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3-A AND 4-A CAPACITY UNBALANCE SETS

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1. GENERAL

1.01 Capacity unbalance sets are portable pieces of apparatus designed for use in measuring capacitance unbalances in sections of cable. On quadded cables a capacity unbalance set is used at certain designated splices during installation to measure the phantom-to-side and side-to-side capacitance unbalances of quads in the sections adjacent to these splices. From these measurements is determined the manner in which the quads in these sections must be connected, in order that the unbalances will tend to neutralize each other. Capacity unbalance sets may also be used in the selection of pairs in entrance or office cables in order to obtain pairs suitable, from a capacitance unbalance standpoint, for the routing of high-frequency carrier systems.

1.02 Due to the need for obtaining better crosstalk conditions as the toll cable plant is extended and for a set in connection with carrier installations which will measure small pair-to-pair unbalances in short lengths with fair precision, the 3-A

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capacity unbalance set was developed to replace the 1-A capacity unbalance set which had been standard for a number of years. In addition to changes in the circuit which make possible greater accuracy in measurement, the 3-A set is an improvement mechanically over the 1-A set. The mechanical changes are of such nature as to facilitate "zero" adjustments and to tend toward prevention of operating troubles through improvements in the apparatus units and their assembly and wiring.

1.03 The 4-A set is essentially like the 3-A set except that further changes have been made in the design of the set to improve the accuracy of measurement of unbalances less than 30-mmf. and to substitute an electrical rather than a mechanical adjustment for the phantom-to-side "zero." The 4-A set is now standard and the following discussion, therefore, will deal particularly with the 4-A set, but, since some 3-A sets will be in use for a number of years, notations will be made at appropriate points to indicate wherein the 3-A set differs from the 4-A set.

1.04 In addition to the 3-A or 4-A capacity unbalance set, an oscillator generating current of about 1,000 to 1,200 cycles, a telephone receiver, leads for connecting the unbalance set to the cable and leads for connecting the oscillator to the set are required.

1.05 The dimensions of both the 3-A and 4-A capacity unbalance sets are about 9" x 13-1/4" x 17-1/2" and their weight about 50 pounds. Face views of the 3-A and 4-A sets are shown in Drawings Nos. 38-Y-2024 and 38-Y-2147, respectively.

2. CIRCUIT OF CAPACITY UNBALANCE SETS

2.01 In Drawing No. 38-Y-2148 are shown in schematic form the arrangements of the 4-A capacity unbalance set when the appropriate switch is thrown in the phantom-to-side and in side-to-side positions.

Phantom-to-Side Arrangement

2.02 As shown in Figure 1 of Drawing No. 38-Y-2148, the circuit of the 4-A capacity unbalance set when in the phantom-to-side position is essentially that of a Wheatstone bridge. In this case the ratio arms of the bridge are two non-inductive resistances of almost exactly 2,000 ohms each. A potentiometer is provided at their apex in order that the resistances of the ratio arms may be exactly balanced in case the other two arms of the bridge are balanced. If a phantom-to-side unbalance exists in the set and leads, the potentiometer may be set to compensate for it. The differential air condenser "U" forms the other two arms of the bridge.

2.03 The circuit of the 3-A set when in the phantom-to-side position is exactly like that of the 4-A set as shown in Figure 1 of Drawing No. 38-Y-2148, except that no potentiometer is provided at the apex of the ratio arms.

2.04 Condenser "U" is so arranged that the capacitances in these two arms are equal, i.e., the bridge is balanced provided the ratio arms are balanced, when the condenser is set with the pointer coinciding with the zero point on the scale. When the movable plates of the condenser are turned to the right or left, capacitance is added to one arm and an equal amount subtracted from the other arm. The scale is calibrated in micro-microfarads in both directions from the zero point and is marked to read the capacitance added to one arm plus the capacitance subtracted from the other arm, i.e., the difference between the capacitances in the two arms.

2.05 In Figure 1 of Drawing No. 38-Y-2148 is also shown the manner in which a quad of cable conductors is connected to the set for measuring "Phantom-to-White" capacitance unbalance. Four binding posts are provided on the set for connection to the four wires of a quad. The pair connected to the terminals marked "W" (White) and "M" (Mate) is arbitrarily called the white pair. The other pair is connected to the "B" (Black) and "M" (Mate) posts and is called the black pair.

Side-to-Side Arrangement

2.06 The circuit of the 4-A capacity unbalance set when in the side-to-side position is that of a Wheatstone bridge in which all of the arms are made up of capacitances instead of resistances, as shown in Figure 2 of Drawing No. 38-Y-2148. The circuit of the 3-A set in the side-to-side position is exactly the same.

2.07 The condenser "U" is the same condenser shown in Figure 1 for the phantom-to-side arrangement. The condenser "A" is an auxiliary differential condenser (with almost the same capacitance value as condenser "U") which is used in the side-to-side bridge circuit instead of the resistance arms and may be set to make all four arms of the bridge very nearly equal when condenser "U" is set on zero. The manner in which two pairs of cable circuits are connected to the set for measuring side-to-side or pair-to-pair unbalance is also shown in Figure 2 of Drawing No. 38-Y-2148.

3. ASSEMBLY OF APPARATUS

3.01 The apparatus comprising the 3-A or 4-A capacity unbalance set is assembled in a 3/4" oak box having a removable lid. The box is provided with three chest-type handles for

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carrying purposes. The chest handles on the 3-A set are somewhat smaller than those on the 4-A set. The keys, binding posts, etc., shown in the face views, Drawings Nos. 38-Y-2024 and 38-Y-2147, are mounted on a metal panel. All other apparatus such as variable condensers, transformers, etc., is attached to the underside of this metal panel so that the entire set can be lifted out of the box by means of the metal handles on the right and left of the panel, after removing the 12 machine screws around the outer edge of the panel. The metal handles on the panel are of such height that the panel may be supported on them with the face down in case it is necessary to clear trouble in the set.

3.02 The four binding posts along the left of the panel marked "White," "Mate," "Black," "Mate" are for the purpose of connecting to the set the circuits between which the capacitance unbalance is to be measured. The "Mate" post just below the "White" post is associated with the "White" post in forming one pair of terminals and the "Mate" post just below the "Black" post and the "Black" post form the second pair of terminals. The binding post marked "Gnd" is connected to the variable condenser shields, the shields between windings of the transformers, the .01-mf. condensers, etc., and this post should always be connected to the sheath of the cable during a test. In measurements on bridle cable, etc., which has no lead sheath, the "Gnd" post should be connected to a ground. The two binding posts marked "Rec" at the left of the panel are connected to the low impedance winding of the transformer marked "Rec" in Drawing No. 38-Y-2148. Similarly, the "Osc" binding posts on the right of the panel are connected across the low winding of the oscillator transformer shown in schematic Drawing No. 38-Y-2148. The purpose of these two transformers which are shielded is to prevent unbalances in either the oscillator or receiver circuit from affecting the measurements.

3.03 To the right of the center near the front of the set is the main differential air condenser which can be turned by means of the hard rubber handle which projects above the panel. The graduated scale of this variable condenser is read through a window which is set into the panel. Beneath the window is supported a fixed pointer of narrow width for the purpose of indicating the point to be read on the scale. The 3-A set differs from the 4-A set in that the main differential condenser is in the center near the front of the set and the window for reading is somewhat smaller. Instead of a fixed pointer the pointer in the 3-A set is arranged so that it may be moved mechanically to the right or left by means of an adjuster which

projects above the panel below the handle of the condenser. This adjuster can be operated either by means of a screwdriver applied to the slots cut into the sides of the knob or with the fingers.

3.04 As stated in paragraph 2.04, the scale on this variable condenser is calibrated in micro-microfarads in both directions from zero; the portion on the left of the zero point being colored black and arbitrarily called "plus" while the portion on the right of the zero point is colored red and is arbitrarily called "minus." Rectangular slots have been cut out of the stator plates of the main differential condenser along the shaft of the rotor in the 4-A set. In this way a non-uniform condenser scale has been secured, as shown on Drawing No. 913-329. The purpose of the wider spacing of the scale divisions in the 0 to 30-mmf. range as compared with the spacing of corresponding scale divisions beyond 30-mmf. and the closer calibration within the 10-mmf. intervals is to permit more accurate measurement of small unbalances. The closer calibration in the lower range is particularly desirable in selecting cable pairs over which high-frequency carrier systems are to be routed and in the final capacitance unbalance tests on loading sections of toll cables. In the 3-A set, rectangular sections have not been removed from the stator plates of the main differential condenser so that the scale on the condenser is uniform throughout its range.

3.05 In case unbalances greater than 220-mmf., the full range of the scale of the variable condenser, are to be measured, the range of either the red or black portion of the scale can be increased by suitable operation of the keys marked "Add to Red"—"Add to Black," located in the upper right corner of the set. One of these keys controls a fixed 200-mmf. condenser and the other a fixed 400-mmf. condenser. By throwing both keys to the "Add to Black" position, for example, the maximum reading of the black scale is increased from 220-mmf. to 820-mmf. The 200-mmf. and 400-mmf. condensers are accurate within 2 to 3 per cent.

3.06 Keys "C" and "D" in the upper left corner of the set, marked "White"—"Black" and "Ph-S"—"S-S," respectively, are for the purpose of obtaining the proper circuit arrangements for measuring unbalances between different types of circuits as outlined in Part 6.

3.07 In front of keys "C" and "D" is a small insulated knob designated as "Ph to S Zero." This knob which can be turned by hand is used in adjusting the potentiometer at the apex of the ratio arm. Since a potentiometer is not included in the 3-A set there is no "Ph to S Zero" knob in the 3-A set.

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3.08 Directly back of the handle of the main differential condenser is a small insulated knob designated as "S to S Zero." The purpose of this knob, which can be turned by hand, is to adjust the auxiliary differential condenser so that it will balance the main variable condenser in its zero position when the set is arranged for side-to-side measurement. In the 3-A set a metal knob which has no marking and which is located slightly to the right of the handle of the main differential condenser and toward the back of the set is used for adjustment of the auxiliary differential condenser. This metal knob can be turned by hand or by means of a screwdriver applied to the slot in the knob.

3.09 The general wiring arrangements of the 3-A and 4-A sets are shown in Drawings Nos. 38-Y-2025 and 38-Y-2159, respectively.

4. CHECKING OPERATING CONDITIONS OF SETS

Preliminary Check of Operating Condition

- (1) Connect the leads from the oscillator to the "Osc" binding posts on the set and standard telephone receivers, such as the No. 528 to the "Rec" binding posts. Connect a wire from the "Gnd" binding post on the set to the cable sheath.
- (2) With keys "D" and "C" operated to "Ph-S" and "White," respectively, and no leads connected to the set, turn the handle of the main condenser until a fair volume of tone is heard in the receiver. Short-circuiting the "White"—"Mate" binding posts should produce silence in the receiver, while placing a short circuit across the "Black"—"Mate" binding posts should not affect the tone heard in the receiver.
- (3) Similarly, with the keys operated to "Ph-S"—"Black" placing a short circuit across the "Black"—"Mate" binding posts should produce silence in the receiver, while a short circuit across the "White"—"Mate" binding posts should not affect the tone heard in the receiver.
- (4) The above tests, (2) and (3), should be repeated after the test leads have been connected to the set. By short-circuiting the clips at the distant end of the leads it can be determined whether the leads are continuous.

Balance of Sets

4.01 The method of measurement employed in the 3-A and 4-A capacity unbalance sets is of the "null" type, i.e., the reading of the calibrated differential condenser for the point of no sound in the receiver gives the measured unbalance.

(1) Check the balance of the set alone by listening to the tone in the receiver when the handle of the main differential condenser is turned to the right and left. For this test the testing leads should not be connected to the set. With keys "D" and "C" operated to "Ph-S" and "White," respectively, no tone should be heard in the receiver when the zero point of the scale coincides with the pointer. If this coincidence does not occur in the 4-A set move the "Ph-S Zero" knob until no tone is heard in the receiver when the zero point of the scale does coincide with the pointer. If coincidence of the zero point with the pointer does not occur in the 3-A set, move the pointer by means of the knob under the handle of the condenser until the pointer does coincide with the zero point when the condenser is set for no sound in the receiver. Operate keys "D" and "C" to "Ph-S" and "Black" and again check the balance of the set. The set has been carefully wired so that the balance for the "Phantom-to-Black" position should be very nearly the same as that for the "Phantom-to-White" position. If the zeros in the two positions differ by more than about 3-mmf., trouble in the set has probably developed. If there is a difference of more than 3-mmf. and it is found after inspection and test that no trouble has developed but that the difference is probably due to slight changes in the capacitances of the wiring, etc., a balancing stub may be connected to certain of the binding posts to make the zeros in the two positions coincide. The manner in which a balancing stub should be connected is the same as that outlined under Section 5 for the test leads.

(2) With keys "D" and "C" operated to "S-S"—"White" or "S-S"—"Black" the set should balance on zero. If the balance point is not the zero point of the scale, the knob attached to the auxiliary differential condenser should be turned until a balance at zero is obtained.

(a) If in the above tests a fairly sharp balance is not obtained, it may be an indication that leakage trouble has developed. In this case the sharpness of balance cannot be improved except by clearing the trouble since the sets contain no arrangement for balancing leakage. Ordinary precaution to prevent moisture from penetrating into the set should be sufficient to keep the insulation resistance high. If trouble of this nature does develop, the set should be thoroughly dried before attempting to use it.

NOTE: Lack of sharpness of balance in the phantom-to-side position may, in case of some 3-A sets, be due to a small capacitance unbalance in the ratio arms. Where this is the case the sharpness of balance can be improved by connecting a balancing stub across the proper resis-

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tance arm. This stub should be connected to terminal 2 of the ratio arms and to either terminal 1 or 3, depending upon which arm has the lower capacitance. The latter point as well as the capacitance required, i.e., length of stub, can be determined experimentally by a cut and try method. A short piece of rubber insulated twisted pair is suitable for use as a stub.

(3) Repeat the above tests after the testing leads have been connected to the set. With the clips on the far end of the leads free from ground and the cable wires and not in contact with each other, the set should still balance sharply on zero in each of the three positions, phantom-to-white, phantom-to-black and side-to-side, provided the insulation resistance of the leads is high. Leads with sufficient leakage to affect the sharpness of balance should not be used. It is assumed in the above that the leads have been balanced by means of a balancing stub as outlined in Part 5 so that they have no inherent capacitance unbalance, and that the capacitance of the leads is not sufficient to make a shift in zero adjustment necessary.

(4) With the testing leads connected to a quad in a cable and the set arranged for measuring phantom-to-white unbalance, reversing the clips connected to the black pair at the cable should not change the balance. Reversing the clips connected to the white pair, however, should shift the unbalance reading from the black scale of the differential condenser to the red scale, or vice versa. Similarly, on a phantom-to-black measurement, reversing the white clips should have no effect, but reversing the black clips should reverse the sign of the condenser reading.

4.03 With the leads connected to a quad in a cable and the set arranged for measuring side-to-side unbalance, reversing either the white or black clips at the cable should shift the unbalance reading from the black scale of the condenser to the red scale, or vice versa, but simultaneously reversing both white and black clips should not change the condenser reading.

Sign of Set Reading

4.04 The matter of signs is of particular importance in cases where unbalances in one portion of a loading section are deliberately increased in order to neutralize large unbalances in the other portion of the section. For this reason, a check of the sign of the set readings should be made whenever any troubles involving the wiring of the set are cleared. A check of signs is also desirable when the operator of a set has not previously checked it for signs.

4.05 To determine whether a capacity unbalance set is wired so as to give the normal sign to an unbalance, a small capacitance such as a foot or two of twisted pair may be connected between the "White" and "Black" binding posts of the set after the zeros of the set have been adjusted. Such a capacitance should result in a black reading (positive) for either the phantom-to-white or phantom-to-black position of the keys. In the side-to-side position the small capacitance should cause a red or negative reading. Referring to Drawing No. 38-Y-2148, it will be noted that this additional capacitance across the terminals indicated will increase the capacitance designated as C_1 . From consideration of the Wheatstone bridge network, it can be determined why increasing capacitance C_1 should have the effect indicated.

4.06 In case the signs of the readings produced by this capacitance are opposite to that indicated above, the main differential condenser has been connected incorrectly with reference to the positive and negative marking of the scale. In order to make sets which are wired incorrectly read correctly, it is necessary to reverse the wires connected to the two sets of stationary plates of the main or calibrated condenser. To do this the shield on the condenser should be removed. From inspection of the condenser it can then be seen which wires are connected to the stator plate terminals and the sign of the readings can be corrected by reversing those wires.

Zero Corrections

4.07 The zeros should be rechecked by means of the reversal tests listed in step 4 of Balance of Sets. If the testing leads have been carefully balanced and if the zero correction devices are readjusted, if necessary, after a cable quad is connected to the set, numerical zero corrections should not be required. It should be noted that the phantom-to-side zero adjustment may be quite different with a cable quad connected to the set from what it was with the set and leads alone. If there is an unbalance in the set and leads, the knob of the zero or pointer adjuster, as the case may be, must be moved to compensate for this. The proper setting of the adjuster depends upon the capacitance of the side circuits connected to the set and, therefore, upon the length of the cable. With the 4-A set, the proper setting of the side-to-side zero adjuster usually depends very little on the length of cable being measured, but in the 3-A set the side-to-side zero adjuster may have to be moved quite a little, depending upon the distance the pointer is shifted for the phantom-to-side zero.

4.08 The zero adjuster settings should always be rechecked when changing to a different group in the cable or to a different section of cable. Slight variations may occur for each

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quad in a particular length, but these are generally so small that they may be neglected.

4.09 In any case numerical zero correction can be limited to one phantom-to-side reading. For example, by adjusting the zero for phantom-to-black and side-to-side readings a numerical correction will be required for phantom-to-white readings only.

4.10 A zero correction may be determined by taking half the algebraic sum of a reading with the leads connected normally to the cable and a reading with a suitable pair reversed at the junction of the leads and cable. For example, if the normal phantom-to-white reading is +25 (25 on the black scale) and the reading with the white pair reversed is -15 (15 on the red scale) the zero correction is $\frac{+25+(-15)}{2} = +5$. This correc-

tion must be subtracted algebraically from each phantom-to-white unbalance as it is read unless the zero or pointer adjuster can be moved to compensate for both the phantom-to-white and phantom-to-black zero corrections. Examples showing how to apply zero corrections are given below:

SET READING	ZERO CORRECTION	METHOD	CORRECTED READING
+25	+5	$+25 - (+5) = +25 - 5 =$	+20
-25	+5	$-25 - (+5) = -25 - 5 =$	-30
+25	-5	$+25 - (-5) = +25 + 5 =$	+30
-25	-5	$-25 - (-5) = -25 + 5 =$	-20

4.11 The corrected reading may be determined directly by taking half the algebraic difference of the normal and reversed readings. For example, readings of +25 and -15 give a correct reading of $\frac{+25 - (-15)}{2} = +20$.

4.12 As stated previously, with balanced set and leads all zero corrections may be avoided by moving the zero or pointer adjuster to obtain the "corrected reading" with the normal connection of the leads to the cable for the first quad tested rather than the "set reading." With the 4-A set this may be done by turning the handle of the calibrated condenser until the corrected reading coincides with the pointer and then turning the knob of the potentiometer until silence is obtained in the receiver. With the 3-A set the pointer adjuster must be moved so that silence will be obtained in the receiver when the pointer coincides with the "corrected reading."

4.13 The setting of the auxiliary differential condenser for the side-to-side zero should be checked by moving the calibrated condenser until the side-to-side "corrected reading" coincides with the pointer and then turning the knob of the auxiliary condenser, if necessary, until no tone is heard in the receiver. It should be noted that with the 3-A set the setting of the auxiliary condenser for the side-to-side zero should not be made until the pointer has been set for the phantom-to-side zero.

4.14 If one phantom-to-side zero error is greater than 10 after the other circuit arrangements of the set have been adjusted to give no zero corrections, the balance of the set alone and of the leads should be checked. In this way the cause for the large zero error can be determined and proper measures can be taken to correct it.

Set Troubles

4.15 If troubles are indicated during the above tests, they will most likely be of the following type:

- (a) **Dampness:** Dampness in the set or in the leads is manifested by the impossibility of eliminating completely the sound in the receiver owing to the fact that the set has no arrangement for balancing leakage.
- (b) **Loose Connection:** Probably indicated by a scratching sound in the receiver and changeable readings.
- (c) **Broken Connection:** Usually causes a very large volume of tone in the receiver on at least one of the phantom-to-side readings. If the broken connection is not visible from inspection, the connections should be traced out as indicated below.
- (d) **Open in Oscillator Lead:** A uniform sound will be heard over the entire scale.
- (e) **Poor Switch Contact:** The accumulation of dust on the key contacts may result in inaccuracy of readings and lack of sharpness of balance even though the contact fingers of the keys are properly adjusted. If switch contact troubles should develop, they will probably give the same indications as loose or broken connections. In cases where dust has accumulated on the key contacts, the contacts should be cleaned with C. P. carbon tetrachloride in the following manner. A few drops of carbon tetrachloride should be placed on the key contacts by means of a toothpick and then the dust or grit can be removed by drawing a piece of clean paper between the contacts. The necessity for such a cleaning routine and the proper interval will depend upon local conditions. The keys with which the 3-A set is

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equipped are provided with springs for definitely defining the various key positions. The neutral position of the "C" and "D" keys is not required, however, in the operation of the set and the springs of these keys may be removed if it is considered desirable to make the operation of the keys easier. The springs are not provided in the "C" and "D" keys in the 4-A set for this reason.

4.16 In case wiring trouble develops, the connections of the set may be checked with the aid of the schematic wiring outline fastened to the inside of the lid on the set or the detailed wiring diagram furnished with each set. If the detailed wiring diagram for a particular set is not available, Drawing No. 38-Y-2025 or No. 38-Y-2159 may be used as a guide in checking the wiring. In general, the arrangements shown on Drawings Nos. 38-Y-2159 and 38-Y-2025 should be correct except that slight differences such as turnovers of pairs, etc., may be found between the wiring of a set and that shown on Drawing No. 38-Y-2159 or No. 38-Y-2025.

4.17 Rewiring of the set should seldom be required because of the rugged construction, type of wire used, etc. If at any time it is considered desirable to rewire a set, it should be returned to the Western Electric Company for this purpose, since it is not considered practicable to wire a balanced bridge of this type in the field. It should be noted in this connection that not all types of wire are satisfactory for use in the set because of their instability under varying humidity conditions and the wiring arrangement has been designed so as to keep unbalances at a minimum. In order that advantage may be taken of the more closely calibrated scale in the 4-A set in obtaining readings of greater accuracy it has been found necessary to wire the set with stranded okonite wire which has somewhat less conductance unbalance, particularly in periods of high humidity, than the printer wire used in the 3-A set.

4.18 The set should be kept free of dust on and under the panel in order to avoid the possibility of leakage troubles. There will be a gradual accumulation of dust within the set due to small openings around the keys, etc., and this should be removed occasionally. In the 4-A set a groove has been cut in the binding post strips parallel to the panel in order to interpose a dry section in possible leakage paths from the binding posts to the panel. This groove should be kept free of dirt and dust.

4.19 The following features which are, in general, peculiar to the 3-A set should be checked occasionally in order that troubles may be prevented. Similar difficulties should not, in general, be experienced with the 4-A set because the 4-A set

has been designed with the idea of obviating troubles of this nature as far as practicable. Some trouble of the nature as indicated in d below may be experienced with the 4-A set. Such trouble if encountered should be treated as indicated.

- (a) The top bearing nut on the shaft of the calibrated condenser should be tightened in case this nut works loose. Loosening of this nut may permit the rotor to move in a vertical direction and touch the stator plates.
- (b) The screws which hold the auxiliary differential condenser to the mounting plate should be tightened. If these screws are not tightened occasionally they may drop out and short the condenser plates or connect them to the shield. The condenser would probably have to be removed to replace screws which drop out.
- (c) The set screw which holds the scale plate in position should be tightened occasionally. If this set screw does not grip the shaft of the condenser tightly enough the scale plate may move sufficiently to require shifting of the pointer considerably off center.
- (d) In case sharp balances cannot be obtained with a set because of leakage which is not mitigated sufficiently by cleaning and drying the set it may be found that enough dirt and moisture have accumulated around and underneath the binding post strips to cause bad leakage conditions.

5. TEST LEADS

5.01 The test leads to be used for connecting the unbalance set to the cable should preferably be made up of two lengths of 16-gauge three-conductor "Heavy Duty Royal Cord," which is manufactured by the United States Rubber Company. The two lengths should be laid parallel to each other and taped together at frequent intervals so that their relative position with respect to each other may be maintained.

5.02 If three-conductor cords are not available, two lengths of two-conductor 16-gauge "Heavy Duty Royal Cord" may be used instead. With the two-conductor cords a fifth wire which may be insulated or bare should be wrapped around the leads with a spacing between wraps of about an inch or so. The fifth wire should also be taped to the leads at frequent intervals in order that its position will be fixed.

5.03 "Universal" type clips are generally satisfactory for use on the ends of the leads to be connected to the cable. At the other end of the leads any type of clip which will fit under a binding post is suitable for use. One wire of one cord is arbitrarily called and marked "White" and a second wire of the same cord is called the "White-Mate." Similarly, one wire of

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the second cord is called and marked "Black" while a second wire of this cord is called the "Black-Mate." The fifth wire in the case of the two-conductor leads and the third wires in the case of the three-conductor leads may be regarded as shields and should be connected to the "Gnd" post on the unbalance set and to the cable sheath at the other end.

5.04 With the test leads connected to the set, color for color, and the "Gnd" post on the set connected to the cable sheath by means of the shield wire, determine the unbalance of the leads. The "Gnd" post on the set should always be connected to the cable sheath or to ground by means of the shield wire when making measurements in order that the capacitances in the bridge and in the leads will maintain constant relations during a test. While measurements with and without the use of a ground may be approximately identical in particular cases, it does not follow that this will be true in all cases.

5.05 If the phantom-to-white and phantom-to-black unbalances of the leads are not the same, they should be brought to the same value, preferably zero, by the use of a suitable balancing stub. It will be noted from Paragraph 4.10 that in order to determine the unbalances it will be necessary to make unbalance readings with the wires of the pairs reversed, as well as with these wires connected, color for color, since the capacitance of the leads may be sufficient to cause a shift in zero adjustment. This balancing stub can be made of rubber insulated twisted pair. After the balancing work on the leads is completed the stub should be taped to the leads, covering it with rubber tape, with friction tape and with shellac in order to prevent moisture from affecting it. A covering of this sort should also be applied over the ends of the leads to prevent moisture from penetrating the cotton filler.

5.06 By referring to Drawing No. 38-Y-2148 it can be determined that connection of a condenser of suitable value between the proper wire of a pair and ground (the shield wire of the leads in this case) will neutralize the phantom-to-side unbalance of the circuit combination under consideration. The condensers which are added in this way for neutralizing the phantom-to-side unbalances should have practically no effect on the side-to-side unbalance. With leads of this type, neutralization of the side-to-side unbalance by means of a balancing stub should rarely be required since the side-to-side unbalance is negligible in most cases.

6. Capacitance Unbalance Measurements

6.01 The series of tests outlined in Part 4 should always be made on a capacity unbalance set in order to determine whether it is in satisfactory working condition before measurements of capacitance unbalance are made with it.

6.02 For measurements within a phantom group as well as measurements between pairs in different groups, connect the wires of one pair to the "White" and "Mate" binding posts and the wires of the second pair to the "Black" and "Mate" binding posts. For measurements between phantom circuits or between a phantom circuit and a pair of another group, connect one phantom circuit to the "White" and "Mate" binding posts and the second phantom circuit or pair of the second group to the "Black" and "Mate" binding posts. The phantom circuit in the case of inter-quad measurements is obtained by short-circuiting each pair of a quad; one short-circuited pair being connected to one binding post and the other short-circuited pair to the mate binding post.

6.03 The positions of the "C" and "D" keys for the various types of measurements are as follows:

UNBALANCE TO BE MEASURED	"C" KEY	"D" KEY
Phantom-to-Side (White)	White	Ph to S
Phantom-to-Side (Black)	Black	Ph to S
Side-to-Side	White or Black	S to S
Pair-to-Pair	White or Black	S to S
Phantom-to-Phantom	White or Black	S to S
Phantom-to-Pair	White or Black	S to S

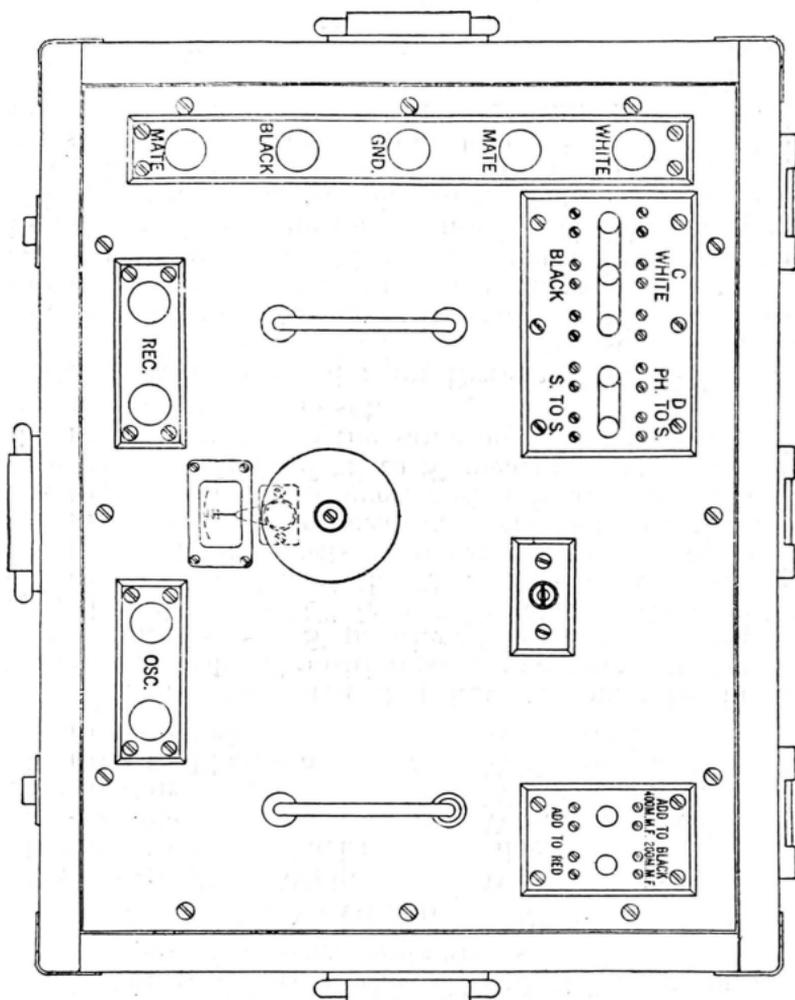
6.04 It will be noted that key "C" may be in either the "White" or "Black" position when measurements are made with key "D" in the "S to S" position. This is true because of the fact that throwing key "C" from "White" to "Black" interchanges the relative position of the "White"—"Mate" and the "Black"—"Mate" binding posts with respect to the terminals of the bridge. Slight differences may exist between the readings in the two positions, however, and it is always desirable, therefore, when a series of "S to S" measurements is made to make them with key "C" in the same position for which the side-to-side zero adjuster was set.

6.05 It will be noted from Drawing No. 38-Y-2148 that the set has been wired so that the oscillator is across the side circuit and the receiver is across the phantom in phantom-to-side measurements. In case measurements are made on a cable partly in service this arrangement may be undesirable since listening will be done on the noisiest circuit, i.e., the phantom. When the noise on the phantom circuits is sufficient to interfere with accurate measurement the listening may be done on the side circuits by connecting the receiver to the "Osc" binding posts and the oscillator to the "Rec" binding posts.

3 - A CAPACITY UNBALANCE SET

FACE VIEW

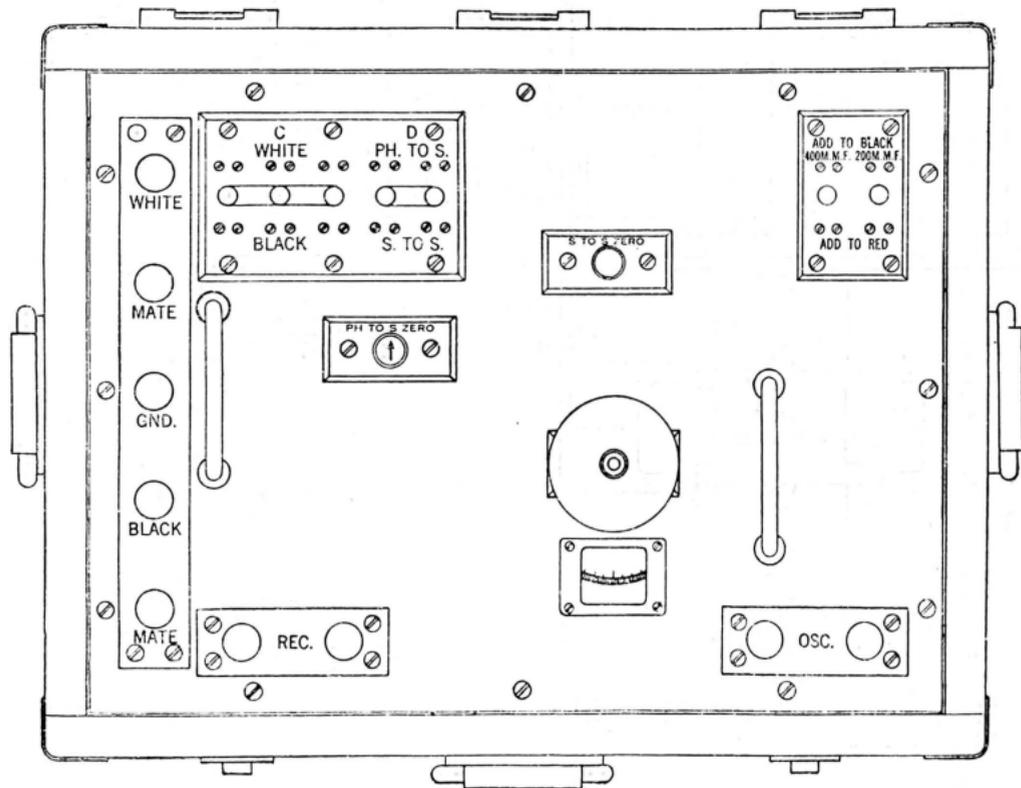
Scale 1" = 1.75" Approx.



38 · Y · 2024

4 - A CAPACITY UNBALANCE SET
FACE VIEW

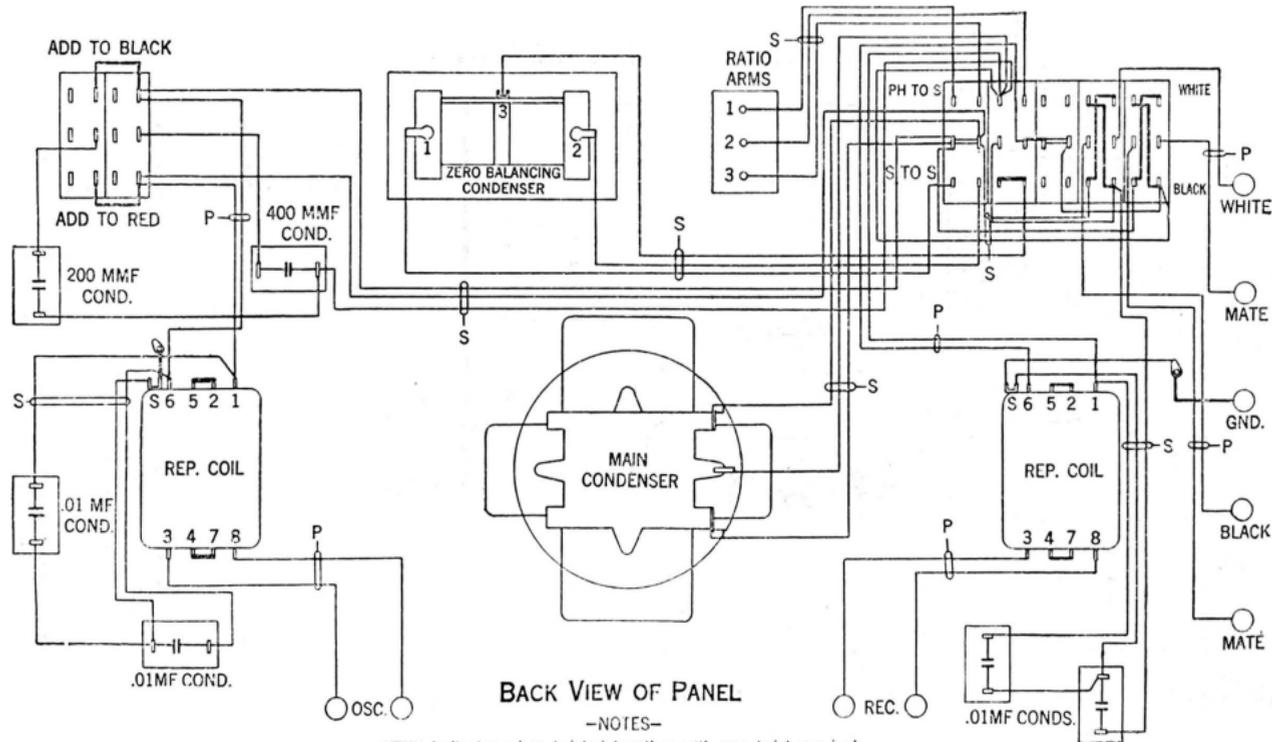
38 - Y - 2147



3-A & 4-A
CAPACITY
UNB. SETS

3 - A CAPACITY UNBALANCE SET WIRING DIAGRAM

38 - Y - 2025
1st Half



BACK VIEW OF PANEL

-NOTES-

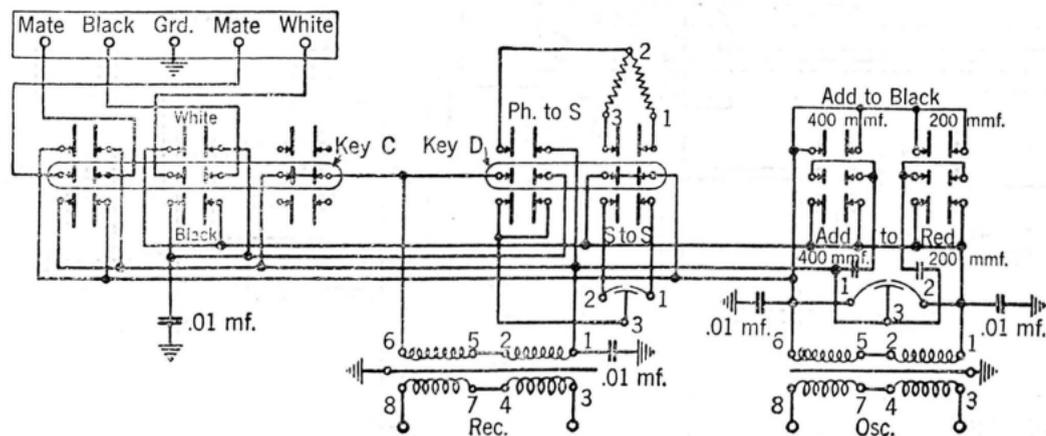
○ Indicates wires twisted together with one twist per inch.
These twists have been carried as far as possible before separating the wires to make the connections.

P = Pairs

S = Spiral three

3 - A CAPACITY UNBALANCE SET SCHEMATIC

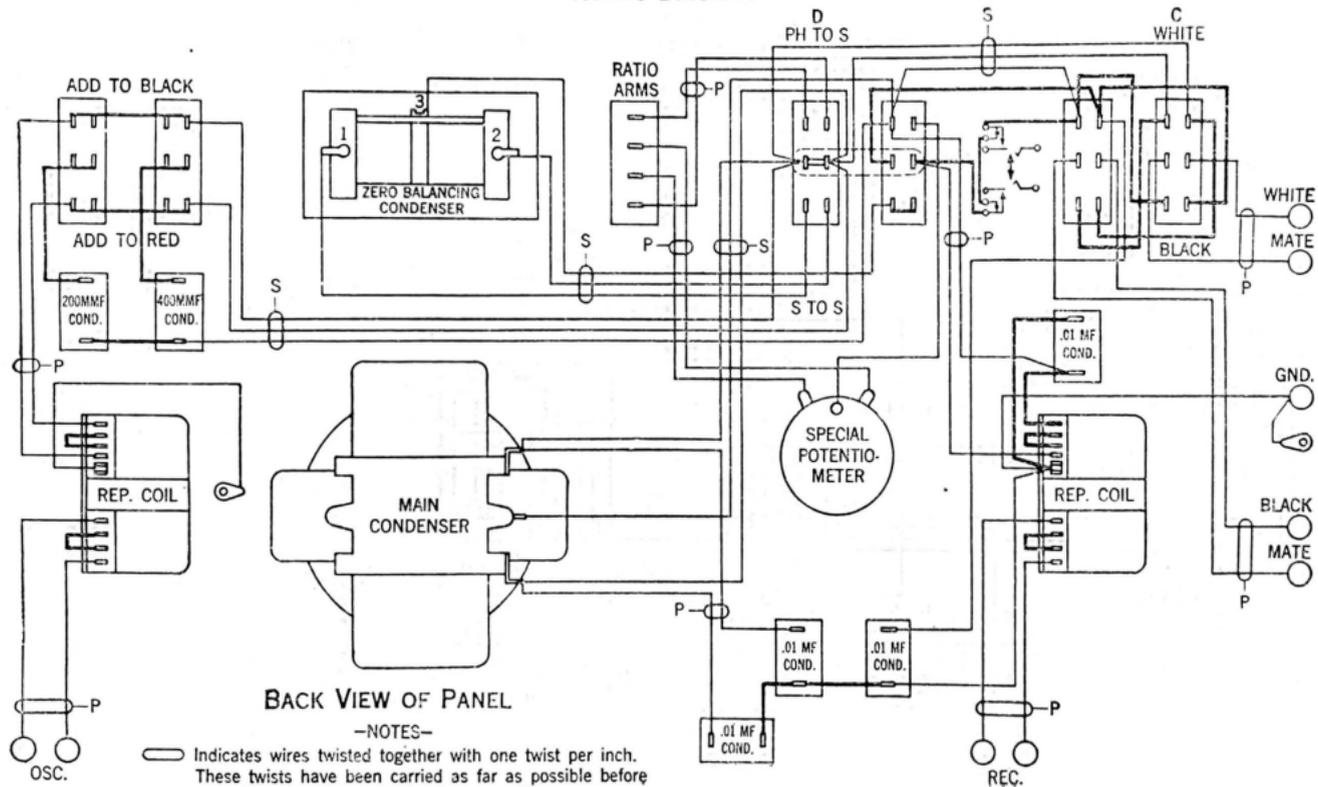
38 - Y - 2025
2 nd Half



3-A & 4-A
CAPACITY
UNB. SETS

4 - A CAPACITY UNBALANCE SET WIRING DIAGRAM

38 - Y - 2159
1st Half



BACK VIEW OF PANEL

-NOTES-

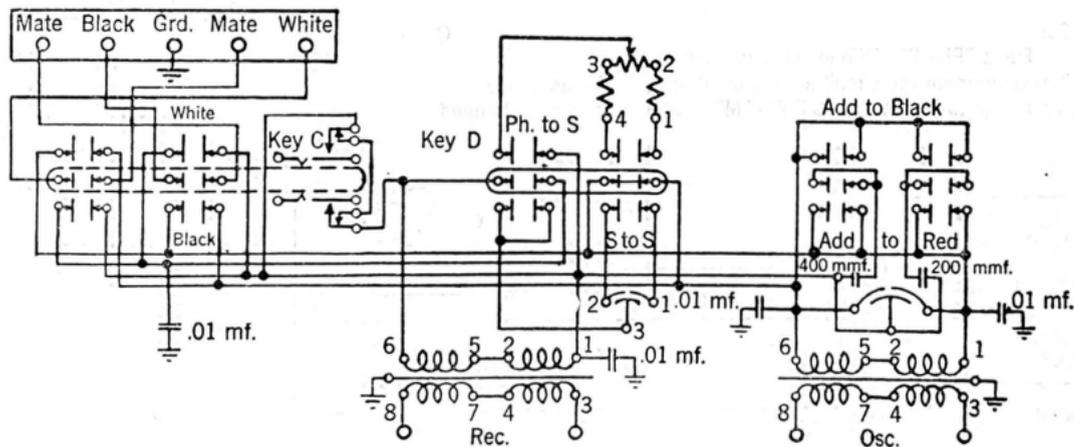
— Indicates wires twisted together with one twist per inch. These twists have been carried as far as possible before separating the wires to make the connections.

P = Pairs

S = Spiral three

4 - A CAPACITY UNBALANCE SET
SCHEMATIC

38 - Y - 2159
2 nd Half



3-A & 4-A
CAPACITY
UNB. SETS

4 - A CAPACITY UNBALANCE SET

SCHEMATIC OF CIRCUIT ARRANGEMENTS

38 - Y - 2148

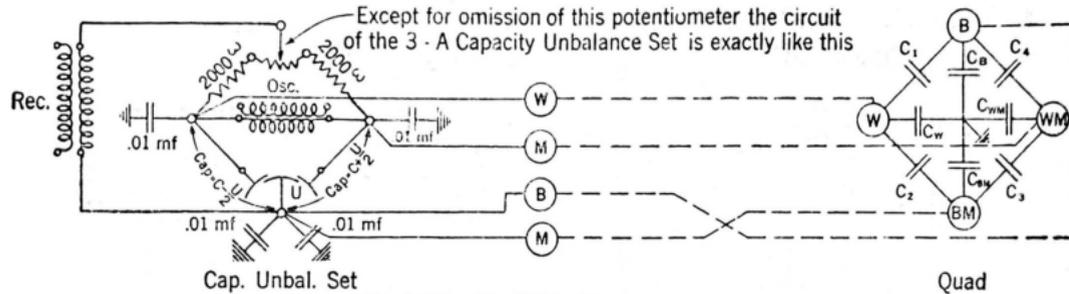


Fig. 1 "Ph - S" - "White" Measurement.

For "Ph - S" - "Black" measurement the circuit arrangement is the same as above except that connections of bridge to binding posts "W" - "M" and "B" - "M" are interchanged.

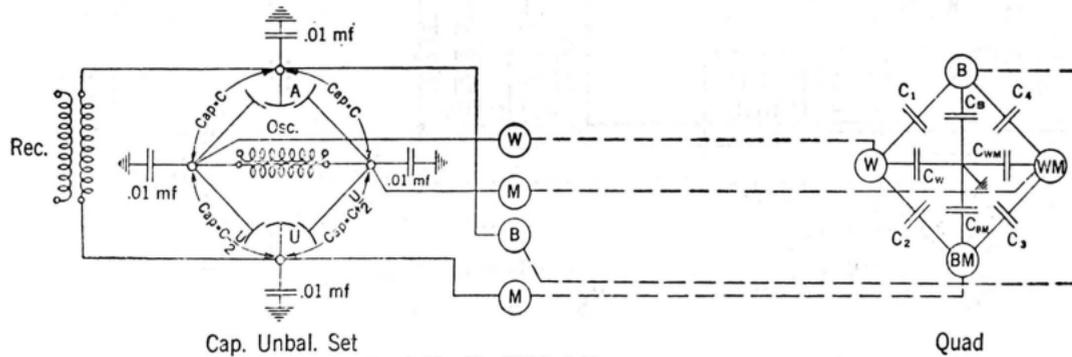
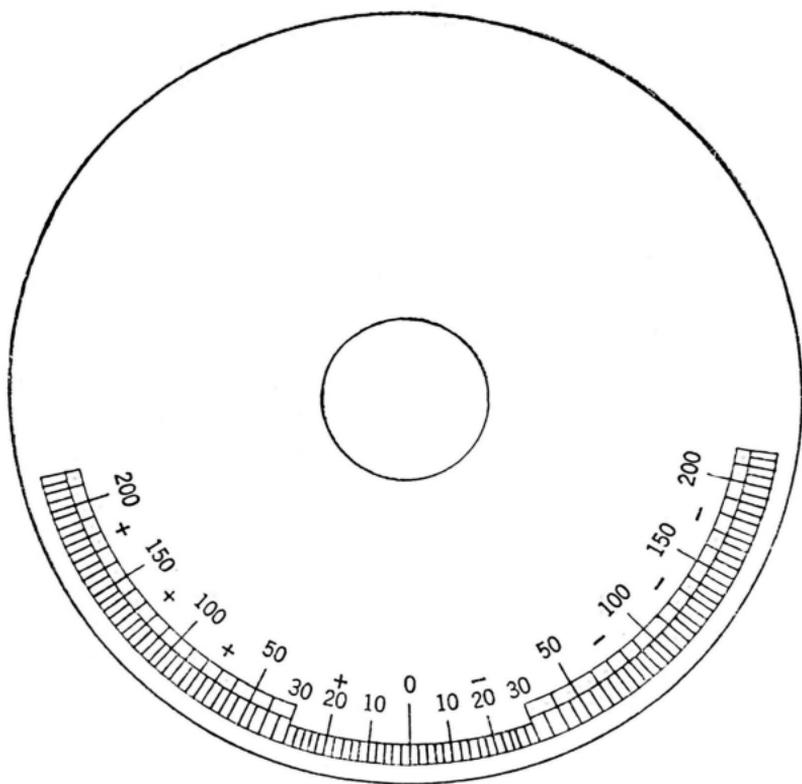


Fig. 2 "S - S" - "White" Measurement.

For "S - S" - "Black" measurement the circuit arrangement is the same as above except that connections of bridge to binding posts "W" - "M" and "B" - "M" are interchanged.

4 - A CAPACITY UNBALANCE SET
SCALE OF BALANCING CONDENSER



Portion of scale marked "+" is black
Portion of scale marked "-" is red