

KS-2749 REGULATOR
FOR PILOT WIRE TRANSMISSION REGULATING SYSTEM
REQUIREMENTS AND ADJUSTING PROCEDURES

1. GENERAL

- 1.01 This section covers the regulator per KS-2749 for pilot wire transmission regulating systems. It also covers certain associated equipment.
- 1.02 This section is reissued to revise the procedure covering differential relay alarm, to revise the procedure covering no voltage alarm, and to revise the procedure covering guard relay operation. Detailed reasons for reissue will be found at the end of the section.
- 1.03 Reference shall be made to Section 020-010-711 covering General Requirements and Definitions for additional information necessary for the proper application of the requirements listed herein.
- *1.04 Asterisk: Requirements are marked with an asterisk (*) when to check for them would necessitate the dismantling or dismounting of apparatus or would affect the adjustment involved or other adjustments. No check need be made for these requirements unless the apparatus or part is made accessible for other reasons or its performance indicates that such a check is advisable.
- †1.05 Dagger: The equipment shall be considered satisfactory for service when it has met the requirements marked with a dagger (†).
- 1.06 Pointer lag may be defined as the difference between the resistance value in the pilot wire arm of the bridge circuit necessary to cause a slide wire rebalancing movement in one direction and the value required to cause the subsequent rebalancing movement to be in the reverse direction.
- 1.07 Size of bite may be defined as the difference between the resistance value in the pilot wire arm of the bridge circuit necessary to cause a slide wire rebalancing movement in one direction and the value required to cause the subsequent rebalancing movement to be in the same direction.
- 1.08 Drift may be defined as a slow continuous movement of the slide wire disc not due to any change in the pilot wire arm of the bridge circuit. Drift may occur in either direction and may be present over all or only part of the range. Fig. 25 is an example of how drift may appear on the regulator chart.

1.09 Hunting may be defined as the tendency of the regulator to take a bite so large that the pointer is thrown under the opposite lever arm causing an immediate rebalancing movement in the reverse direction. The regulator may hunt in one direction only if the size of bite in that direction is too large or it may hunt in both directions if the size of bite in both directions is too large. Fig. 26 is an example of how hunting may appear on the chart.

1.10 Caution: Due to the important relation of this mechanism to associated circuits in the office, proper precautions shall be taken when working on this regulator to prevent unnecessary interference with service on working circuits.

1.11 When ordering parts for replacement purposes, order the part by name from the Leeds and Northrup Company.

2. REQUIREMENTS

2.01 Cleaning

- (a) The motor contacts on the back of the casting and the associated spring contacts on the regulator case shall be cleaned when necessary in accordance with approved procedures.
- (b) The rod on which the pen carriage slides shall be cleaned at least once every two weeks of continuous operation.
- (c) The slide wire shall be cleaned and lubricated, when necessary, in accordance with the section on cleaning and lubricating procedures for this apparatus.
- (d) The pen shall be cleaned and filled when necessary in accordance with approved procedures.
- (e) The dial switch contacts shall be cleaned when necessary in accordance with the section on procedures for cleaning and treating stud-type rotary switches.

2.02 Lubrication

- (a) The grease cups which supply grease to the ball bearings of the motor shall be filled once every three months with the grease supplied with the regulator.
- (b) All shaft bearings, socket and pivot bearings, worm and gear drives, and the bearing surfaces of all cams shall be adequately lubricated with KS-2245 oil.

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(c) After turnover, it is recommended that the parts mentioned in (b) above be lubricated every two weeks of continuous operation. This interval may be extended if periodic inspections have indicated that local conditions are such as to insure that requirement (b) will be met during the extended interval.

2.03 Record of Lubrication: During the period of installation a record shall be kept, by date, of the lubrication of the regulator and this record shall be turned over to the telephone company with the equipment. If no lubrication has been done the record shall so state.

2.04 Mounting: The regulator shall be mounted level.

Gauge by eye at both front and side of regulator.

2.05 Galvanometer

†(a) Coil Position: Fig. 1(A) - The galvanometer coil shall be centrally located, horizontally and vertically, with respect to the core and shall swing freely in both directions.

Gauge by eye.

* (b) Suspension Tension: Fig. 2 - There shall be no appreciable sag in the galvanometer suspension when the galvanometer system is laid in a horizontal position.

Gauge by eye.

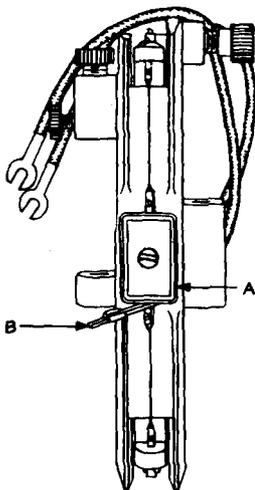


Fig. 1 - Galvanometer

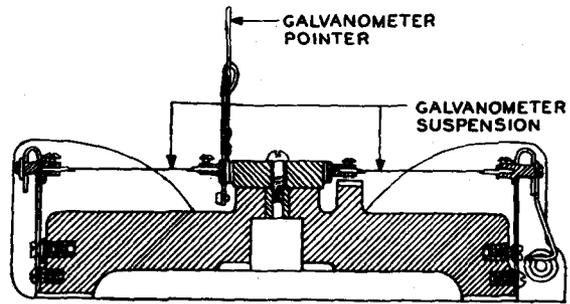


Fig. 2 - Cross Section of Galvanometer

* (c) Balance: Fig. 1(B) - The end of the galvanometer pointer shall not swing more than one-quarter inch when the galvanometer system is tilted in any direction 10 or 15 degrees from the vertical.

Gauge by eye.

†(d) Clamping Nut: Fig. 4 - The galvanometer clamping nut shall be turned down until it touches the lug but shall not be so tight as to throw the galvanometer system out of alignment.

Gauge by feel and by eye.

†(e) Pointer - Fig. 4(A)

(1) With the lever arms in their normal position, the galvanometer pointer shall clear the lower edges of the lever arms by 0.015 inch.

Gauge by eye.

(2) The upper face of the pointer shall be parallel to the plane of the lower edges of the lever arms.

Gauge by eye.

(3) The pointer shall not stick to the rocker arm, the lever arms, or the side stops.

Gauge by eye.

†(f) Zero Adjustment: Fig. 4(B) - With the galvanometer leads short-circuited and the motor in operation, the galvanometer pointer shall rise in the gap between the lever arms without moving either lever.

Gauge by eye.

2.06 Cams

(a) All cams shall be tight on the shaft.

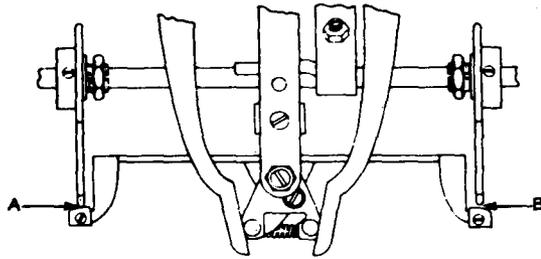
Gauge by feel.

(b) When the operating cam just begins to move the disengaging lever, the sweep cams shall have approximately $3/8$ inch of travel on the clutch arm extensions.

Gauge by eye.

(c) The sweep cams shall be in the same angular position relative to each other.

Gauge by eye.



TOUCHING AT A AND A CLEARANCE AT B
(OR VICE VERSA)

Fig. 3 - Sweep Cams

(d) Fig. 3 - The linear location of the sweep cams on the camshaft shall be such that when the high point of one cam is resting on a clutch arm extension, the high point of the other cam shall clear its associated clutch arm extension by

Max 0.002 inch

Use the No. 74D gauge.

2.07 Clutch - Fig. 4

(a) The clutch arm, when disengaged, shall be just tight enough in its bearings to remain in any position to which it is tilted.

Gauge by eye.

(b) The clutch disc shall be tight on its shaft.

Gauge by feel.

(c) The clutch corks shall engage the clutch disc simultaneously and their surfaces shall be parallel to the plane of the disc.

Gauge by mechanical test.

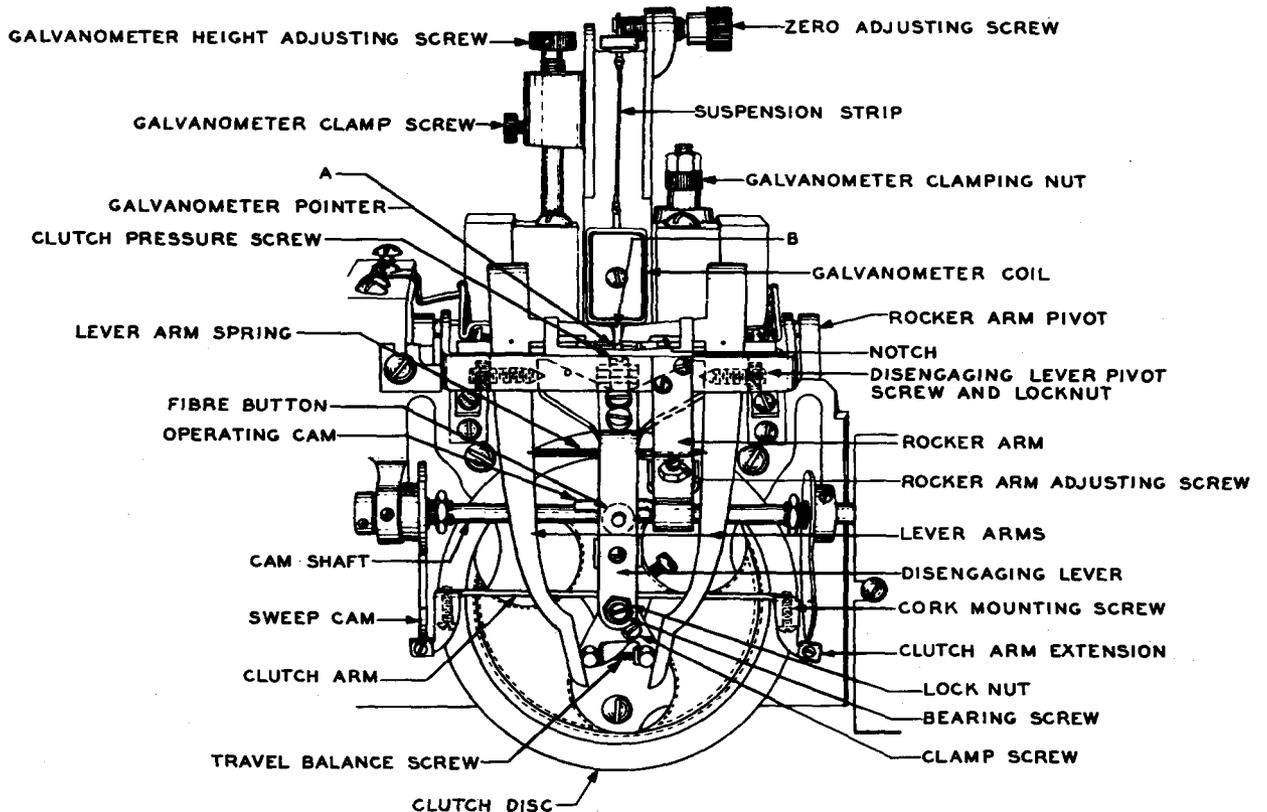


Fig. 4 - Balancing Mechanism

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- (d) The tension of the clutch disengaging lever spring when the clutch is engaged shall be

Min 1150 grams or 2-1/2 lbs
Max 1550 grams or 3-1/2 lbs

Use the No. 79F gauge or the No. 4841M scale (spring balance) and measure at the bottom end of the lever.

- (e) The clutch arm shall turn the clutch disc without slipping when the regulator is running.

Gauge by eye.

†2.08 Lever Arms

- (a) The lever arms shall move freely in their bearings without shake.

Gauge by eye and feel.

- (b) When the galvanometer pointer lies under the notch of either lever arm and the rocker arm is raised the lever arms shall not move.

Gauge by eye.

Check both lever arms.

2.09 Overstep Alarm: When the galvanometer pointer lies under the notch of either lever arm and the rocker arm is raised, the overstep alarm contacts shall close. Closure of the contacts is indicated by proper operation of the associated circuit. Check both lever arms.

2.10 Motor

- (a) The motor shall operate when the central office voltage is applied to its terminals.
- (b) The speed of the motor shall cause the camshaft to turn at a speed of 6 to 10 revolutions per minute.

Gauge by timing.

- (c) On regulators having a rheostat speed control, the speed of the motor shall cause the camshaft to turn at a speed of 7 to 9 revolutions per minute.

Gauge by timing.

2.11 Reduction Gears - Figs. 5 and 6

- (a) The worm (A) shall be lined up to center with gear (B).

Gauge by eye.

- (b) There shall be no bind or appreciable backlash between the gear and the worm.

Gauge by feel.

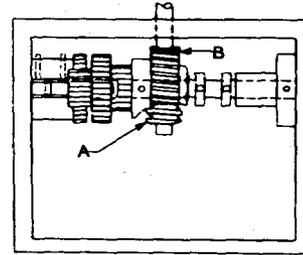


Fig. 5 - Reduction Gears (Old Type)

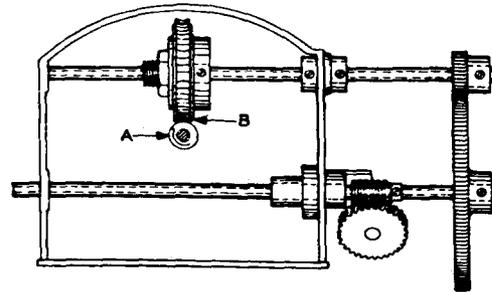


Fig. 6 - Reduction Gears (New Type)

2.12 Dial Switch - Fig. 7

- (a) When the slide wire contact is at the mechanical center of the slide wire, the dial switch arm shall be centered on the zero stud and shall be tight on the shaft.

Gauge by eye and feel.

- (b) The pressure of each half of the dial switch arm on the contact studs shall be

Min 100 grams
Max 200 grams

Use the No. 79C gauge.

To check this requirement measure at the center of the +1/2, +6 1/2, and -6 1/2 positions.

2.13 Slide Wire

- (a) Fig. 7 - The pressure of the spring contact on the slide wire shall be

Min 100 grams
Max 200 grams

Use the No. 79C gauge.

- (b) With the regulator balanced so that the dial switch arm is centered on the zero stud, an increase in the pilot wire arm resistance of 396 ±5 ohms when a

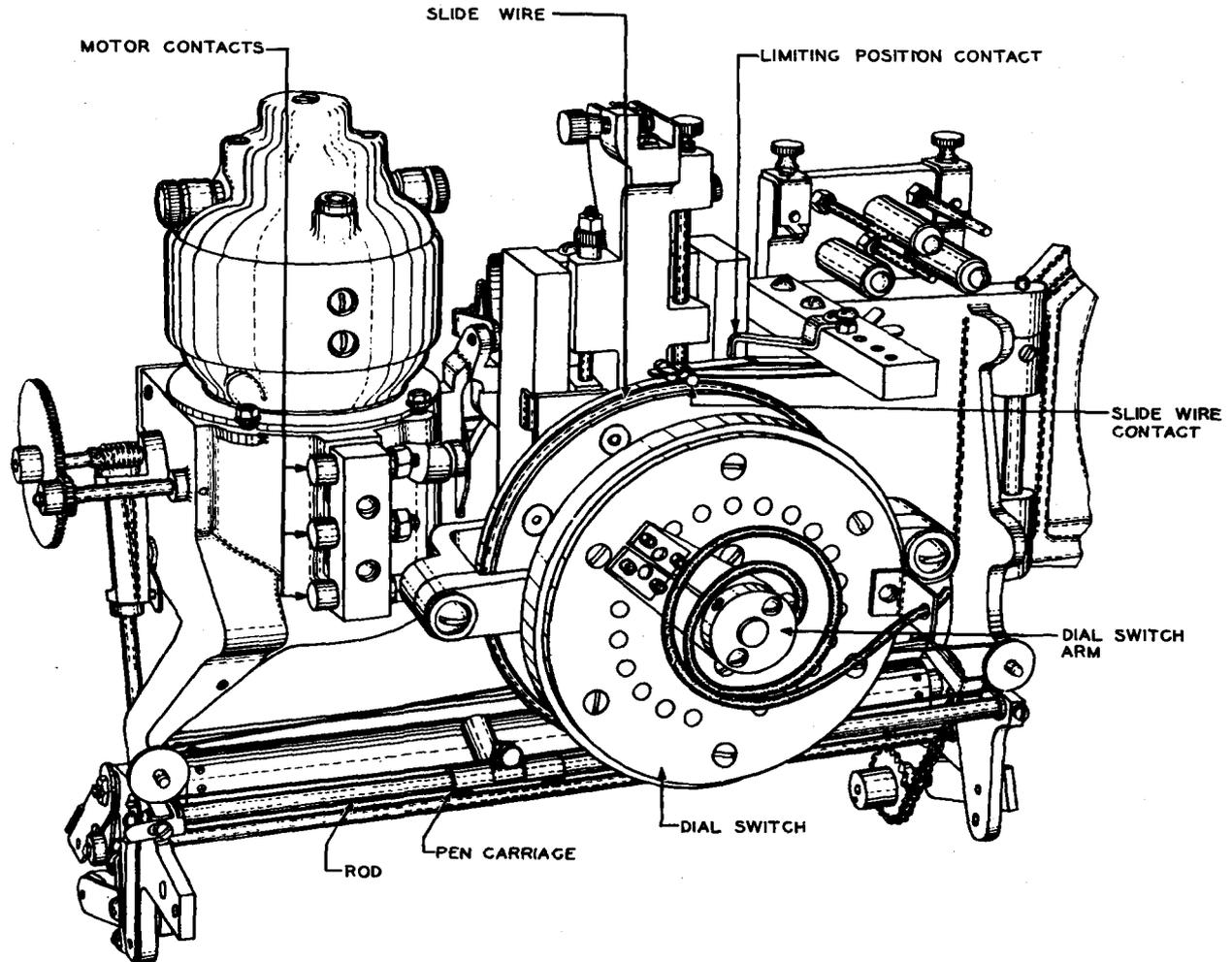


Fig. 7 - Rear View of Regulator (Later Type)

20,000-ohm shunt is provided on the slide wire, or 405 ± 5 ohms when a 20,000-ohm shunt is not provided, shall cause the regulator to balance so that the dial switch arm is centered on the +9 stud. A decrease of the same resistance when the regulator is balanced on the zero stud shall cause the regulator to balance so that the dial switch arm is centered on the -9 stud.

Gauge by electrical test.

2.14 Fixed Arm of Bridge Circuit (Initial Test on New Equipment)

- †(a) 5A Pilot Wire System: The L resistor in the fixed arm of the bridge circuit shall be such a value that the regulator is balanced so that the dial switch arm is centered on zero stud when a resistance of 9350 ohms is connected to the REG jacks. Gauge by electrical test.

- (b) 4A Pilot Wire System: No requirement.

2.15 Bridge Balance (Maintenance Test Only)

- (a) 5A Pilot Wire System: The regulator should balance so that the dial switch arm is centered on zero stud when a resistance of 9350 ohms is connected to the REG jacks on the jack strip.

Gauge by electrical test.

- (b) 4A Pilot Wire System: The regulator should balance so that the dial switch arm is centered on zero stud when a resistance equal to the value of R_f (as found on the label pasted on the galvanometer terminal plate) is connected to the REG jacks.

Gauge by electrical test.

- †2.16 Limiting Position Alarm: Fig. 7 - The limiting position alarm shall not

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operate until the dial switch arm has made contact with the +10 (or -10) stud and has broken contact with the +9 (or -9) stud by at least 1/8 inch, but it shall operate just before the slide wire disc reaches its stop.

Gauge by eye.

†2.17 Pen Carriage

(a) When the dial switch is centered on zero stud the pen shall be in the center of the scale.

Gauge by eye.

(b) There shall be no perceptible lost motion of the pen carriage when the direction of motion of the clutch disc is reversed.

Gauge by eye.

†2.18 Bridge Potential: The bridge potential shall be

Min 110 volts
Max 135 volts

Means are provided at the master regulator power supply bay for measuring the bridge potential. Where other means are not provided the bridge potential may be measured by means of a portable voltmeter by connecting it across terminals BA+ and BA- at the regulator panel.

†2.19 Pointer Lag: The average of four measurements of pointer lag for increasing resistance shall be

Min 2-1/2 ohms
Max 3-1/2 ohms

The average of four measurements of pointer lag for decreasing resistance shall be

Min 2-1/2 ohms
Max 3-1/2 ohms

The average value of lag in the two directions shall be within half an ohm of each other. No single value shall be over 4 ohms or under 2 ohms.

Gauge by electrical test.

†2.20 Size of Bite: The average of four measurements of size of bite for decreasing resistance shall be

Max 8 ohms

The average of four measurements of size of bite for increasing resistance shall be

Max 8 ohms

For initial test on new equipment gauge by electrical test.

For maintenance test gauge by inspection of chart when regulator is operating on its own pilot wire.

†2.21 Drift: There shall be no appreciable drift present in the regulator.

For initial test on new equipment, gauge by inspection of chart when regulator is operating on resistance box.

For maintenance test, gauge by inspection of chart when regulator is operating on its own pilot wire.

†2.22 Hunting: There shall not be more than five indications of hunting in a five-hour period and there shall be no hunting in both directions.

For initial test on new equipment, gauge by inspection of chart when regulator is operating on resistance box.

For maintenance test, gauge by inspection of chart when regulator is operating on its own pilot wire.

†2.23 Differential Relay Alarm

(a) When the bridge circuit is suddenly unbalanced by 6000 ohms, the differential relay alarm shall function.

Gauge by electrical test.

(b) When the bridge circuit is opened, the differential relay alarm shall function.

Gauge by electrical test.

†2.24 No-voltage Alarm: Failure of the bridge battery supply shall cause the no-voltage alarm to function.

Gauge by electrical test.

†2.25 Dial Switch Contact Alarm: (4A Pilot Wire System) - Failure of the circuit through the dial switch arm shall cause the associated alarm to function.

Gauge by electrical test.

†2.26 Guard Relay Operation: The guard relays shall operate as indicated by the circuit drawing.

3. ADJUSTING PROCEDURES

3.001 List of Tools, Gauges, Materials, and Test Apparatus

<u>Code or Spec No.</u>	<u>Description</u>
<u>Tools</u>	
-	Kit of Tools Furnished With Regulator

<u>Code or Spec No.</u>	<u>Description</u>
<u>Tools (Contd)</u>	
-	Pair of Dividers
-	Ink Dropper (glass medicine dropper)
-	Pen Cleaner (rubber bulb for cleaning pen of photoelectric recorder - General Electric Co., Schenectady, N. Y.)
<u>Gauges</u>	
74D	Thickness Gauge Nest
79C	0-200 Gram Push-Pull Tension Gauge
79F	0-6000 Gram Push-Pull Tension Gauge
4841M	12-lb Scale (spring balance)
-	Voltmeter, 150 Volts DC
<u>Materials</u>	
KS-2245	Oil
KS-2423	Cloth
KS-7860	Petroleum Spirits
WECO 57997	Petrolatum (Unmedicated white Vaseline may be used.)
-	L&N Grease for Motor Bearings (furnished with regulator)
-	Ink (Bell System writing fluid)
-	Sandpaper No. 0000
-	Sandpaper No. 00
-	Cellulose Acetate Sleeve
-	White Shellac
-	Toothpicks, Hardwood, Flat at One End and Pointed at Other
<u>Test Apparatus</u>	
310	Plug With Tip and Sleeve Short-circuited
2W33A	Cord
2W33A	Cord (modified locally) (See note.)
-	Dial Decade Resistance Box 4754, or the electrical equivalent

Note: When used with the 4A pilot wire system, the 2W33A cord shall be modified as follows:

Remove the 310-type plugs from the cords and then remove the 35-type tips from the cords.

Solder 38-type tips to the ends of the cords in place of the tips which were removed, or whip both conductors of a cord together with tinned wire and solder to a 38-type tip.

Connect the 38-type tips of the cord to a 47-type plug.

3.002 General

(1) A cellulose acetate sleeve is now available for use with the idle regulator (4A system equipped with a one conductor switch arm) the purpose of which is to insulate the contacts of the dial switch arm from the studs and thus prevent false settings of regulating repeaters connected to the working regulator. This sleeve should be in position on the dial switch arm at all times except when such tests are being made as require its removal. It is especially important that it be in place if the clutch disc has to be moved manually.

(2) When removing this sleeve on the idle regulator, as for special tests, be sure that the dial switch arm of the idle regulator is in such a position with respect to that of the working regulator that the operation of three adjacent master relays is prevented.

(3) In connection with the No. 4A system, it should be noted that touching the galvanometer terminals or any electrically conductive part of the Wheatstone bridge circuit of the idle regulator will add leakage to ground which may cause a false deflection of the galvanometer on the working regulator. If necessary to work on this part of the idle regulator circuit, the working regulator may be stopped temporarily.

(4) In order to make mechanical adjustments of the regulator mechanism the regulator should be stopped in the position in which the clutch arm is away from the clutch disc. In this position all pressure is released from the clutch and there is no danger of having the galvanometer pointer damaged while moving the clutch disc manually. It should also be made certain that the pointer is free.

(5) In order to facilitate maintenance operations the regulator mechanism is so mounted that it may be swung outward from its case. The main casting which bears the mechanism is hinged at the

left-hand side to the back of the case and is held in position in the case by a knurled head screw located at the right-hand side. When making adjustments, remove this knurled head screw and swing the mechanism outward.

(6) Care should be taken to avoid touching or handling the front rim of the clutch disc as any slight trace of oil will cause the clutch to slip and will collect dust and dirt. Care should be taken that the galvanometer pointer, the lever arms with which the pointer comes in contact, the rocker arm, and the clutch surfaces are clean and free from oil.

(7) Due to its sensitivity to air currents, the galvanometer pointer should be protected from drafts during tests and while adjustments are being made.

(8) When reconnecting the galvanometer leads, make certain that each lead is connected to its proper terminal.

(9) Fig. 8 - When putting a new paper roll into position, proceed as follows: Slip the paper roll on the mandrel so that the slotted edge is at the pointed end of the mandrel. Mount the mandrel in its bearings, first inserting the pointed end in the right-hand bearing which will cause the slotted edge of the paper to be at the right. Thread the end of the paper below the guide rod, then up and over the top of the paper drive roll. The scale strip will have to be raised so that the paper may be inserted between it and the paper drive roll. Draw forward underneath the writing shelf a length of paper of 10 or 12 inches. Adjust the roll of paper lengthwise on the mandrel so that the round holes on the left are in line with the teeth at the left end of the paper drive roll. See that the holes and slots near the edges of the paper mesh with the teeth of the paper drive roll and that the cross lines are parallel to the scale strip. See that the paper clamp on the reroll spool is at the center of the spool. Cut a 45-degree chamfer from both sides of the end of the paper and insert it into the paper clamp. Turn the reroll spool by means of the knob at the left until the slack in the paper is taken up. Make certain that the paper is started straight on the reroll spool.

(10) Make certain that the bracket arm attached to the left side of the writing shelf is swung into position so that it provides a firm support for the shelf.

(11) When connecting the resistance box to the REG jacks of the regulator being tested, both terminals of one 2W33A cord should be connected to one terminal of the resistance box and both terminals of the

second 2W33A cord should be connected to the other terminal of the resistance box.

Caution: The clutch disc should not be moved manually when the regulator is connected to working repeaters except when specified.

Caution: Caution shall be exercised when turning down the galvanometer clamping nut not to screw it down tight as this will cause the galvanometer system to be tilted out of alignment.

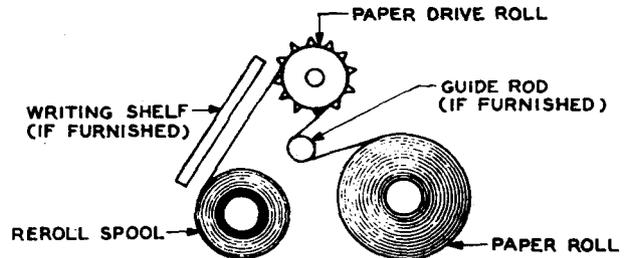


Fig. 8 - Paper Feed

3.003 The K resistance shown in Fig. 22 is not used in the No. 5B pilot wire regulator.

3.01 Cleaning (Rq 2.01)

(1) For cleaning the motor contacts on the back of the casting, the associated spring contacts on the regulator case, and the rods on which the pen carriage slides, use a dry clean KS-2423 cloth.

(2) Clean and lubricate the slide wire as covered in the section on cleaning and lubricating procedures for this apparatus.

(3) Clean the dial switch contacts as covered in the section on procedures for cleaning and treating stud-type rotary switches.

(4) If the ink is not flowing freely from the pen or if the pen stops writing, raise the point of the pen from the paper and with the bulb of the pen cleaner depressed, insert the end of the platinum tube of the pen in the small hole at the end of the pen cleaner. Release the pressure on the bulb slightly in order to draw a small amount of ink through the pen tip. If this does not restore the pen to normal, proceed as follows: Remove the pen from its holder. If the position of the pen carriage is such that there is interference to the removal of the pen, turn the pen at right angles to its normal position and push it back in its holder, then lift up the scale strip and remove the pen

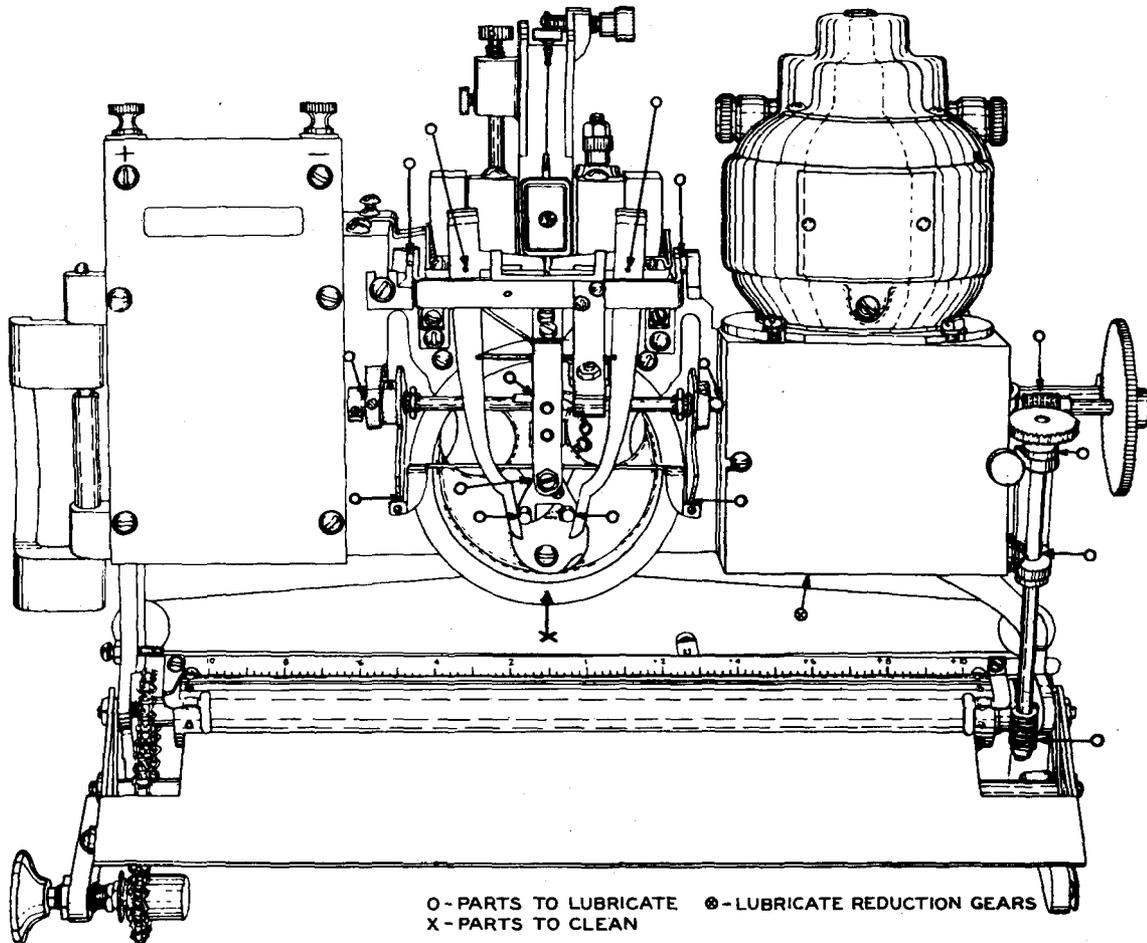


Fig. 9 - Front View of Regulator (Later Type)

through the space beneath the raised scale strip. Dust and lint which have collected on the point should be wiped off. Incrusted ink and dirt should be removed by carefully pushing one of the short lengths of steel wire, provided with the regulator for this purpose, through the platinum tube of the pen. With the bulb of the pen cleaner depressed, insert the platinum tube of the pen in the small hole at the end of the pen cleaner. Release the pressure on the bulb slightly in order to draw any loosened dirt or dried ink through the pen tip. Fill the pen with ink to the proper level as shown in Figs. 11 and 12.

3.02 Lubrication (Rq 2.02)

(1) Motor Ball Bearings: Remove the cup screws at the upper and lower grease cups using a screwdriver furnished with the kit of tools. Fill the cups with the grease supplied with the regulator and insert and tighten the grease cup screws. Do not use any other grease.

(2) Shaft Bearings, Socket and Pivot Bearings, Worm and Gear Drives, Bearing Surfaces of the Cams, and Reduction Gears: Apply KS-2245 oil with the oilcan furnished with the regulator and wipe off all excess oil with a clean dry KS-2423 cloth. To gain access to the lubrication point located at the middle of the shaft on which the clutch disc and slide wire are fastened, it is necessary to remove the galvanometer. To do this, proceed as covered in 3.05(2).

3.03 Record of Lubrication (Rq 2.03)

No procedure.

3.04 Mounting (Rq 2.04)

(1) If the regulator is not mounted level, correct by turning the four adjusting screws located on the lower regulator mounting plate in or out as required.

3.05 Galvanometer (Rq 2.05)

(1) Take care when working with the galvanometer that the small parts are not strained and that everything is kept clean.

(2) Removing Galvanometer: To remove the galvanometer proceed as follows: Disconnect the galvanometer leads at their screw terminals. Remove the galvanometer clamping nut (Fig. 16) and loosen the galvanometer clamping screw. On the latest regulators there is a locking arrangement which locks this galvanometer clamping nut and which will have to be released before the nut can be removed. If the pointer is deflected and touches the levers, it may be pushed into the gap by means of a piece of fine wire or a pin which is free from dirt and grease. When the pointer lies between the levers, slowly lift out the galvanometer by the lug on the left-hand side and lay it flat on a table (Fig. 13).

(3) Replacing Galvanometer Suspension Strips: If one of the suspension strips is broken, hold the suspension binding post with the pair of tweezers furnished with the kit of tools and, using the jeweler's screwdriver, loosen the small suspension binding post screws - Fig. 13(A), (A') or (B), (B') - and remove the broken parts. At the base of each of the flat springs (C) and (D) which serve to support and to put tension upon the galvanometer system, is located a screw (E) or (F) for adjusting the tension. Turn the screw (E) or (F) on the spring associated with the suspension strip to be installed in the direction which would normally reduce the tension and insert the new suspension strip. Be sure that the red-colored side of each soldered joint is on top and that the suspension strip is not twisted. Tighten the suspension binding post screws and adjust the tension as covered in (6).

(4) Replacing Galvanometer Pointer: To replace the galvanometer pointer, proceed as follows: Loosen the small suspension binding post screws, Fig. 13(A') and (B'), remove the suspension strips, and lift out the galvanometer coil. Holding the coil at the point where the balance nuts are mounted, remove the front one of the two small screws at P and loosen the back screw. The pointer will now be free from its mounting on the coil. When replacing the pointer, be sure that the small extension on the bottom of the coil to which the pointer is fastened fits into the channel in the pointer. Remount the small screw at P and tighten both screws. Remount the suspension strips as covered in (3). If necessary, adjust the pointer so that it is at right angles to the plane of the coil by bending it at the point R.

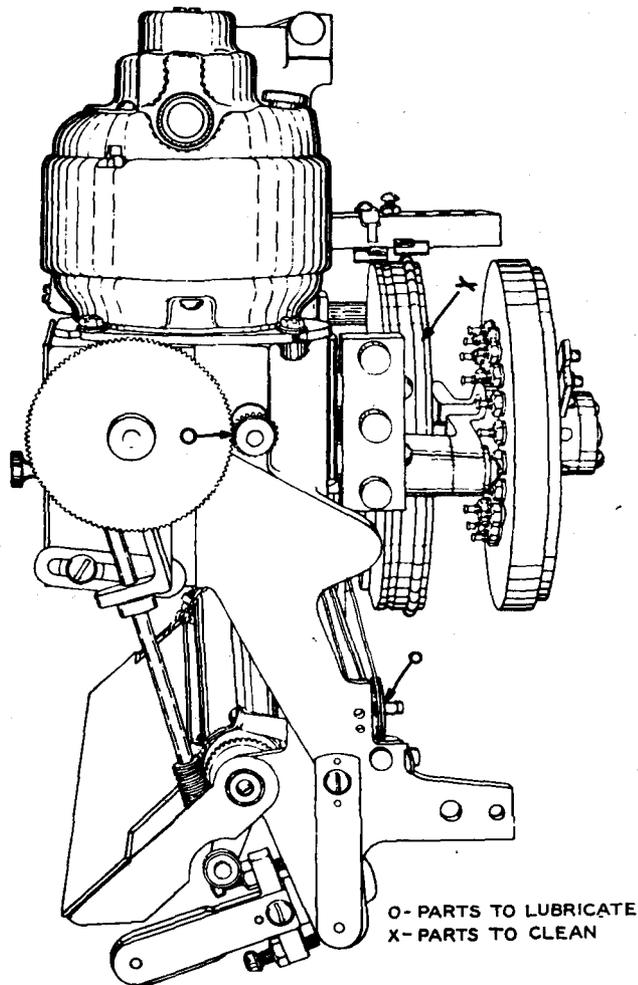


Fig. 10 - Side View of Regulator (Later Type)

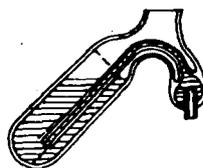


Fig. 11 - Old-type Pen

(5) Coil Position: If the galvanometer coil is not vertically central with respect to the core, the coil may be lowered by turning the tension screw Fig. 13(E) in a clockwise direction and screw (F) in a counterclockwise direction. The screws should be turned in the reverse direction to raise the coil. If the coil is not horizontally central with respect to the core, loosen (very slightly) the

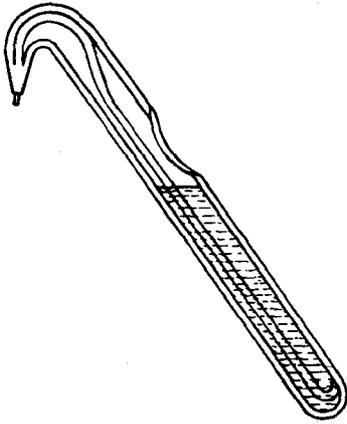


Fig. 12 - New-type Pen

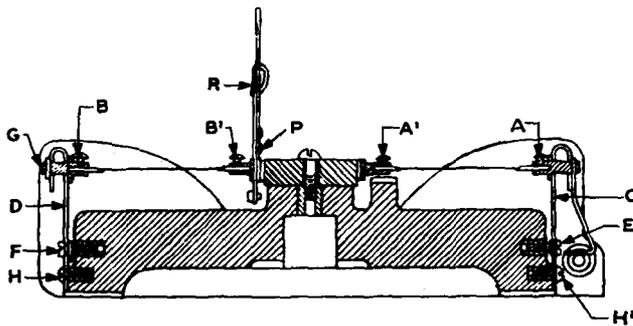


Fig. 13 - Cross Section of Galvanometer

screws (H) and (H') which hold the flat springs (C) and (D) and shift the position of these flat springs sufficiently to bring the coil into the desired position. Retighten the screws, being careful not to let this affect the position of the flat springs. Turn the lower suspension at (G) to make the galvanometer pointer stand at approximately its central position.

(6) Suspension Tension: The galvanometer suspension tension should be such that there is very little sag, if any, when the galvanometer is laid in a horizontal position. The tension is increased by turning the tension screw Fig. 13(E) and (F) in a counterclockwise direction and is decreased by turning the screws in a clockwise direction. A very fine adjustment is required as one-eighth of a turn causes a large change in tension when nearly taut. Care should be taken that the tension put on the system is not too great as this will break the suspension strip. If the suspension tension is not correct, the pointer may vibrate excessively when the galvanometer system is in place in the regulator. Usually the remedy is to increase the tension slightly.

(7) Balance: When checking the balance of the galvanometer coil system, two tests for balance are to be made. The purpose of the first test is to indicate whether the pointer and its counterweight at the back of the system are balanced. The purpose of the second test is to indicate whether the left and right sides of the system are balanced. To make the first test for balance, hold the galvanometer in an upright position with the end of the pointer toward the observer. Then tilt the top of the galvanometer frame toward the left 10 or 15 degrees. If the pointer moves toward the left, it indicates that the pointer is heavier than its counterweight. If the pointer moves toward the right, the reverse is true. The method of adjustment depends upon whether the galvanometer is of the old type shown in Fig. 14 or of the new type shown in Fig. 15. For the old type proceed as follows: Lay the galvanometer flat on a table and, holding the coil steady by means of the pointer, press the small jeweler's file supplied with the repair kit lightly against the small nut at the back of the galvanometer coil and then draw it across the nut in such a direction as to move the nut toward the end of the threaded rod if the pointer is too heavy, and toward the coil if the pointer is too light. For the new type shown in Fig. 15 proceed as follows: Hold the galvanometer with the flat back of the frame against the palm of the hand. Extend the thumb and second finger around the frame and hold the coil carefully between them. If the pointer is too heavy, move the small weight on the pointer toward the coil, and if the pointer is too light move the weight away from the coil. If it is impossible to balance the pointer in this manner an attempt at bending the lugs of the suspension strips should be made only as a last resort. The suspension tension will have to be decreased until the strip is slack. Care is necessary as it is very easy to break the suspension strips. In bending the lugs bend them toward the heavy side. Several attempts may be necessary.

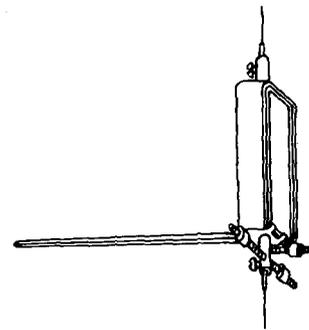


Fig. 14 - Galvanometer Coil and Pointer (Old Type)

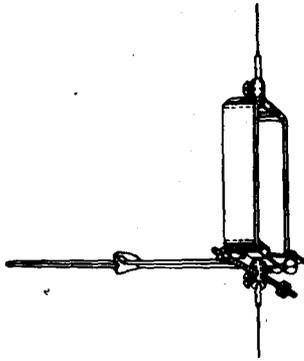


Fig. 15 - Galvanometer Coil and Pointer
(New Type)

(8) The second test for balance is made by holding the galvanometer in an upright position with the end of the pointer toward the observer. Tilt the top of the galvanometer frame forward 10 or 15 degrees. If the pointer moves toward the left it indicates that the right side of the galvanometer is heavier than the left side. If the pointer moves toward the right, the reverse is true. When the right side is heavier, move the small nut on the threaded rod at the right side of the coil toward the coil, and the nut on the left side away from the coil in the manner covered in (7). When the left side is heavier, move the nut in the reverse direction. If the nuts are moved as far as they can go and still the coil is not balanced, remove the nut from the heavy side and put it on the lighter side. Several adjustments for balance as described in this paragraph and in (7) will probably have to be made before the galvanometer is balanced. It is sufficiently balanced when tilting it in any direction 10 or 15 degrees from vertical, the movement of the pointer is not greater than 1/4 inch. If it is impossible to balance the coil in this manner, an attempt at bending the lugs of the suspension strips should be made but only as a last resort. The suspension tension will have to be decreased until the strip is slack. Care is necessary as it is very easy to break the suspension strips. The lugs should be bent toward the heavy side of the coil. Several attempts may be necessary. After making adjustments repeat both tests for balance.

(9) Remounting Galvanometer: To remount the galvanometer system in the regulator proceed as follows: With the left hand hold the galvanometer leads together in such a manner as to short-circuit them. This keeps the galvanometer needle from swinging as it nears the gap between the lever arms. With the right hand, slide the galvanometer system down slowly along

the two upright rods of the regulator until the galvanometer needle lies in the gap between the two lever arms. Then with the galvanometer system resting upon its support, turn the galvanometer height adjusting screw (Fig. 16) slowly in a counterclockwise direction to lower the pointer into its correct position. After it is in place, be sure to tighten the galvanometer clamping screw and remount the galvanometer clamping nut. The galvanometer clamping nut should not be screwed down tight as this will tend to tilt the galvanometer toward one side. Connect the galvanometer leads to their proper terminals. If the leads are reversed, the regulator will work away from balance instead of toward it. The zero adjustment of the pointer as covered in (13) should be made every time after the galvanometer has been remounted in the regulator.

(10) Pointer: Fig. 16 - If the galvanometer pointer is too high or too low with respect to its vertical position, the galvanometer system should be lowered or raised by means of the height adjusting screw, first loosening the galvanometer clamping nut and the galvanometer clamping screw. On the latest type regulator there is a locking arrangement which locks the galvanometer clamping nut and which will have to be released before the nut can be moved. If the pointer is too low and the tension in the suspension system is too great, this condition may result in broken suspension strips when the rocker arm lifts the pointer against the lever arms. After adjustment, tighten the galvanometer clamping screw. Screw down but do not tighten the galvanometer clamping nut.

(11) If the upper face of the pointer is not parallel to the plane of the lower edge of the lever arms, this may cause the pointer to deflect or to vibrate as the rocker arm leaves it. To correct, hold the galvanometer system at the base of the pointer and twist the end of the pointer until the above two edges are parallel.

(12) If the pointer sticks to the rocker arm, the lever arms, or the side stops, the cause usually is dirt and oil on the pointer and on the parts which the pointer touches. To remedy this, carefully clean the different parts with KS-7860 petroleum spirits applied with a toothpick.

(13) Zero Adjustment: The adjustments for zero position of the pointer should be made with the motor in operation and with the galvanometer leads short-circuited. The pointer is moved to the zero position by means of the zero adjusting screw. Since the galvanometer is very sensitive to air currents, it may be necessary to make several adjustments before the correct result

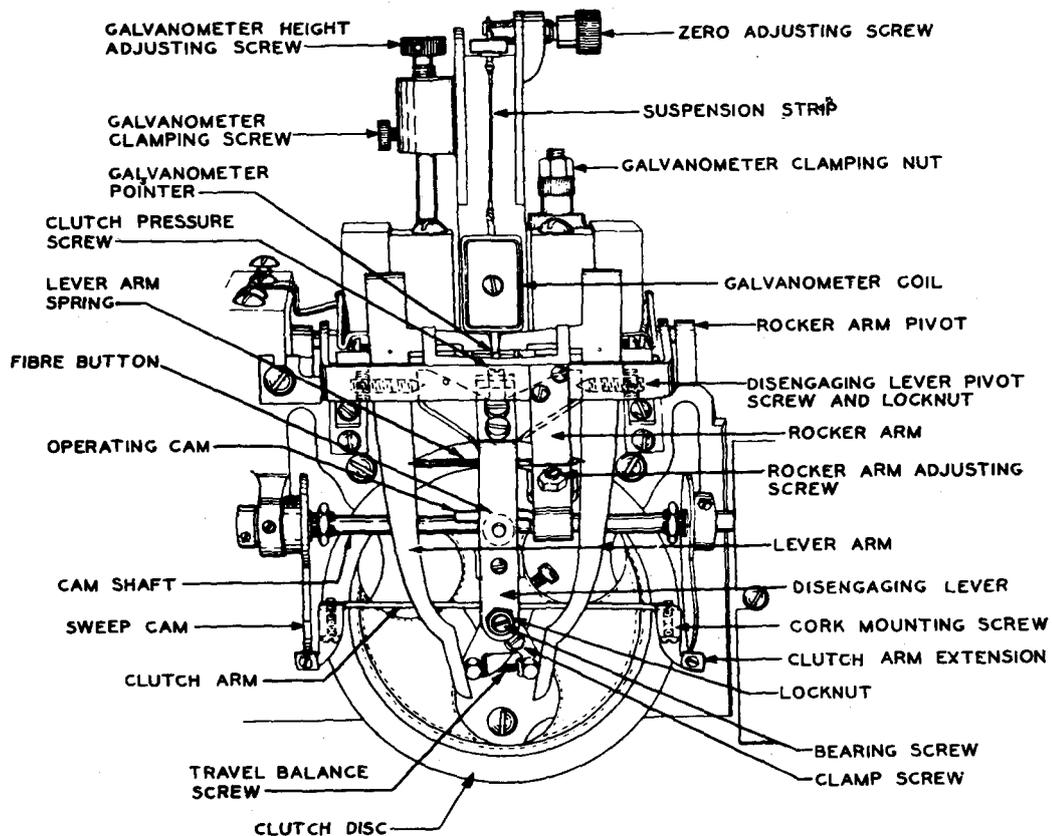


Fig. 16 - Balancing Mechanism

is attained, closing the regulator case after each trial. If the pointer cannot be brought to zero in this way, it will be necessary to remove the galvanometer and to turn the lower suspension Fig. 13(G) so that when the galvanometer is remounted the final adjustment can be made by means of the zero adjusting screw. After this adjustment is made, connect the galvanometer leads to their proper terminals. If the leads are reversed the regulator will work away from balance instead of toward it.

3.06 Cams (Rq 2.06)

- (1) If the cams are loose on the shaft they can be tightened by means of the setscrews holding them to their shaft. Care should be exercised that the cams are not shifted from their correct position while doing this.
- (2) If the sweep cams do not have the correct angular position relative to each other or to the operating cam or as regards their linear position on the shaft, loosen the setscrews holding them to the shaft. On the latest type of regulator these cams are held in place by a locknut which screws

on to a tapered sleeve in addition to being held by the setscrews which should also be loosened. Then shift the cam into its correct position and tighten the setscrew and locknut. Care should be taken while correcting the position of a cam in one respect that the adjustment of the cam in other respects is not destroyed. The sweep cams are in the correct position relative to each other when both cams leave the extensions of the clutch arm at exactly the same time. Special attention is called to the fact that on some regulators the highest point on the cam with respect to its own center is not at the end point of the cam but may be as much as $\frac{3}{8}$ inch from the end point. This is illustrated in the view of the cam shown in Fig. 17.

3.07 Clutch (Rq 2.07)

- (1) If the clutch arm is too tight or too loose in its bearings this may be corrected as follows: Short-circuit the galvanometer leads and make certain that the clutch arm is disengaged and that the pointer lies in the gap between the two lever arms. Tilt the clutch arm as far as it will go. If it falls back toward the

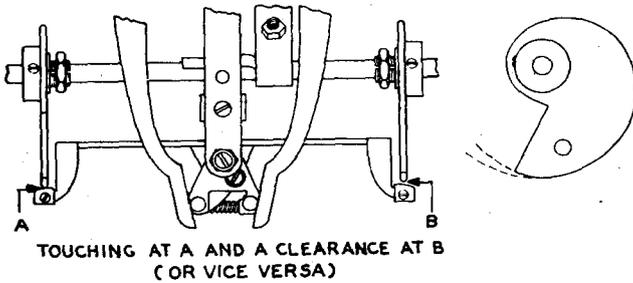


Fig. 17 - Sweep Cams

horizontal position, the locknut should be loosened and the bearing screw turned in a clockwise direction. Do not tighten the bearing screw any more than is necessary. It should be just tight enough so that the clutch arm will remain in any position to which it is tilted. After adjusting the bearing screw, tighten the locknut and reconnect the galvanometer leads.

(2) If the clutch disc is loose on its shaft, the clutch disc will be seen to move before the pen carriage begins to move. If the disc is very loose on the shaft it may even rotate without moving the pen carriage at all. To correct the trouble tighten the clutch disc setscrew.

(3) To check whether the two clutch corks engage the clutch disc simultaneously, remove the cover from the gear box and turn the motor shaft by hand until the corks are almost engaging the clutch disc. Insert a piece of paper between each cork and the disc and turn the motor shaft slowly until the corks touch the papers. By moving the pieces of paper up and down between the corks and the clutch disc it is possible to determine, after every slight turning movement of the motor shaft, just when each clutch cork engages with the clutch disc and also if the two corks engage the clutch disc simultaneously. If the corks do not engage simultaneously, the high cork should be refaced with sandpaper. To reface the corks use a piece of No. 00 sandpaper 4-1/2 inches square with a U-shaped piece cut out of the top edge to allow room for the clutch arm bearing. Insert the sandpaper between the corks and the clutch disc with the rough side of the sandpaper toward the corks. Hold the clutch arm steady but without causing any pressure on it against the sandpaper and move the sandpaper up and down. As the high cork is worn down it will be necessary to turn the motor shaft in order to make the cork come against the sandpaper.

(4) If the pressure of the disengaging lever needs to be changed this may be done by means of the clutch pressure screw. Turn the screw only a small amount at a time until the desired pressure is obtained.

(5) If the clutch arm slips on the clutch disc, the cause may be one of the following: (1) The main shaft on which the clutch disc is mounted may be binding in its bearings. To correct, remove the galvanometer and lubricate the shaft bearing as covered in 3.02(2). Then turn the disc back and forth to work the oil into the bearing. (2) There may be oil on the clutch disc. To correct, carefully clean the disc surface and the corks on the clutch arm with a KS-2423 cloth moistened with KS-7860 petroleum spirits. (3) Too great a pressure on the slide wire contact and of the dial switch arm as well as too light a pressure of the clutch arm against the clutch disc may cause the clutch to slip. To correct the last condition proceed as covered in (4). To correct the other two conditions proceed as covered in 3.12 covering dial switch and 3.13 covering slide wire. (4) The corks may be worn or oil soaked in which case the clutch arm should be replaced as covered in (6).

(6) Replacement of Clutch Arm and Corks:

If the corks on the clutch arm become so worn or oil soaked that the clutch arm slips on the clutch disc and cannot be adjusted as outlined in (5), replace the corks as follows. Short-circuit the galvanometer leads and make certain that the clutch arm is disengaged. Loosen the locknut and then loosen the bearing screw on the lower part of the disengaging lever. With the clutch arm disengaged, press the clutch arm toward the clutch disc and remove the clutch arm from its bearings. If the clutch arm is unsatisfactory, replace it. If it is satisfactory, proceed as follows. Remove the clutch arm cork mounting screws and remove the corks from the clutch arm. Coat one surface of the corks with white shellac. Mount the corks in place so that the rounded edges of the corks are in the angles formed by the clutch arm and its extensions. The length of the corks from the surface which touches the clutch disc to the clutch arm should be approximately 9/32 inch. Insert and securely tighten the clutch arm cork mounting screws. Remount the clutch arm and adjust as covered in (1).

(7) Replacement of Fiber Button: To replace the fiber button on the disengaging lever proceed as follows: Remove the galvanometer as covered in 3.05(2). Release the pressure from the clutch by loosening the clutch pressure screw. Loosen the disengaging lever pivot locknut and the disengaging lever pivot screw at the left of the disengaging lever until the lever can be removed from its bearings. If it cannot be removed after loosening only the left side locknut and pivot screw, it will be necessary to also loosen the locknut and pivot screw on the right-hand side of the lever. Take care when removing the disengaging lever that the clutch arm does not strain the lever arms and that the

disengaging lever does not catch on the lever arm spring. The fiber button will now be exposed to view and can readily be removed and replaced. When remounting the disengaging lever, if both of the pivot screws have been loosened, it will be necessary to carefully adjust them until the clutch arm axis and the clutch disc axis coincide. This is done best by placing one leg of a pair of dividers in the center of the bearing screw and adjusting the disengaging lever pivot screws until the other leg of the dividers rotates exactly true with the outer edge of the clutch disc. Tighten the locknuts and be sure that the pivot screws do not turn. Adjust the pressure of the disengaging lever as covered in (4).

3.08 Lever Arms (Rq 2.08)

(1) If the lever arms are too tight or too loose in their bearings correct as follows: Remove the galvanometer as covered in 3.05(2) and then remove the rocker arm by pressing together the two ends of the horizontal part of the rocker arm at the pivots. The lever arm spring should then be removed after which either of the lever arms may be removed. The U-shaped part of the lever arm should be pressed together a bit at its pivot points if the lever arm is too loose in its bearings. If too tight, the U-shaped part should be spread apart slightly. Replace the lever arm and before connecting the lever arm spring in place, make certain that each lever arm moves freely but yet is not loose. Also make certain that the lever arms do not scrape against the camshaft.

(2) If the pointer lies under the notch of either lever arm when the rocker arm is raised, the lever arm should not move. If the lever arm does move it is due to the overstep alarm lever and the lever arm being too close together. Separate them by moving the overstep alarm lever inward along the pivot shaft.

3.09 Overstep Alarm (Rq 2.09)

(1) If the overstep alarm does not operate when the rocker arm is raised while the pointer lies under the notch of either lever arm, adjust the overstep contact springs so that the contacts close correctly.

3.10 Motor (Rq 2.10)

(1) Fig. 18 - If the motor fails to operate with the voltage applied, proceed as follows: Examine the spring contacts between the main regulator casting and the case. If the trouble is not located there remove the small plate at the top of the motor and observe the commutator and brushes. If the commutator looks dirty, clean it with a piece of No. 0000 sandpaper and wipe it off with a clean KS-2423

cloth. In cleaning the commutator great care must be taken to avoid damaging the motor winding. The brushes should be so adjusted that each brush holder is about an eighth of an inch from the commutator. To replace worn down brushes remove the brush retaining screws and insert the new brushes in place. Be sure to replace the motor connections when replacing the brush retaining screws.

(2) No adjustment can be made for motor speed on regulators not having a rheostat speed control.

(3) If the regulator has a rheostat speed control for the motor the speed may be decreased or increased by turning the rheostat in a clockwise or counterclockwise direction respectively.

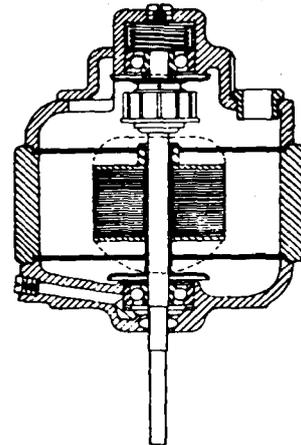


Fig. 18 - Cross Section of Motor

3.11 Reduction Gears (Rq 2.11)

(1) The reduction gears are located below the motor. The old type of regulator has all the gears located inside the gear box as in Fig. 19. In the new type of regulator only the worm and the fiber gear are located within the gear box as in Fig. 20, two other gears and a worm being outside the box.

(2) If the fiber gear and the worm are not correctly lined up or if they bind, loosen the screws which hold the motor to the gear box. This will permit shifting the position of the motor so that the worm can be correctly located with respect to the fiber gear. When the worm and fiber gear are properly located they will wear for a long time. Improperly located, they will wear out rapidly.

(3) To replace the worm, disconnect the motor leads, take out the screws holding the motor to the gear box, and remove the motor. Force out the small pin which holds the worm to the motor shaft and remove the worm. Place the new worm on the shaft and force the pin into position. Then remount the motor being careful that the correct location of the worm with respect to the fiber gear is obtained.

(4) If the fiber gear needs to be replaced with a new one, it will be necessary to first loosen all screws on the shaft and then slide out the shaft through its bushing until the gear is disengaged. Remove the old gear and replace it with a new one. Then slide the shaft into place and tighten all screws. It may be necessary to shift the position of the motor slightly after this in order to have the worm and fiber gear correctly located so that wear will be reduced to a minimum.

(5) If it is necessary to replace the other gears in the old-type gear box, the fiber gear and its shaft must first be removed as covered in (4). Then remove the pin or screw holding the gears to their shaft and slip off the gears. Slip on the new gears and tighten the screw or force the pin into place holding them to their shaft. Remount the fiber gear and its shaft. Be sure to tighten all screws after the adjustments are made.

(6) The gears outside the gear box on the new-type regulator may very readily be removed for replacement by loosening the screws holding them to their shaft.

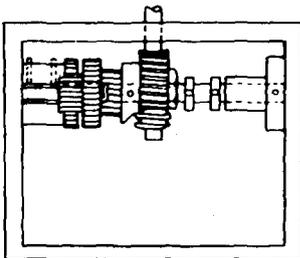


Fig. 19 - Reduction Gears (Old Type)

3.12 Dial Switch (Rq 2.12)

(1) To check that the dial switch arm is centered on zero stud when the slide wire contact is at the mechanical center of the slide wire, proceed as follows: Turn the clutch disc manually until the slide wire disc is against one of its stops and observe the position of the switch arm in relation to the final stud. Turn the clutch disc in the other direction

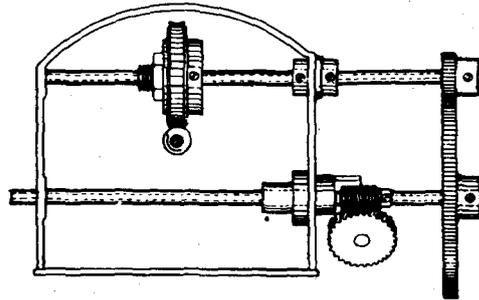


Fig. 20 - Reduction Gears (New Type)

until the slide wire disc is against the other stop and observe the position of the switch arm in relation to the other final stud. If the switch arm has exactly the same amount of travel over the negative side as it has over the positive side, then the dial switch arm will be centered on zero stud when the slide wire contact is at the mechanical center of the slide wire. If this requirement is not met, the switch arm must be shifted slightly in its angular position until a perfect adjustment is obtained. When the dial switch arm is held to the shaft by means of a pin, this may be done after first loosening the two screws on the face of the brass hub. When the dial switch arm is held to the shaft by means of a setscrew, the setscrew must be loosened in order to turn the arm the necessary amount, care being exercised that the switch arm is not moved along the shaft so as to change the contact pressure. When the dial switch arm is properly located with respect to the slide wire, be sure that the screws holding it in place on the shaft are tight. Adjustment of the dial switch arm should always be followed by the bridge balance test.

(2) To adjust the pressure of a dial switch arm held to the shaft by means of a setscrew, loosen the setscrew and then move the arm inward on the shaft to increase the pressure or outward to decrease it. When doing this be careful not to change the adjustment obtained in (1). If each half of the switch arm does not have the same pressure it will be necessary to remove the switch arm from its shaft. The two contact points of the switch arm should then be adjusted so that they lie in the same plane. When remounting the switch arm it should be moved inward along the shaft until the correct pressure adjustment is obtained. Care must be exercised that its angular position is the same as before it was removed. It may be necessary to repeat (1) above.

(3) In order to adjust the pressure of a dial switch arm which is held to the

shaft by means of a pin, it is necessary to remove the switch arm from the shaft. To do this remove the pin which fixes the position of the arm on the shaft. Bend the halves of the arm inward to increase the pressure and outward to decrease the pressure, being careful to keep them in the same plane as otherwise they will give unequal pressure. Remount the switch arm on the shaft and insert the pin in its place and tighten.

3.13 Slide Wire (Rq 2.13)

(1) Fig. 21 - If the spring contact pressure is not correct, it may be changed by turning the contact pressure screw until the correct value is obtained.

(2) The test of the slide wire to see that it has no short-circuited turns in it and that its resistance is uniform may be made as follows:

(a) Connect a resistance box adjustable in one-ohm steps to the REG jacks of the regulator being tested.

(b) Start the regulator and adjust the resistance box so that the regulator assumes a balance with the dial switch arm centered on the zero stud.

(c) Slowly decrease the setting of the resistance box by 396 ± 5 ohms when a 20,000-ohm shunt is provided on the slide wire or by 405 ± 5 ohms when the 20,000-ohm shunt is not provided. (This should be done in steps small enough so that the galvanometer overstep alarm will not be operated.) Allow the regulator to assume a balance and observe the position of the dial switch arm with respect to the -9 stud.

(d) Slowly increase the setting of the resistance box until the regulator is balanced with the dial switch arm centered on the zero stud. Then slowly increase the setting of the resistance box by 396 ± 5 ohms when a 20,000-ohm shunt is provided on the slide wire or by 405 ± 5 ohms when a 20,000-ohm shunt is not provided. (This should be done in steps small enough so that the galvanometer overstep alarm will not be operated.) Allow the regulator to assume a balance and observe the position of the dial switch arm with respect to the +9 stud.

3.14 Fixed Arm of Bridge Circuit (Rq 2.14)

5A Pilot Wire System

The adjustment of the L resistor in the fixed arm of the bridge circuit shall be made as described in the following paragraphs:

(1) Make the motor inoperative by removing the screw at the right which holds the regulator mechanism in position and then swinging the regulator mechanism forward on its hinges as far as possible with the cover on.

(2) Adjust the L resistor to an approximate value of 9350 ohms using a Wheatstone bridge and inserting open-circuit plugs in the REG jacks.

(3) Connect a resistance box adjustable in one-ohm steps to the REG jacks of the regulator to be tested. The resistance should be set at 9350 ohms.

(4) Set the dial switch arm on the center of the zero stud.

(5) Open the galvanometer shunt (resistance D). Operate the REG ON key of the No. 5A regulator or the REG key of the No. 5B regulator, and readjust the L resistor using the smallest resistance steps so that there will be minimum deflection of the galvanometer pointer with the pointer remaining between the lever arms.

(6) Restore the REG ON key to normal and also restore the galvanometer shunt (resistance D).

3.15 Bridge Balance (Rq 2.15)

Test Procedure

The bridge balance test shall be performed as described in the following paragraphs:

5A Wire System

(1) Connect a resistance box adjustable in one-ohm steps to the REG jacks of the regulator to be tested. The resistance box should be set at 9350 ohms.

(2) Manually turn the clutch disc so that the pen is at the midpoint of the scale. With the regulator in adjustment the dial switch arm will then be on the zero stud.

(3) Start the regulator by means of the REG ON key of the No. 5A regulator or the REG and MOT keys of the No. 5B regulator and allow it to assume a balance. The regulator should balance so that the pen is within half a scale division of the midpoint of the scale.

4A Pilot Wire System

(4) Make certain that the cellulose acetate sleeve is in place on the dial switch arm when one-conductor switch arms are provided.

(5) Connect a resistance box adjustable in one-ohm steps to the REG jacks of the

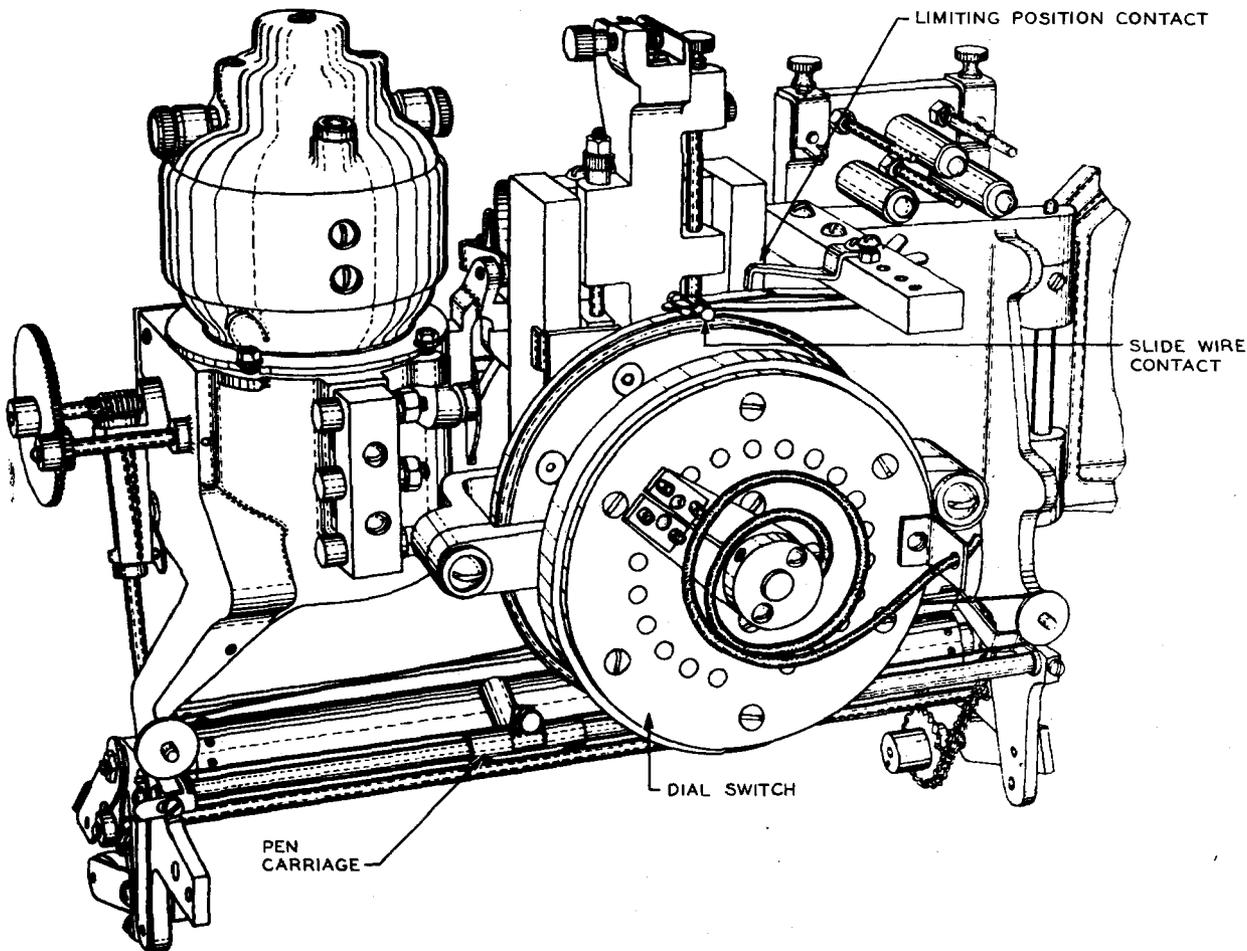


Fig. 21 - Rear View of Regulator (Later Type)

regulator to be tested. The resistance should be set at a value equal to R_f (as found on the label pasted on the galvanometer terminal plate).

(6) Manually turn the clutch disc so that the pen is at the midpoint of the scale. With the regulator in adjustment, the dial switch arm will then be on the zero stud.

(7) Start the regulator by means of the REG CONTROL key and allow it to assume a balance. The regulator should balance so that the pen is within one scale division of the midpoint of the scale.

Adjusting Procedure

(8) If the bridge balance requirement is not met this may indicate that the dial switch arm has changed its angular position with respect to the slide wire. This may be checked and corrected, if necessary, as covered in 3.12(1). The slide wire may not have uniform resistance or

may have some short-circuited turns. Check the slide wire as covered in 3.13(2). A third check, in case the bridge balance requirement is not met, is to check that the L (or R) resistor in the fixed arm of the bridge circuit has the correct value. This may be checked and corrected, if necessary, as covered in 3.14.

3.16 Limiting Position Alarm (Rq 2.16)

(1) If the limiting position alarm contacts do not close at the right time, the springs should be adjusted so that the contacts close correctly.

3.17 Pen Carriage (Rq 2.17)

(1) Fig. 21 - If the pen is not in the center of the scale when the dial switch arm is centered on zero stud, unclamp the carriage from the violin string and shift the carriage until the pen is in the center of the scale. Clamp the pen carriage to the violin string. Make certain also that the pen is straight in its holder.

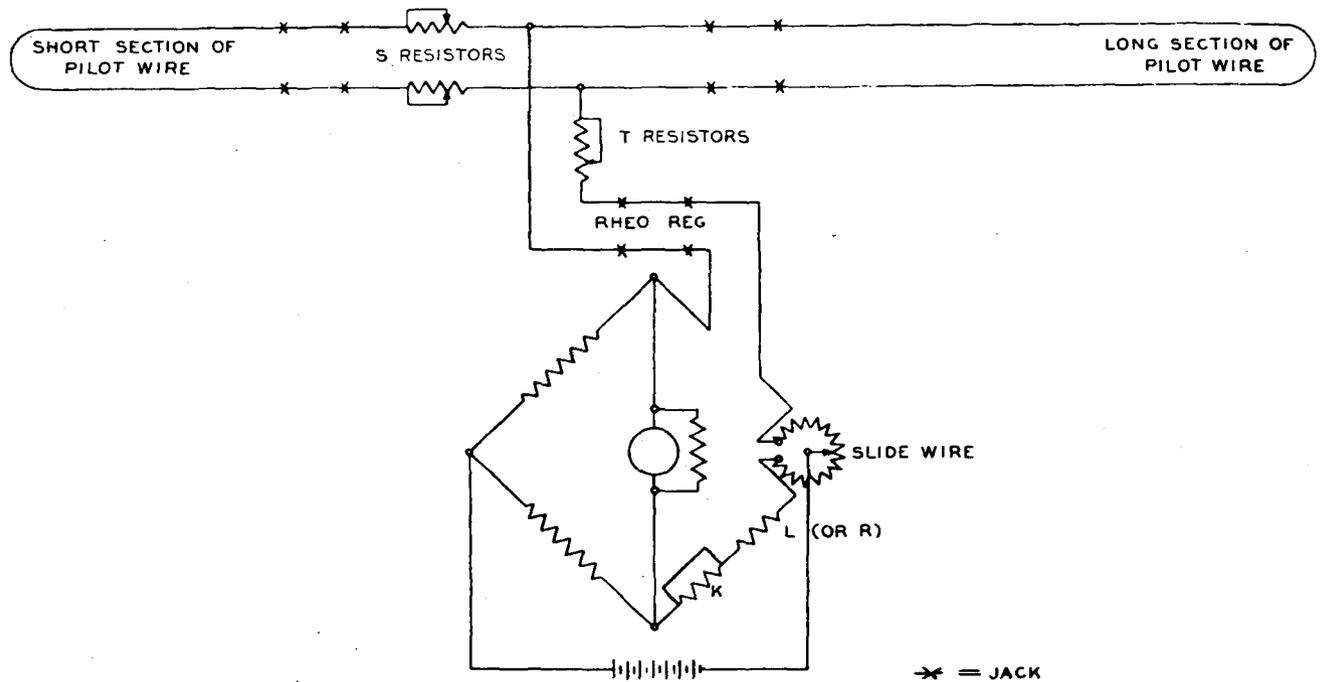


Fig. 22 - Wheatstone Bridge Circuit of Regulator

(2) If the pen carriage has any lost motion when the direction of movement of the clutch disc is reversed, it is due to slackness in the violin string which serves as a belt. To correct this condition turn the screw whose head projects through the slide wire disc so that the tension in the string is increased.

(3) Replacing Belt: The belt which transmits the motion of the slide wire to the pen carriage is a gut violin E string. If it becomes necessary to put a new string into position this may be done as follows: Remove the galvanometer as covered in 3.05(2). Back of the slide wire is a disc with two channels cut in it along the outside of its rim. This rim has a gap cut in it about $\frac{3}{8}$ inch wide. Turn the disc so that the gap is on top and easily reached and block the disc in this position by wedging a piece of wood between it and the galvanometer magnet. Tie a knot in one end of the violin string and slip it through the gap and under the rim of the disc so that the string will lie in the channel away from the operator. Then pass the free end of the string toward the right and partly around the channeled disc, then across to the pulley at the left of the operator. Pass it partly around the pulley and then from the bottom of this pulley across to the bottom of the pulley at the right of the operator. Pass it partly around this pulley and from the top of this pulley across to the bottom of the channeled disc. Place the string in the channel

nearest the operator and pass it upward and partly around the disc. Hold the string in this position and turn the screw whose head projects through the slide wire resistance disc until the hole in this screw is opposite the channel in which the string is being held. Pass the string through the hole in this screw and cut off the free end of the string about one inch from the screw. While holding the string, turn the screw until the string is taut. Clamp the pen carriage to the string and adjust the tension of the string by means of the tightening screw. The tension should be such that when pressing lightly on the string between the channeled disc and the small pulley, there is a slight movement of the pen carriage.

3.18 Bridge Potential (Rq 2.18)

No procedure.

3.19 Pointer Lag (Rq 2.19)

Test Procedure

The measurement of pointer lag shall be made as follows:

- (1) If the regulator is equipped with a one-conductor dial switch arm and is used with the 4A system, make certain that the cellulose acetate sleeve is in place on the dial switch arm.
- (2) Connect a resistance box adjustable in one-ohm steps to the REG jacks of the

regulator to be tested. The resistance box should be set at a value which will approximately balance the regulator at the step where it is to be tested. It will probably be found convenient to start with the one-ohm dial of the resistance box set at 5, that is, at the center of its range.

(3) Start the regulator by means of the REG CONTROL (No. 4A regulator), the REG ON (No. 5A regulator), or the REG and MOT (No. 5B regulator) keys and allow it to operate for a short period to secure a steady balance.

(4) After the regulator is properly balanced, decrease the resistance in the resistance box slowly in one-ohm steps until the galvanometer pointer just engages the right lever arm and causes a slide wire rebalancing movement. This can be observed by watching the pointer, or the movement of the clutch and the recording pen. The changes in the resistance box setting should be made immediately after the pointer is released by the rocker arm in order to allow the maximum possible time for the pointer to come to

rest in its new position before it is again clamped by the rocker arm. Sufficient time should be allowed between each one-ohm change to permit at least two revolutions of the camshaft. Record the value of resistance as R_1 .

(5) Increase the resistance in the resistance box slowly in one-ohm steps until the galvanometer pointer just engages the left lever arm and causes a slide wire rebalancing movement in the direction opposite to that previously obtained. Record this value of resistance as R_2 .

(6) Decrease the resistance in the resistance box slowly in one-ohm steps until the galvanometer pointer just engages the right lever arm and causes a slide wire rebalancing movement in the same direction as that obtained in (4) and opposite to that obtained in (5). Record this value of resistance as R_3 .

(7) Change the value of resistance in the resistance box 10 ohms and allow the regulator to assume a balance. Then repeat (4), (5), and (6).

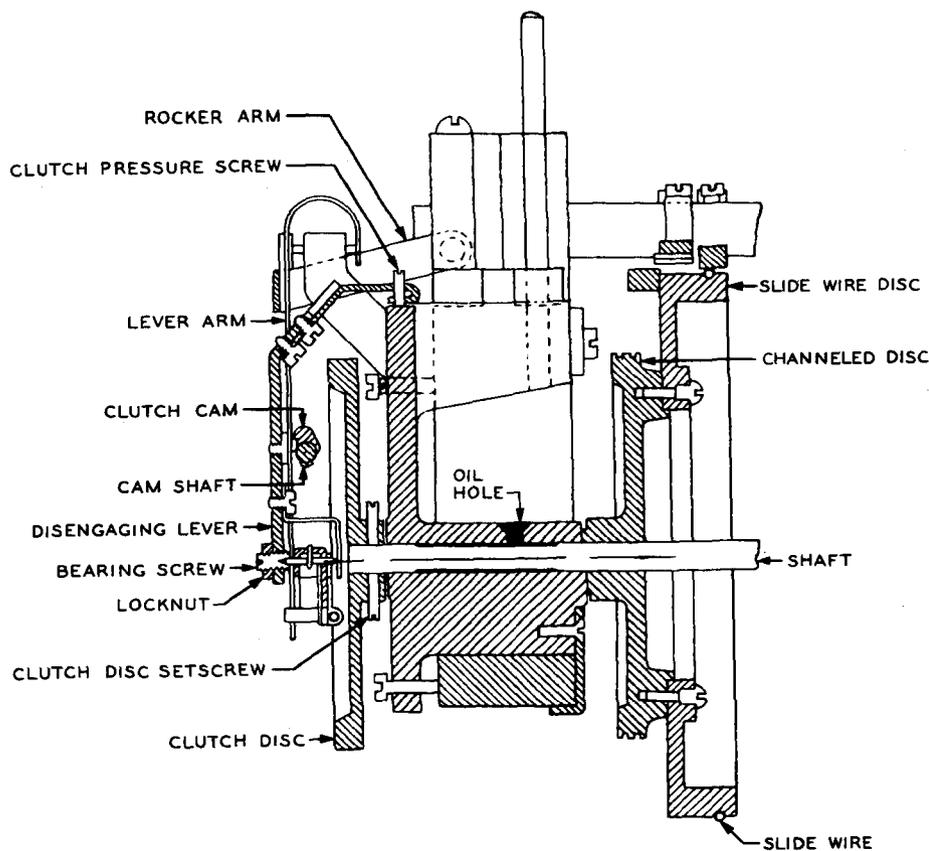


Fig. 23 - Cross Section of Regulator

- (8) Repeat (7).
- (9) Repeat (8).
- (10) The difference between R_2 and R_1 in each of the above cases is the pointer lag for increasing resistance. Determine the average of the values of R_2-R_1 .
- (11) The difference between R_2 and R_3 in each of the above cases is the pointer lag for decreasing resistance. Determine the average of the values of R_2-R_3 .

Adjusting Procedure

(12) If the average lag for increasing resistance differs from the average lag for decreasing resistance by more than half an ohm, the size of bites in the two directions are not equal and should be more nearly equalized by an adjustment of the travel balance screw. Loosen the clamp screw and turn the travel balance screw a very small amount. If the lag for increasing resistance is the greater, turn the travel balance screw a very small amount in a counterclockwise direction. If the lag for decreasing resistance is the greater, the screw should be turned in a clockwise direction. Several trials may be necessary to obtain a satisfactory adjustment. The clamp screw should be tightened after each adjustment and the lag measured again to determine that it is approximately the same in the two directions.

(13) When the lags in the two directions are approximately equal but the requirement for the average value of lag is not met, the rocker arm lift requires adjustment. If the lag is too large the locknut should be loosened and the rocker arm adjusting screw turned clockwise a very small amount. If the lag is too small the adjusting screw should be turned counterclockwise. A very fine adjustment is required as a few degrees turn of the adjusting screw has a large effect. After each adjustment of the rocker arm lift, tighten the locknut and measure the lag in both directions. A series of trials may be necessary to bring the lag within the required limits. Hold screw firmly when turning locknut.

3.20 Size of Bite (Rq 2.20)

Test Procedure

The measurement of size of bite shall be made as follows:

- (1) If the regulator is equipped with a one-conductor dial switch arm and is used with the 4A system, make certain that the cellulose acetate sleeve is in place on the dial switch arm.

(2) Connect a resistance box adjustable in one-ohm steps to the REG jacks of the regulator to be tested. The resistance box should be set at a value which will approximately balance the regulator at the step where it is to be tested. It will probably be found convenient to start with the one-ohm dial of the resistance box set at 9 or 10.

(3) Start the regulator by means of the REG CONTROL (No. 4A regulator), the REG ON (No. 5A regulator), or the REG and MOT (No. 5B regulator) keys and allow the regulator to operate for a short period to secure a steady balance.

(4) After the regulator is properly balanced, decrease the resistance in the resistance box slowly in one-ohm steps until the galvanometer pointer just engages the right lever arm and causes a slide wire rebalancing movement. This can be observed by watching the pointer, or the movement of the clutch and the recording pen. The changes in the resistance box setting should be made immediately after the pointer is released by the rocker arm in order to allow the maximum possible time for the pointer to come to rest in its new position before it is again clamped by the rocker arm. Sufficient time should be allowed between each one-ohm change to permit at least two revolutions of the camshaft. Record the resistance value as R_1 .

(5) Again decrease the resistance in the resistance box slowly in one-ohm steps until the galvanometer pointer just engages the right lever arm and causes a slide wire rebalancing movement in the same direction as that previously obtained. Record this value of resistance as R_2 .

(6) Again decrease the resistance slowly in one-ohm steps until the galvanometer pointer just engages the right lever arm and causes a slide wire rebalancing movement. Record this value of resistance as R_3 .

(7) Continue in the same manner to obtain resistance values of R_4 and R_5 .

(8) The difference between R_1 and R_2 , R_2 and R_3 , R_3 and R_4 , R_4 and R_5 represents size of bite. Determine from these values the average value of size of bite for decreasing resistance.

(9) Allow the regulator to assume a balance, and then in a similar manner to that just described for decreasing resistance, determine the average size of bite for increasing resistance.

Obtaining Size of Bite From Chart

- (10) The size of the bite may be determined from the regulator chart obtained from

the regulator when operating on its own pilot wire, by dividing the number of ohms resistance change by the number of rebalancing movements involved in the change. The regulator chart width is divided into 100 small divisions, each division representing 9 ohms. To determine the size of bite use the following method.

- (a) Count the number of bites in a chart width equivalent to a resistance change of at least 45 ohms. The bites counted should be successive bites and should all be in the same direction.
 - (b) Determine the number of ohms resistance change involved for the particular number of bites.
 - (c) Divide the number of ohms resistance change by the number of bites.
- (11) The size of bite should be determined for both increasing and decreasing resistance.

Example: On the increasing resistance portion of the curve shown in Fig. 24 there are 18 bites between lines A and B. The resistance change involved is 99 ohms. Dividing 99 by 18 gives 5.5 which is the size of bite in ohms for increasing resistance. Similarly for decreasing resistance portion of the curve between lines C and D the size of bite equals 5.6 ohms.

Adjusting Procedure

(12) If the pointer lag adjustment has been properly made, the regulator will ordinarily meet the size of bite requirement. If the size-of-bite requirement is not met it may be due to the gap between the lever arms being too great or the pointer having its edges rounded. To correct, replace the lever arms or the pointer as required and then measure the pointer lag and readjust if necessary.

3.21 Drift (Rq 2.21)

Test Procedure

- (1) When the regulator is operating on its own pilot wire, inspection of the chart will reveal whether drift is present in the regulator. Fig. 25 is an example of how drift may appear on the regulator chart.
- (2) Drift may also be checked with the regulator operating on a resistance box connected to the REG jacks. This method is as follows:
 - (a) If the regulator is equipped with a one-conductor dial switch arm and is used with the 4A system, make certain that the cellulose acetate sleeve is in place on the dial switch arm.

(b) Connect the resistance box to the REG jacks of the regulator to be tested. The resistance box should be set at a value which causes the regulator to balance on zero stud.

(c) Start the regulator by means of the REG CONTROL (No. 4A regulator) the REG ON (No. 5A regulator) or the REG and MOT (No. 5B regulator) keys and allow it to operate for a period of 15 minutes or half an hour. If there is no drift present the pen will draw a line which is parallel to the lines on the paper. If the regulator has drift present, the pen will draw a line which slants to one side or the other and is periodically brought back to its normal position by a rebalancing movement resulting in a graph made up of a series of saw teeth.

(d) This test for drift should be repeated at the +5 stud and also at the -5 stud.

Adjusting Procedure

(3) If drift is present in the regulator, check that the requirements for clutch pressure, slide wire contact pressure, and dial switch arm pressure are met. Check that the pen carriage belt is tight. Also check that the clutch corks touch the clutch disc simultaneously and that they are parallel to the face of the clutch disc. If drift is present even though the above requirements are met, it may be desirable to increase the pressures of the slide wire contact and the dial switch arm toward their upper limits and to decrease the clutch pressure toward its lower limit bearing in mind that these adjustments increase the tendency for clutch slippage. If drift cannot be corrected by the above method it may mean that the trouble is caused by the face of the clutch disc not being at right angles to the shaft. To correct, replace the disc after which it may be necessary to reface the clutch corks as covered in 3.07.

3.22 Hunting (Rq 2.22)

- (1) Hunting may take place in either or both directions whenever the size of bite is so large that the pointer is thrown to the opposite side of the gap causing an immediate rebalancing movement in the reverse direction. Hunting results when the lag in either or in both directions is too small. Hunting may develop due to a change in the adjustment which causes the size of bite to increase. If slight errors in the measurement of pointer lag are made, resulting in the lag being made too low, hunting may develop at times due to slight variations in the uniformity of the slide wire or to other irregularities.
- (2) Hunting in both directions may be corrected by decreasing the rocker arm

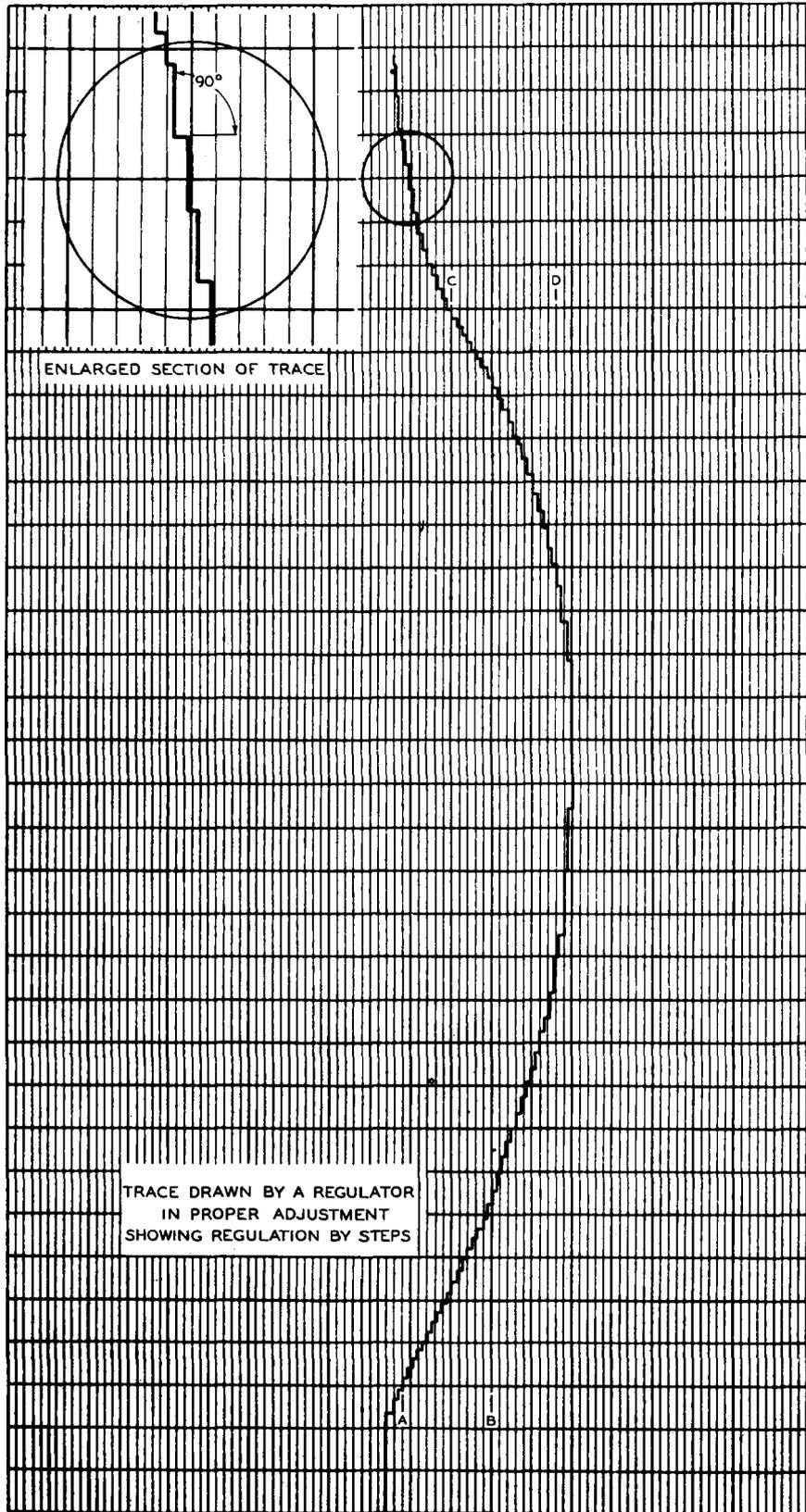


Fig. 24
(Reproduced Half Size From FS-507202)

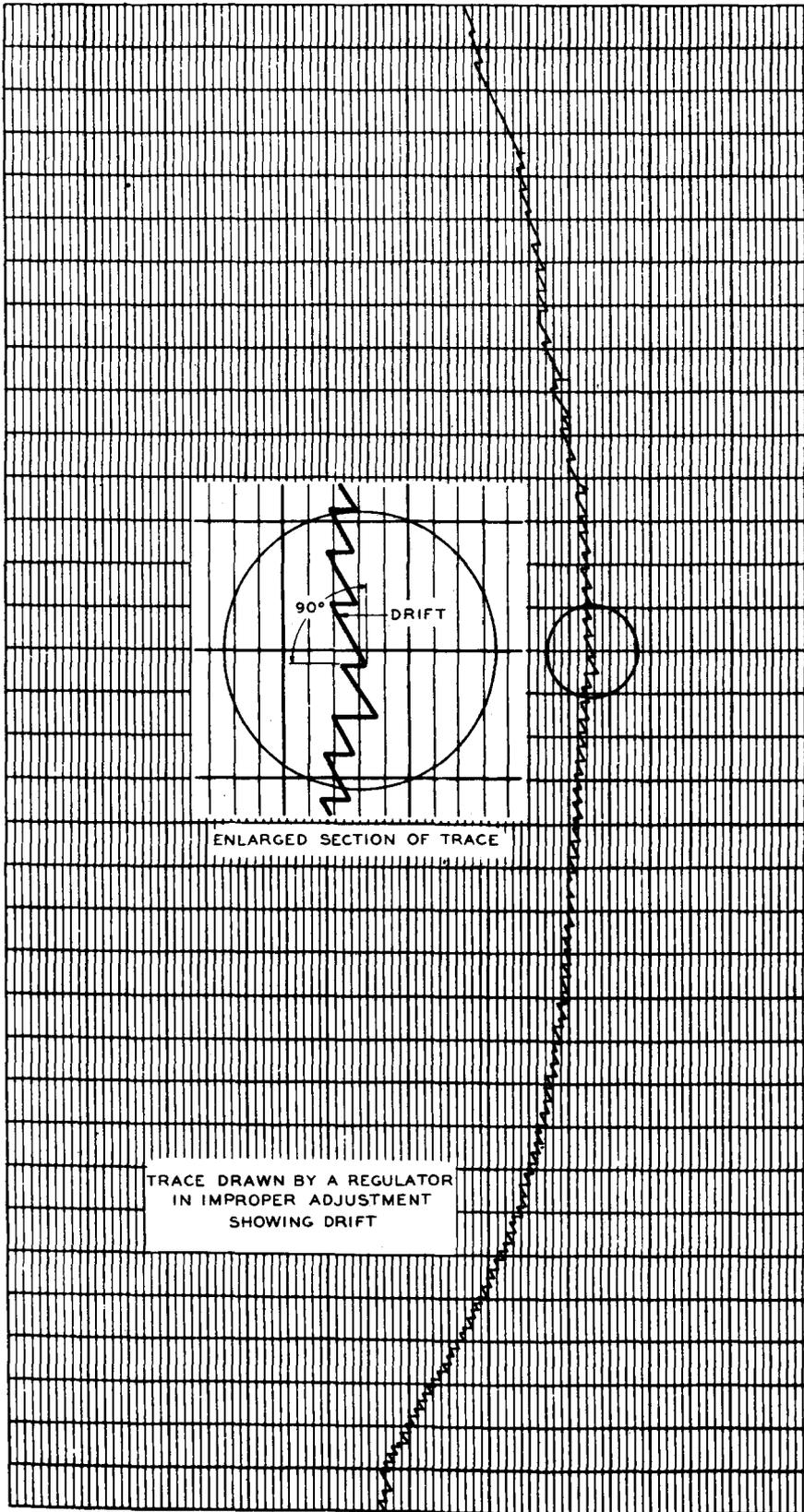


Fig. 25
(Reproduced Half Size From ES-507202)

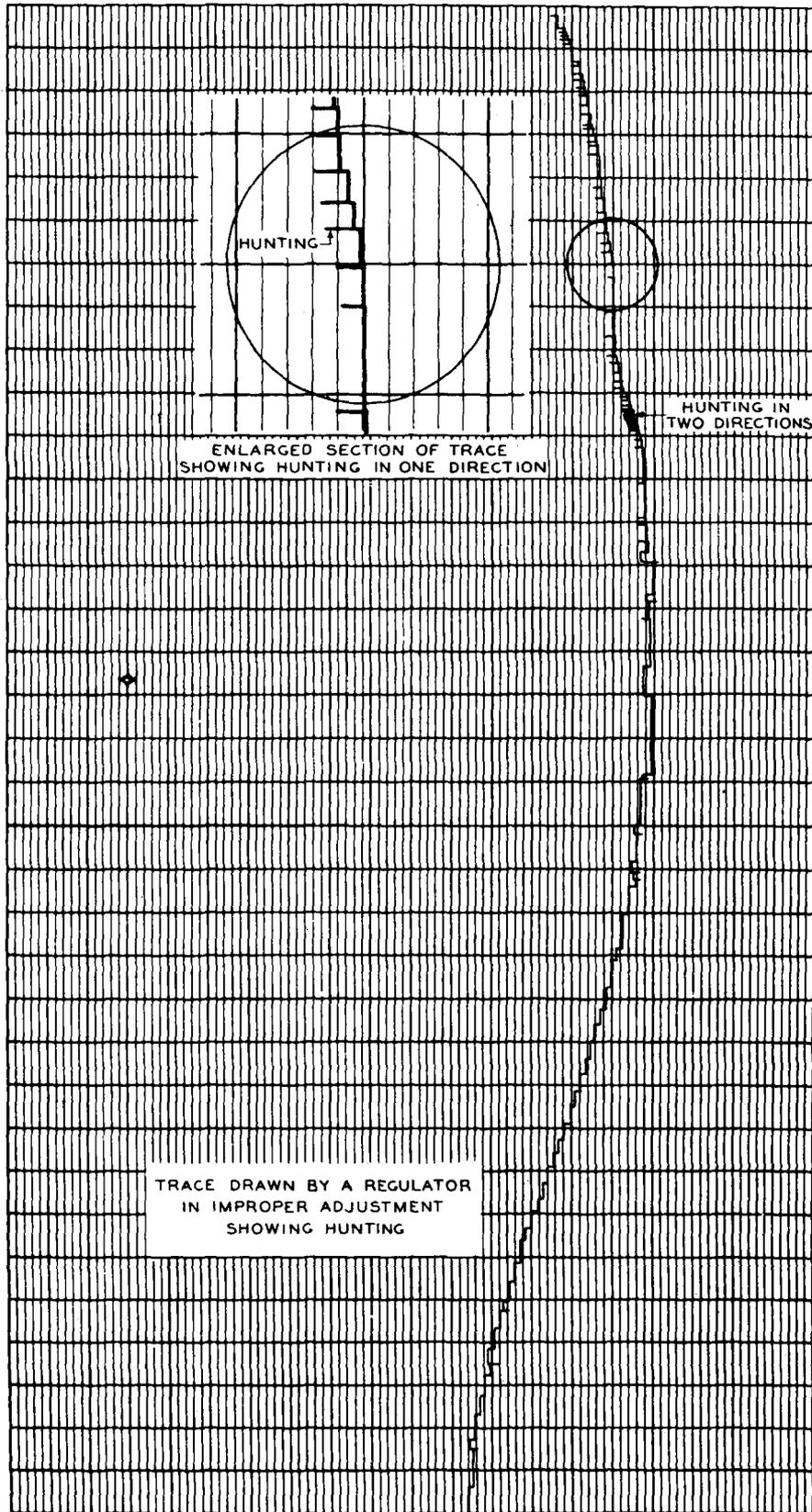


Fig. 26
(Reproduced Half Size From ES-507202)

lift. Hunting in one direction may be corrected by a very slight adjustment of the travel balance screw. As these two adjustments have an effect upon the pointer lag, it is therefore important that the smallest adjustment which will correct hunting be used.

3.23 Differential Relay Alarm (Rq 2.23)

(1) If the regulator is equipped with a one-conductor dial switch arm and is used with the 4A system, make certain that the cellulose acetate sleeve is in place on the dial switch arm.

(2) Connect the resistance box to the REG jacks of the regulator to be tested. The resistance box should be set at the value which will cause the regulator to balance on zero stud.

(3) Start the regulator by means of the REG CONTROL (No. 4A regulator), the REG ON (No. 5A regulator), or the REG and MOT (No. 5B regulator) keys and allow the regulator to assume a balance.

(4) Quickly decrease the resistance box setting by 6000 ohms.

(5) The trouble lamp (UNBAL for 5A and 5B systems, OVERSTEP for the 4A system) should light steadily, the audible alarm should operate continuously, and the motor should stop. The galvanometer pointer should return to its zero position after an initial kick.

(6) Change the resistance box setting back to the value used in (2). The regulator should automatically resume operation and assume a balance, the audible alarm should stop, and the lamp should be extinguished.

(7) Remove one of the plugs by means of which the resistance box is connected to the REG jacks. The UNBAL (or OVERSTEP) lamp should light steadily, the audible alarm should operate continuously, and the motor should stop. The galvanometer pointer should return to its zero position after an initial kick.

(8) Reinsert the plug into the REG jacks. The regulator should resume normal operation as before.

3.24 No-voltage Alarm (Rq 2.24)

(1) This test may be made at any time whether the regulator is operating on its own pilot wire or on a resistance box connected to the REG jacks and may be combined with any other test as found convenient.

(2) Temporarily remove the resistance lamp or fuse in series with the positive 120- or 130-volt bridge battery supply

except when this is fed direct from a copper oxide rectifier. In the latter case, remove instead the rectifier cord plug from the service receptacle.

(3) The NO VOLTAGE (No. 4A regulator) or the NV (Nos. 5A and 5B regulators) lamp should light and the audible alarm should operate continuously. In the No. 5B regulator the motor will stop.

(4) Reinsert the plug of the rectifier cord into the service receptacle if used and reinserting the resistance lamp or fuse should extinguish the lamp and stop the operation of the audible alarm and in the No. 5B regulator should also start the motor.

3.25 Dial Switch Contact Alarm (Rq 2.25)

4A Pilot Wire System

(1) Remove the lighted indicating lamp (or lamps). The REGULATOR SWITCH OPEN alarm lamps should light and the audible alarm should operate.

3.26 Guard Relay Operation (Rq 2.26)

4A Pilot Wire System

(1) Stop the working regulator in the position in which the clutch arm is disengaged from the clutch disc and see that the galvanometer pointer is free. Note the position of the dial switch arm.

(2) Block the armatures of all primary master relays and all relays on B22 applique circuits, when provided, in whatever position they are in at the time.

(3) Manually turn the clutch disc of the regulator, taking care not to touch the face of the disc, so that the regulator is on the zero step. Observe that the proper guard relays operate as indicated by the circuit drawings.

(4) Insulate the dial switch arm contacts from the zero stud. The guard relays should remain operated. The REGULATOR SWITCH OPEN lamp should light and the audible alarm should operate.

(5) Remove the insulation from the dial switch arm contacts. The REGULATOR SWITCH OPEN lamp should be extinguished and the audible alarm should cease.

(6) Manually turn the clutch disc so that the regulator is on the +1/2 step (0 and +1 lamps lighted). Observe that the proper guard relays operate.

(7) Insulate the dial switch arm contacts from the contact studs. The even-numbered (0) guard relay should remain operated but the odd-numbered (+1) guard relay should release. The REGULATOR

SWITCH OPEN lamp should light and the audible alarm should operate.

(8) Remove the insulation from the dial switch arm contacts. The REGULATOR SWITCH OPEN lamps should be extinguished and the audible alarm should cease.

(9) Repeat (3), (4), and (5) for all the full steps and (6), (7), and (8) for all the half steps.

(10) Restore the dial switch arm to the position noted in (2). Release the armatures of the blocked relays and start the controller.

5A Pilot Wire System

(11) For the purpose of describing this test, it is assumed that regulator No. 1 is the working regulator and that it is connected to the No. 1 set of master relays.

(12) See that regulator No. 2 is stopped in the position in which the clutch arm is disengaged from the clutch disc and also see that the pointer is free.

(13) Manually turn the clutch disc of No. 2 regulator, taking care not to touch the face of the disc, so that the regulator is on the zero step.

(14) Operate the multicontact switch MAS REL 2 REG 2 and observe that the proper guard relays associated with this multicontact switch operate as indicated by the circuit drawings.

(15) Restore the MAS REL 2 REG 2 switch. The guard relays should remain operated. The GD lamp should light and the audible alarm should operate. Operate momentarily the GUARD RELEASE key. The guard relays should release, the GD lamp should be extinguished and the audible alarm should cease.

(16) Manually turn the clutch disc so that the regulator is on the +1/2 step.

(17) Operate the MAS REL 2 REG 2 switch and observe that the proper guard relays operate.

(18) Restore the MAS REL 2 REG 2 switch. The odd-numbered (1) guard relay shall remain operated but the even-numbered (0) guard relay should release. The GD lamp should light and the audible alarm should operate. Operate momentarily the GUARD RELEASE key. The odd-numbered guard relay should release, the alarm should cease, and the GD lamp should be extinguished.

(19) Repeat (14) and (15) for all the full steps and (17) and (18) for all the half steps.

(20) Transfer all regulating network circuits to the No. 2 set of master relays and regulator No. 2.

(21) Repeat (14) and (15) for all the full steps and (17) and (18) for all the half steps using MAS REL 1 REG 1 switch in place of MAS REL 2 REG 2 switch.

(22) Transfer all regulating network circuits back to No. 1 set of master relays and regulator No. 1.

5B Pilot Wire System

(23) Assuming that the regulating network circuits are under control of the automatic regulator, set the manual dial switch used for transmission measuring on the step indicated by the automatic regulator step lamp. Transfer all regulating network circuits to the auxiliary primary relays and manual dial switch used for transmission measuring.

(24) Stop the operation of the pilot wire regulator by restoring the REG and MOT keys to normal and insulate the contact arm of the dial switch from the dial studs.

(25) Block the CO relay nonoperated.

(26) Set the manual dial switch on step -10. Note that when only V1 repeaters arranged for voice-frequency telegraph are regulated, switch contacts from steps -5 to -10 are strapped together and switch operations in this range will produce no external circuit change.

(27) Operate the REG TRNS (regulator transfer) switch to its operated position to connect the dial switch to the guard and primary master relays. Note that the proper guard relays operate as indicated by the circuit drawings, that the associated step lamp lights, that the MAN (manual) lamp lights, and the AUTO (automatic) lamp is extinguished.

(28) Restore the REG TRNS switch to its normal position. Note that the guard relays remain operated and associated lamp remains lighted, that the MAN lamp is extinguished and the AUTO and GD (guard) lamps light and that the audible alarm is operated.

(29) Again operate the REG TRNS switch and note that the MAN lamp is lighted and the AUTO and GD lamps are extinguished and the audible alarm is silenced.

(30) Set the manual dial switch on step -4.5 in case only V1 repeaters arranged for voice-frequency telegraph are regulated. In all other cases set the manual dial switch on step -9.5. Note that the proper guard relays operate and two associated step lamps light.

(31) Proceed as outlined in (28) and (29).

↑ (32) While operating the manual dial switch slowly, successively set it on all full steps and half steps repeating tests as outlined in (27), (28), and (29) for all full steps and (30) and (31) for all half steps. Note that on all steps and half steps above +5, when only V1 repeaters arranged for voice-frequency telegraph operation are regulated, relay +6 is operated and no alarms are initiated.

L (33) Move the manual dial switch slowly back to step -5.5. The guard relays -5, -6, and H should operate and the lamps -5 and -6 should light. Note that when only V1 repeaters arranged for voice-frequency telegraph are regulated, only guard relay -5 should operate and only the -5 lamp should light.

(34) Remove fuse E and note that the guard relays and associated lamps remain operated, that the GD lamp lights, and that the audible alarm is operated.

(35) Restore fuse E. Note that the GD lamp is extinguished and the audible alarm silenced.

↑ L (36) Remove fuse F and note that guard relays -5, -6, and H remain operated and associated lamps -5 and -6 remain lighted, that the GD lamp lights, and that the audible alarm is operated. Note that when only V1 repeaters arranged for voice-frequency telegraph are regulated, only guard relay -5 remains operated, associated lamp -5 remains lit, the GD lamp lights, and the audible alarm is operated.

(37) Restore fuse F. Note that the GD lamp is extinguished and the audible alarm silenced.

(38) Remove the insulator from the contact arm of the pilot wire regulator and operate the REG and MOT keys. Allow the regulator to operate until it is balanced.

(39) Restore the REG TRNS switch to the pilot wire regulator. Note that the MAN lamp is extinguished and the AUTO lamp is lighted.

(40) Transfer all regulating network circuits to the regular guard and primary master relays.

(41) Remove the blocking tool from the CO relay.

REASONS FOR REISSUE

1. To revise the list of tools, gauges, and materials (3.001).
2. To add a note specifying the lubrication of reduction gears (Fig. 9).
3. To revise the procedure covering Differential Relay Alarm (3.23).
4. To revise the procedure covering No-voltage Alarm (3.24).
5. To revise the procedure covering Guard Relay Operation (3.26).