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CUBIC CORPORATION

San Diego 11, California

Electronic Engineering

With a Dimension for the Future

OPERATING AND MAINTENANCE
INSTRUCTIONS
FOR
CUBIC MODEL V-45
DIGITAL VOLTMETER

Manufactured by:

CUBIC CORPORATION
5575 Kearny Villa Road
San Diego 11, California

ADDENDUM & REVISIONS

Revision #1:

DELETE

1. Figure 8 sheets 1 & 2
2. Paragraph 3-4 "Comparison Amplifier"
3. Paragraph 3-5 "Switch Driver Assembly"

ADD

1. Schematic drawing #21-0500 D/C "F"
2. Paragraph 3-4A "Amplifier Board Assembly"
3. Paragraph 3-5A "Switch Driver Board Assembly"

3-4A. AMPLIFIER BOARD ASSEMBLY: The amplifier board contains circuitry to raise the level of the differentiated pulses presented to pin 26 by the chopper. Transistor Q1 serves as a ripple filter while decoupling the -22v dc at pin 33. The resulting -20v dc is used throughout the amplifier. The +22v dc at pin 32 is decoupled by RC network R3 and C2. The amplifier assembly consists of the input limiting circuit, an impedance matching transformer, and an amplifier.

a. Input Limiting Circuit - Input limiting is accomplished by CR1 and CR2. Any voltage below -0.6v dc causes CR1 to conduct the excess voltage to ground. Any voltage above +0.6v dc causes CR2 to conduct the excess voltage to ground. This limitation of the voltage range prevents large signals from saturating the amplifier.

b. Impedance Matching Transformer - Transformer DO-T7 provides a high input impedance and an optimum source impedance for the first amplifier stage (Q2).

c. Amplifier - The amplifier consists of four amplifier pairs. In the first pair, Q2 is a grounded emitter amplifier stage coupled through a voltage divider to Q3, an emitter follower. Feedback from the emitter of Q3 is applied through R6 to the base of Q2. R6, in conjunction with R4, accurately determines the gain of this stage. Each of the other three pairs operates in an identical manner. The second pair consists of Q4 and Q5, the third pair is Q6 and Q7, and the fourth pair is Q9 and Q10. The output of Q7 is applied to emitter follower Q8. The output from Q8 is applied to the potentiometer, and through R26, C3, and C4 to the base of Q2 as an over-all feedback loop. This particular loop stabilizes the operating points of all amplifier stages by reducing the over-all gain to approximately 15 db. The wiper arm of the sensitivity potentiometer feeds pin 20 of the driver board, and through pin 30 provides an input to amplifier pair Q9 and Q10. This

is accomplished through cross-coupling from the collector of Q8 through R16 to the base of Q3. This prevents the possibility of both driver circuits firing simultaneously.

Transistor Q5 is a threshold amplifier stage which raises the level of the drive circuits so that a signal must exceed the preset threshold established by emitter bias network R22, R21, and C3. Any negative signal from the collector of this transistor is applied through R26 to the base of Q7 which, in conjunction with Q9, forms a bistable circuit. When Q5 does not conduct, a negative voltage is present at the base of Q7 causing it to conduct. The collector of Q7 is grounded as is the base of Q9. This grounded base keeps Q9 turned off. This same ground signal is applied to the base of Q4 causing it to be cut off and allowing the driver channel to operate. When a negative signal which exceeds the established threshold is applied to the base of Q5, the transistor conducts heavily and its collector goes to ground. This allows a positive voltage to be applied to the base of Q7 through R26 and R27 and turns Q7 off. The negative voltage applied to the collector of Q7 and the base of Q9 causes Q9 to conduct. This same negative voltage is applied to the base of Q4 causing it to conduct and inhibit its driver circuit.

Diodes CR3 and CR4 at the emitter of Q9 provide -1.2v dc off bias and establish a threshold for this stage. Once Q9 has been triggered, it will continue to conduct until a turnoff signal is applied to its base because the Q9 collector voltage is fed back to the base of Q7 to keep it cut off. The turnoff signal consists of a ground applied through diode CR11 to the base of Q9 which forcibly turns it off. The turnoff signal originates from the self-interrupter contact of a stepping switch. To prevent excessive negative overshoot from the stepping switch coils to Q9 at cutoff, the induced voltage from the stepping switch coil is limited to -50v dc by clamp diode CR6 and zener diode CR5 in conjunction with the -30v dc supply.

pair functions as a unity gain amplifier. Its output voltage, 180 degrees out of phase with the input, is applied through pin 31 to pin 21 of the driver board. Resistor R21 in conjunction with potentiometer R23 provides a gain control for the amplifier. R23 should be adjusted for the minimum gain which permits the instrument to step down one digit at a time. Excessive gain can result in instability; insufficient gain can result in a lack of sensitivity.

3-5A. SWITCH DRIVER BOARD ASSEMBLY: The switch driver board contains the gating, timing, and power amplification circuitry to drive the stepping switches in accordance with the data fed from the amplifier. The signals applied to pins 20 and 21 are 180 degrees out of phase. They drive separate, identical switch driver circuits to provide up and down pulses for the stepping switch balance logic. Since the circuits are identical in function, only one channel is described.

The input signal at pin 20 is coupled through C1 to diode CR1 which allows only negative-going signals to pass through the transistor gates, Q1 and Q3. Transistor Q1 provides a dual gating function. A 60 cycle reference voltage from the power supply board is applied to the Q1 base through R10. During the negative half-cycle of this signal transistor Q1 conducts. No input signal can be developed between its collector and emitter, so none can be transmitted to the following driver circuitry. Similarly, a timing signal is applied through R12 from the delay circuitry (Q11, Q12, and Q13). This disables both driver channels for a period of 34 msec following each drive pulse, thereby timing the operation of the instrument.

Transistor Q3 functions in a similar manner except that it inhibits transmission of drive signals when the opposite driver circuit has fired. This

When the driving circuit is triggered, a positive-going pulse is fed through C4 and CR8 to a monostable delay circuit composed of Q11, Q12, and Q13. The pulse is applied to the base of Q13 cutting it off. At the same time C6 discharges. After discharge, R40 and R41 recharge C6 while keeping Q13 cut off. During the period that Q13 is cut off, a negative voltage is fed back from its collector to the base of Q11 causing it to conduct. This same negative voltage is fed back through a delay network consisting of R45 and C7 to the bases of Q1 and Q2 causing them to conduct and inhibit both driver circuits for a 34 msec period. While C6 is charging, Q13 gradually begins to conduct thereby placing a ground at the Q11 base. This cuts it off and returns the negative voltage to the base of Q12 causing it to conduct. The delay which disables both drivers for 34 msec results in a 50 msec period between drive pulses. Adjustment of R40 controls the period of this delay and should be considered a maintenance procedure.



Frontispiece. Cubic Model V-45 Digital Voltmeter

SPECIFICATIONS

| | |
|---------------------------|--|
| Display: | 4 digits, polarity, decimal point. |
| Potentiometer Linearity: | 0.003%. |
| Potentiometer Resistance: | 55,000 ohms. |
| Voltage Ranges: | ± 0.000 to 10.999 ± 00.00 to 109.99 ± 000.0 to 1,099.9 |
| Accuracy: | 0.01% ± 1 digit. |
| Input Filter: | 50 db rejection at 60 cycles, increasing at approximately 24 db/octave with frequency. |
| Input Terminals: | Front panel mounted jacks- a. Signal input b. Signal ground c. Chassis ground |
| Input Impedance: | 10 megohms at balance. |
| Balance Time: | Two seconds average. |
| Mounting: | Supplied with brackets for rack mounting and rubber feet for bench use. |
| Weight: | 26 pounds. |
| Power Input: | 105 - 125V, 50 - 60 cps, 25 watts standby, 30 watts operating. |

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SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION: The Cubic Model V-45 Digital Voltmeter is a self-contained transistorized dc voltage measuring instrument operating on the stepping switch logic principle. It is designed to measure dc voltages from 1 millivolt to 1099.9 volts with an accuracy of $\pm 0.01\%$, ± 1 digit. The input filter permits stable dc measurements to a resolution of 1 mv in the presence of 60 cycle ac signals up to 0.3 volts peak-to-peak. A floating input allows measurements to be made with up to 30 volts peak-to-peak at 60 cycles between chassis and signal grounds. A 10% overrange on all ranges provides greater resolution near the range change points.

1-2. EQUIPMENT SUPPLIED: The voltmeter is shipped complete with input cable, operator's manual, rack mounting brackets, and accessory kit. If damage caused by shipment is found, or if the instrument does not perform as specified, the purchaser is requested to follow the warranty instructions included in this manual.

SECTION II
INSTALLATION

2-1. GENERAL: The Model V-45 Digital Voltmeter can be installed and used in any laboratory environment as well as many industrial environments. A dust cover is provided over the switch section for complete dust, thermal, electrical, and acoustical isolation. The operating range of the instrument is from 0° to +55°C.

2-2. ACCEPTANCE CHECK: When the instrument is unpacked, inspect it for shipping damage. The following procedure may be used as a rapid check for correct operation.

- a. Connect the power cord to 117 volts $\pm 10\%$, 60 cycle ac.
- b. Plug the input cable into the jacks on the front panel. The hot lead goes to the red jack and the ground to the green jack.
- c. Turn the RANGE switch to the 10 position.
- d. Short the input leads together and turn on the POWER switch. The readout should indicate a balance of 0.000 ± 1 digit within 30 seconds.

SECTION III
THEORY OF OPERATION

3-1. GENERAL: Figure 1 is a functional block diagram of the V-45 Digital Voltmeter illustrating the principle of operation. The comparison amplifier senses the difference between the input voltage from the input attenuator and the voltage that appears across the lower half of the potentiometer. This presents a signal to the switch driver which moves the arm of the potentiometer in the direction that equalizes the two inputs. When the input voltage is greater than the reference voltage, the input attenuator is used to divide it by either ten or one hundred. This makes it possible for the input to be balanced to the potentiometer. At null the input voltage equals the reference voltage multiplied by the fraction of the bridge used and multiplied once more by the input attenuation used. Since these quantities are all accurately known, the input voltage can be precisely defined. The readout indicates the position of the potentiometer arm, and, with proper placement of the decimal point, displays the input voltage in digital form. The following paragraphs discuss the operation of each portion of the instrument.

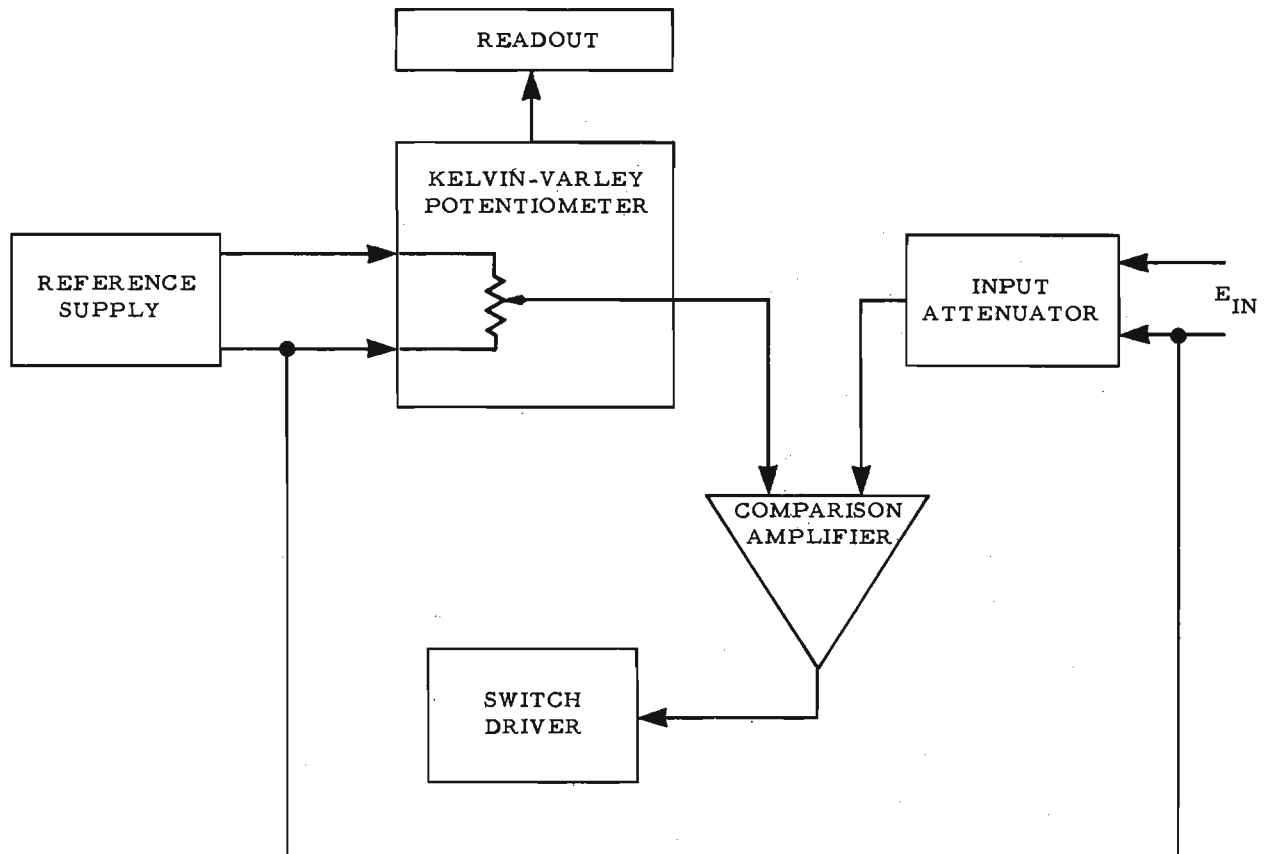


Figure 1. Functional Block Diagram of the V-45 Digital Voltmeter

3-2. POWER SUPPLY AND REFERENCE ASSEMBLY: This assembly consists of a main power supply and a precision reference voltage supply. The majority of the circuitry is located on a printed circuit plug-in board on the far left of the instrument, as viewed from the front. A power transformer and filter capacitors are located remotely on the main chassis.

a. Main Power Supply (Figure 8). The power transformer (T1) is shielded to provide isolation from the line voltage to permit the instrument to read voltages above ground. A center-tapped winding feeds CR1 and CR2 which are the negative supply rectifiers and CR3 and CR4 which are the positive supply rectifiers. C1 is the ripple filter for the -30V supply used to power the stepping switches and to supply the input voltage to the -22V regulator composed of Q1, Q2, Q3, and associated circuitry. C2 is the filter capacitor for the +22V supply which feeds CR8 through R9 to form a shunt Zener diode regulator. The +22V is used in the amplifier and driver circuits and serves as a reference for the -22V supply.

b. Precision Reference Voltage Supply (Figure 8). A shielded, center-tapped winding on transformer T1 powers the precision reference circuit. Rectifiers CR6 and CR7 with R10 and C6 produce 37V dc. The output of the precision reference supply is standardized by precision resistor R11 and potentiometer R12 to exactly 10.99V dc which is fed to the bridge potentiometer through the POLARITY switch.

3-3. STEPPING SWITCH CIRCUITRY: The stepping switch circuitry consists of the Kelvin-Varley potentiometer, balance logic, and the readout. The potentiometer, stepping switches and the balance logic are located under the dust cover. The readout is attached to the front panel.

a. Kelvin-Varley Potentiometer. Figure 2 is a simplified schematic of the potentiometer circuit used in the instrument. Each pair of potentiometer wipers and associated contacts are physically a level on a stepping switch.

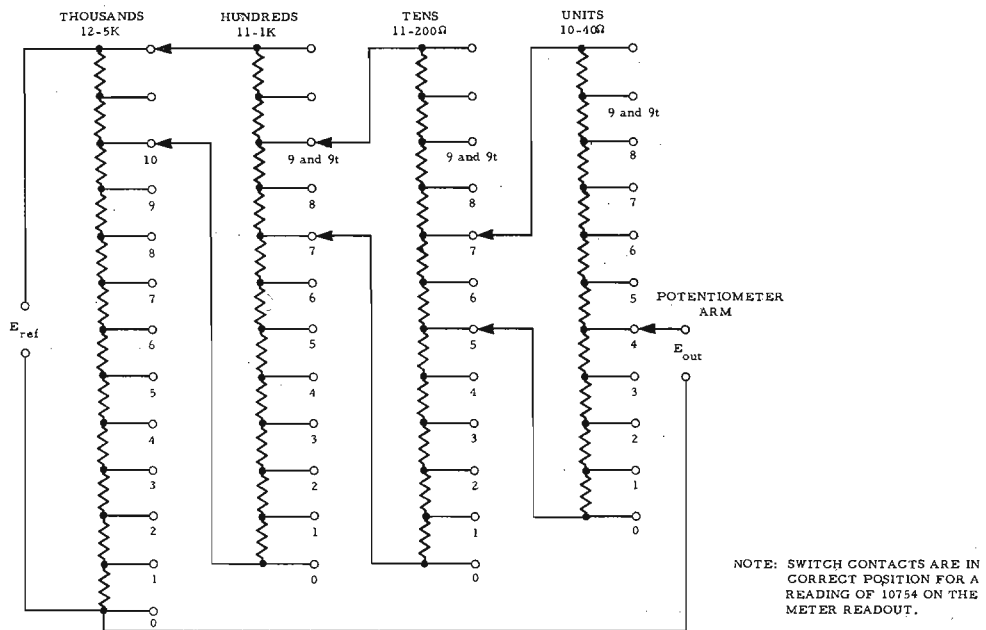


Figure 2. Simplified Schematic of Kelvin-Varley Potentiometer Circuit

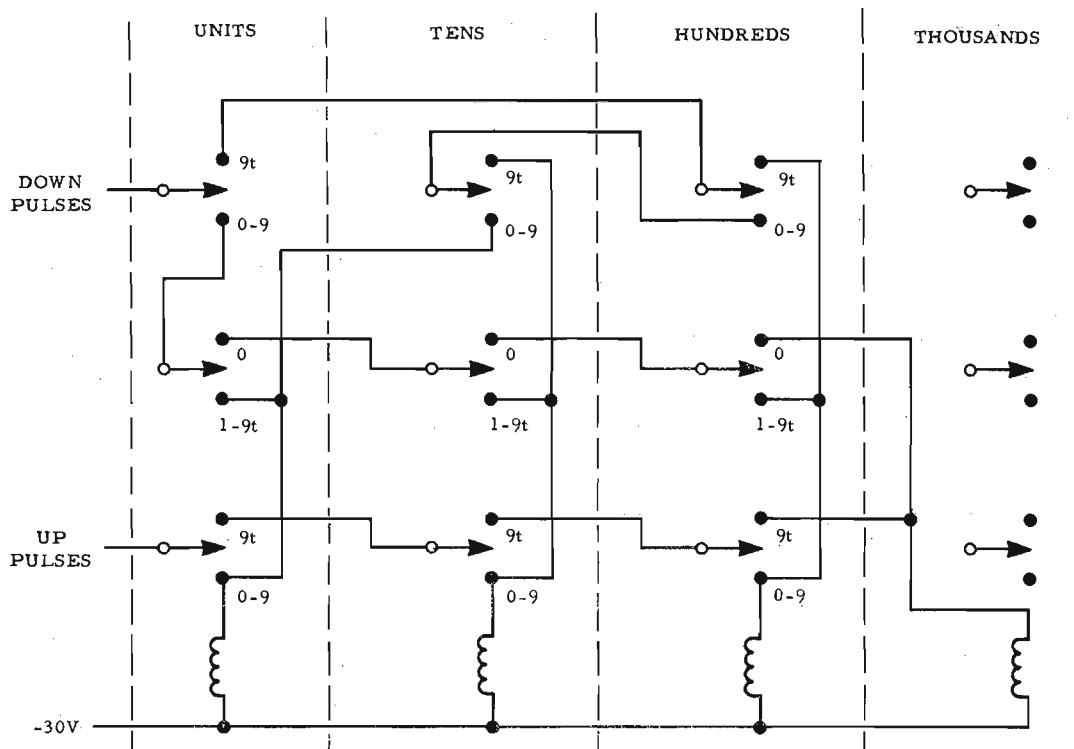


Figure 3. Simplified Stepping Switch Balance Logic Diagram

b. Balance Logic. Figure 3 is a simplified schematic of the balance logic functions performed by the stepping switches. The switch driver assembly provides a pulse on either the "up" or "down" line entering the switch logic. The line upon which the pulse appears depends upon whether the input voltage is greater or less than the voltage put out by the potentiometer. The pulse is routed through the contact network to a stepping switch coil. The routing is determined by the position of the stepping switches. The contact network is so arranged that the meter drives itself to null. Table I illustrates the logical events necessary to measure 1.324V when the instrument is at 0.000.

TABLE I
UPRANGING AND BALANCE LOGIC

| Event | Voltmeter Reading | Pulses | Switch Involved | Action |
|-------|-------------------|--------|-----------------|---------|
| 1 | 0 . 0 0 0 | 10 up | Units | 0 to 9t |
| 2 | 0 . 0 0 9t | 10 up | Tens | 0 to 9t |
| 3 | 0 . 0 9t 9t | 10 up | Hundreds | 0 to 9t |
| 4 | 0 . 9t 9t 9t | 1 up | Thousands | 0 to 1 |
| 5 | 1 . 9t 9t 9t | 1 down | Hundreds | 9t to 0 |
| 6 | 1 . 0 9t 9t | 3 up | Hundreds | 0 to 3 |
| 7 | 1 . 3 9t 9t | 1 down | Tens | 9t to 0 |
| 8 | 1 . 3 0 9t | 2 up | Tens | 0 to 2 |
| 9 | 1 . 3 2 9t | 1 down | Units | 9t to 0 |
| 10 | 1 . 3 2 0 | 4 up | Units | 0 to 4 |
| 11 | 1 . 3 2 4 | null | --- | --- |

c. Readout. One level on each stepping switch is utilized for readout illumination. The digit illuminated is a visual indication of the position of the bridge potentiometer and the magnitude of the input voltage when the instrument has nulled.

3-4. COMPARISON AMPLIFIER: The comparison amplifier board is located on the right side and toward the rear of the mother board. This board contains semiconductor circuitry to amplify the signal presented to it by the chopper (see figure 8). The chopper is located to the left and in front of the amplifier board. It consists of a mechanical switch operating at 60 cps which alternately switches the input of the amplifier between the input voltage and the output of the bridge potentiometer. This produces a 60 cycle square wave whose amplitude is determined by the difference between these voltages. This square wave is then differentiated by C12. The resulting pulses are amplified by Q2, Q3, Q4, Q5, Q6, and Q9 and then fed to gain potentiometer R29. R26, R27, R28, R10, R11, R12, C10, C4, and C5 comprise a feedback network designed to eliminate the effects of transistor drift and to standardize and stabilize the gain of the amplifier. Q1 and Q10 with their associated circuits provide decoupling and ripple attenuation for the amplifier power supplies. The output of the sensitivity potentiometer R29 feeds the up driver. Q7 and Q8 which form a unity gain inverting amplifier feeds the down driver.

3-5. SWITCH DRIVER ASSEMBLY: The switch driver board is located immediately in front of the amplifier board and contains the gating, timing, and power amplification circuitry to drive the stepping switches in accordance with the intelligence fed from the comparison amplifier. (See figure 8.) Q1, Q2, Q3, Q4, and Q11 form the up driver with Q5, Q6, Q7, Q8, and Q12 performing the same functions respectively in the down driver circuit. Q1 is a two-purpose gate: First, the signal fed to it through R5 causes it to inhibit the switch driver input during the negative half cycle of the 60 cycle line to which the chopper is synchronized, thereby eliminating undesired information pulses. In addition, a signal derived from Q9 and Q10 is applied through R39. This inhibits input pulses for a period following a driver pulse to allow time for transients to die out and reduce the operating speed of the stepping switches. Q2 is a similar shunt gate and receives an inhibit signal from the down driver when it is putting out a pulse. This prevents both drivers from firing simultaneously. The gate output goes to amplifier Q3, the output of which is used to trigger the flip-flop formed by Q4 and Q11. The collector of Q11 feeds the "up" logic input of the stepping switch circuitry through CR5. Once triggered, this flip-flop remains in a set state until reset by the closing of the self-interrupter contacts of any of the four stepping switches. This action occurs when any switch armature pulls in. This grounds one side of CR4 and clamps the base of Q11 turning it off, thereby resetting the flip-flop. CR6 and CR3 in the collector circuit of Q11 prevent the stepping switch flyback voltage from rising any higher than -50V, at which time Zener diode CR3 breaks down. When the drive pulse terminates, the delay circuit formed by Q9 and Q10 is triggered through C5 and R31 or C4 and R30. This circuit is a one-shot multivibrator which inhibits both drivers during the stepping switch settling time.

3-6. INPUT ATTENUATOR ASSEMBLY: The input attenuator assembly (see figure 8) is located behind the RANGE and POLARITY switches on the front panel. The assembly consists of a 10-megohm resistor string with calibrating potentiometers, a neon tube, input filters, and switches. Stable metal film resistors provide attenuation factors of 0, 10, or 100 as selected by the RANGE switch. Potentiometers R8 and R9 are used to calibrate the attenuation to the desired value. The attenuator output is fed to the NE2 neon tube, I1, which conducts when excessive input voltage is applied, thereby protecting the filter, chopper, and amplifier. The input filter consists of four RC networks providing roughly 50 db of attenuation to 60 cps signals. The attenuation increases with frequency at about 24 db per octave. The output of the filter is fed to the chopper through R7 where it is compared to the output of the precision bridge potentiometer. The front deck of the attenuator switch (RANGE switch) switches the readout decimal point to correspond to the selected range. The POLARITY switch reverses the reference voltage, exchanges the functions of the "up" and "down" pulse drivers, and provides power to illuminate the + or - readout plate.

SECTION IV

OPERATION

4-1. GROUNDING: The V-45 Digital Voltmeter is provided with a floating input circuit to permit stable readings to be made when the voltage to be measured is isolated from earth ground by either an ac or dc signal. To use the instrument in this manner disconnect the shorting link between the black jack (chassis ground) and the green jack (signal ground). Stable measurements can now be made with up to 500V dc between these terminals or up to 30V peak-to-peak at 60 cps when on the 10V range.

4-2. NOISY SIGNALS: An input filter incorporated into the unit permits measurements to be made in the presence of noise, transients, or other signal disturbances. For example, readings may be made to a resolution of 1 mv with up to 0.3V peak-to-peak at 60 cps between the input terminals. This rejection increases by roughly a factor of 8 for each doubling of frequency.

4-3. READOUT INTERPRETATION: The digits illuminated in the four right-hand windows of the readout represent the absolute magnitude of the input voltage when the meter is at null. These shall be referred to as units, tens, hundreds, and thousands windows, reading from right to left. The RANGE switch positions the decimal point to provide the correct reading when the range attenuator is in use. If, upon application of an input signal, the units, tens, and hundreds windows contain all 9s and the thousands window rotates continuously, advance the RANGE switch to the next higher position. Input protection prevents damage to the instrument when high voltages are applied on the low ranges. In general, the RANGE switch should be on the lowest range which will permit display of the input voltage without overloading the instrument, as this will give the most accurate reading. If this is accomplished, no zeros will show to the left of the most significant digit. The voltmeter can be made to read as high as 10,999, giving a 10% range extension and, therefore, greater resolution. If the units, tens, and hundreds windows read 000 and the thousands window rotates continuously, turn the POLARITY switch to the opposite setting. The sign displayed in the polarity window will then represent the polarity of the voltage applied to the red jack with respect to the green jack.

4-4. SENSITIVITY CONTROL: In those cases where input disturbances are greater than can be rejected by the instrument unstable operation will result with the voltmeter continuously seeking a null. The SENSITIVITY potentiometer in the lower right-hand corner of the front panel permits continuous adjustment of instrument sensitivity over a range of roughly 20 digits, with a STANDBY position which completely desensitizes the instrument. If less sensitivity is required it can also be achieved by setting the instrument to a higher range. It is important that the SENSITIVITY potentiometer be set to the FULL position when maximum accuracy is desired. At a critical setting of the SENSITIVITY potentiometer near STANDBY, instability may occur. Avoid this setting of the potentiometer when operating the instrument.

SECTION V
MAINTENANCE

- 5-1. GENERAL: Preventive maintenance for the V-45 Digital Voltmeter consist mainly of periodic inspection, cleaning, and lubrication.
- 5-2. PERIODIC INSPECTION: Depending upon operating time and environment, periodically inspect the instrument for broken leads, mechanical security, damage to printed circuits, and loose components.
- 5-3. CLEANING: Remove dirt and dust from the components and printed circuit boards with a low velocity air stream.

NOTE

Do not clean stepping switches with a brush. A pipe cleaner may be used safely.

In corrosive atmospheres (salt air, etc.) clean printed circuit boards with Lonco No. MC1136 resin flux remover (Claude Michael, Glendale, California). Clean the polarizer plate (located in front of the readout) with a small amount of alcohol and a very soft lint-free cloth. Use light horizontal strokes in one direction in order not to scratch the surface.

- 5-4. REPAIR: Standard repair procedures are used throughout the instrument. Stepping switch disassembly and repair are discussed in paragraph 5-9.
- 5-5. CALIBRATION: The only equipment necessary to calibrate the Model V-45 Voltmeter is a voltage source capable of providing 10.000, 100.00, and 1000.0V dc within a tolerance $\pm 0.01\%$ and a small tuning tool. The following steps are to be accomplished in the order given.
- a. Remove the top cover from the Voltmeter.
 - b. Power the Voltmeter and allow a minimum of 15 minutes warmup to completely stabilize the instrument.
 - c. Set the instrument to the 10V range and to + polarity.
 - d. Apply 10.000V $\pm 0.01\%$ to the input terminals. If the Voltmeter does not read correctly, adjust trimming potentiometer R12 on the power supply reference board for a correct reading.
 - e. Set the instrument to the 100V range.
 - f. Apply 100.00V $\pm 0.01\%$ to the input terminals. If the Voltmeter does not read correctly, adjust trimming potentiometer R8 on the right side of the attenuator assembly for a correct reading.
 - g. Set the instrument to the 1000V range.
 - h. Apply 1000.0V $\pm 0.01\%$ to the input terminals. If the Voltmeter does not read correctly, adjust trimming potentiometer R9 (located next the R8) for a correct reading.

5-6. LUBRICATION, GENERAL: Except for the stepping switches, no lubrication is required in the unit. These switches were lubricated, adjusted, and carefully run-in at the factory. They should require very little or no maintenance (other than cleaning and lubrication) and have a service life of many thousands of operational hours.

The lubrication schedule presented below is recommended by Cubic Corporation and the switch manufacturer. Some interpretation may have to be made to fit particular environmental conditions, specific operations and elapsed time in service. In general, however, clean and lubricate the switches each 30 days. If the instrument is used over 8 hours a day or in elevated temperatures, a 15-day maintenance cycle is recommended.

5-7. METHOD OF LUBRICATION: Before attempting lubrication, clean all contacts as outlined in paragraph 5-3. Apply only the amount of lubricant indicated below. Too much lubricant, or application to parts not requiring lubrication, will be as detrimental as too little lubricant. To establish a recommended amount, the term "dip" will be used as a guide and defined thus: Dip a No. 4 Artist's Sable Rigger brush into the lubricant about 3/8 of an inch. Wipe the brush gently against the side of the container to remove the drop which forms at the point of the bristles.

In most cases one "dip" will be sufficient to lubricate several parts, since only a light film of lubricant is desired on each part. Brush the lubricant over the parts; do not scrub the brush on the parts as such action usually results in too much lubricant on the first and surrounding parts with little or no lubricant on succeeding parts. If the unit is operated at temperatures of 90° F or higher, lubricate the switches about twice as often as recommended above.

During the manufacturing process, the undercut portion of the rotor shaft is filled with ANG-3-A grease. A small portion of this grease is also applied to the end of the shaft opposite the mounting hub before the shaft is assembled to the hub. This lubrication is good for the life of the switch and needs repeating only when replacing the rotor assembly. The following list of lubricants recommended by and available from Cubic Corporation are in accordance with Automatic Electric Company Standard Specifications:

Watch Oil Spec. 5228 Approved Material: Nye's Watch Oil manufactured by William F. Nye, Inc., is the only oil approved for use under this specification.

Switch Lubricant Spec. 5232 Grade "C". Approved Material: Grade "C" one part by volume blended Lubricating Oil Spec. 5684, (Standard Oil Company), one part by volume concentrated Oildag, (Acheson Oildag Company).

ANG-3-A Grease for Rotor Shaft Spec. 5692. Approved Material: The Hi-Lo Temperature grease manufactured by the Gaplerud Lubricants Company, Mason City, Iowa is the only grease approved under this specification.

5-8. LUBRICATION PROCEDURE: Lubricate the switch according to the following steps. The lubrication points are shown in figure 4.

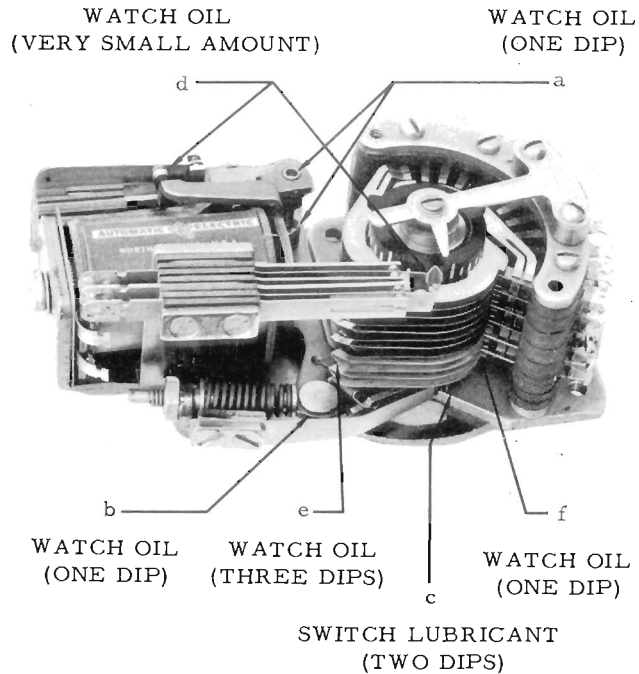


Figure 4. Stepping Switch Showing Lubrication Points

- a. Distribute one dip of watch oil between the armature and the yoke and around the pin where it passes through the yoke.
- b. Apply one dip of watch oil to the pawl bearing where the pawl and pawl bearing pin contact the armature.
- c. Apply two dips of switch lubricant to the ratchet teeth with the rotor assembly turning. This will distribute the lubricant. Use a bare minimum of lubricant. The lubricant has a graphite base, and an accumulation will lower the switch insulation resistance.
- d. Apply a small amount of watch oil to the interrupter spring buffer and to the off-normal lobes of the indicator wheel.
- e. Lubricate the wipers and stator bank contacts by distributing one dip of watch oil between the wiper tips of one end of the six pairs of wiper springs. All ends of the wiper springs should be lubricated, i. e., a six level wiper assembly would require three dips of oil, one for each end. Rotate the wipers to distribute the oil on the bank.
- f. Lubricate the stator brush springs as follows: With the wipers resting on the first contact, apply watch oil to each wiper at some spot which will contact the brush spring. Use one dip for three pairs of wipers. Repeat this procedure with the other wiper tips on the bank.

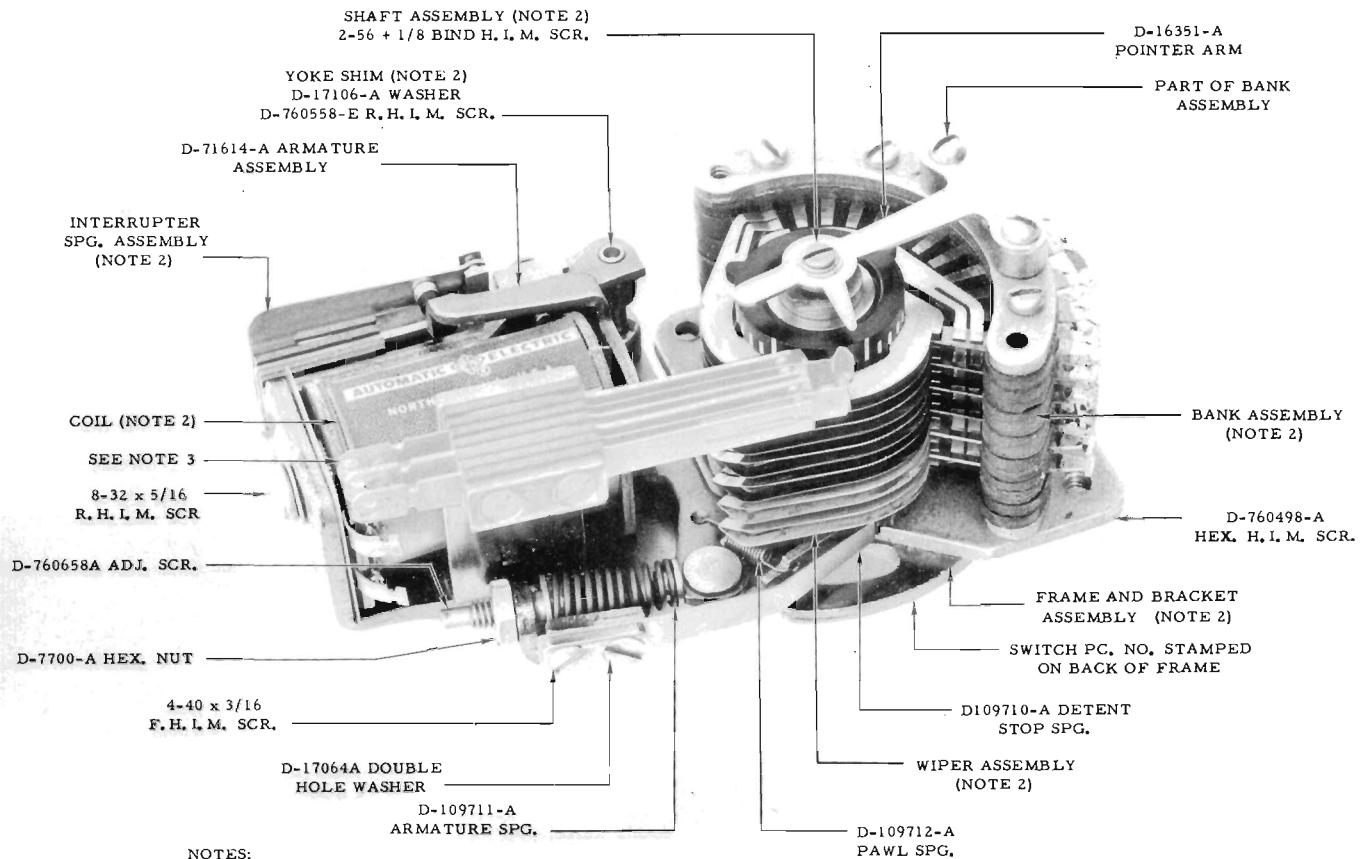


Figure 5. Switch Parts Identification

5-9. STEPPING SWITCH DISASSEMBLY AND REPAIR: The Automatic Electric type 44 stepping switch has an expected minimum life span of 33 million, 0 to 9 operations. Greatly extended life span and reliability can be had if the switches are lubricated according to the preventive maintenance instructions given in paragraph 5-6 through 5-8.

It is recommended that the technician make no mechanical adjustments on the stepping switch unless trouble shooting procedures definitely indicate that this is a necessity. Mechanical adjustment will not compensate for electrical failure. Follow all procedures in their given order. Refer to figure 5 for identification of parts and the vendor's numbers.

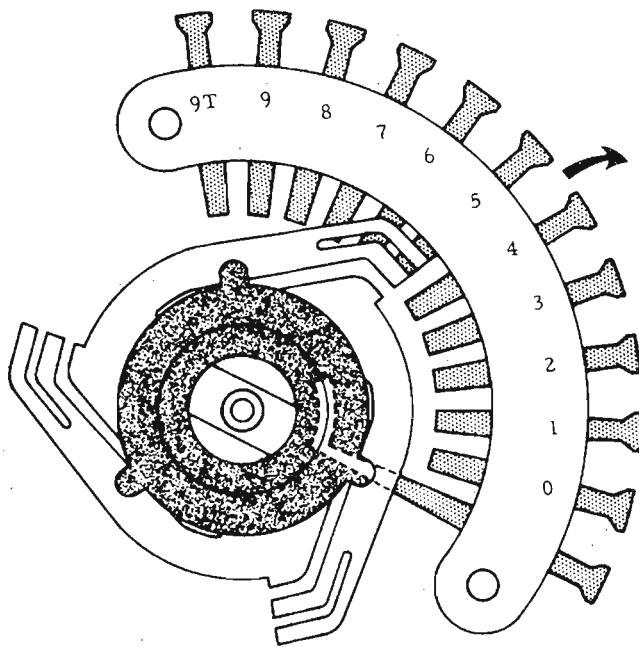


Figure 6. Rotor Removal

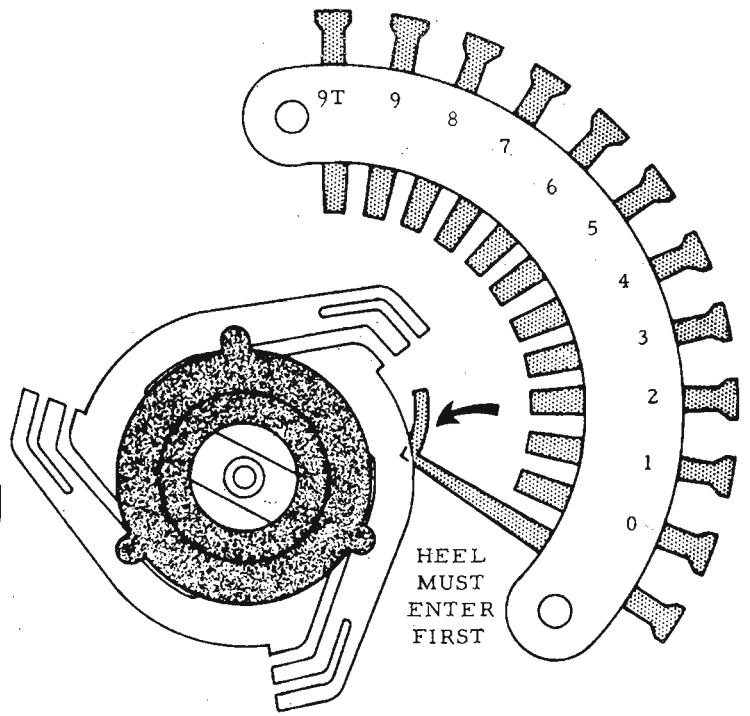


Figure 7. Rotor Assembly

a. Rotor Replacement.

1. Remove the instrument from its case.
2. Remove the 6-32 Phillips-head screw from the front mounting of the stepping switches. The switch will now swing upward for easy access.
3. The pointer arm can be lifted aside after removing the screw securing it to the rotor shaft and the two screws securing it to the stator bank assembly. Do not lose the metal spacers under these screws.
4. Manually step the switch until the rotor contacts are in the No. 5 position (see figure 6). In this position, the stator arm contacts can be slid out of the rotor wiper assembly without damage.
5. Loosen the two hexagonal bolts on the back of the switch frame behind the stator bank.
6. Carefully slide the stator bank assembly outward away from the rotor assembly (in the direction shown in figure 6) until the stator arm contacts are free from the rotor assembly.
7. Slide the rotor off its shaft.
8. Inspect the stator contacts for damage and brush lubricant on them according to the instructions given in paragraph 5-6.
9. Fill the undercut portion of the new rotor shaft with grease.
10. Slip the rotor onto its shaft.
11. While manually holding in the solenoid armature, lift the detent stop and pawl to permit the rotor to go all the way onto its shaft. The detent and pawl should not engage the detent wheel.

12. Make certain that the wiper contacts of the new rotor are oriented to the same position as for removal, and slide the stator bank assembly toward the coil, frame and rotor assembly so that the "heel" of the stator arm contacts is inserted into the space between the rotor wiper contacts first. (See figure 7.)

13. With a slight rotation of the stator bank assembly, the stator arm and contacts will compress and slide into place between the rotor wiper contacts.



An attempt to engage the rotor wiper contacts with the stator bank contacts at this time may cause damage. Follow the next step carefully.

14. Manually rotate the switch until the rotor wiper contacts engage the arm of the stator banks. The stator bank may now be slid into place against the rotor and frame assembly.

15. With the rotor in place align it by making certain that the flat area on the tips of the rotor wiper contacts falls squarely on the stator contacts with no overhang on either side.

16. Now secure the stator banks in place by tightening the hexagonal bolts on the back of the switch.

17. Rotate the switch rotor manually to check the alignment of the contacts from point to point. Realign as necessary until the optimum position is reached and secure the two hexagonal bolts.

b. Stator Bank Replacement - If any contacts on the stator bank are damaged or badly worn, replace the entire stator bank assembly as follows:

1. Follow steps 1 through 6 of (a) above.

2. Disconnect all wires, labeling each to insure correct replacement.

3. To obtain the correct stator, contact the factory or one of its representatives giving the serial number and type of the stepping switches. This information may be found in back of the switch frame.

4. Reconnect all wires to their proper location on the new assembly.

5. Follow steps 12 through 17 of (a) above.

6. Lubricate the switch according to the instructions given in paragraph 5-7.

c. Interrupter Contacts.

1. Disconnect all wires, labeling each to insure correct replacement.

2. Remove the two 4-40 flat-head screws securing the interrupter contacts to the switch frame. The interrupter contacts can now be moved aside.

3. Replacement is in the reverse order of the above procedure.

d. Switch Coil.

1. Disconnect the wires to the switch coil.

2. Remove the two 4-40 slotted screws securing the armature to the switch frame.

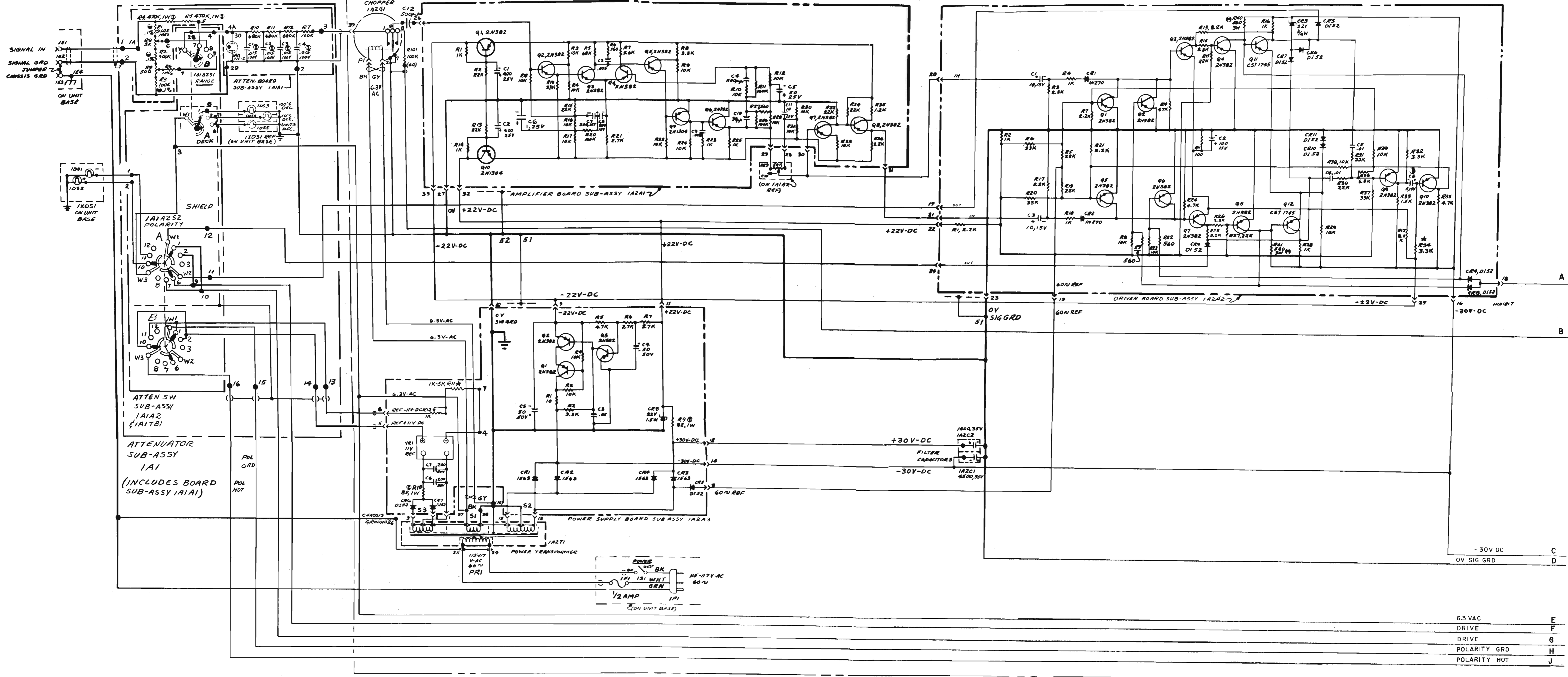


There are thin metal shims between
the armature mount and the frame.

Do not lose these shims.

3. Carefully remove the armature so as not to damage the rotor contacts or lose the coiled driver spring.
4. Remove the 8-32 slotted screw securing the switch coil to the frame. The switch coil can now be moved aside.
5. Replace the switch coil and the armature in the reverse order of the above procedure.
6. Check the armature adjustment as in (e) below.
- e. Armature Adjustment - Note that the armature-mounting screw holes are elongated to permit adjustment for optimum performance. Binding on the frame will result if the armature is too close to the pole piece. If the armature is too far from the pole piece, it will not "pull in" adequately. Adjust the armature for a spacing of 0.003 to 0.005 inches between the armature and heel when the armature is held against the pole piece.
- f. Drive Spring Adjustment.
 1. Manually drive the rotor to position 9. When the rotor moves from the 9 to the 9t positions, maximum friction occurs due to the actuating of the off-normal contacts by the 9t lobe.
 2. Manually "pull in" the armature and slowly release it.
 3. The rotor should now move completely around from the 9 to the 9t positions without any assistance. If it does not, loosen the driver spring locknut and tighten the driver spring until this occurs.
 4. Tighten the driver-spring locknut.
- g. Detent Spring Adjustment.
 1. Loosen the two 4-40 flat-head screws that secure the detent spring to the switch frame.
 2. Center the detent spring on the ratchet wheel and adjust it so that it just falls in behind a tooth of the ratchet wheel as the rotor moves around one position.
 3. Tighten the two 4-40 flat-head screws.
 4. It should now be possible to rotate the rotor approximately 1/10 step.

SECTION VI
SCHEMATIC
DIAGRAMS



- NOTE: UNLESS OTHERWISE SPECIFIED:**
1. ALL RESISTANCE IS IN OHMS.
 2. ALL RESISTORS ARE $\pm 10\%$, $\frac{1}{2}$ WATT CONR. EXCEPT: * = $\pm 1\%$, * = $\pm 5\%$, * = $\pm 10\%$, * = $\pm 20\%$, * = $\pm 50\%$, * = $\pm 100\%$.
 3. ALL CAPACITANCE IS IN MFD.
 4. ALL CAPACITORS ARE 10 W.V.D.C. PAPER EXCEPT: * = ELECTROLYTICS (VOLTAGES AS SHOWN), * = SOLID TANTALUM (TEMP. STABILIZED), * = POLYSTYRENE DIELECTRIC.
 5. REF. DES. BREAKDOWN-EXAMPLE:
 COMPLETE REF DESIG.
 1 A2 A2 R1 ABBREVIATED COMPONENT REF DESIG.
 SUB-ASSY REF DESIG.
 EQUIPMENT SUB-ASSY REF DESIG.
 EQUIPMENT (UNIT)
 6. FOR ASSOC. ASSEMBLY DRAWING SEE 21-1000 REF.
 7. ROTARY SWITCHES SHOWN AS VIEWED FROM KNOB END, *A DECK NEAREST KNOB.
 8. FOR DRAWING BREAKDOWN SEE 21-0100 REF.

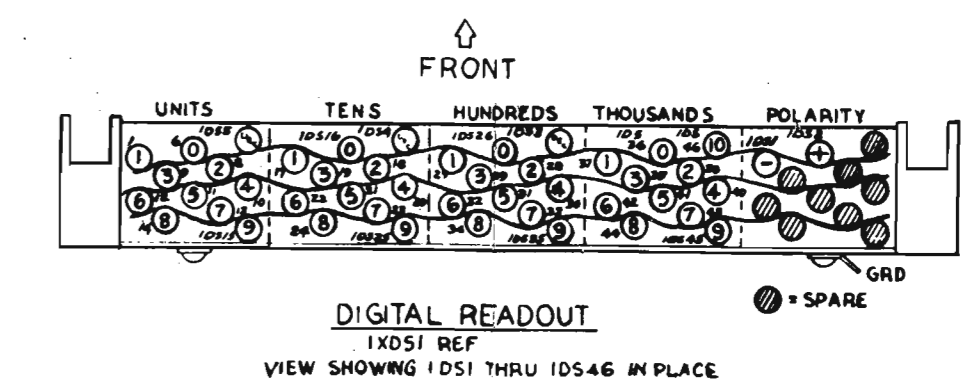
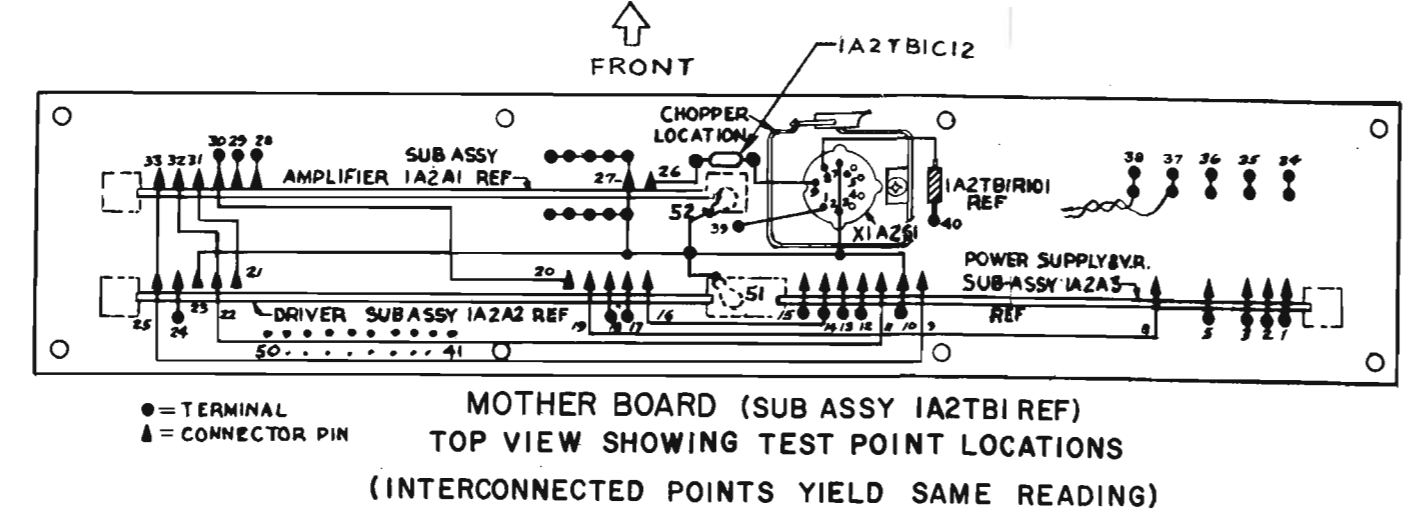
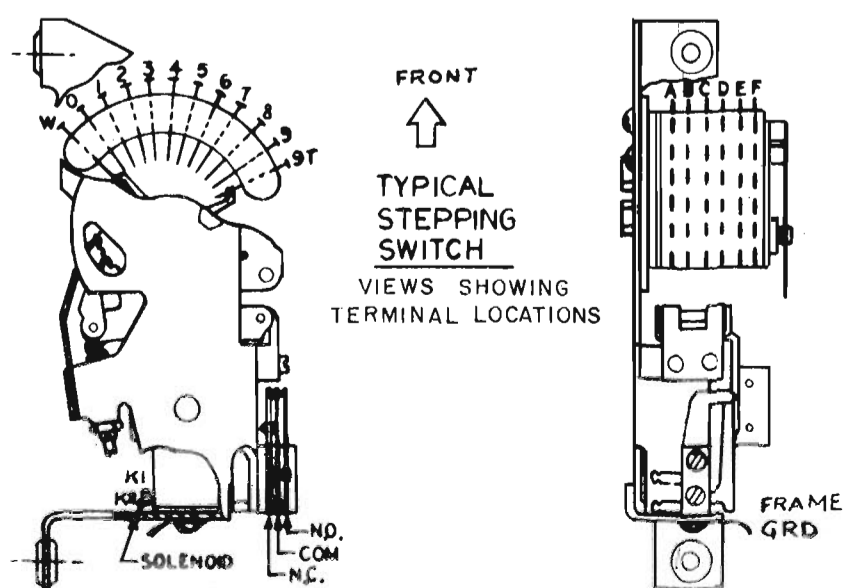
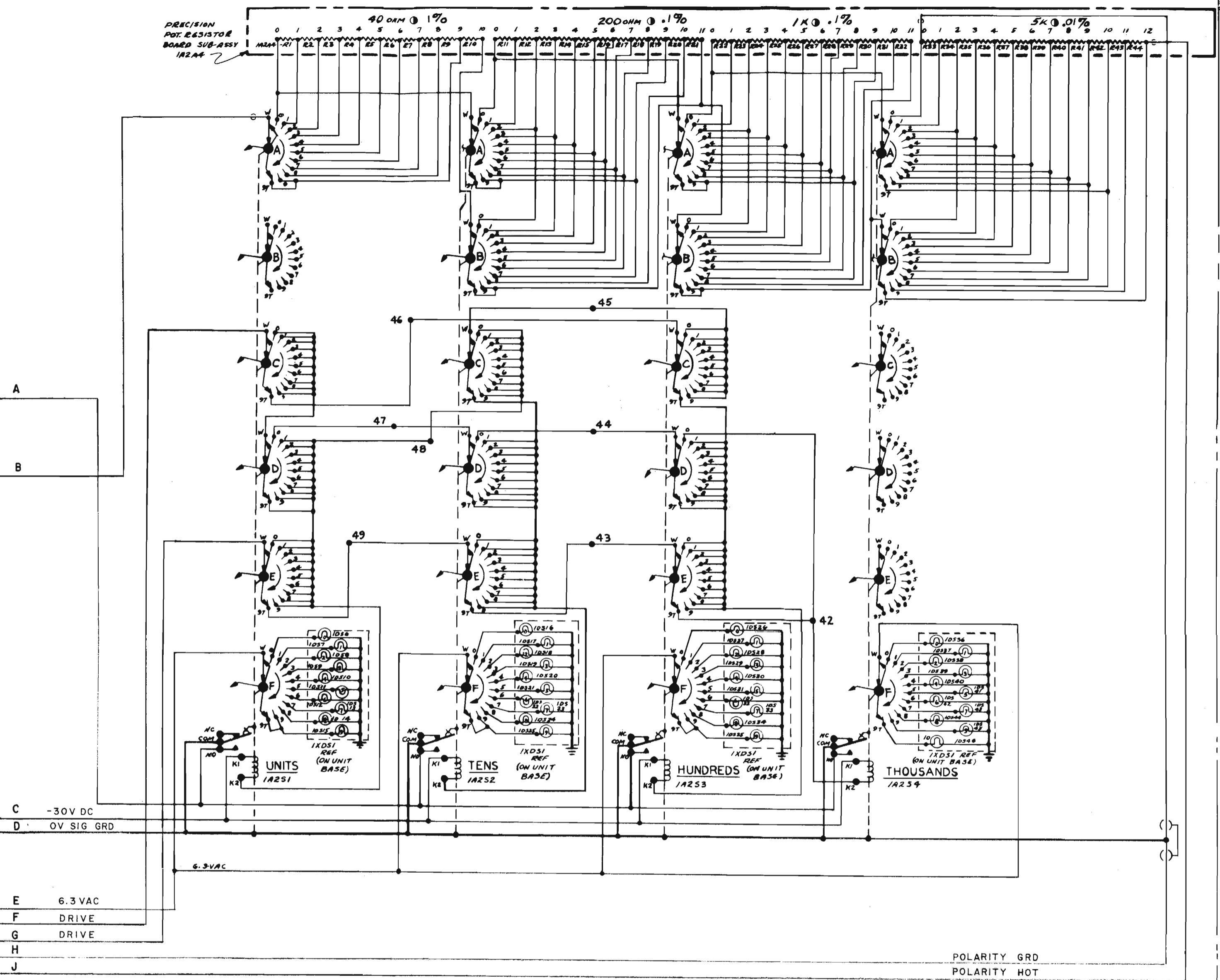
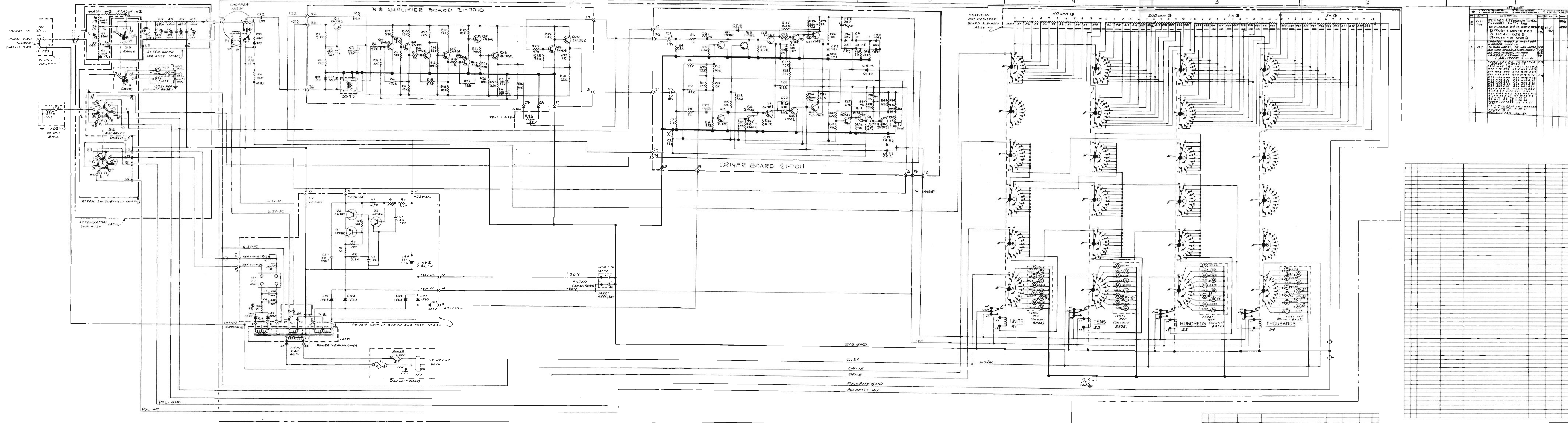


Figure 8. Schematic Diagram of Cubic Model V-45 Digital Voltmeter (Sheet 1)



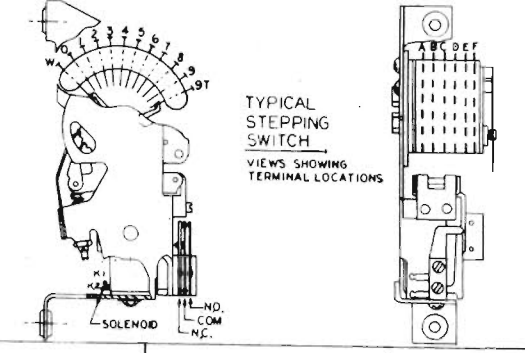
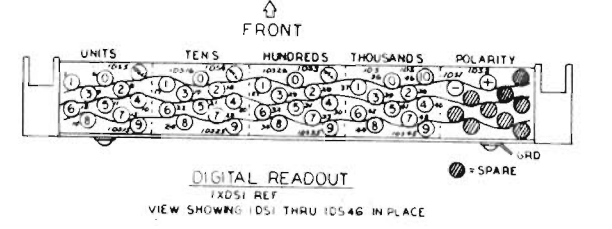
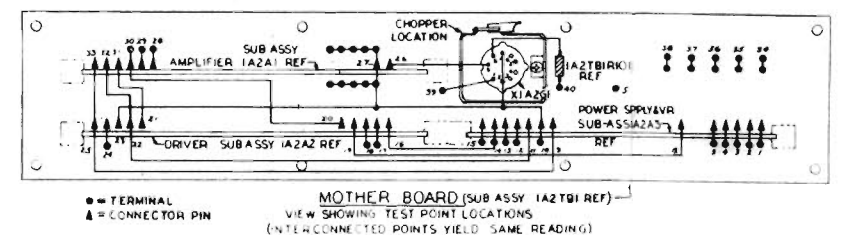
| PART NUMBER | PART NAME | MATERIAL DESCRIPTION | SPECIFICATION | FINISH | REF DES | UNIT | WT |
|-------------|--------------|----------------------|---------------|--------|---------|--------|----|
| 21-6007-1 | PLATE ASSY | ATTEN MTG | | | | 1A1T81 | |
| 21-6000-1 | BOARD ASSY | MOTHER | | | | 1A2T81 | |
| 21-7001-1 | BOARD ASSY | PRECISION RESISTOR | | | | 1A2A4 | |
| 21-7005-1 | BOARD ASSY | POWER SUPPLY | | | | 1A2A3 | |
| 21-7004-1 | BOARD ASSY | DRIVER | | | | 1A2A2 | |
| 21-7003-1 | BOARD ASSY | AMPLIFIER | | | | 1A2A1 | |
| 21-1102-1 | CHASSIS ASSY | VOLTMETER | | | | 1A2 | |
| 21-5000-11 | SW SUB ASSY | ATTENUATOR | | | | 1A1A2 | |
| 21-7002-1 | BOARD ASSY | ATTENUATOR | | | | 1A1A1 | |
| 21-5000-1 | ATTEN ASSY | VOLTMETER | | | | 1A1 | |
| 21-1101-1 | BASE ASSY | VOLTMETER | | | | UNIT 1 | |

Figure 8. Schematic Diagram of Cubic Model V-45 Digital Voltmeter (Sheet 2)



NOTE: UNLESS OTHERWISE SPECIFIED:

- ALL RESISTANCE IS IN OHMS.
- ALL RESISTORS ARE 1/4 WATT, 5% TOL, UNLESS OTHERWISE SPECIFIED.
- ALL CAPACITANCE IS IN MFD.
- ALL CAPACITORS ARE 50 MFD, UNLESS OTHERWISE SPECIFIED.
- REF DES BREAKDOWN TABLE: COMPLETE REF DES.
- REF DES BREAKDOWN TABLE: EQUIPMENT SUB-ASSY REF DES.
- REF DES BREAKDOWN TABLE: EQUIPMENT (UNIT) REF DES.
- ON ASSOC. ASSEMBLY DRAWING SEE 21-7010 REF.
- QUARTZ CRISTALS SHOWN UNLESS OTHERWISE SPECIFIED.
- SPECIAL PRECISION RESISTORS: 1% TOL, 0.1% TOL.
- ALL RESISTORS ON THIS BOARD HAVE 25% TOL.
- SEE SHEET 2 FOR V-45P.



| REF. DES. | PART NUMBER | PART NAME | MATERIAL DESCRIPTION | QUANTITY | REMARKS |
|-----------|---------------------------|-----------|----------------------|----------|---------|
| 21-7001 | BOARD DISTRIBUTION | | | 1 | |
| 21-7002 | BOARD ASSY. DRIVER | | | 1 | |
| 21-7003 | BOARD ASSY. POWER SUPPLY | | | 1 | |
| 21-7004 | BOARD ASSY. DRIVER | | | 1 | |
| 21-7005 | BOARD ASSY. AMPLIFIER | | | 1 | |
| 21-7006 | SW. CRISTAL (POLARITY) | | | 1 | |
| 21-7007 | SW. CRISTAL (TENS) | | | 1 | |
| 21-7008 | SW. CRISTAL (HUNDREDS) | | | 1 | |
| 21-7009 | SW. CRISTAL (THOUSANDS) | | | 1 | |
| 21-7010 | BOARD ASSY. VOLT-METER | | | 1 | |
| 21-7011 | BOARD ASSY. ATTENUATOR | | | 1 | |
| 21-7012 | BOARD ASSY. LOG-AMPLIFIER | | | 1 | |

| REF. DES. | PART NUMBER | PART NAME | MATERIAL DESCRIPTION | QUANTITY | REMARKS |
|-----------|---------------------------|-----------|----------------------|----------|---------|
| 21-7001 | BOARD DISTRIBUTION | | | 1 | |
| 21-7002 | BOARD ASSY. DRIVER | | | 1 | |
| 21-7003 | BOARD ASSY. POWER SUPPLY | | | 1 | |
| 21-7004 | BOARD ASSY. DRIVER | | | 1 | |
| 21-7005 | BOARD ASSY. AMPLIFIER | | | 1 | |
| 21-7006 | SW. CRISTAL (POLARITY) | | | 1 | |
| 21-7007 | SW. CRISTAL (TENS) | | | 1 | |
| 21-7008 | SW. CRISTAL (HUNDREDS) | | | 1 | |
| 21-7009 | SW. CRISTAL (THOUSANDS) | | | 1 | |
| 21-7010 | BOARD ASSY. VOLT-METER | | | 1 | |
| 21-7011 | BOARD ASSY. ATTENUATOR | | | 1 | |
| 21-7012 | BOARD ASSY. LOG-AMPLIFIER | | | 1 | |

21-0500
SCHEMATIC DIAGRAM - DIGITAL VOLTMETER, MODEL V-45
21-0500

WARRANTY

Cubic Corporation warrants each instrument it manufactures to be free from defects in material or workmanship. Liability under this Warranty is limited to servicing or adjusting or replacing defective parts (except tubes, fuses, diodes, transistors, and batteries) in any instrument returned to the factory for that purpose. This Warranty is effective for one year after delivery, when the instrument is returned by the original purchaser, transportation charges prepaid.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Cubic Corporation, and Cubic Corporation neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Cubic Corporation instruments.

GENERAL INFORMATION

SPECIFICATIONS: Cubic Corporation reserves the right to change specifications at any time without notice and without incurring any obligation to incorporate new features in instruments previously sold.

DAMAGE IN SHIPMENT: Each Cubic Corporation instrument is carefully examined and checked before it is shipped. It should be visually and operationally checked as soon as it is received. If it is damaged in any way, a claim should be filed with the carrier. New or repaired instruments damaged in transit should not be returned to the manufacturer without first obtaining specific shipping instructions.

REPAIRS: If any fault develops, the following steps should be taken:

- (1) Notify Cubic Corporation, giving full details of the difficulty. Include the model number, type number and serial number of the affected instrument. On receipt of the information, Cubic Corporation will issue service instructions or shipping data.
- (2) If shipping instructions are issued, forward the instrument prepaid, and repairs will be made at the factory. If the instrument is not covered by the Warranty, or if it is determined that the fault is caused by misuse, repairs will be billed at cost and an estimate submitted for customer approval prior to commencement of repairs.

CUBIC CORPORATION
5575 Kearny Villa Road
San Diego 11, California

INSTRUMENT REPAIR REQUEST

TYPE OF INSTRUMENT _____

MODEL NO. _____ SERIES NO. _____ DATE OF PURCHASE _____

TROUBLE SYMPTOMS: _____

PERTINENT ENVIRONMENTAL OR AMBIENT CONDITIONS: _____

RETURN SHIPPING INSTRUCTIONS: _____

DO NOT WRITE BELOW THIS LINE

REPAIR TECHNICIAN: _____ CHARGE NO. _____ DATE _____

REPAIRS EFFECTED: _____

COMMENTS: _____

CUBIC CORPORATION • 5575 KEARNY VILLA ROAD • SAN DIEGO 11, CALIFORNIA