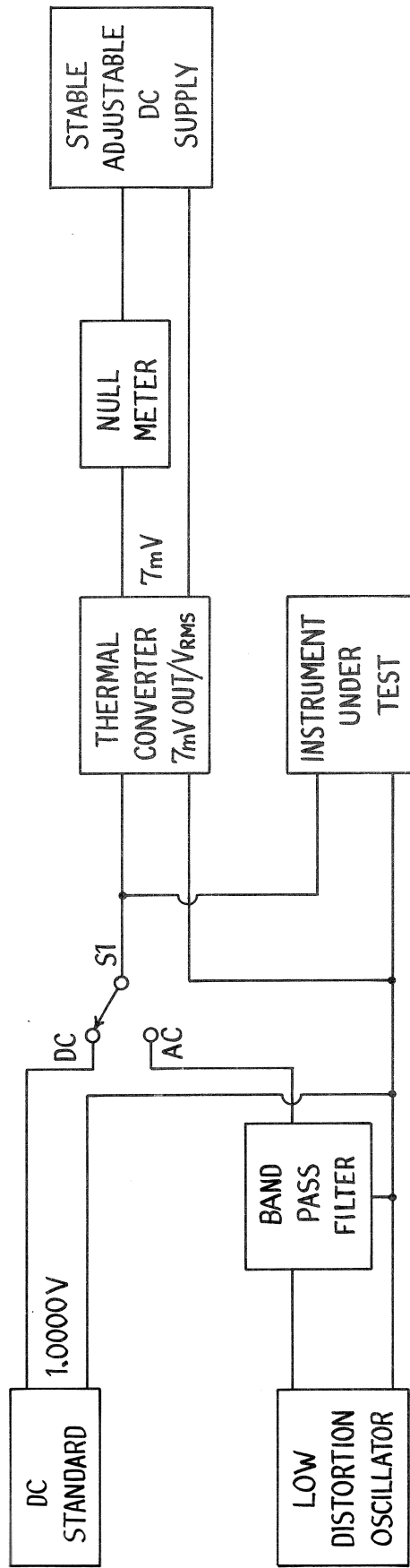


COMMON MODE REJECTION IS THE AMOUNT OF REDUCTION (BY GUARDING OR DIFFERENTIAL INPUT) OF THE DROP ACROSS THE 1K Ω UNBALANCE CAUSED BY THE COMMON MODE SIGNAL.

EFFECTIVE COMMON MODE REJECTION:

THE COMBINED EFFECTS OF NORMAL MODE REJECTION AND COMMON MODE REJECTION.

TRADITIONAL AC CALIBRATION TECHNIQUES

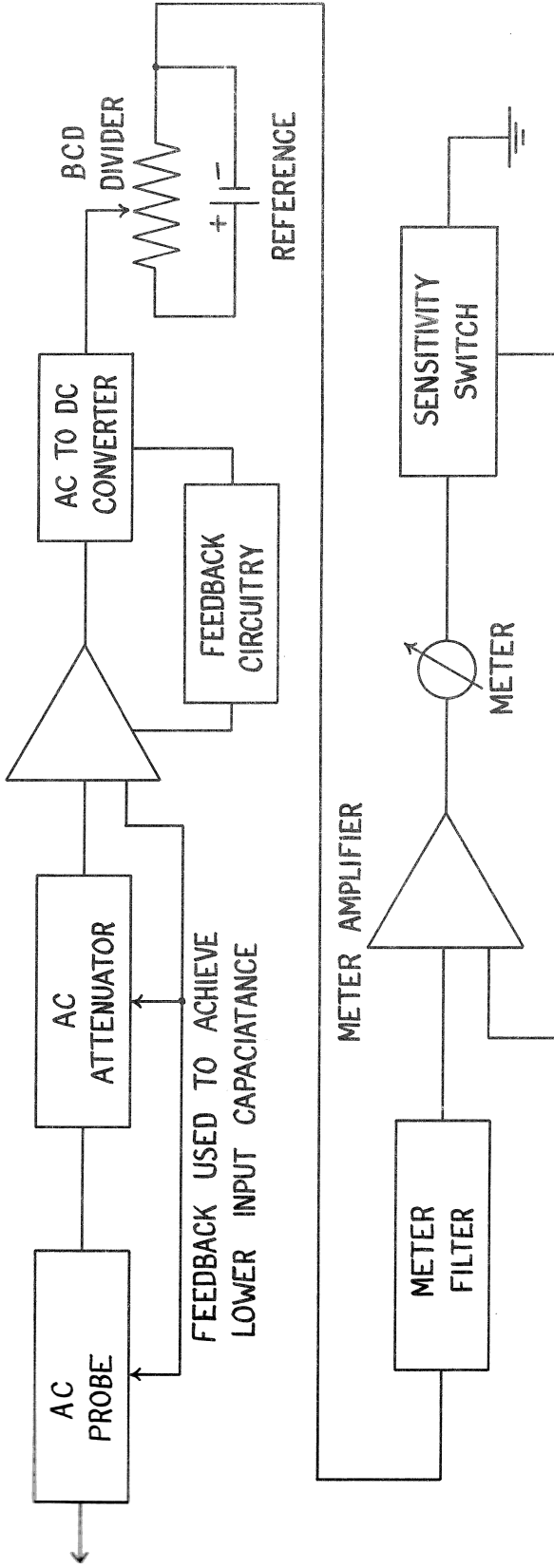


1. CONNECT S1 TO DC POSITION. ADJUST STABLE ADJUSTABLE DC SUPPLY TO ACHIEVE NULL ON NULL METER.
2. REVERSE POLARITY OF STANDARD. NOTE READING ON NULL METER (X)
3. CONNECT S1 TO AC POSITION. ADJUST LEVEL OF LOW DISTORTION OSCILLATOR UNTIL NULL METER INDICATES $\frac{X}{2}$.

VOLTAGE APPLIED TO INSTRUMENT UNDER TEST IS 1.000 V AC RMS. AT MIDBAND FREQUENCIES - 20Hz TO 20 KHz - ACCURACIES ON THE ORDER OF $\pm 0.01\%$ WITH RESPECT TO STANDARD AND AN UNCERTAINTY OF $\pm .003\%$ CAN NOW BE ACHIEVED (AS OF JAN. 1968).

741B AC-DC DIFFERENTIAL VOLTMEETER / DC STD.

LOW VOLTAGE
AMPLIFIER

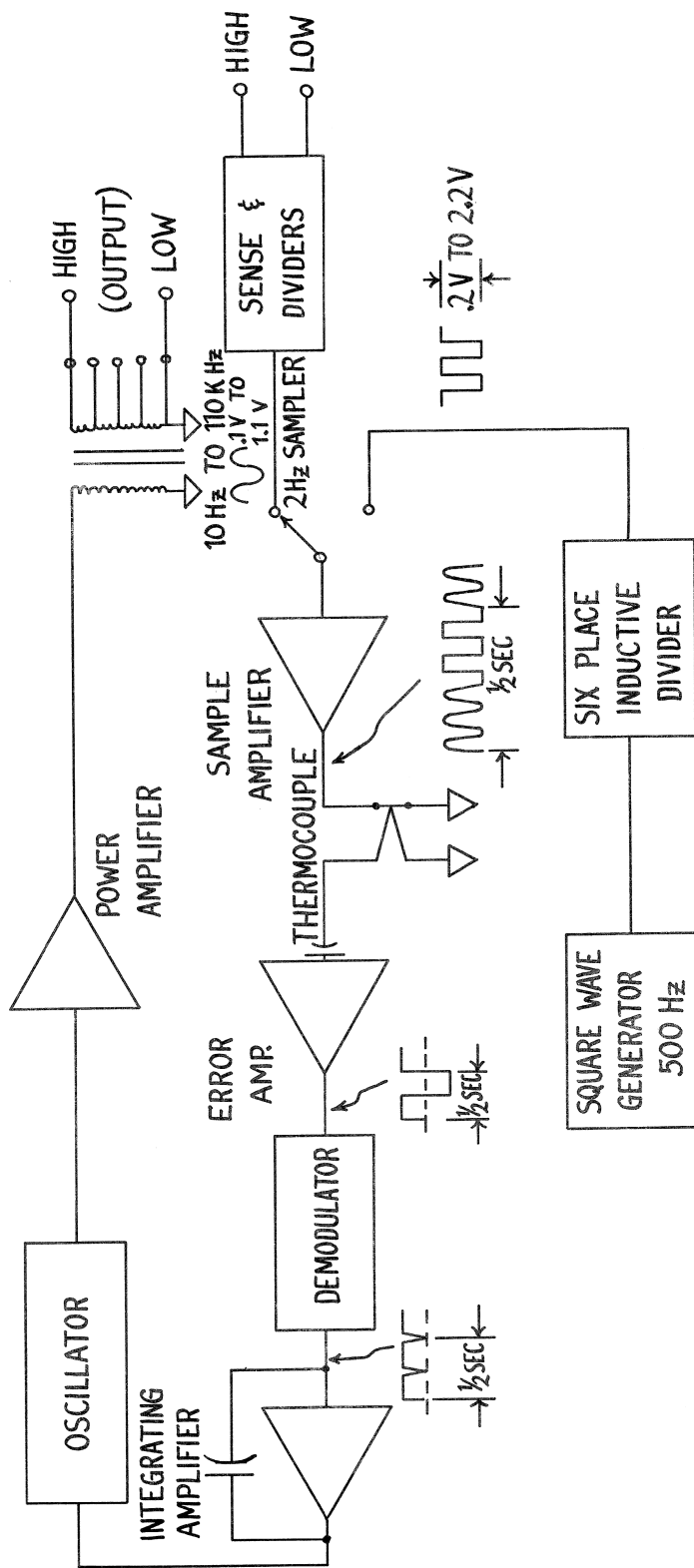


AC DIFFERENTIAL VOLTMEETER

RANGES: 1 TO 1000 V FULLSCALE
RESOLUTION: 4 PARTS IN 10⁵

ACCURACY: ±(.04% OF READING + .01% OF RANGE)
FROM 50mV TO 1,000 VOLTS
FROM 100 Hz TO 10 K Hz
FOR A PERIOD OF 90 DAYS

745A AC CALIBRATOR



VOLTAGE RANGES: 1mV TO 100V FS - 10% OVERRANGE
 1 PART IN 10^6 RESOLUTION
 1nV SENSITIVITY

FREQUENCY RANGES: 10 Hz TO 110 KHz (4 RANGES)
ACCURACY: .02% - 20 Hz TO 20 KHz