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INSTRUCTION MANUAL

MODEL SB-10

SWITCH AND BALANCE UNIT

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Model SB-10 Switch and Balance Unit

1.0 GENERAL DESCRIPTION

The SB-10 Switch and Balance Unit is designed to provide a method of sequentially reading the output of ten (10) channels of strain gage information on a single strain indicator. Each channel can be initially balanced to zero output to greatly simplify data interpretation and reduction. In addition, any SB-10 will intermix quarter-, half- and full-bridge circuits and offers full isolation for each individual circuit, thus preventing any defect in one input from having any effect on any other inputs. An OPEN switch position permits the use of more than one SB-10 with the same strain indicator.

Although designed primarily as a companion switch and balance unit for the Model P-3500 Digital Strain Indicator, the SB-10 can be used with any strain indicator.

The unique gold-plated push clamp binding posts allow fast, convenient, reliable connection of input circuits.

"Common dummy" connections are provided for use with strain indicators which do not incorporate built-in dummies, or to use a common compensating gage.

The balancing controls are ten-turn potentiometers which permit very fine balance adjustments for each input circuit. The Model SB-10 is provided with locking, concentric-dial counting knobs that permit the user to easily reproduce a previous balance setting. The Model SB-10L, a basic version of the SB-10, also features locking potentiometers, but without turns-counting dials.

CAUTION

When it becomes necessary to clean the SB-10, do not use solvents on the front panel or on the information label inside the lid.

2.0 SPECIFICATIONS

CAPACITY:	Ten channels plus OPEN position.
EXTERNAL CIRCUITS:	Will accept quarter-, half-, or full-bridge circuits in any combination.
INPUT BRIDGE RESISTANCE:	50 to 10 000Ω.
OUTPUT:	Compatible with any strain indicator.
BALANCE RANGE (GF=2):	**Quarter and Half Bridge:** ±2000με with 350Ω half bridge in strain indicator. **Full Bridge:** ±2000με for 350Ω bridge. Range proportional to bridge resistance.
BALANCE CONTROL KNOBS:	**SB-10:** Locking, concentric turns-counting knobs. **SB-10L:** Locking knobs.
BALANCE RESOLUTION (GF=2):	Better than 1με in ±2000με range.
SWITCHING REPEATABILITY:	Better than 1με for gage resistance of 120Ω or higher.
CASE:	Aluminum. Dust- and spray-tight with detachable cover.
SIZE:	9 W x 6 H x 6 D in *(230 x 150 x 150 mm).*
WEIGHT:	5-1/2 lb *(2.4 kg).*

3.0 DESCRIPTION OF CONTROLS

3.1 OUTPUT BINDING POSTS:

For connection to strain indicator.

3.2 DUMMY BINDING POSTS:

For connection of common "dummy" or compensating gage in quarter-bridge applications.

3.3 CHANNEL SWITCH:

To select desired strain gage input channel. OPEN position is used when reading inputs from other SB-10's wired in parallel to the same strain indicator.

3.4 BALANCE KNOBS:

Ten-turn controls used to compensate for the initial unbalance in each input gage circuit (see ***4.5e***).

The balance knobs are provided with locking turns-counting dials to permit the user to easily repeat a previous balance setting, and to prevent accidental rotation. The SB-10L incorporates only the locking feature on the balance knobs.

3.5 INPUT PUSH-POSTS:

Five push-posts are provided for each input channel. Various bridge configurations require the use of two, three, or four push-posts (see ***4.4c***).

4.0 OPERATING PROCEDURE

All set-up and operating instructions in the manual apply to both the Model SB-10 and the Model SB-10L. It is strongly recommended that the operator read this manual in its entirety before commencing to operate the SB-10 or SB-10L Switch and Balance Units.

This manual is written primarily covering use with the following strain indicators: the P-3500, P-350, P-350A, Model 3800, V/E-20, V/E-20A, and BAM-1. However, operation with most other strain indicators is possible using essentially the same procedures.

4.1 DETACHABLE COVER

The instrument as supplied is equipped with hinges which will allow removal of the cover. To effect removal, bend the open-sided portion of the cover hinge upwards far enough to clear the center section of the body hinge.

4.2 INDICATOR CONNECTIONS

4.2a While the Model SB-10 Switch and Balance Unit is designed primarily for use with the Model P-3500 Portable Strain Indicator, it can be used with any similar self-contained indicator designed for use with a single strain gage circuit.

AWG-18, -20, or -22 stranded wire is recommended for connecting the SB-10 to the strain indicator. Six leadwires are provided for this purpose.

4.2b **Connections to Model P-3500, P-350, P-350A, and Model 3800 Strain Indicators:**

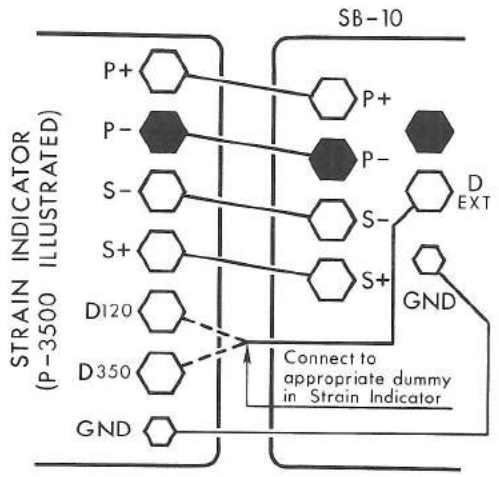


Fig. 1

SB-10 binding posts P+, P–, S+, and S– must always be connected to the strain indicator. Good engineering practice dictates that the two GND terminals be connected together and grounded (see Fig. 1).

If one or more channels on the SB-10 are to be used for measuring 120Ω or 350Ω quarter bridges, the yellow "D_{EXT}" binding post on the SB-10 must be connected to one of the "D" terminals on the P-3500, P-350, P-350A, or the Model 3800 (D_{120} for 120Ω gages, D_{350} for 350Ω gages). Alternately, this wire may be omitted and a "dummy" gage or highly stable resistor of appropriate resistance must then be attached between the black and yellow DUMMY binding posts on the SB-10.

If one or more channels on the SB-10 are to be used for measuring quarter bridges with a resistance other than 120Ω or 350Ω, the alternate procedure above must be used.

NOTE: Many P-350's of earlier manufacture used slightly different designations for the four corners of the bridge as follows:

Current Designation	Earlier Designation
P+	P1
P–	P2
S+	S2
S–	S1

4.2c **Connections to V/E-20, V/E-20A, and BAM-1 Strain Indicators:**

SB-10 Binding Posts	V/E-20A Binding Posts	V/E-20 Binding Posts	V/E-20 or V/E-20A INPUT Connector	BAM-1 Binding Posts
P+	S+	+Signal	C	C
P–	S–	–Signal	D	D
S+	P+	Power+	A	A
S–	P–	Power–	B	B
D_{EXT}	D_{120} or D_{350}	BCR_{120} or BCR_{350}	F or G	D_{120} (if present)
GND	GND	GRD	E	GRD

SB-10 binding posts P+, P–, S+, S–, and GND must always be connected to the strain indicator.

If one or more channels on the SB-10 are to be used for measuring 120Ω or 350Ω quarter bridges, the yellow "D_{EXT}" binding post on the SB-10 must be connected to the appropriate DUMMY binding post (or connector pin) on the strain indicator (older BAM-1's do not provide this feature so the following procedure must be used). Alternately, this wire may be omitted and a "dummy" gage or highly stable resistor of the appropriate resistance must then be attached between the black and yellow DUMMY binding posts on the SB-10.

If one or more channels on the SB-10 are to be used for measuring quarter bridges with a resistance other than 120Ω or 350Ω, the alternate procedure above must be used.

4.2d **Connections to strain indicators other than the P-3500, P-350, P-350A, Model 3800, V/E-20, V/E-20A, or BAM-1:**

(a) ® Connect the P+ and P– binding posts to the bridge excitation terminals on the strain indicator; the P+ binding post should be connected to the strain indicator terminal normally adjacent to a single "active" gage.

(b) Connect the S+ and S– binding posts to the "bridge output" terminals on the strain indicator; the S– binding post should be connected to the strain indicator terminal normally used at the center-tap of a fully active half bridge [that is, the binding post(s) electrically common to the "active" and "compensating" gages]; the S+ binding post should be connected to the strain indicator terminal normally used only for full-bridge inputs.

(c) The "D_{EXT}" binding post on the SB-10 may not have a counterpart on some strain indicators (external completion required).

(d) The GND terminal on the SB-10 must be connected to the ground terminal on the strain indicator, and must be physically grounded to provide adequate shielding.

4.3 MULTIPLE SB-10'S

Two or more SB-10's can be simultaneously connected to the same strain indicator to read more than ten input circuits, which may be mixed quarter, half and full bridges. It is also possible to use two or more SB-10's to group quarter-bridge inputs of different resistance [e.g., ten 120Ω inputs and ten 350Ω inputs].

The same respective binding posts (P+, P–, S+ and S–) on all SB-10's must be connected in parallel. The black and yellow completion post(s) are each wired in accordance with the gage circuits connected to each individual SB-10; thus all D_{EXT} binding posts are often, but not always, wired in parallel.

4.4 GAGE CONNECTIONS

4.4a The existing environment may determine the type of wire used. The following characteristics must be carefully considered:

(a) The insulation must be compatible with temperatures involved.

(b) To avoid an excessive loss of sensitivity (decreased effective gage factor) with long lead lengths, leads should have low resistance (at the operating temperature).

(c) To provide stability with changing ambient temperature, the product of resistance and temperature coefficient of resistance must be held to an absolute minimum (at the operating temperature). Copper is thus better than any other generally available material except constantan at normal ambient temperatures; however, the loss in sensitivity caused by the increased resistivity of constantan can be very appreciable, and its use is therefore not recommended.

(d) The conductor material must be readily solderable for most installations.

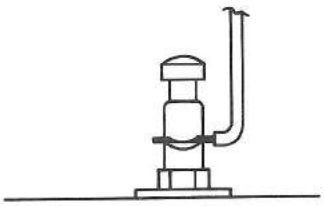
(e) In quarter- and half-bridge circuits, all conductors (for a given input) should be of the same AWG size and length.

4.4b **Wire Size and Stranding:**

The input push-posts will accept wire from AWG-18 to AWG-30 *(1.0 to 0.25 mm)*. Especially when using the heavier wire, stranded is more satisfactory. Unless other circumstances dictate a choice, AWG-26 or -30 *(0.4 or 0.25)* stranded wire will normally give good performance. At the SB-10 ends, the insulation should be stripped about 3/8 in *(10 mm)* and the strands twisted and tinned with solder.

When leads longer than 10 ft *(3 m)* are used, careful consideration should be given to the apparent reduction in gage factor of the strain gages, especially with the larger AWG numbers.

To attach a wire to the push-posts, bend a right-angle hook about 1/2 in *(13 mm)* from the end of the wire, press the push-post with one hand and hook the wire in the notch with the other; release the push-post.



4.4c **Input Gage Circuits:**

QUARTER BRIDGE — Independent circuits (Fig. 2A): "Quarter-bridge" operation indicates that only one gage is active with strain. If the strain indicator has built-in dummy gages as in the P-3500, the D_{EXT} binding post on the SB-10 is tied directly to the D_{120} or D_{350} binding post on the indicator. Alternately, a single dummy resistor may be used for all ten inputs — this ultra-stable resistor (same resistance as the active gage) must be attached between the black and yellow completion binding posts on the SB-10 (using short leads).

In either arrangement above, good strain gage practice dictates the use of the three-wire circuit as shown in Fig. 2A.

Under very unusual circumstances, two-wire circuits may be used by shorting together the S- and D push-posts. In this case, if all inputs are quarter bridges, the short can be placed at the large S- and D_{EXT} binding posts; the D push-post is not used.

Due to the high temperature coefficient of resistance of copper wire, ambient temperature changes on the leadwires can give a large false indication of strain when only two leadwires are used. [Using 30 ft *(9 m)* of twisted-pair AWG-26 *(0.4 mm)* wire to a 120Ω gage, the apparent zero will shift more than 200$\mu\epsilon$ for a 10° F *(5.6° C)* change. Even using AWG-20 wire in this situation, the shift would be over 50$\mu\epsilon$.] The recommended three-wire system puts half of the temperature-induced leadwire resistance change in series with the dummy gage while the other half remains in series with the active gage. Equal changes in lead resistances in these adjacent arms do not affect the strain measurement.

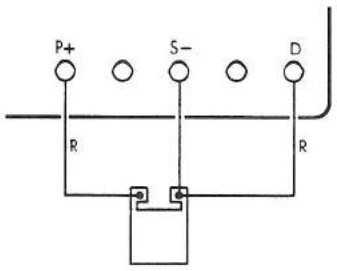
The best practice is to ALWAYS use three leads.

QUARTER BRIDGE — External compensating gage (Fig. 2B): Use of an external compensating gage may be required for special test conditions involving **remote** measurements at temperatures somewhat beyond normal ambient. In this configuration, the common compensating gage is mounted to an unstrained member of the part to be tested. It should be noted that **all** leadwires must be the same length (resistance), and in the same temperature environment. A fault in a common compensating gage will affect all active gage readings.

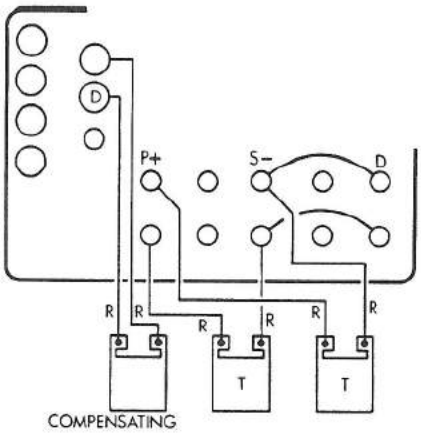
HALF BRIDGE (Figs. 2C and 2D): "Half-bridge" operation indicates that two gages are bonded to the specimen; both may be active with strain or one may be in an unstressed area adjacent to the active gage and thus becomes a compensating gage. (With a uniform temperature over the test specimen, a common compensating gage is more economical — see ***Quarter Bridge***, above).

FULL BRIDGE: See Figs. 2E and 2F.

NOTE: Leads marked "R" must be same length and size for best balance and stability.

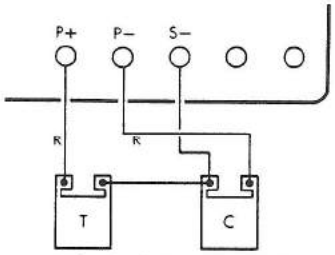


2A. INDEPENDENT CIRCUITS

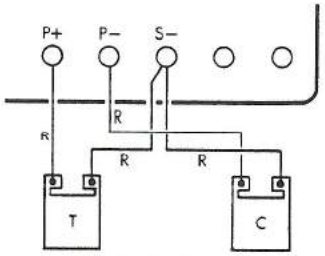


2B. EXTERNAL COMPENSATING GAGE

QUARTER BRIDGE

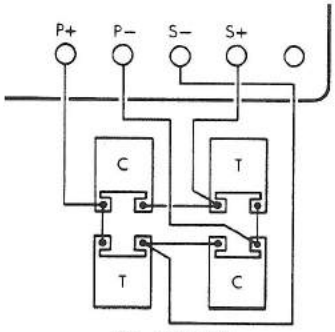


2C. GAGES ADJACENT

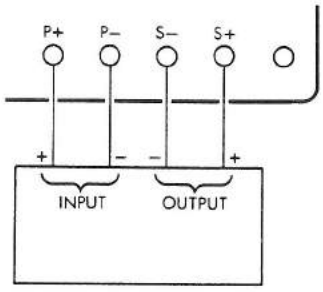


2D. GAGES APART

HALF BRIDGE



2E. GAGES



2F. TRANSDUCER

FULL BRIDGE

Fig. 2: Input Connections

4.5 OBTAINING READINGS

4.5a Strain Indicator BRIDGE Selector:

NOTE: Where more than one bridge configuration is used with the same SB-10, follow the specific instructions for the configuration corresponding to each position of the CHANNEL Selector Switch.

Full Bridge: Set the BRIDGE Selector Switch on the indicator to FULL ("4" on the BAM-1).

Half or Quarter Bridge: Set the BRIDGE Selector Switch on the indicator to HALF ("2" on the BAM-1).

4.5b Strain Indicator BALANCE Control:

(a) ***P-3500*** — Set coarse BALANCE switch to 0, and lock fine BALANCE control at 500 (mid-point).

(b) ***P-350*** — Turn BALANCE control about 5 turns from ccw stop and lock it (if there is a counting knob on this control, set it to 500).

(c) ***P-350A*** — Set the BALANCE toggle switch at OFF (down).

(d) ***Model 3800*** — Set coarse BALANCE switch at 0, BALANCE RANGE switch at 10%, and lock fine BALANCE control at 500 (mid-point).

(e) ***V/E-20 or V/E-20A*** — Set BALANCE - COARSE at "0", and lock BALANCE - FINE at 500.

(f) ***BAM-1*** — Set BRIDGE balance control at 500.

NOTE: With a perfectly balanced bridge, the SB-10 BALANCE control range is symmetrical (positive and negative portion of range are equal). If the initial unbalance of the input channels is nonsymmetrical, it may be possible to bring the nominal unbalanced reading within the balance range of the Model SB-10 by adjusting the strain indicator balance control. See ***4.5e*** regarding range.

4.5c Setting BALANCE Controls on SB-10 (under "no load"):

The standard SB-10 and many Measurements Group strain indicators utilize a locking turns-counting knob on the balance controls. In order to prevent accidental lock engagement, these knobs have a rigid detent. To lock the knob in position, the locking lever must first be pulled away from the panel and then rotated clockwise (towards the bottom of the panel). To unlock the knob, simply rotate the lever to the counterclockwise stop.

(a) ***P-3500 and Model 3800*** — Set SB-10 to CHANNEL 1; turn corresponding BALANCE control on SB-10 until a readout display of 000 is obtained and lock knob. Repeat for remaining nine channels.

(b) ***P-350 or P-350A*** — Set digital counter on P-350A to -0000. Set SB-10 to CHANNEL 1; turn corresponding BALANCE control on SB-10 and lock when null meter is exactly centered. Repeat for remaining nine channels.

(c) ***V/E-20 or V/E-20A*** — Set RANGE selector to X1 range. Set SB-10 to CHANNEL 1; turn corresponding BALANCE control on SB-10 and lock when the digital display indicates 000. Check SPAN within CALIB position and reset SB-10 BALANCE (and V/E-20 SPAN) as required in the normal manner. Repeat BALANCE procedure for remaining channels (the SPAN setting will be the same for all channels).

(d) ***BAM-1*** — Turn GAIN fully clockwise. Check amplifier BALANCE as usual, then turn BDG PWR to ON. Set SB-10 to CHANNEL 1; turn (and lock) corresponding BALANCE control on SB-10 to center BAM-1 meter. Repeat for remaining channels.

4.5d **Taking Strain Readings:**

Readings can now be taken under various load conditions in the normal manner for the strain indicator in use, selecting the desired strain gage circuit with the CHANNEL selector switch. If desired, record the balance counting knob settings for future reference.

If more than one SB-10 is used (they are all connected in parallel to the indicator — see ***4.3***), all CHANNEL switches should be set at OPEN except the one containing the circuit to be measured.

4.5e **Range of the Balance Potentiometers:**

It is noted that the range of the BALANCE potentiometers is dependent on both (1) the resistance in series with the potentiometer wiper and (2) the value of the bridge resistance attached between terminals P+, S+, and P–.

Should it be desired to increase the $\pm 2000\mu\epsilon$ range, the 86 600Ω resistor (R11) can be replaced with a somewhat smaller value (a Vishay resistor or a wire-wound type should be used to preserve stability); half the value will double the range, etc.

The balance range is also directly proportional to the bridge resistance. Obviously then, in full-bridge operation the balance range will be approximately $\pm 2000\mu\epsilon$ for a 350Ω bridge, $\pm 680\mu\epsilon$ for a 120Ω bridge, etc. On half- or quarter-bridge operation, the range is dependent on the value of the "dummy" half bridge between P–, S+ and P+. For the P-3500 and Model 3800, the "dummy" half bridge is 350Ω, thus giving a range of $\pm 2000\mu\epsilon$. For the P-350 and P-350A Strain Indicators this is 120Ω, yielding a balance range of $\pm 680\mu\epsilon$. For the V/E-20A and BAM-1, the "dummy" half bridge is 400Ω, yielding a range of $\pm 2280\mu\epsilon$.

5.0 MAINTENANCE

Within the warranty period, you should not attempt any repairs or maintenance to the SB-10 Unit. In the event of a possible malfunction during this period, contact our local sales representative or Measurements Group, Inc. Since the SB-10 is basically a passive device, no regular maintenance should be necessary.

5.1 CONTACTS

Should the repeatability of readings deteriorate, and provided you are assured there is no change in the input to the instrument (two-wire quarter-bridge circuits are extremely sensitive to temperature changes and often give effects similar to a defective switch), the most likely cause would be excessive corrosion on the silver contacts of the channel selector switch. In this event, the unit should be disassembled by removing the instrument from its case (four Phillips screws at the corners of the front panel). Spray the switch contact surfaces with Miller-Stephenson MS-230/CO2 Contact Re-Nu and manually rotate switch, followed by spray application of CRC 3-36 to lubricate contacts. Avoid solvent contact to the front panel to prevent permanent marring.

5.2 SCHEMATIC

The schematic of the SB-10 Unit is included in the back of this manual.

5.3 PARTS LIST

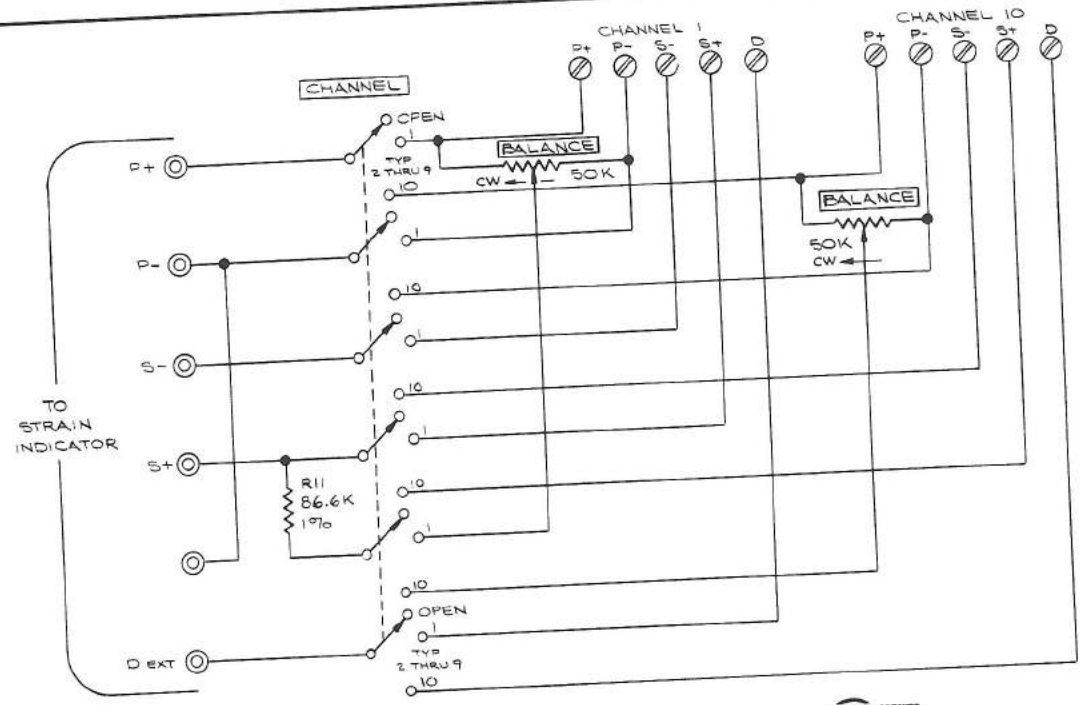
The following maintenance and repair parts are available:

DESCRIPTION	PART NO.
Output and Dummy Binding Posts:	
Red	13X200150
Black	13X200151
White	13X200152
Green	13X200153
Yellow	13X200155
Input Push-Posts:	
Post w/ Red Cap	12X700072
Post w/ Black Cap	12X700070
Post w/ White Cap	12X700079
Post w/ Green Cap	12X700075
Post only	12X700097
Yellow Cap only	12X700064
Balance Potentiometer (50K)	24X400169
Balance Resistor (86.6K)	15X300351
Channel Selector Switch	10X500132
Counting Knob for Balance Potentiometer (SB-10)	13X400057
Knob for Balance Potentiometer (SB-10L)	13X400023
Knob Lock for Balance Potentiometer (SB-10L)	13X400028
Knob for Channel Selector Switch	13X400088

5.4 For repairs or replacements involving other than the above, contact Measurements Group, Inc.

5.5 IMPORTANT NOTE:

To avoid damage, do not allow cleaning solvents of any kind to come in contact with the front panel. Limited use of Windex will usually provide satisfactory results.



MEASUREMENTS GROUP, INC.

SCHEMATIC
SWITCH & BALANCE UNIT
SB-10

200-130981A

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