INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE S TRANSMITTER FOR CURRENT BALANCE TELEMETER

CAUTION Before putting instruments into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment.

GENERAL

Remote-indicating apparatus of the current-balance type is used for the totalization or remote transmission of readings of voltage, current, power, water level, position, etc. The transmitters themselves consist of two measuring elements mechanically connected in opposition. One element is adapted to measure the quantity to be transmitted while the other is a permanent-magnet moving-coil element adapted to measure direct currents of the order of 20 milliamperes. In the upper part of the case is a motor-operated rheostat, which is controlled by contacts on the meter element. This rheostat controls the current which passes through the rheostat itself, the d-c. element, the transmission line, the remote indicator and returns to the source as is shown schematically in Fig. 1.

Normally, a balanced condition exists between the forces exerted by the d'Arsonval element and the measuring element. When this balanced condition exists, the contacts in the motor circuit are open and a constant current, which is taken from the supply source, passes through the receiving circuit. The schematic diagram, shown in Fig. 1, indicates that in case the measured quantity increases it will, by exerting additional force, disturb the balance and close the contact which causes the motor to move the rheostat to a position where an increased current will flow and re-establish the balanced condition, and then the contact is opened. A decrease in the measured quantity will cause a similar operation in the opposite direction.

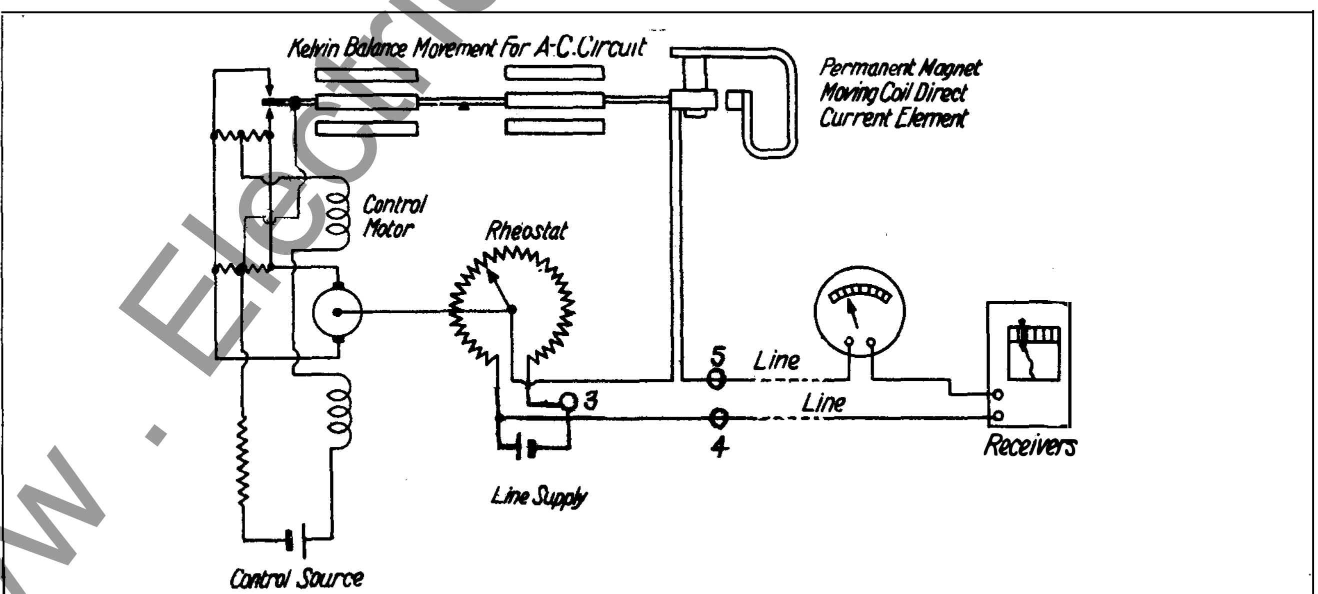

Fig. 1—Connection Diagram of One Transmitter to Receivers Connected in Series.

INSTALLATION

Unpack according to the directions given on the label attached to the packing case, and preserve the packing case for future use, whenever it may be necessary to store or reship the instrument.

Familiarize yourself with the contents of this instruction book. Mount the instrument on the switchboard or other support.

Take care when tightening the mounting stud nuts not to tighten them so tight that the base is warped, as that will throw the instrument out of alignment. THE NUTS ON THE TERMINAL STUDS SHOULD NOT BE TIGHTENED AGAINST THE PANAL. (The mounting studs are sufficient to support the meter).

Connect according to the diagrams, Figs. 4, 5, 6, 7 or 8.

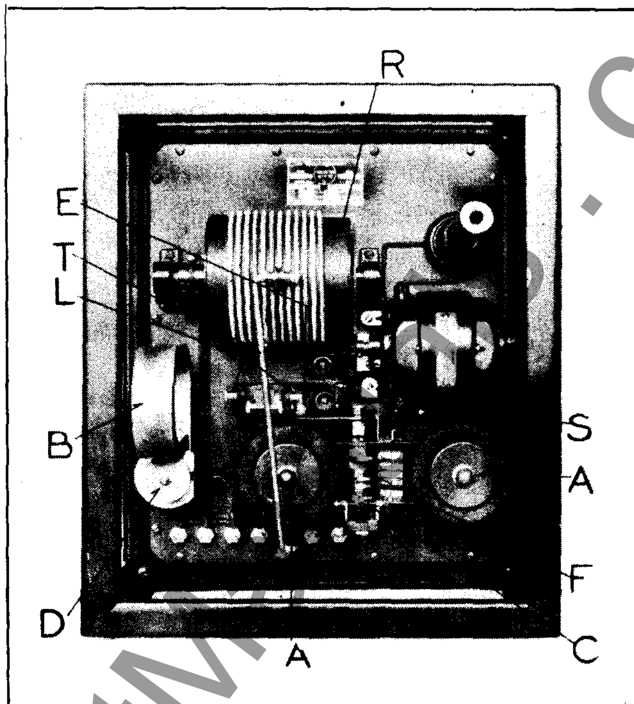

Fig. 2—Transmitting Voltmeter.

With no power on the meter element apply control voltage to terminals 1 and 2. Voltage can also be applied to terminals 3 and 4, but terminal 5 should not be connected. In this condition, there are no electrical forces on the element. Operate the contacts by hand to see that the motor runs properly. Release the movement; both contacts should open and the motor idle. If this does not occur, the movement is out of mechanical balance, and the zero adjustment E can be used to correct this condition.* Place trolley contact wheel in the middle of the rheostat coil and complete the connections. The transmitter is now in operating order, if proper polarity is on the direct current supply and the meter element torque is in the correct direction. Reversal of direct current polarity will cause the rheostat to move to the maximum current position at the extreme right. Incorrect meter element polarity, which can occur only on direct current and wattmeter transmitters, will cause the rheostat to move to the left against the limit switch. If both are reversed, the operation will be unstable and the rheostat will stop at one end or the other of its travel. Care should be taken to eliminate such troubles by checking out connections as damage may result. If it is desired to install switches to cut out a transmitter operating in parallel with others when its circuit is out of use, a three-pole switch connected in leads 1, 3, and 5 is required. If single-pole switches are used, they should be opened in the order 1, 5, 3. A double pole switch in leads 1 and 5 will also do the work but will leave the rheostat across the d-c supply. It is not necessary to disconnect the meter element as the transmitter will not be damaged by operation without direct current on the rheostat.

*IMPORTANT

Note that the zero adjustment referred to on pages 2 and 5 applies only to the cases where the telemeter line current is zero at zero measured load. Where a base value such as 5 milliamperes is used, the zero calibration includes this value, which must exist when resetting the zero adjuster to the correct position.

A portable milliammeter connected at the sending end between the transmitter and the line will be found very convenient for making and testing adjustments in the field.

POWER REQUIREMENTS

The tables given below give the power requirements of the motor and rheostat circuits for various voltages and the burdens of alternating-current instruments on the instrument transformers. Direct-current ammeters operate from shunts having a drop of 50 millivolts or higher. Direct-current voltage transmitters of the polarized type have a resistance of 50 ohms per volt. For most direct-current work, the alternating-current voltage transmitter is used as the square law of deflection gives it the advantage of wider scale divisions and better sensitivity above half of the full scale value.

DESCRIPTION OF APPARATUS

The Transmitter

The essentials of the current-balance type of transmitter are embodied in the transmitting meter as shown in Fig. 2. The coils A-A constitute a Kelvin balance type element which develops torque on the meter element proportional to the a-c. quantity. B is a permanent magnet, and with its associated coils forms a direct-current element for measuring the transmitted telemeter line current. Its torque is proportional to the current transmitted and balances the torque of the a-c meter element A-A. This is the normal condition of the measuring element. If either part of the element has a higher torque than the other, the measuring element turns and closes one or the other of the contacts C, which causes the motor M to adjust the rheostat R, so that the current in element B is corrected to balance the torque of the element A-A. The direct-current transmitted is proportional to the a-c or d-c quantity metered. A direct-current receiving meter may have its dial graduated accordingly and may be place in the circuit wherever convenient.

The rheostat R is of special design to give a large number of steps in a small space to permit close accuracy. It has about 3500 steps. A resistance wire is wound helically around and insulating core which in turn is wound around an insulating drum. The two ends or the winding are brought out to slip-rings and connect to the source of d-c voltage. Each slip-ring has four brushes in multiple to insure positive contact at all times. Contact is made to the wire through a trolley arm pivoted on a post at the bottom of the base. A V-groove wheel is used to provide two point contact at all times. Contact is made to the wheel by means of a spring bearing on the end of the wheel hub. Limit switches L-L are operated by a block on the trolley arm to prevent the operation of the rheostat beyond its limits when overloads or line trouble may prevent a balance being obtained. The operating motor M is connected to the rheostat by a single spur gear reduction, and uses a peculiar control circuit to provide rapid starting and dynamic braking, thereby permitting faster operation.

The measuring element is constructed with a rigid frame carrying the coils of the meter element and the small coil of the direct current balance element. The movement is pivoted on hardened and polished alloy "jewels" which

	Current Circuit								Voltage Circuit 25-60 Cycles			
	25 Cycles				60 Cycles							
	VA	W	RVA	PF	VA	W	RVA	PF	VA	W	RVA	PF
									10.8	10.8	0	100
Transmitting Wattmeter	4.32	4.12	1.26	95.5	5.37	4.12	3.12	77	7.5	7.5	0	100
Transmitting Ammeter	3.78	3.66	.94	96.8	3.87	3.3	2.03	85.3	....	....	..	....
Transmitting Voltmeter	....	.....	....	....	....	....	....	....	10.5	10.5	.1	99+

Control Circuit	VA	W	RVA	PF
110 Volts, 60 Cycles	35.4	32	15	90.4
110 Volts, 25 Cycles	35.4	33.9	10	96.0
110 Volts, D-C..	....	35..	....	....
250 Volts, D-C.	....	45	....	....
48 Volts, D-C.	....	28	....	....

Rheostat Circuit requires approximately 120 milliamperes at 110 or 220 volts and 60 milliamperes at 48 volts.

are readily replaceable in the event of being damaged. The current is brought into the element through flexible leads. A spring S with a micrometer adjustment E is provided to set the transmitter in the position of zero or mechanical balance, so that the only forces acting on the element are the electrical forces. The inner pole of the permanent magnet carries a magnetic shunt D which permits adjustment of the balancing forces by varying the permanent magnetic flux in which the coil operates.

The direct-current transmitters are similar to the alternating-current types shown in Fig. 2 except that the measuring element consists of two elements of the same type as the balancing element mounted at the opposite ends of a balance arm.

Totalizing wattmeters are equipped with the device shown in Fig. 3. The motor-operated rheostat is the same as that in the single transmitter Fig. 2 and is operated by contacts on the transmitting element mounted vertically alongside the lower three elements of the totalizing meter. The two forces acting on this element are the mechanical force of a spring which is connected to the recording mechanism of the meter and the torque of the balance coils which depends on the transmitted current. The tension of the spring is proportional to the load shown on the chart, which results in the current transmitted being proportional to the load. The connections between the two parts of the transmitter are only the connecting wires. What is actually transmitted is the position of the pen on the chart.

The receiving instruments are standard direct-current milliammeters calibrated to read in the values of the load, voltage, position or whatever quantity is to be transmitted. Either indicating or recording instruments may be used and as many as desired may be connected in series.

ADJUSTMENTS TO SUIT SERVICE CONDITIONS

In order to meet the varying needs of different kinds of service, the following adjustments are possible:

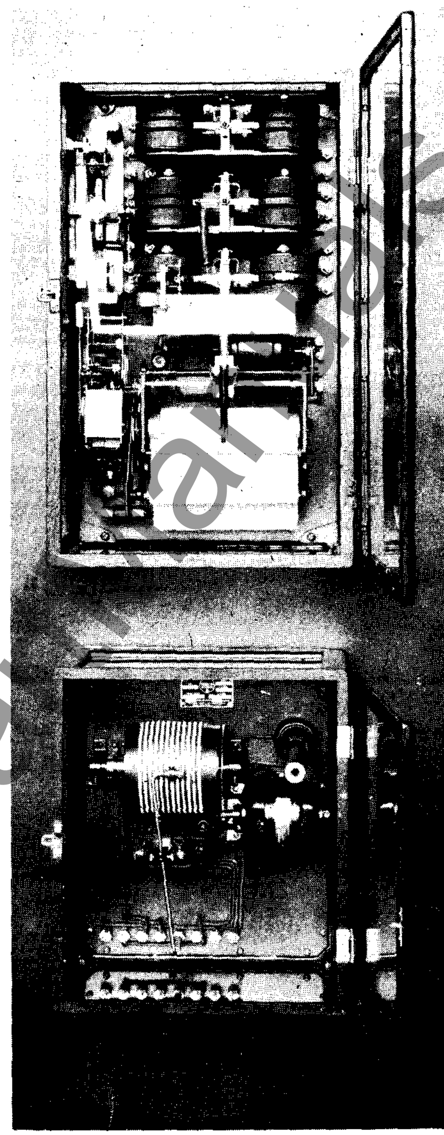

Fig. 3—Totalizing Wattmeter and Transmitter.

(a) Motor control resistance.

The motor resistance to a certain extent governs the speed of the motor but is to be used mainly to correct for differences in control circuit voltage. If faster response is desired, the resistance may be reduced. Too low a resistance will cause hunting to take place, and in general a speed of six seconds for full scale travel is about the fastest that is obtainable.

(b) Working resistance of output circuit. This includes the line and the resistor in series with terminal 5.

The output resistance (of the telemeter line circuit) should be high enough so that the full scale range of the meter will cover about 80% of the rheostat travel.

Line Resistor Unit

In figures 7, 8, and 9, the external resistor connected to terminal No. 5 is used in cases where the resistance of the telemeter loop through the receiving instruments is less than normal which would otherwise cause the internal rheostat to operate within too narrow a zone.

Rheostat

The rheostat has a resistance of 1200 ohms. The portion of the rheostat used in full scale deflection of the receiver depends upon the applied voltage and the loop resistance of the line. Where full scale deflection requires too small a portion of the rheostat, the additional line resistor, as above, is added to terminal No. 5.

The required value of this resistor (R) may be calculated as follows:

$$R = 2/3 \times E/I - L$$

Where E = applied battery voltage
I = full scale telemeter current
L = loop resistance

When the result is "minus", no extra resistance is required.

Contact Spacing

The spacing of the contacts affects the sensitivity or the amount of change required to cause an operation of the rheostat to readjust the current. The usual spacing is about .008" total for both gaps. The further apart the contacts are set, the greater the possible error and the less the sensitivity. The sensitivity can be varied from about 1/4 to 2%. However, 1/2 to 1% is recommended as a good working figure. The greater the sensitivity, the greater the maintenance required as the apparatus operates more frequently.

Telemeter Current Value

This is generally .020 amp. for full scale. In supervisory control, it is necessary to start with a base value of 5 m.a. =) load. Thus giving .005 + .020 = .025 amp. for full scale. To establish this value at 0 load, a resistor is placed within the telemeter between the rheostat and terminal No. 4, Figs. 10, 11 and 12.

Control Battery Voltage

This should be sufficient at all times to give the full scale telemeter amperes, through the total loop resistance.

Center Zero Calibration

Where power may flow in either direction, zero center calibration of the transmitter is secured by use of a center-tap resistor, as shown in diagram, Fig. 7.

Receiving Instruments

Instructions for installation and care of receiving instruments are the same as those normally furnished with the particular type of instruments used.

THE TELEMETER LINE CIRCUITS

Probably more than any other single cause, the circuit affects the accuracy and operation of the equipment. It is, briefly, the variable, uncertain factor; and is the thing that distinguishes one installation from the other. The quality of a line for use with the current balance type of equipment can be determined by measuring the resistance of the line at the sending end with the receiving end open and then repeating with the line shorted at the receiving end. The ratio of these two values should exceed 100 and the open circuit resistance should exceed 5000 ohms also for best results. Passable results can be obtained

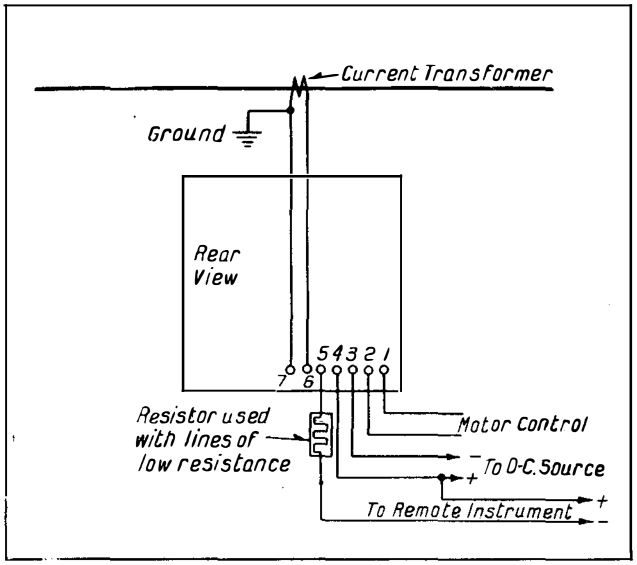

Fig. 4—Transmitting A-C Ammeter Diagram.

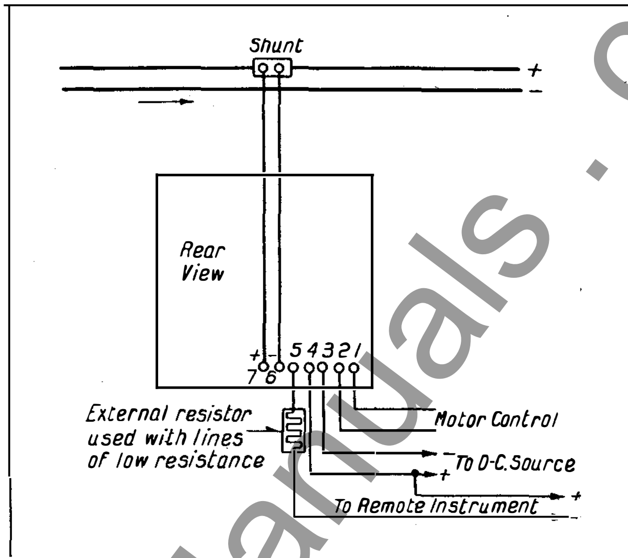

Fig. 5—Transmitting D-C Ammeter Diagram

with values of the resistance ratio as low as 30, but this is not recommended. The above applies to lines having good insultaion from ground or with the remote indicating apparatus supplied by an insulated source of direct current. Open wire lines should be measured in wet and dry weather as the decrease of resistance due to leakage over the wet insulators may be considerable. The worst transmission usually occurs in a period of wet weather following a long period of dry weather, when insulators are coated with a mixture of dust and water. Lines in cables are greatly to be preferred due to their freedom from weather troubles. It is possible to transmit from 20 to 30 miles in good cable. It is not usually desirable to work through a circuit of a loop resistance of 4000 ohms or higher as the leakage over the sending end terminal connections will become an appreciable part of the current transmitted unless great care and good maintenance are used. Next in importance to having lines with good enough electrical constants is to have proper protection against line disturbances.

PROTECTION OF LINES AND APPARATUS

Remote indicating apparatus is subjected to disturbances arising in the circuit being measured and also in the circuit used for transmitting the indications. The first condition is the least troublesome as the protective equipment on the circuit measured serves to limit the extent of such trouble.

Disturbances coming in on the line used for transmission may be several times any possible strength that may be built into the instrument so that additional apparatus may be needed to keep such disturbances from reaching the transmitting apparatus and in some cases the receiving apparatus.*

MAINTENANCE AND INSPECTION

The amount of maintenance required depends upon local conditions to a very great extent. The following is only intended as a suggestion to follow until experience indicates that more or less attention will be required. For this reason, considerable material is included in the book which may not be required in any given installation. The following is suggested as an installation check up at periods of two weeks:

*For further details on Telemeter Line Circuits and their protection, see "Telemetering Supervisory Control and Associated Circuits", the Oct. 1941 report of the A.I.E.E. joint Committees on Automatic Stations and Instruments and Measurements.

(a) Clean contacts by passing a sheet of paper between them.

(b) Move the rheostat drum by hand and see that the contacts operate to restore it to the former position within limits of about one inch around the circumference. When the contacts close, the motor will jerk the drum a short distance which will be felt by the hand moving the drum.

(c) Close the contacts by hand and operate the drum through at least a complete revolution in each direction.

The following should receive attention about every six months.

(d) Replace used grease in the grease cups on the motor and the rheostat shafts and wipe off any excess that may be on the outside of the bearings.

(e) Remove contact pulley from the rheostat arm and thoroughly clean the arm and the pulley and re-assemble with a small amount of vaseline for lubrication. Also inspect the slip rings and give them similar attention if they control motor. See section on this subject.

(f) Check up the alignment and smoothness of the contact points and if necessary smooth them up and reset them. Ordinarily one or two years service can easily be obtained before this operation will be needed. Also check the condition of the wire resistance coil rheostat and if it is badly worn, replace it, as a break in the coil will put the instrument out of service. The drum may be removed for this purpose by removing four nuts from the bearing pedestals and pulling the drum and bearing straight out. The drive gear and the drum end are removed and the coil changed, the new coil is anchored the same as the old one. The resistance cannot readily be soldered so it is recommended that good mechanical joints be made and that the joints be covered with solder to prevent loosening and corrosion. Care should be taken to keep the joints away from the drum ends when assembling to prevent short circuits and grounds.

CARE OF THE MOTOR

Since the motor is a very vital part of the mechanism, it is worthy of special attention. The control motor used is of the universal type and may be operated on either alternating or direct current provided that the proper resistors are used. A bridge network of four resistors is used which, when the contacts are open, serves the double purpose of a dynamic brake resistance and a field resistance in order to insure quick stopping and prevent overtravel. When the contacts close, the bridge is unbalanced and an armature current flows and the motor revolves at a constant speed due to the action of the resistor across the armature.

The grease cups should require refilling about every six to eight months in usual service. The commutator should be cleaned about every six months in severe service. In many cases annual attention may be sufficient. The brushes should be watched from time to time and when worn down to about 1/4 inch, should be replaced. The direction of the motor may be reversed by transposing the field or top pair of leads or else the armature of bottom pair of leads. Three different windings are used for voltages of the order 50, 110, 220.

CALIBRATION AND ADJUSTMENT

Two independent adjustments are provided by means of which the instrument may be readjusted if required. The Zero Adjustment is a small spring on the measuring element with a fine screw adjustment to facilitate its use. To make this adjustment, all electrical forces must be removed from the measuring element by removing voltage or load from the element and disconnecting the wire leading to terminal 5.

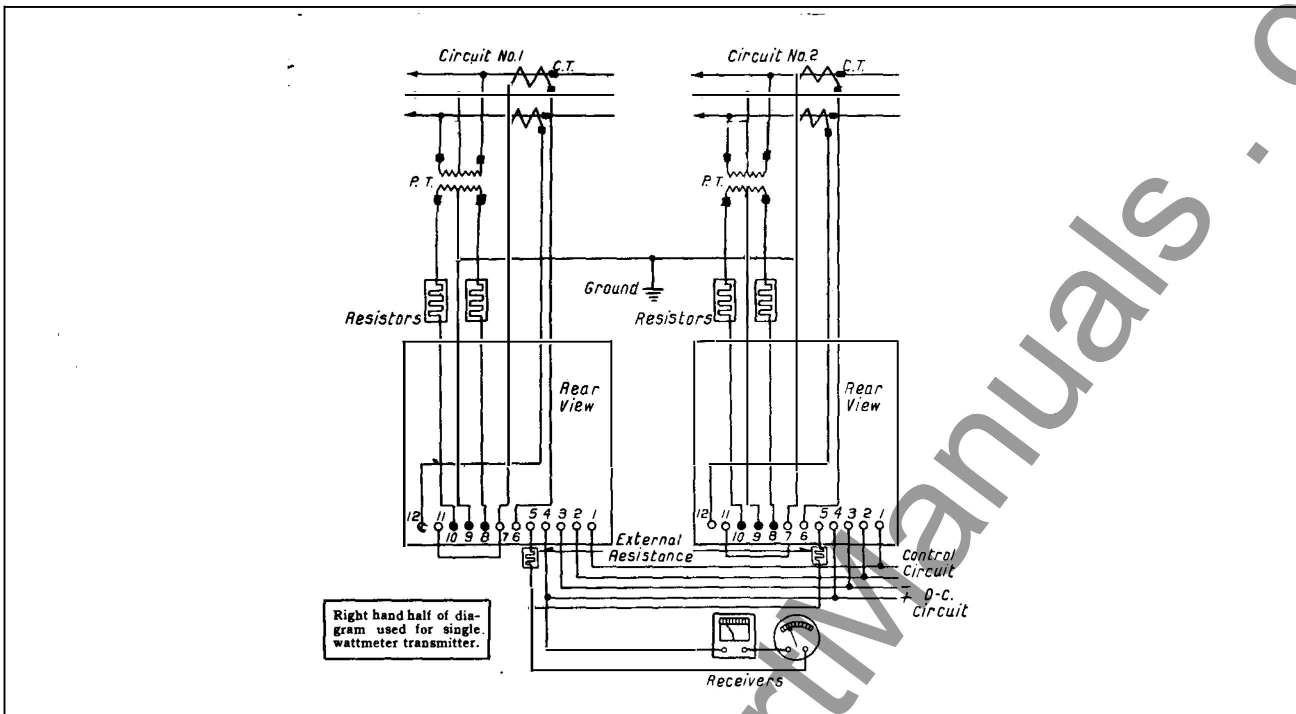

Fig. 6—Two Transmitting Wattmeters Operated in Parallel. Left Zero Connections for Totalizing Two-3 Phase 3 Wire Circuits. For Single Transmitter, use this Diagram Omitting one of the Transmitters shown.

The adjustment is made by turning the screw in the proper direction until the motion of the rheostat ceases when the contact roller is in the middle.* The mechanical forces are to be balanced with all electrical forces removed. It may happen when a meter has been repaired, that this condition cannot be reached in the range of adjustment provided; then it will be necessary to shift the position of the outer end of the spring to obtain a balance. Be sure that the turns of the spring do not drag on each other. The strength of the spring is of little importance, the tension is the important thing. Caution--Be sure that the contact roller is somewhere near the center of the rheostat coil before reconnecting terminal 5, to avoid damaging instrument by excessive current.

The Other Adjustment is a load adjustment and is made with some load on the instrument. The more load that is used, the greater the accuracy with which this adjustment may be made. The adjustment is a magnetic shunt which changes the strength of the direct current balance coil by varying the magnetic field in which it works. The magnetic shunt is located on the pole pieces of the permanent magnet and is secured by a lock nut. Turning the shunt to the right increases the transmitted current. The range of adjustment is about 15% total. Instruments are shipped with the adjustment set near the upper current limit so that recalibration will be possible after any accident or damage which might result in weakening of the magnet. CAUTION--BE SURE THAT LOCK NUT IS PROPERLY TIGHTENED AFTER THIS ADJUSTMENT TO INSURE ITS PERMANENCY.

The relation between the current transmitted and the quantity measured is fixed and determines the scale distribution of the receiving instruments. On wattmeters the current is proportional to the power. The same is also true of direct current ammeters and voltmeters where the current is also proportional to the current or voltage. Alternating-current ammeters and voltmeters transmid d-c. current proportional to the square of the a-c. current or voltage.

*See footnote on page 2.

The sensitivity of the transmitter may be improved by setting the contacts on the measuring element closer in some certain cases. A spacing of about 1/4% of the full scale current, in most cases may result in hunting due to changes in control voltage. The more reasonable value of 1/2% is a better operating proposition. This value means a contact spacing of about .01 inch (.25 MM) total for both gaps. Care should be taken to see that the contacts are set so that they do not in any position of the movement short circuit the stationary contacts. Such a condition will cause an erratic failure in operation.

TO DISMANTLE THE INSTRUMENT

In case it should ever become necessary to dismantle the instrument, for overhaul or repairs the following procedure should be followed.

Meter Element

Remove the magnetic shunt after noting its position and the number of turns required to tighten it down, so that it may be replaced in the proper position when instrument is reassembled. Remove the screws holding down the ends of the flexible conducting leads. Remove the cap nuts and washers holding the stationary coils in place and pull off the top stationary coils, bending the leads down out of the way. Remove the slotted cap nut on the upper bearing screw holding the zero-adjusting screw in place. Loosen the lower bearing screw. The moving element may be lifted out by sliding the direct current coil off the pole piece and turning the movement around its longer axis. When re-assembling follow the reverse procedure and take care not to tighten up too hard on the bearing screws as that will damage the pivots. The screws should never be tightened up on the pivots but some small clearance should always exist.

Rheostat

The rheostat arm may be removed by turning the mounting post to the left which will thread if off its mounting stud and on the arm. When replacing the rheostat arm, the proper tension should be present. It should not be so light that the friction of the contact wheel on the resistance spiral will not turn the wheel or so heavy that the motor will not start the drum when the wheel is placed on the drum at the start of the spiral. Adjustment of the tension is made by bending the arm taking care not to put too much strain on the mounting post. The method to use in dismantling the rest of the instrument is obvious from the construction.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

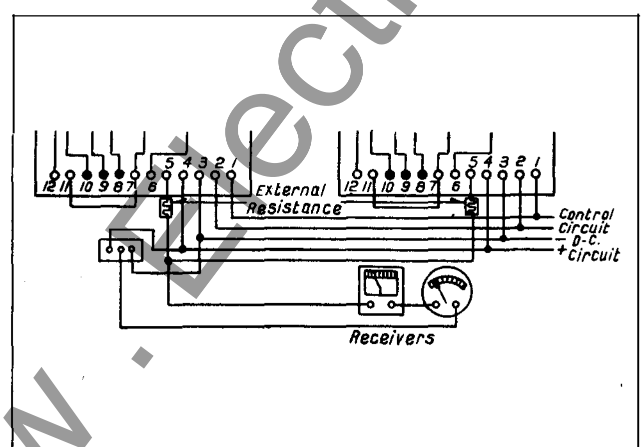

Fig. 7—Showing Center-Tap External Resistor Used For Wattmeters Calibrated for Center Zero. In Other respects this Diagram is the Same as Figure 6.

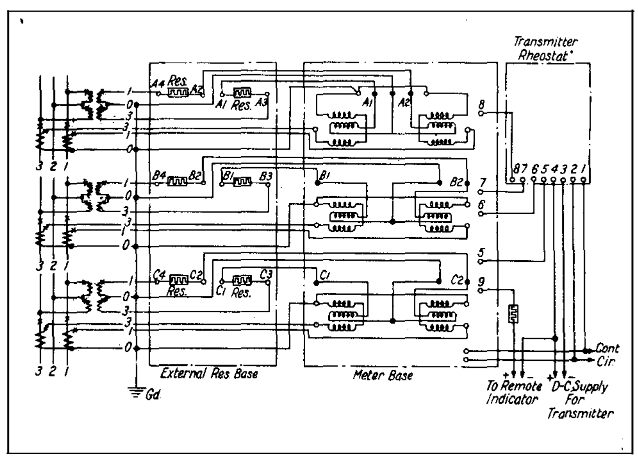

Fig. 8—Totalizing Wattmeter With Transmitting Rheostat. Three Phase Three Wire Left Zero. For Center Zero see also Figure 7.

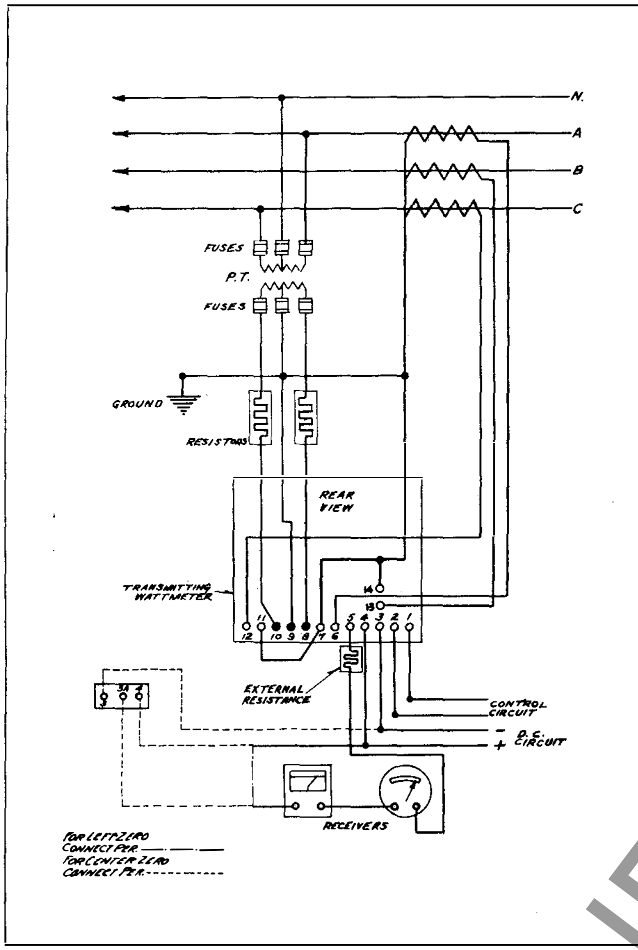

Fig. 9—3 Phase 4 Wire 3 Current Coil Wattmeter.

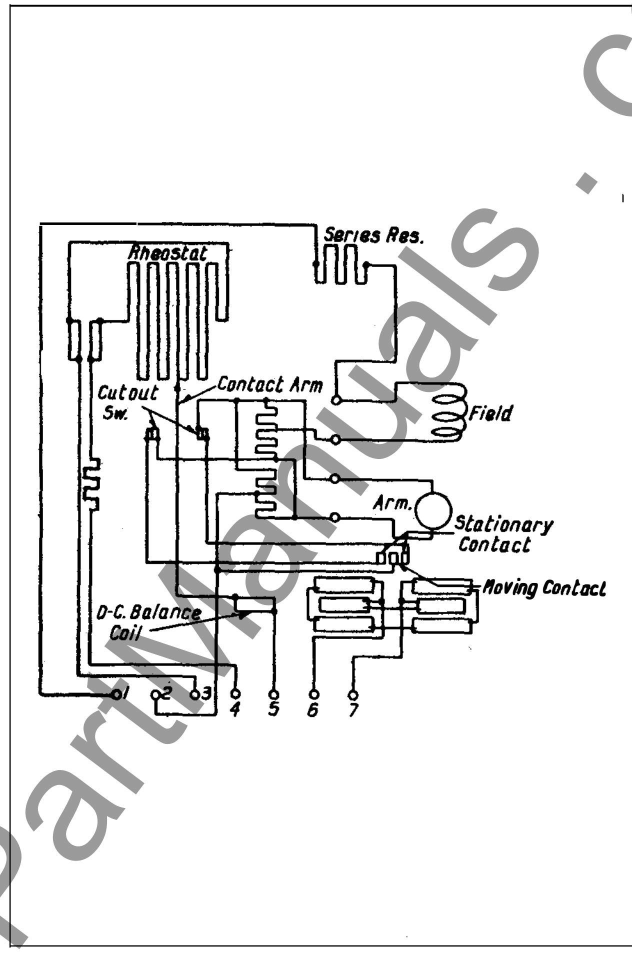

Fig. 10—Transmitting A-C. Ammeter—Internal Connections.

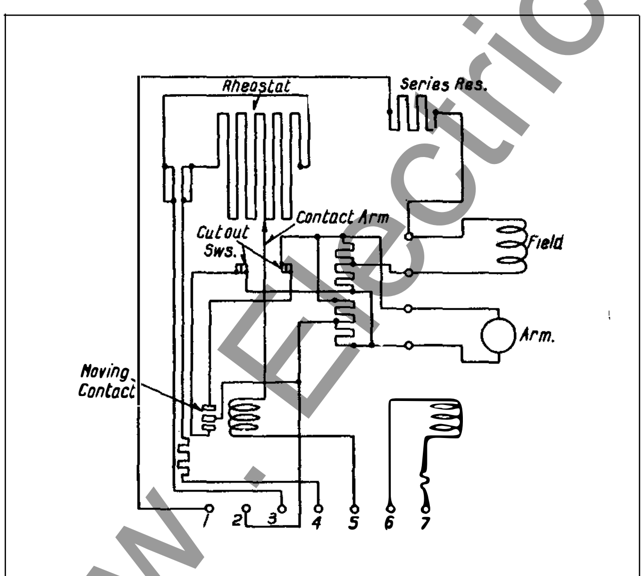

Fig. 11—Transmitting D-C. Ammeter or Voltmeter Internal Connections.

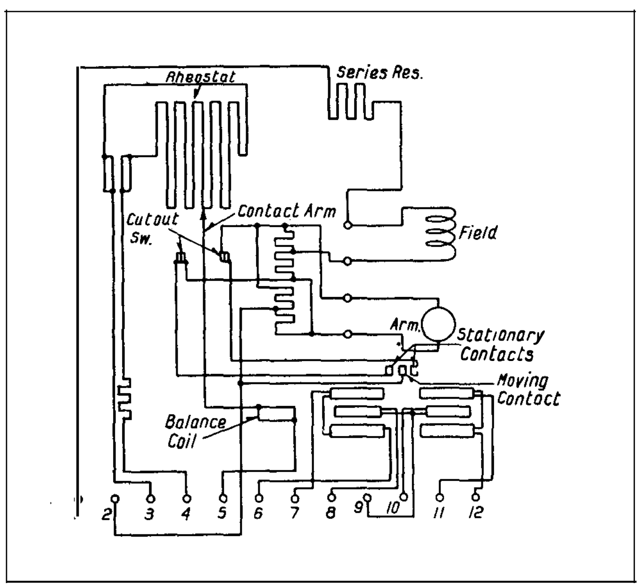

Fig. 12—Transmitting A-C. Polyphase Wattmeter Internal Connections—3 Phase 3 Wire.

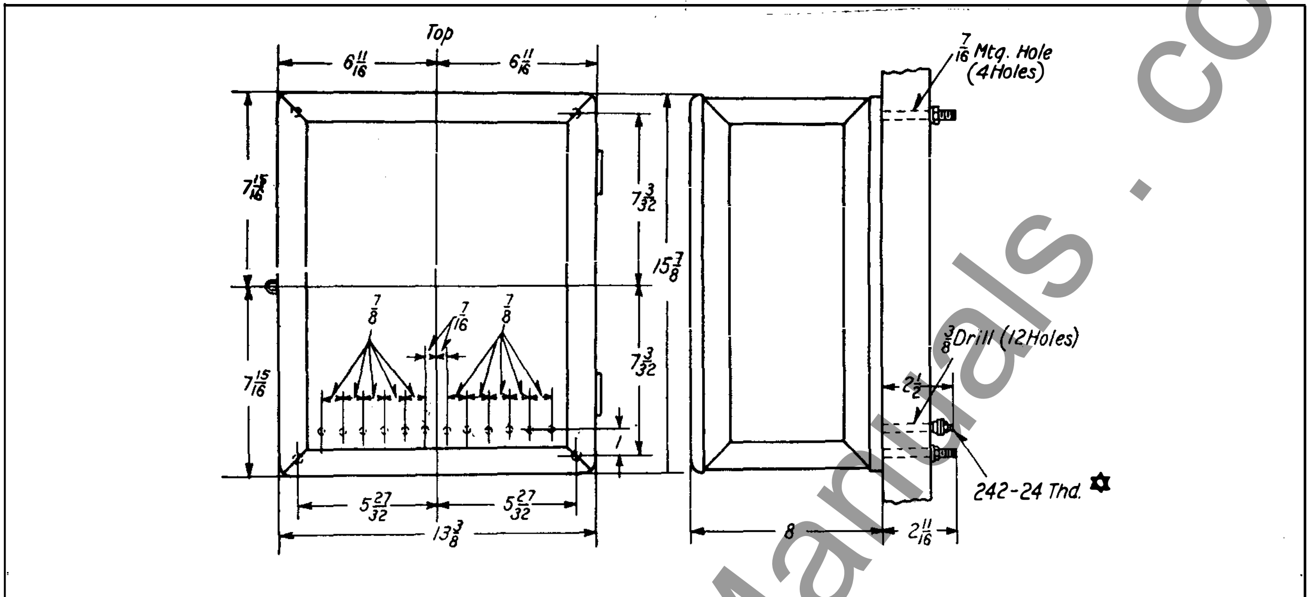

Fig. 13—Outline and Drilling Plan.

*Warning: Do not Tighten Connection Stud Nuts Against Rear of Panel.

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