H E Hogan

TRAINING MANUAL No. 16

FIELD EMPLOYEES

STEP BY STEP SWITCHES, MECHANISMS AND RELAYS

Western Electric Company
INCORPORATED
INSTALLATION DEPARTMENT

OPERATION TRAINING OUTLINE 301
GENERAL INFORMATION
FOR
CLASSROOM TRAINING ON STEP-BY-STEP SWITCHES AND RELAYS

1. TEST AND READJUST REQUIREMENTS

Step-by-Step equipment is initially adjusted at the time of manufacture and should not ordinarily require extensive adjustment by the installer. Slight changes, however, may take place during shipment and handling, which make it necessary to check the equipment at the point of installation before it is turned over to the Telephone Company for service.

Test Requirements are to be used in determining whether or not the equipment is in proper condition for delivery to the Telephone Company. When the test requirements are not met the parts involved will require adjustment.

Readjust Requirements are for use when adjusting equipment that fails to meet the test requirement. Frequently the readjust are more severe than the test requirements so as to provide a margin of safety. When a requirement is not specifically designated as test or readjust it is to be considered both test and readjust.

2. SEQUENCE OF CHECKING AND ADJUSTING

(a) The requirements and adjusting procedures are in the order which experience has indicated to be the proper sequence to follow in checking and adjusting the equipment.

(b) Two or more requirements may be covered by the same adjusting procedure. In such instances, the adjusting procedure headings list the associated requirement numbers and titles. These requirements are interdependent and in making an adjustment to meet one or more of those requirements, consideration must be given to others.

3. USE OF GRAM GAUGES

Fan type gauges are designed for use in a horizontal position with the movement of the reed to the right or left. When fan typed gauges are used in a vertical position an allowance should be made for the weight of the reed. The position of the reed with respect to the zero mark should be noted and an equivalent allowance made in reading the tension being checked.

4. TIGHTNESS OF NUTS AND SCREWS

(a) When checking for loose nuts and screws apply force in the direction which tends to tighten them.

(b) All nuts and screws loosened for the purpose of making adjustments should be securely tightened.

5. 197 TYPE SWITCH

General views of the 197 Type Switch are shown in Figures 1 and 2. The various parts referred to in the Training Outlines, to be covered in this class, are shown.

6. GENERAL CONSIDERATIONS BEFORE STARTING EACH OPERATION

While the following information is not to any great extent applicable to work being performed in the classroom it applies in all cases to job work and therefore should be given consideration before the start of each operation.

(a) Survey Work Area for Safety to Personnel

(1) Place protection on protrusions to avoid bumps, cuts or scratches.

(2) Consider possible injury from surrounding work operations.

(3) Consider possible effect your work will have on surrounding workmen.

(b) Survey Work Area for Safety to Service

(1) Place protection for adjacent equipment.

(2) Place protection for exposed working circuits.

(c) Self check to determine if requirements and methods to be followed are understood.

(d) Arrange Tools, Supplies and Protection

(1) To provide personal safety.

(2) To provide safety to service.

(3) To provide maximum efficiency (eliminate lost motion).

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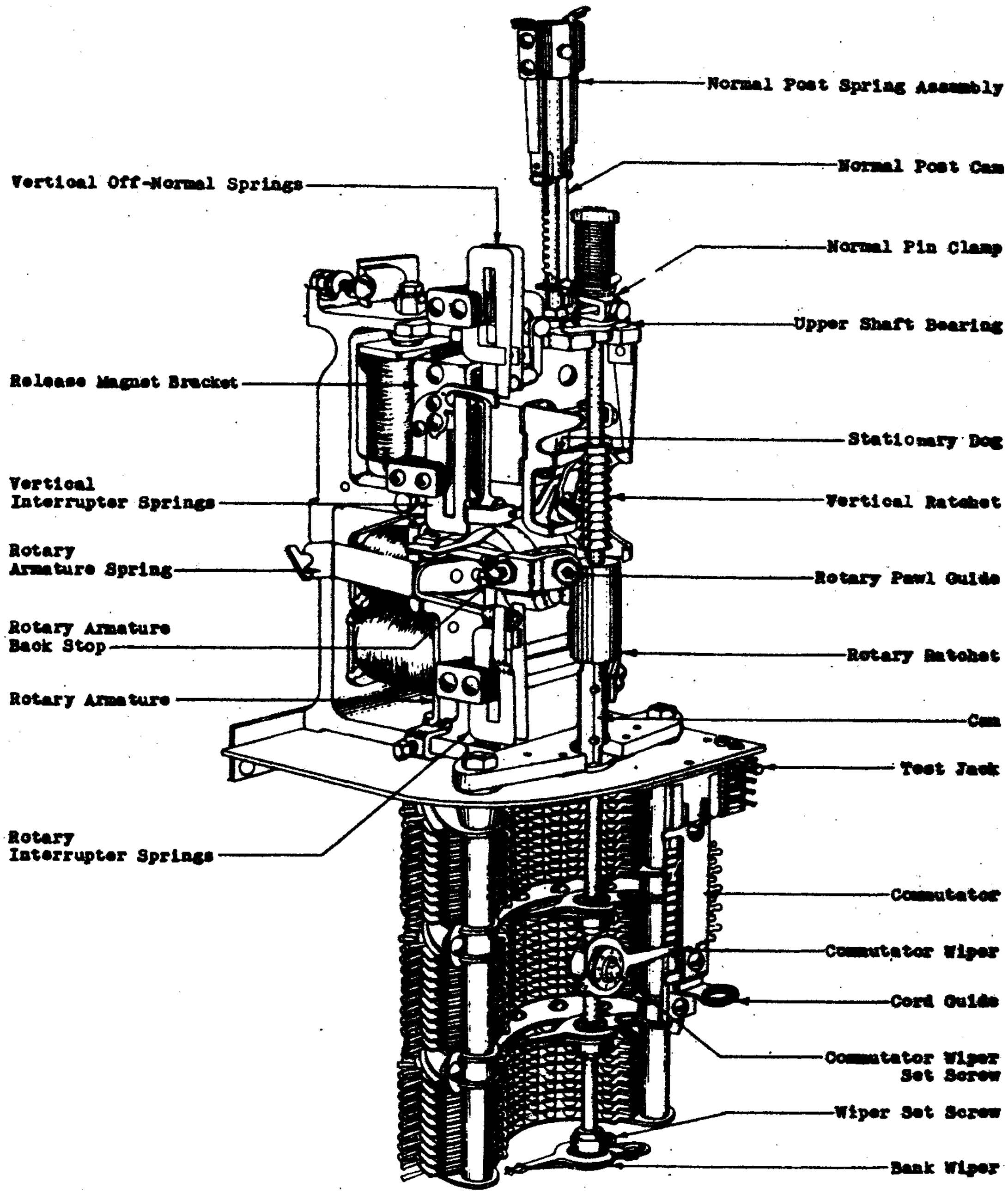

FIG. 1 ILLUSTRATING PARTS OF 197 TYPE SWITCH
AS VIEWED FROM THE LEFT SIDE

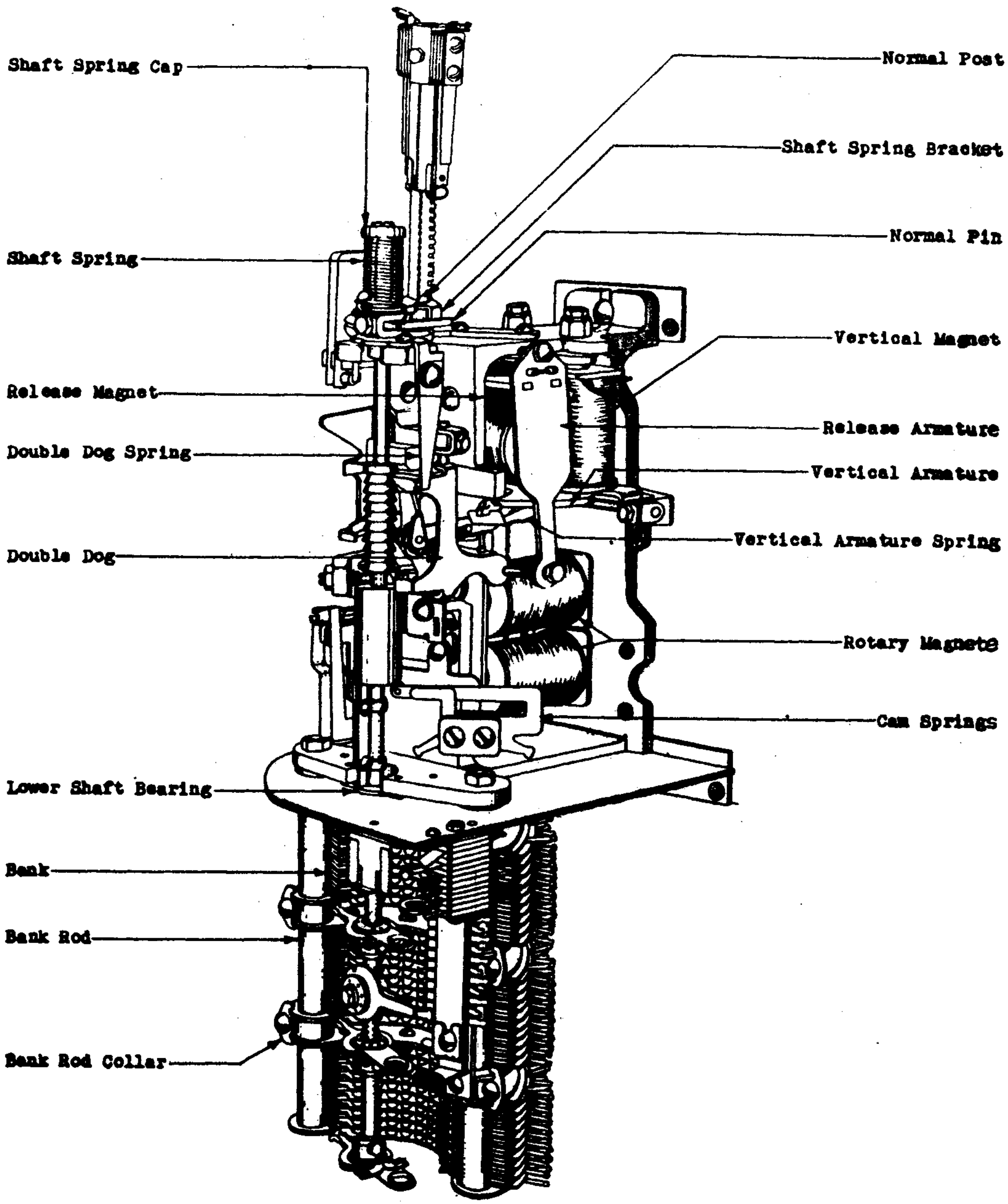

FIG. 2 ILLUSTRATING PARTS OF 197 TYPE SWITCH
AS VIEWED FROM THE RIGHT SIDE

OPERATION TRAINING OUTLINE NO. 302
PART 1
REQUIREMENTS AND CHECKING PROCEDURES FOR ROTARY MOVEMENT
197 TYPE SWITCHES

1. ROTARY DOG ALIGNMENT

(a) Requirement: The stopping face of the rotary dog shall engage approximately flat with the radial face of the rotary teeth. Figure 1 (A).

(b) Checking Procedures: The requirement for the rotary dog alignment shall be met with the shaft on the 5th rotary step of the 5th bank level. Gauge by eye.

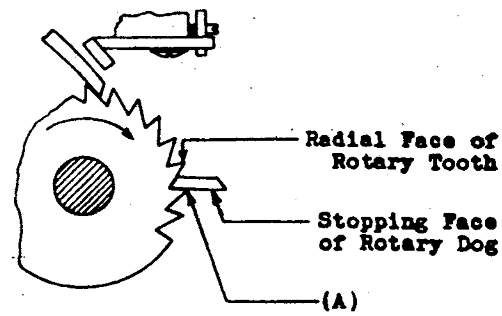

FIGURE 1

2. ROTARY ARMATURE PLAY

(a) Requirement: The rotary armature shall not bind nor have more than .003" vertical play. Figure 2(A).

(b) Checking Procedures: Gauge by eye or feel.

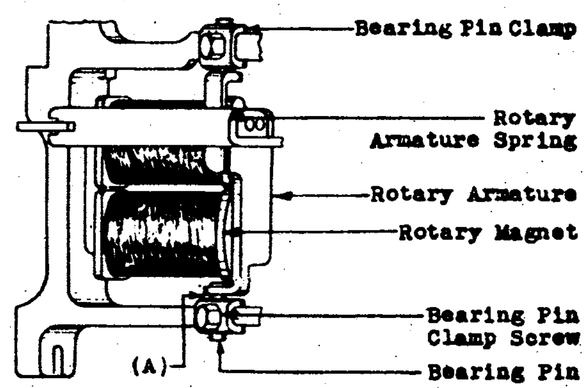

FIGURE 2

3. ROTARY PAWL PLAY

(a) Requirement: The rotary pawl shall be free from bind. Figure 3(A).

(b) Checking Procedures: Gauge by feel.

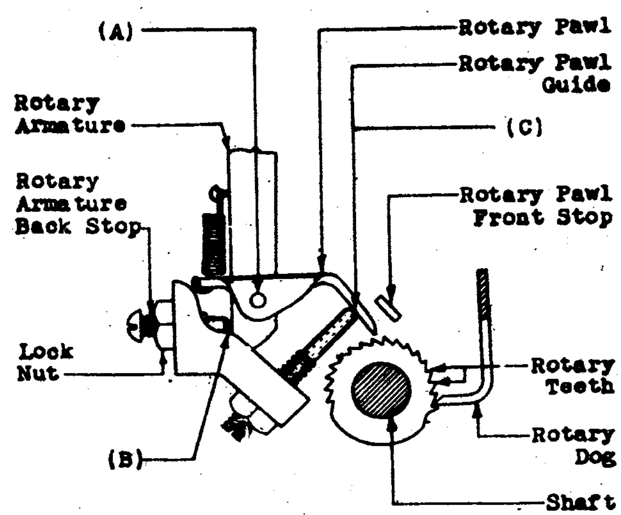

FIGURE 3

This Training Outline includes material from BSP A477.002, Issue 4-D and Addendum A477.002, Issue 2-D

4. VERTICAL POSITION OF ROTARY ARMATURE

(a) Requirement: With the rotary armature in its normal position:

(1) The rotary armature shall overlap a minimum of 2/3 the diameter of the back stop. Figure 3(B).

(2) The rotary pawl shall entirely overlap the end of the rotary pawl guide. Figure 3(C).

(b) Checking Procedures: Gauge by eye.

5. ROTARY PAWL POSITION

(a) Requirement

(1) The rotary pawl shall strike the teeth of the rotary ratchet squarely when the rotary armature is operated manually.

(2) With the shaft on the last rotary step the tip of the rotary pawl shall align itself with the cylindrical part of the shaft hub as it slides along the hub.

(b) Checking Procedures

(1) Gauge by eye as follows: As the pawl begins to rotate the shaft from the rotary normal position, the actuating surface (beveled surface) of the rotary pawl shall align itself with the outer edge of the radial face of the tooth. Use the No. 510B test lamp and the P-220366 dental mirror. This shall be checked at the following points: Figure 4(A).

Viewed from top of ratchet	With the shaft held between the first and second levels so that the top edge of the rotary pawl is slightly above the ratchet teeth.
Viewed from bottom of ratchet	9th Level

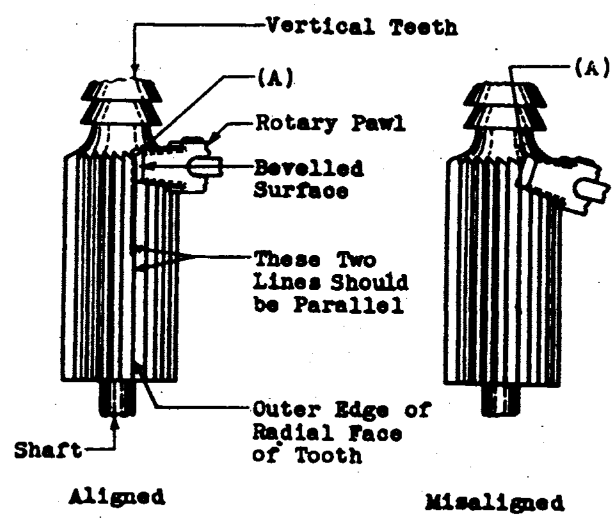

FIGURE 4

5. ROTARY PAWL POSITION (CONT'D)

(2) Use the No. 510A test lamp and the P-220366 dental mirror and check on the 9th level. Direct the light of the test lamp from the right and observe the rotary pawl from the left as it slides along the hub. This can also be checked by holding a P-220366 dental mirror at an angle of approximately 45 degrees below and to the left of the rotary ratchet. Figure 5(A).

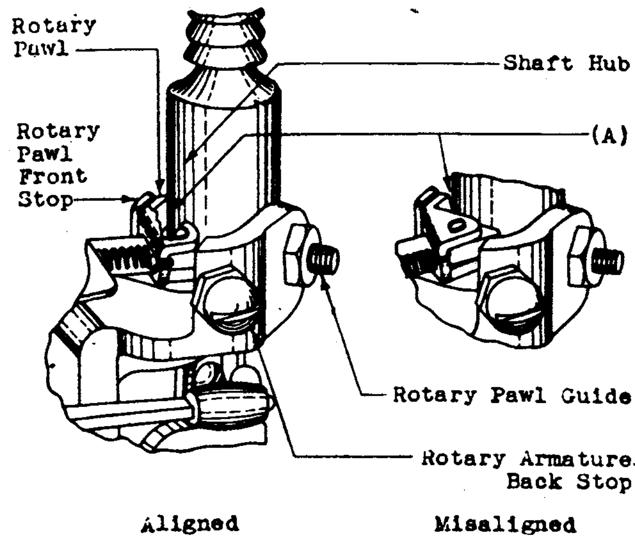

FIGURE 5

6. ROTARY MAGNET POSITION

(a) Requirement

(1) With the rotary magnets electrically operated, there shall be a space between the rotary dog and the radial face of the rotary tooth of:

Test	- Min.	.005"
	- Max.	.012"
Readjust	- Min.	.005"
	- Max.	.010"

This requirement shall be met on at least one of the first ten teeth on the fifth level. Figure 6(A).

(2) With the rotary magnets electrically operated, the rotary armature shall strike both magnet cores. This requirement is met if, when the armature is in contact with one core, the space between the armature and the closest point on the other core does not exceed .002". Figure 8(A).

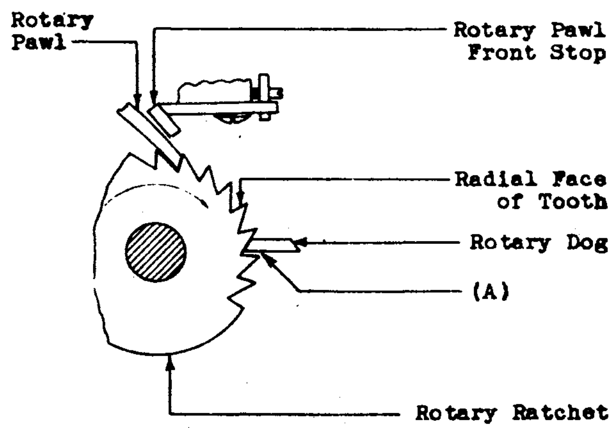

FIGURE 6

6. ROTARY MAGNET POSITION (CONT'D)

(b) Checking Procedures

(1) Use the KS-6909 gauge as shown in Figure 7.

(2) Place the .002" blade of the KS-6909 gauge between the armature and one of the rotary magnet cores as shown in Figure 8 so that the gauge completely covers the core and then energize the rotary magnets. The gauge should be tight. Repeat the check on the other rotary magnet. The gauge should also be tight.

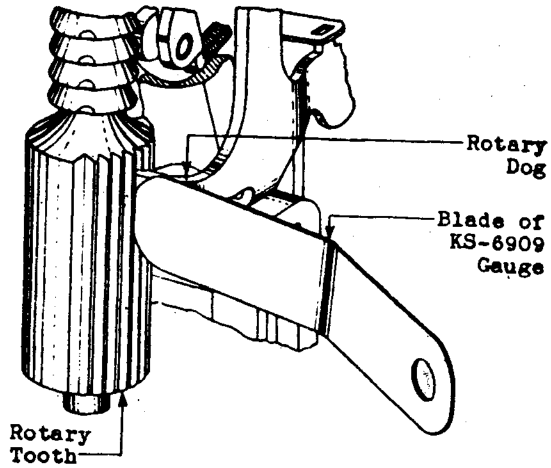

FIGURE 7

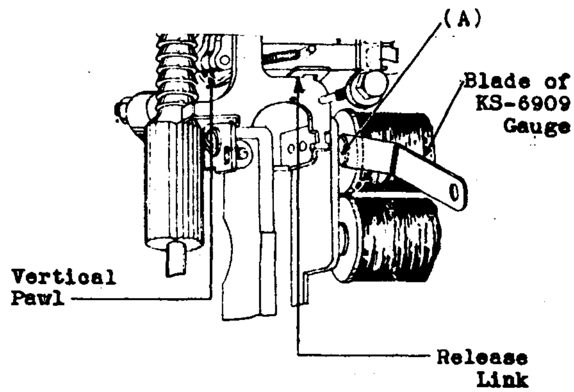

FIGURE 8

7. ROTARY PAWL FRONT STOP POSITION

(a) Requirement: With the rotary magnets electrically operated the clearance between the rotary pawl and the rotary pawl front stop shall be:

Test	- Min.	.002"
	- Max.	.008"
Readjust	- Min.	.002"
	- Max.	.006"

This requirement shall be measured on the first, fifth and tenth rotary steps of the fifth level. Figure 9(A).

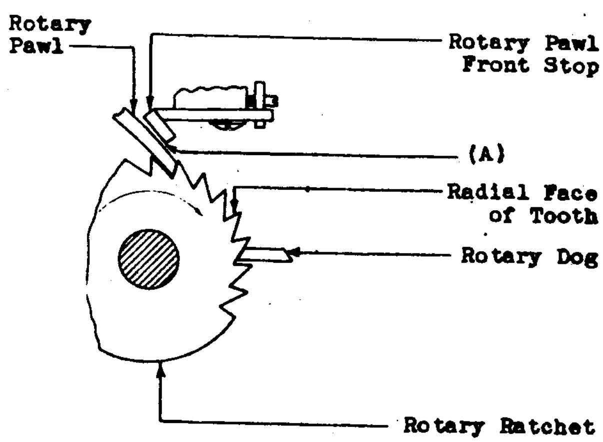

FIGURE 9

7. ROTARY PAWL FRONT STOP POSITION (CONT'D) 5

(b) Checking Procedures: Measure the maximum values with the No. 117A gauge as shown in Figure 10 and the minimum values with the KS-6909 gauge.

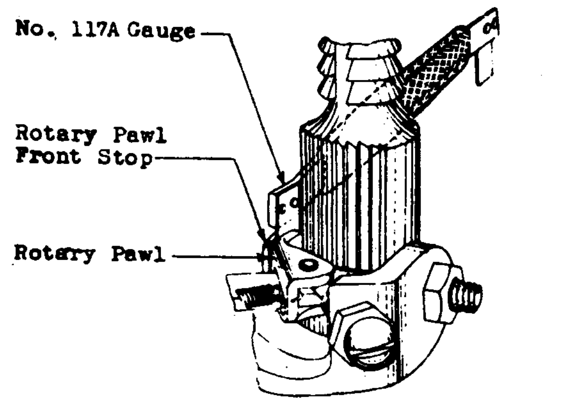

FIGURE 10

8. ROTARY PAWL GUIDE POSITION

(a) Requirement: When the rotary armature is operated manually, sufficiently to bring the rotary pawl into contact with the rotary teeth on the indicated rotary steps of the first and tenth levels, the following requirements shall be met. (On switches equipped with a commutator wiper the shaft spring bracket shall be held against the left side of the normal post when checking requirements involving the first rotary step.)

(1) With the shaft on the first, fourth and ninth rotary steps the tip of the pawl shall strike the flank of the tooth before it engages the radial face of the preceding tooth.

(2) The rotary pawl tip shall first strike the flank of the tooth within the areas indicated in the following table. Figure 11(A) and (B).

	Check On Rotary Steps	Area in Fig. 11
Test & Readjust	1 and 9	B
Readjust Only	4	A

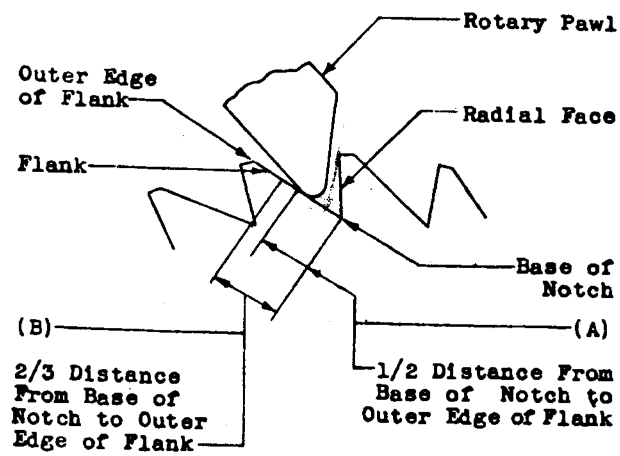

FIGURE 11

(b) Checking Procedures: Gauge by eye. Use the P-220366 dental mirror.

9. NORMAL PIN POSITION

(a) Requirement: The step from rotary normal position to the first bank contact shall be equal to the steps between bank contacts. This requirement shall be checked on the first and tenth levels. Figure 12(A).

(On switches equipped with a commutator wiper the requirement shall be met with the shaft spring bracket held against the left side of the normal post. Figure 12(B).

NOTE: This requirement is met if, when the rotary armature is operated manually with the shaft in rotary normal, the tip of the pawl strikes the flank of the tooth within the area (B) on Figure 11 before it strikes the radial face.

(b) Checking Procedures: Gauge by eye. Use the P-220366 dental mirror.

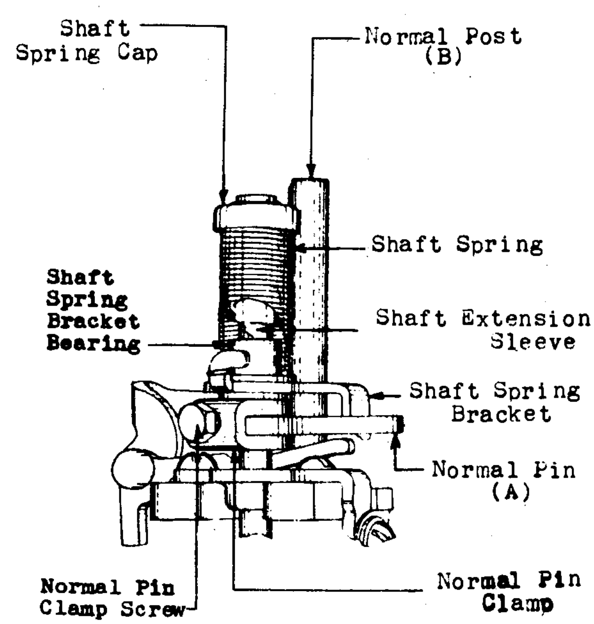

FIGURE 12

10. ROTARY ARMATURE BACK STOP POSITION

(a) Requirement: With the rotary armature against its back stop the rotary pawl shall clear the rotary teeth as the shaft slowly restores to rotary normal from the last rotary step of every level, but this clearance shall not exceed 1/64" checked on the fifth level. Figure 13(A).

(b) Checking Procedures: Gauge by eye.

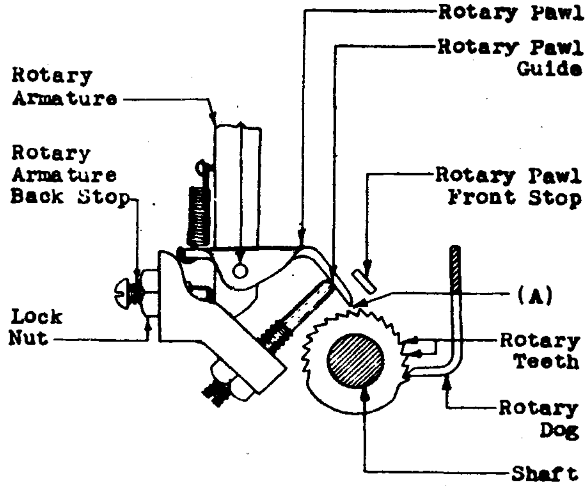

FIGURE 13

11. SHAFT SPRING BRACKET POSITION

(a) Requirement: With the switch shaft at normal the shaft spring shall restore the shaft spring bracket against the normal pin clamp when the bracket has been lifted to its maximum limit and then released. Figure 14(A).

(b) Checking Procedures: Compress the shaft spring as far as possible against the shaft spring cap by lifting the shaft spring bracket by hand. Then release the shaft spring bracket and see that it restores against the normal pin clamp.

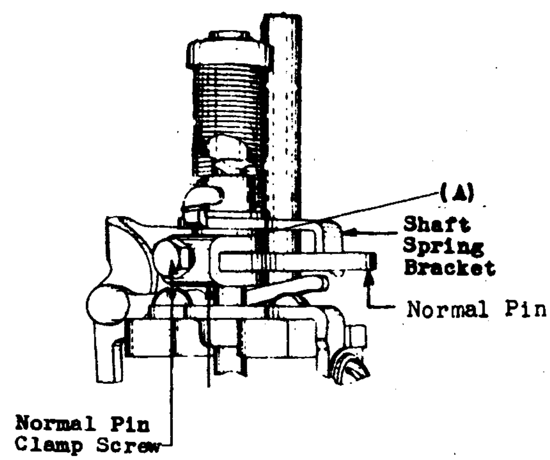

FIGURE 14

12. SHAFT SPRING TENSION

(a) Requirement: The shaft spring tension shall be sufficient to restore the shaft to rotary normal from the second rotary step of the first bank level against a tension of:

Test - Min. 85 grams
Readjust - Min. 100 grams

(b) Checking Procedures: To measure the tension, open the circuit to the release magnet, step the switch manually to the specified position and apply the No. 79C gauge to the radial face of the rotary tooth engaged by the rotary dog at a point below the rotary dog as shown in Figure 15. Set the gauge at the specified minimum tension, operate the release magnet manually and observe that the shaft restores to rotary normal.

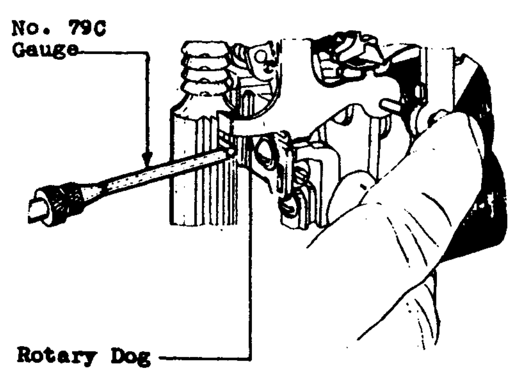

FIGURE 15

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OPERATION TRAINING OUTLINE NO. 302
PART 2

ADJUSTING PROCEDURE FOR ROTARY MOVEMENT
197 TYPE SWITCHES

1. ROTARY DOG ALIGNMENT

(c) Adjusting Procedures: Where the requirement has not been met it is an indication that the rotary dog is incorrectly formed and the double dog should be replaced.

2. ROTARY ARMATURE PLAY

(c) Adjusting Procedures: If the rotary armature binds or has too much vertical play, loosen the set screw in the top or bottom bearing pin clamp (as determined by the position of the rotary armature with respect to the rotary armature backstop) and move the bearing pins as required. The rotary armature is in its correct position when the rotary armature backstop approximately centers on the contacting surface of the rotary armature. Use the No. 556A wrench.

3. ROTARY PAWL PLAY

(c) Adjusting Procedures: If the rotary pawl binds the rotary armature should be replaced.

4. VERTICAL POSITION OF ROTARY ARMATURE
5. ROTARY PAWL POSITION

(c) Adjusting Procedures: If the rotary armature does not properly overlap the backstop or if the rotary pawl does not properly overlap the end of the rotary pawl guide, raise or lower the rotary armature. If raising or lowering the rotary armature does not correct the condition adjust the armature arm as required with the No. 13398 adjuster applied at a point just back of the rotary pawl as shown in Figure 1(a).

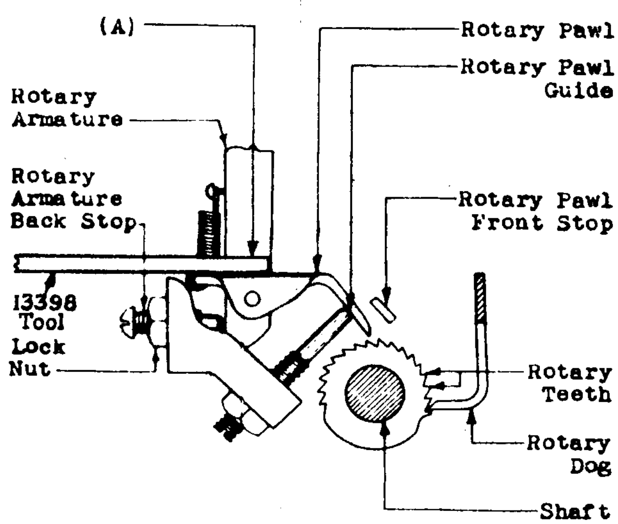

FIGURE 1

6. ROTARY MAGNET POSITION

(c) Adjusting Procedures: To change the clearance between the stopping face of the rotary dog and the radial face of the rotary teeth, remove the cover located in back of the rotary magnets with the R-2443 screwdriver and change the position of the rotary magnets as required. Loosen the clamping screws with the R-1681 wrench.

This Training Outline includes material from BSP'S 477.002, Issue 4-D and Addendum A477.002, issue 2-D

6. ROTARY MAGNET POSITION (CONT'D)

Then turn the locking cap clockwise with the R-2185 wrench to decrease the gap between the stopping face of the rotary dog and the radial face of the rotary teeth and counter-clockwise to increase this gap. If the .002" gauge does not fit tight, move the magnet farthest away from the armature closer to the armature taking care not to disturb the adjustment already made for clearance between the stopping face of the rotary dog and the radial face of the rotary teeth.

7. ROTARY PAWL FRONT STOP POSITION

(c) Adjusting Procedures: To change the clearance between the rotary pawl and the rotary pawl front stop, move the rotary pawl front stop closer to or farther away from the rotary pawl by raising the shaft to the tenth level, loosening the rotary pawl front stop locking screw with the R-2443 screwdriver and then turning the rotary pawl front stop adjusting screw as required. Always complete adjustment of rotary pawl front stop by turning the adjusting screw in a clockwise direction with the locking screw tightened slightly so that the friction between the rotary pawl front stop and the casting will cause a noticeable resistance to the turning of the adjusting screw. For example, if it is necessary to increase the clearance between the rotary pawl and the rotary pawl front stop, loosen the rotary pawl front stop locking screw and move the rotary pawl front stop away from the pawl in excess of the required amount by turning the adjusting screw in a counter-clockwise direction. Then tighten the front stop locking screw slightly and turn the adjusting screw in a clockwise direction until the clearance between the pawl and the front stop is within the specified limits. Then tighten the locking screw securely and recheck the clearance. Do not bend the pawl front stop to increase or decrease the clearance between the pawl and the front stop. See Figure 2.

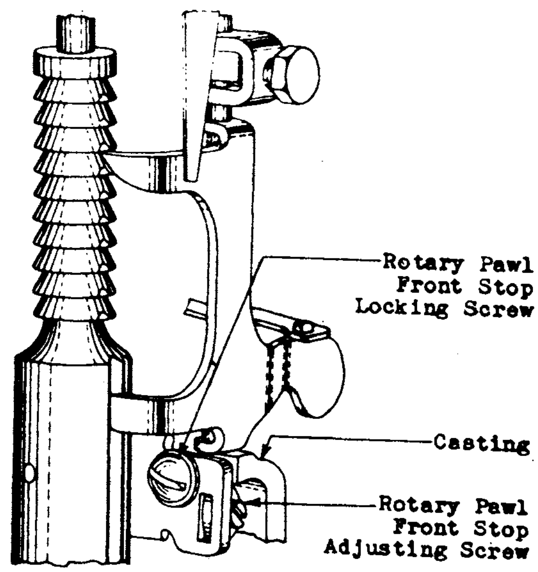

FIGURE 2

8. ROTARY PAWL GUIDE POSITION

(c) Adjusting Procedures: If the rotary pawl tip does not strike the flank of the tooth as shown on Figure 3, loosen the lock nut on the pawl guide with the No. 418A wrench and shift the position of the pawl guide with the screwdriver portion of the No. 48 combination wrench and screw-driver. It is desirable to have the pawl tip strike on the flank of the tooth as near the bottom of the notch between the two teeth as possible.

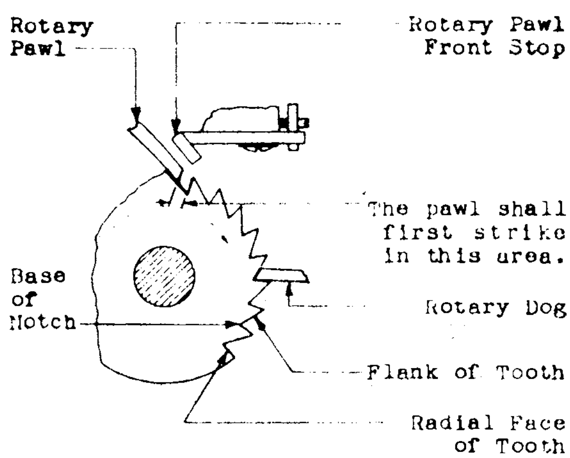

FIGURE 3

9. NORMAL PIN POSITION

(c) Adjusting Procedures: Raise the shaft to the first level and manually operate the rotary armature. Repeat this operation on the second rotary step. If the rotary pawl does not strike the first tooth in the same relative position that it strikes the second tooth, change the position of the normal pin by loosening the normal pin clamp screw and moving the pin to the required position. Use the No. 556A wrench to turn the normal pin clamp screw. Exercise care not to tighten this screw to the point where it will bend the shaft.

10. ROTARY ARMATURE BACK STOP POSITION

(c) Adjusting Procedures: To readjust the clearance between the rotary pawl and the rotary teeth of the shaft, loosen the lock nut on the rotary armature backstop with the No. 418A wrench and shift the position of the backstop with the screwdriver portion of the No. 48 combination wrench and screwdriver. On switches equipped with a round head backstop screw, use the R-2443 screwdriver to turn the screw.

11. SHAFT SPRING BRACKET POSITION

(c) Adjusting Procedures: If the shaft spring bracket does not restore properly, remove the shaft spring, free the shaft spring cap and remove the shaft spring and cap as a unit. (See Figure 4) Observe that the shaft spring bracket rides smoothly on the normal post. If the shaft spring bracket rides smoothly, gradually elongate the shaft spring, taking care that the spring is elongated evenly with even spaces between the loops, and that the overall height of the coil and cap does not exceed 2". To stretch the spring hold the cap in one hand and grasp the first loop at the other end of the spring with the KS-7782 pliers. Remount the shaft spring and recheck for the positioning of the shaft spring bracket. Repeat the operation if necessary.

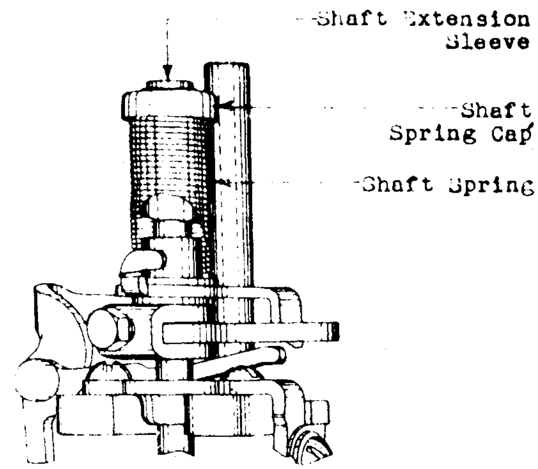

FIGURE 4

12. SHAFT SPRING TENSION

(c) Adjusting Procedures: To change the tension of the shaft spring, turn the shaft spring cap in a clockwise direction as far as the bayonet slots in the shaft extension sleeve will permit, and then lift the cap so that the crossbar is free of the slot in the shaft extension sleeve. Turn the cap in a clockwise direction to increase the tension and in a counter-clockwise direction to decrease the tension. After each one-quarter turn, the crossbar in the spring cap may be dropped into the slots in the shaft extension sleeve to maintain the spring tension while a new hold is secured for any further increase or decrease in tension that may be required. When finally adjusted, make sure that the crossbar in the spring cap is engaged in the bayonet slots so as to lock the spring in the adjusted position. Check the tension of the readjusted shaft spring as shown on Figure 5.

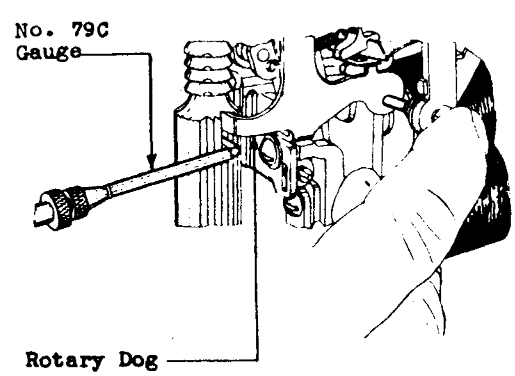

FIGURE 5

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OPERATION TRAINING OUTLINE NO. 303
PART 1
REQUIREMENTS AND CHECKING PROCEDURES FOR VERTICAL MOVEMENT
197 TYPE SWITCHES

1. VERTICAL PAWL PLAY

(a) Requirement: The pawl shall not bind nor have more than .008" side play. Figure 1(A).

(b) Checking Procedures: Gauge by eye and feel.

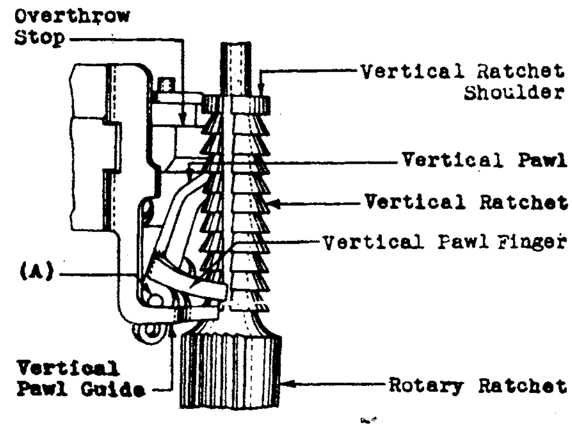

FIGURE 1

2. VERTICAL ARMATURE PLAY

(a) Requirement: The vertical armature shall not bind and shall have a maximum play of 1/64". Figure 2(A).

(b) Checking Procedures: Gauge by feel.

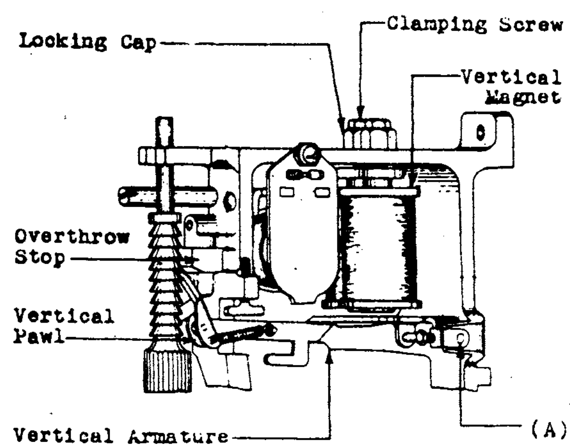

FIGURE 2

3. VERTICAL PAWL POSITION

(a) Requirement: With the pawl resting on the shoulder of the vertical ratchet above the first (top) tooth, both corners formed by the arc at the pawl tip shall touch the periphery of the shoulder in some one position of the armature permitted by the side play of the vertical armature and pawl. Figure 3(A).

(b) Checking Procedures: To check the vertical pawl position, raise the vertical pawl finger from the vertical pawl guide and at the same time operate the vertical armature manually so that both corners formed by the arc at the pawl tip will ride on the outside surface or periphery of the vertical ratchet shoulder as shown on Fig. 3. Move the armature to the left and right as far as the vertical armature side play will permit. Gauge by eye.

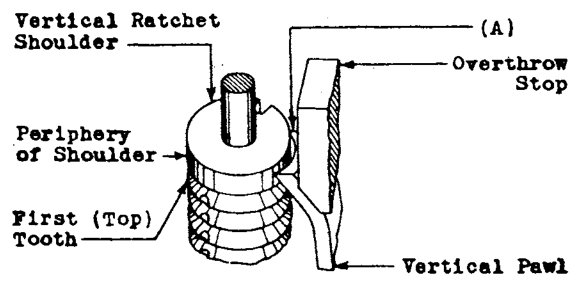

FIGURE 3

This Training Outline includes material from BSP 477.002, Issue 4-D and Addendum A477.002, Issue 2-D

4. CLEARANCE BETWEEN VERTICAL PAWL FINGER AND VERTICAL PAWL GUIDE

(a) Requirement: There shall be a clearance between the vertical pawl finger and the vertical pawl guide just as the shaft starts to move vertically under the control of the vertical armature of Min. .010". Figure 4(A).

(b) Checking Procedures: This requirement shall be checked as the switch is stepped manually from the fifth level. Gauge by eye.

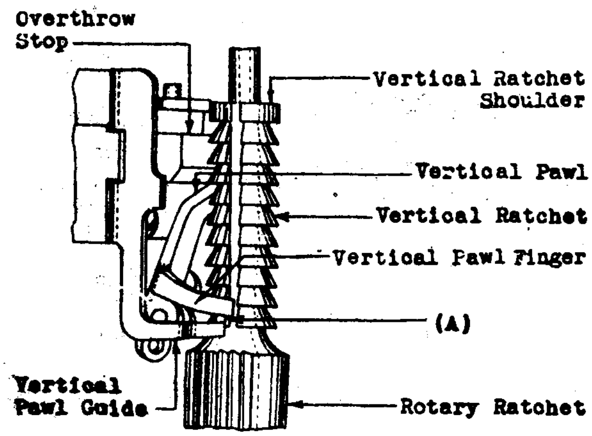

FIGURE 4

5. CLEARANCE BETWEEN VERTICAL PAWL AND VERTICAL TEETH

(a) Requirement: With the vertical armature released, the vertical pawl shall clear all vertical teeth. The pawl shall clear the top of the rotary ratchet when the shaft is up ten steps. Figure 5(A) and (B).

(b) Checking Procedures: Gauge by eye.

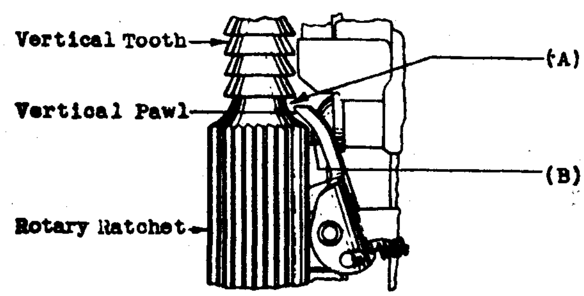

FIGURE 5

6. DOUBLE DOG PLAY

(a) Requirement: The double dog shall not bind nor have more than .002" vertical play. Figure 6(A).

(b) Checking Procedures: Check the minimum value by eye and feel and the maximum value with the KS-6909 gauge. To detect bind in the double dog, it will be necessary to relieve it of the tension of the double dog spring and the release link.

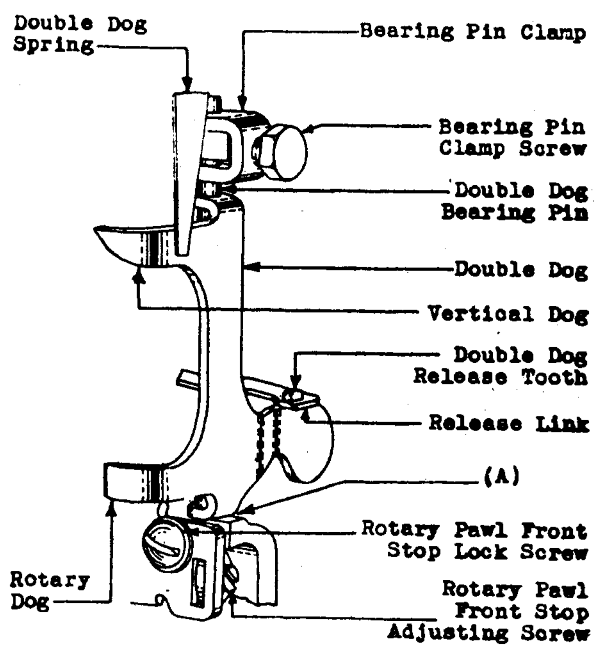

FIGURE 6

7. VERTICAL MAGNET POSITION

(a) Requirement:

(1) Minimum: With the vertical magnets electrically operated and the double dog held away from the ratchet there shall be vertical movement of the shaft when a force sufficient to take up any vertical pawl bearing play is applied to the shaft alternately in an upward and downward direction. Figure 7(A) and 8(B).

Maximum: With the vertical magnets electrically operated and the shaft raised by hand so that the vertical pawl is resting against the casting (overthrow stop) there shall be a gap between the top of the vertical dog and the undersurface of the vertical tooth of Max. .010".

(2) With the vertical magnets electrically operated the vertical armature shall strike both magnet cores. This requirement is met if, when the armature is in contact with one core, the space between the armature and closest point on the other core does not exceed .002". Use the KS-6909 gauge. Figure 9A.

(b) Checking Procedures

(1) Check by feel on the first, fifth and tenth levels.

(2) This requirement shall be checked with the shaft on the first, fifth and tenth levels. Use the KS-6909 gauge.

To check this requirement insert the .010" blade of the KS-6909 gauge between the top of the vertical dog and the undersurface of the vertical tooth. The gauge should not enter or should be tight.

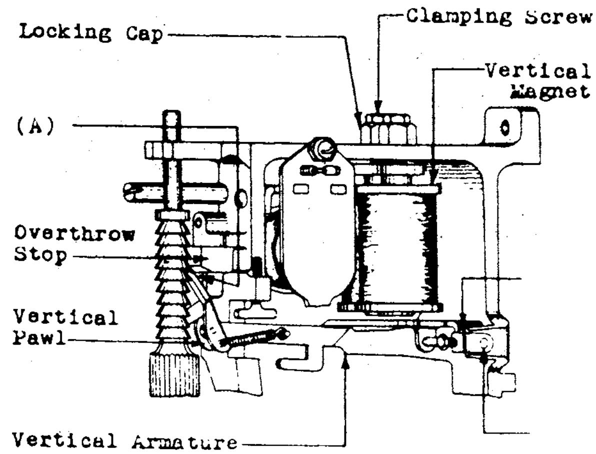

FIGURE 7

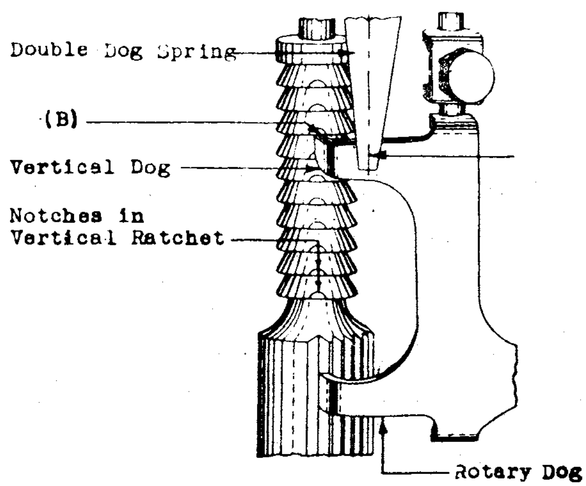

FIGURE 8

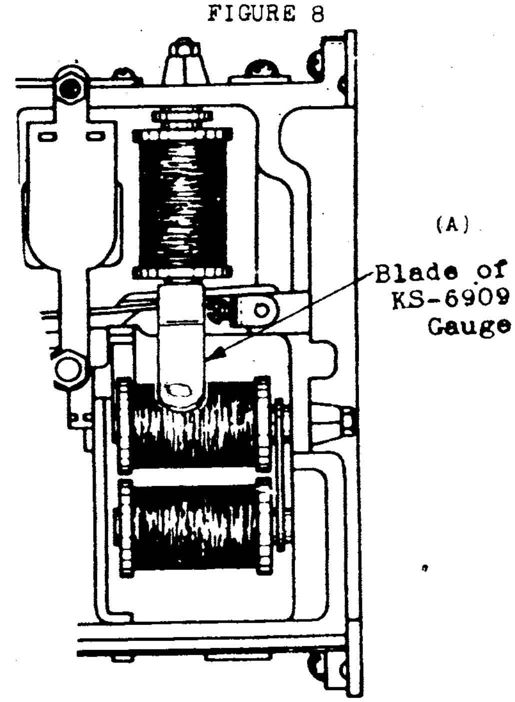

FIGURE 9

8. HORIZONTAL ALIGNMENT OF VERTICAL DOG

(a) Requirement: With the shaft at rotary normal and with the vertical dog engaging the vertical ratchet, the tip of the vertical dog shall ride within the notches in the teeth as the shaft is moved vertically. (On switches equipped with a commutator wiper this requirement shall be met with the shaft spring bracket held against the left side of the normal post.) Figure 10(A).

(b) Checking Procedures: Gauge by eye.

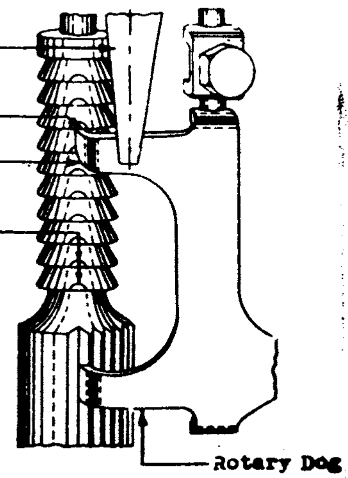

FIGURE 10

9. VERTICAL ALIGNMENT OF VERTICAL DOG

(a) Requirement: With the vertical magnet electrically operated and the shaft at rest the vertical dog shall drop all the way in on all levels after the double dog is pulled free from the vertical ratchet and then allowed to restore slowly. On at least one level the vertical dog shall not allow a drop of more than .003" in the shaft when the armature is released. With the shaft at rotary normal and the rotary dog engaged with the rotary ratchet it shall be possible to raise the shaft without moving the vertical dog, but this movement shall not exceed Max. .010". Figure 11(A).

(b) Checking Procedures: This requirement should be checked with the play between the lower lug of the double dog and the casting taken up in a downward direction. Gauge by eye.

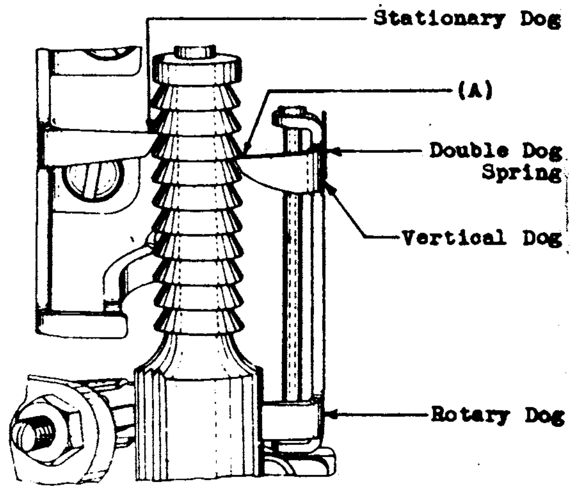

FIGURE 11

10. DEPTH ENGAGEMENT OF VERTICAL DOG

(a) Requirement: Depth of Engagement of Vertical Dog - Figure 12(A): With the shaft at rotary normal and the rotary dog engaged with the rotary ratchet it shall be possible to raise the shaft without moving the vertical dog, but this movement shall not exceed Max. .010". Figure 12(A).

(b) Checking Procedures: This requirement shall be checked on the first, fifth and ninth levels. (On switches equipped with a commutator wiper the requirement shall be met with the shaft spring bracket held against the left side of the normal post.)

To check this requirement insert the proper blade of the KS-6909 gauge between the top of the vertical dog and the under-surface of the vertical tooth as shown in Figure 13.

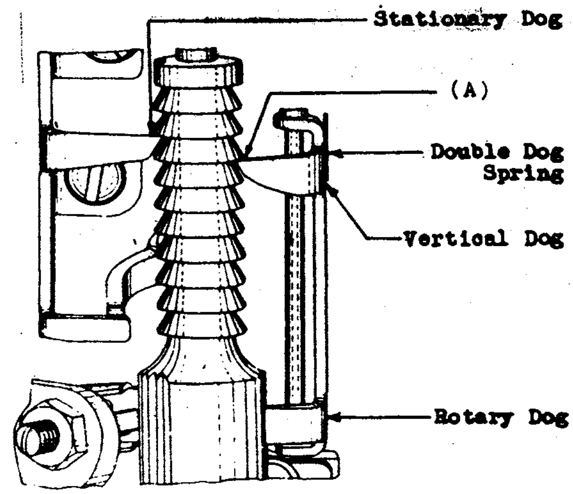

FIGURE 12

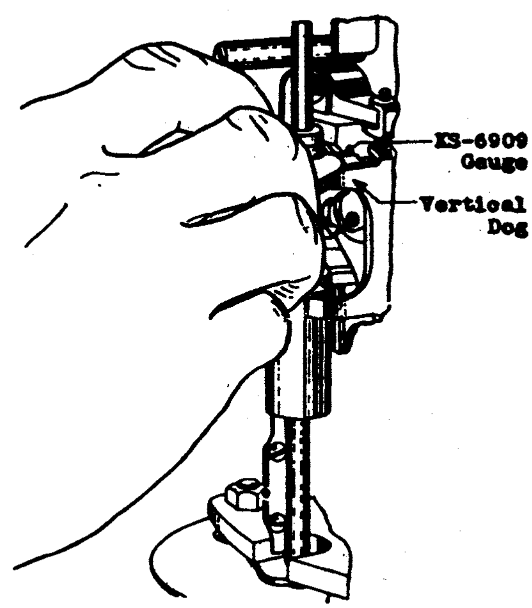

FIGURE 13

11. HORIZONTAL ALIGNMENT OF STATIONARY DOG

(a) Requirement: With the play between the shaft spring bracket and the left side of the normal post taken up by applying a light pressure to the shaft spring bracket near the normal post.

(1) The front side of the stationary dog shall clear the nearest vertical tooth during vertical motion of the shaft from vertical normal to the tenth level, but this clearance shall be Max. .004". Fig.14(A).

(2) There shall not be any bind between the stationary dog and the lowest vertical tooth as the shaft is moved to its uppermost position.

(b) Checking Procedure: Use the KS-6909 gauge.

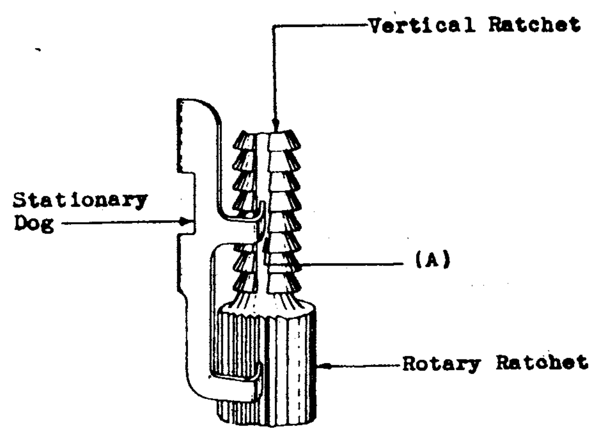

FIGURE 14

12. VERTICAL ALIGNMENT OF STATIONARY DOG

(a) Requirement

(1) The stationary dog shall not cause any rise nor more than a perceptible (.003") drop as it cuts in on the fifth level. Figure 15(A).

(2) With the rotary magnets energized so as to step the switch from rotary normal to the first rotary step, the shaft shall rest on the stationary dog so that the vertical dog will drop all the way in when the double dog is pulled away from the shaft and allowed to restore slowly. This shall be met on all levels with the play between the lower lug of the double dog and the casting taken up in a downward direction.

(b) Checking Procedure: Gauge by eye.

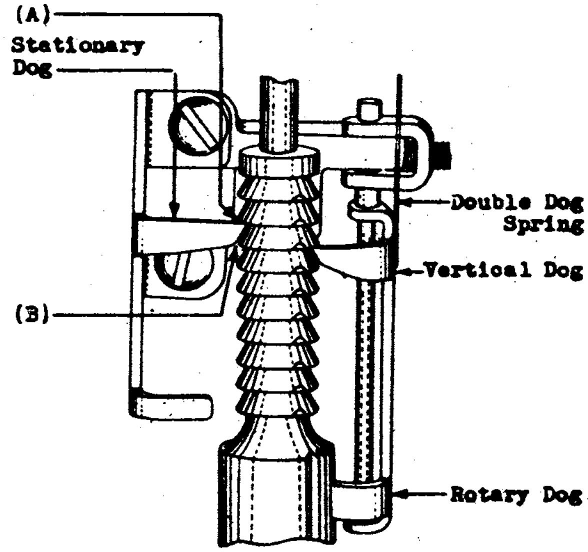

FIGURE 15

13. DEPTH ENGAGEMENT OF STATIONARY DOG

(a) Requirement: With the shaft cut in on the second rotary step and the double dog disengaged from the shaft it shall be possible to move the shaft vertically but this movement shall not exceed Max. .010". Figure 16(A).

(b) Checking Procedures: Gauge the minimum by feel and the maximum value with a KS-6909 gauge. This requirement shall be checked on the first, fifth and tenth levels. There shall be a freedom from binding on all other rotary steps. Gauge by feel.

With the switch at the proper level and rotary position, gently lift the shaft and measure the vertical movement of the shaft by inserting the proper blade of the KS-6909 gauge between the upper edge of the stationary dog and the under surface of the vertical tooth, see Figure 16A.

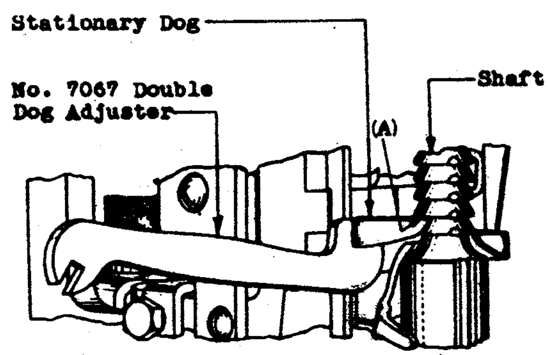

FIGURE 16

14. VERTICAL ARMATURE SPRING POSITION

(a) Requirement: There shall be a perceptible clearance between the verticle armature spring and the release armature in its operated position.

(b) Checking Procedures: Gauge by eye.

J. P. Kelly,

Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 303
PART 2
ADJUSTING PROCEDURES FOR VERTICAL MOVEMENT
197 TYPE SWITCHES

1. VERTICAL PAWL PLAY

(c) Adjusting Procedures: If the vertical pawl binds or has an excessive amount of side play. The vertical armature should be replaced.

2. VERTICAL ARMATURE PLAY

(c) Adjusting Procedures: If the vertical armature binds on the vertical armature bearing pin clamp, or has excessive side play, loosen the bearing pin clamp screw and shift the clamp slightly as required. Use the No. 556A wrench.

3. VERTICAL PAWL POSITION
4. CLEARANCE BETWEEN VERTICAL PAWL FINGER AND VERTICAL PAWL GUIDE
5. CLEARANCE BETWEEN VERTICAL PAWL AND VERTICAL TEETH

(c) Adjusting Procedures:

(1) To realign the vertical pawl horizontally, place the slotted offset end of the No. 13398 armature adjuster over the armature just above and to the rear of the arm which controls the release link and adjust the armature to the right or left as required. See Figure 1.

(2) Make the adjustment for clearance between the vertical pawl finger and vertical pawl guide and between the vertical pawl and the vertical teeth at the same time, by adjusting the vertical pawl guide with the No. 485A pliers. To increase the clearance between the vertical pawl finger and the vertical pawl guide, adjust the guide downward. To increase the clearance between the vertical pawl and the vertical teeth, adjust the guide upward.

6. DOUBLE DOG PLAY

(c) Adjusting Procedures: To increase or decrease the vertical play of the double dog, loosen the set screw in the bearing pin clamp with a No. 556A wrench. Move the bearing pin up or down as required. Securely tighten all screws.

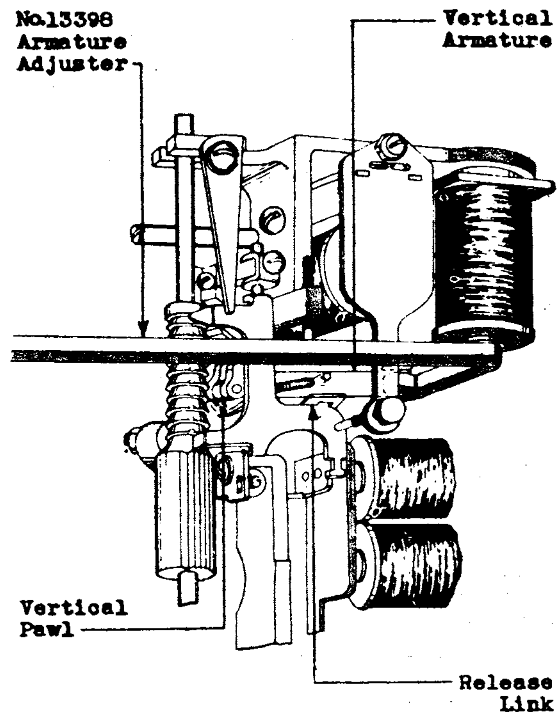

FIGURE 1

7. VERTICAL MAGNET POSITION

(c) Adjusting Procedures:

(1) If the play between the vertical pawl and the casting is insufficient, lower the magnet slightly. To change the position of the vertical magnets, loosen the clamping screw with the No. 418A wrench, Then place the No. 417A wrench over the locking cap and turn the wrench in a clockwise direction to lower the magnets and in a counter-clockwise direction to raise the magnets. Retighten the clamping screws each time the position of the magnets is changed and recheck for gap and play. Turning the locking cap also turns the adjusting screw, which changes the position of the vertical magnet. See Figure 2 (A) and (B).

If the play between the top of the vertical dog and the under surface of the tooth is too great this may be due to the vertical magnets being located too low with respect to the vertical armature, the misalignment of the shaft bearings or to incorrect adjustment of the vertical dog.

(2) If the .002" gauge does not fit tight, adjust the magnet farthest away from the armature, closer to the armature as described in (1).

8. HORIZONTAL ALIGNMENT OF VERTICAL DOG
9. VERTICAL ALIGNMENT OF VERTICAL DOG
10. DEPTH ENGAGEMENT OF VERTICAL DOG

(c) Adjusting Procedures:

(1) If the vertical dog does not ride within the notches in the vertical ratchet, hold the double dog stationary with No. 485A smooth jaw pliers and adjust the vertical dog toward or away from the switch frame as required with the No. 7067 double dog adjuster. See Figure 3.

(2) If the vertical dog does not drop in on all levels, adjust the tip of the vertical dog downward as required with the No. 7067 double dog adjuster. See Figure 4.

(3) If there is a drop in the shaft of more than .003" on all levels when the vertical armature is released, raise the shaft to the level where there is the least amount of drop. Then adjust the tip of the vertical dog upward with the No. 7067 double dog adjuster until there is no drop in the shaft on this level when the vertical magnets are deenergized. See Figure 4.

(4) To change the depth of engagement between the beveled surface of the shaft tooth and the vertical dog, adjust the dog toward or away from the shaft with the No. 7067 double dog adjuster as shown in Figure 4.

(5) After making any of the adjustments described in (2) to (4) inclusive, recheck the clearance between the vertical pawl and the casting in accordance with the following paragraph.

With the vertical magnets electrically operated and the double dog held away from the ratchet there shall be vertical movement of the shaft when a force sufficient to take up any vertical pawl bearing play is applied to the shaft alternately in an upward and downward direction. This requirement shall be checked with the shaft on the first, fifth and tenth levels.

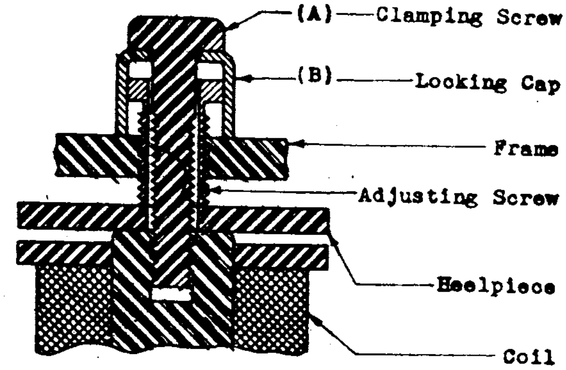

FIGURE 2

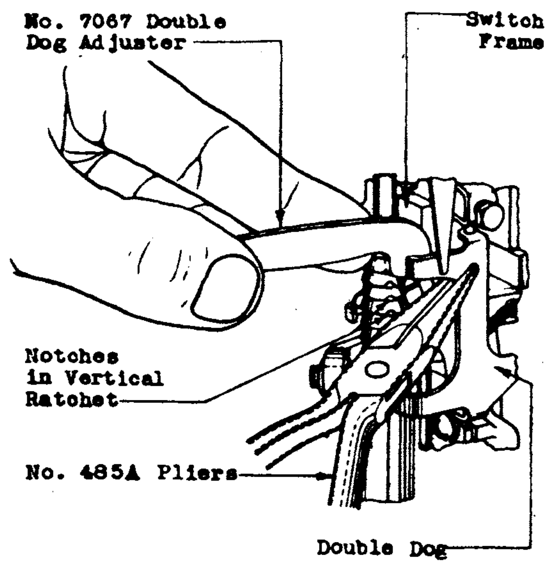

FIGURE 3

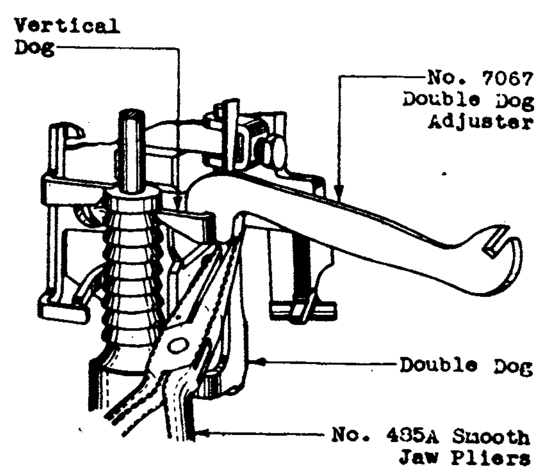

FIGURE 4

11. HORIZONTAL ALIGNMENT OF STATIONARY DOG
12. VERTICAL ALIGNMENT OF STATIONARY DOG
13. DEPTH ENGAGEMENT OF STATIONARY DOG

(c) Adjusting Procedures:

(1) To adjust for horizontal alignment of the stationary dog, adjust the stationary dog toward or away from the switch frame as required with the No. 7067 double dog adjuster. See Figure 5.

(2) If the stationary dog does not take the weight of the shaft during rotary motion or if there is a perceptible rise or fall in the shaft as it cuts in, adjust the stationary dog upward or downward with the No. 7067 double dog adjuster. See Figure 6.

(3) To change the depth of engagement of the stationary dog, adjust the stationary dog toward or away from the shaft with the No. 7067 double dog adjuster. See Figure 6.

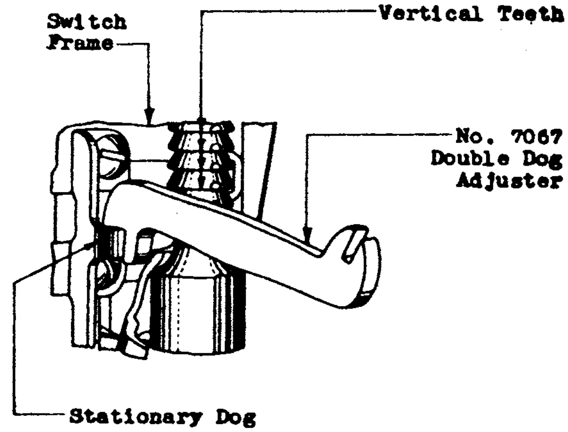

FIGURE 5

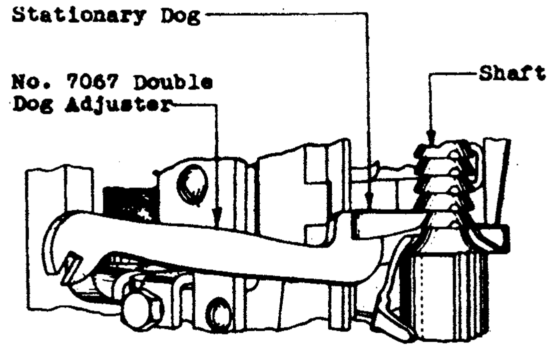

FIGURE 6

14. VERTICAL ARMATURE SPRING POSITION

(c) Adjusting Procedures: If the vertical armature spring does not clear the release armature when the release armature is in its electrically operated position, move the spring farther away from the release armature until the specified clearance is obtained.

J. P. Kelly,

Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 304
PART 1
REQUIREMENTS AND CHECKING PROCEDURES FOR DOUBLE DOG AND RELEASE
197 TYPE SWITCHES

1. ALIGNMENT OF DOUBLE DOG SPRING

(a) Requirement: The double dog spring shall be free from irregular bends or excessive bowing and the centerline of its broad surface shall be approximately parallel to the shaft. Figure 1(A).

(b) Checking Procedure: Gauge by eye.

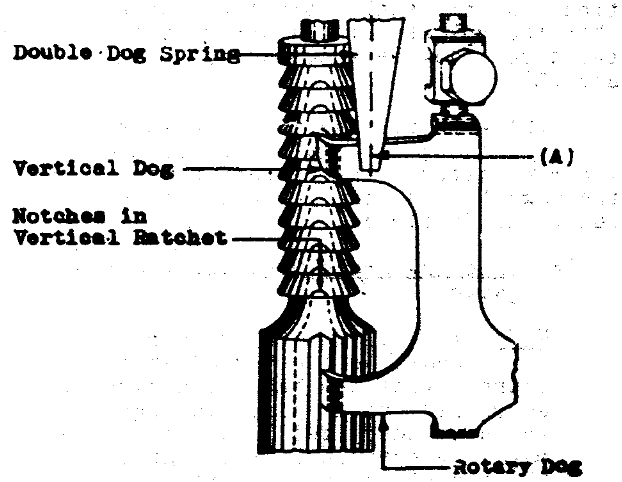

FIGURE 1

2. DOUBLE DOG SPRING TENSION

(a) Requirement: The tension of the double dog spring with the release magnet energized shall be as follows. See Figure 2(A).

Min. 250 grams
Max. 400 grams

(b) Checking Procedure: Use the No. 62B gauge and check the tension at a point just above the double dog.

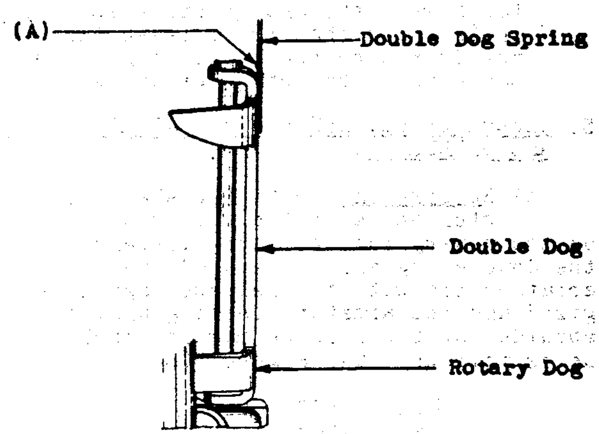

FIGURE 2

3. CLEARANCE BETWEEN ROTARY DOG AND ROTARY TEETH

(a) Requirement: There shall be a clearance between the tip of the rotary dog and the tip of the rotary teeth on each step of the fifth level of:

Min. .030"
Max. .045"

See Figure 3(A).

(b) Checking Procedure: With the double dog engaged in the release link, measure the clearance with the R-80223 gauge as shown in Figure 3(A).

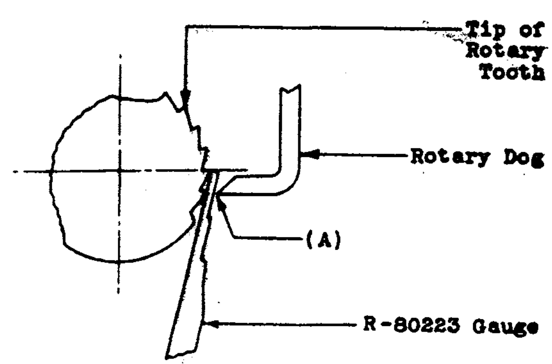

FIGURE 3

4. RELEASE ARMATURE PIN POSITION

(a) Requirement

(1) With the release armature at rest in its electrically operated position, the pin shall hold the double dog so that the release link drops completely over the double dog release tooth. Figure 4(A) and (B).

(2) With release magnet electrically energized against a .006" gauge inserted between the release armature and the magnet core, the release link shall not latch the double dog.

(b) Checking Procedure: Use the KS-6909 gauge.

NOTE: The (1) and (2) requirements shall be checked after the release magnet has been electrically energized, deenergized and again electrically energized. With the release magnet electrically reenergized check (1) and (2) by raising the release link with a KS-6320 orange stick. In (1) note that the release link drops completely over the double dog release tooth when the orange stick is removed. In (2) note that the release link does not drop over the double dog release tooth when the orange stick is removed.

5. CLEARANCE BETWEEN RELEASE ARMATURE PIN AND DOUBLE DOG

(a) Requirement: With the shaft up one step and with the rotary dog resting on the rotary ratchet, the clearance between the double dog and the end of the release armature pin with the release magnet deenergized and the armature resting against the shoulder of the release magnet bracket shall be as follows. See Figure 5(A).

Min. .060"
Max. .120"

(b) Checking Procedure: Use the R-80223 gauge.

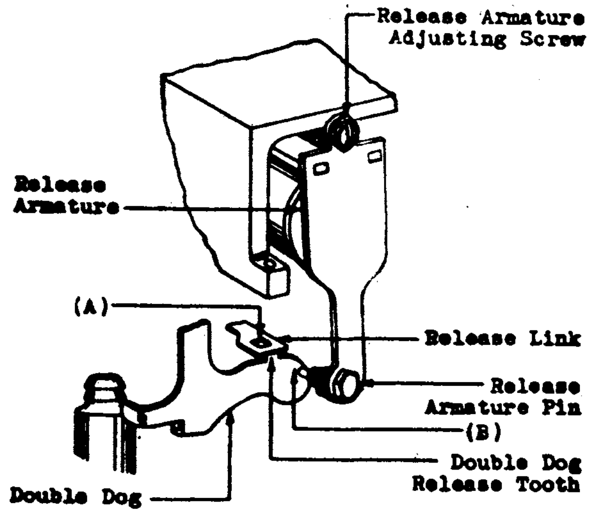

FIGURE 4

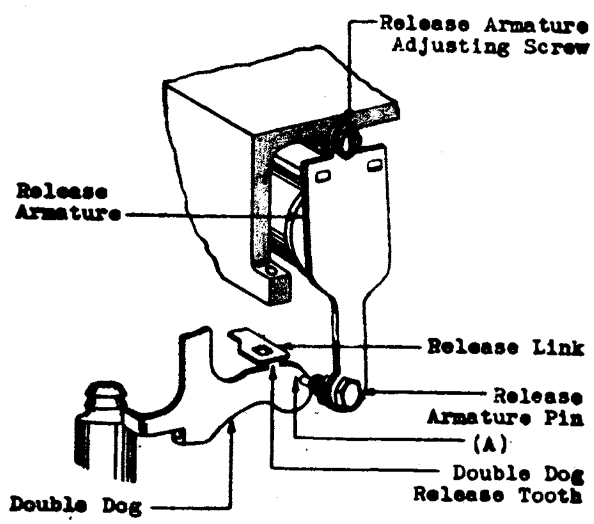

FIGURE 5

J. P. Kelly,

Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 304
PART 2
ADJUSTING PROCEDURE FOR DOUBLE DOG AND RELEASE
197 TYPE SWITCHES

1. ALIGNMENT OF DOUBLE DOG SPRING
2. DOUBLE DOG SPRING TENSION

(c). Adjusting Procedure

(1) Change the tension of the double dog spring by loosening the mounting screw with the Nos. 563A and 564A offset screwdrivers and bringing the spring forward until it is at right angles to the shaft. Alter the tension of the double dog spring as required by drawing it between the thumb and the forefinger. Exercise care not to get any kinks, sharp bends or unnecessary bow in the spring when making this adjustment. Place the spring in its proper position, tighten the mounting screw and recheck the tension.

3. CLEARANCE BETWEEN ROTARY DOG AND ROTARY TEETH

(c) Adjusting Procedure: To change the clearance between the rotary dog and the rotary teeth, operate the switch to the fifth level and loosen the release link mounting screw with the No. 418A wrench, after which the link may be shifted as required to meet this requirement. Before tightening the release link mounting screw, see that the double dog release tooth centers approximately in the slot of the release link. Check that this requirement is met on each tooth of the rotary ratchet and readjust if necessary.

4. RELEASE PIN POSITION

(c) Adjusting Procedure: If the release link does not drop over the double dog release tooth as specified, loosen the release armature pin lock nut with the No. 418A wrench and turn the armature pin in a clockwise or counter-clockwise direction as required. Use the No. 417A wrench to turn the release armature pin.

5. CLEARANCE BETWEEN RELEASE ARMATURE PIN AND DOUBLE DOG

(c) Adjusting Procedure: To adjust for clearance between the release armature pin and the double dog, loosen the lock nut on the release armature adjusting screw with the No. 418A wrench, and turn the screw in the required direction with the No. 417A wrench.

J. P. Kelly,

Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 305
PART 1
REQUIREMENTS AND CHECKING PROCEDURES FOR SPRINGS ASSEMBLIES
197 TYPE SWITCHES

VERTICAL OFF-NORMAL SPRINGS

1. CLEARANCE BETWEEN NORMAL PIN AND OFF-NORMAL FINGER ON FIRST ROTARY STEP

(a) Requirement: With the shaft up one and in one step, the normal pin shall clear the off-normal finger by Min. .010". Figure 1(A).

(b) Checking Procedure: Gauge by eye.

2. CLEARANCE BETWEEN NORMAL PIN CLAMP AND OFF-NORMAL FINGER ON LAST ROTARY STEP

(a) Requirement: With the shaft on the last rotary step of the first level there shall be clearance between the normal pin clamp and the off-normal finger. Figure 1(B).

(b) Checking Procedure: Gauge by eye.

3. CONTACT SEPARATION

(a) Requirement: The contact separation for make or break contacts shall be: Min. .008".

(b) Checking Procedure: Gauge by eye. The separation for break contacts shall be measured with the shaft in the rotary normal position.

4. CLEARANCE BETWEEN LEVER STUD AND FIRST LEVER SPRING

(a) Requirement: When the No. 1 spring is a make contact there shall be clearance between the stud on the off-normal lever and the first lever spring when the off-normal finger is in its highest position, but this clearance shall not be great enough to cause a bind between the normal pin and the off-normal finger which will prevent the restoration of the shaft when it is released from the third contact of the first level. Figure 2(A).

(b) Checking Procedure: To check this requirement force the stop on the off-normal lever against the casting. This will put the off-normal finger in its highest position.

5. CLEARANCE BETWEEN LEVER SPRING AND STUD OF NEXT LEVER SPRING

(a) Requirement: There shall be a clearance between a lever spring and the stud on the next lever spring to the left, when the left-hand spring is associated with a make contact, with the off-normal finger in its highest position of Min. .002". Figure 2(B).

(b) Checking Procedure: Use the KS-6909 gauge.

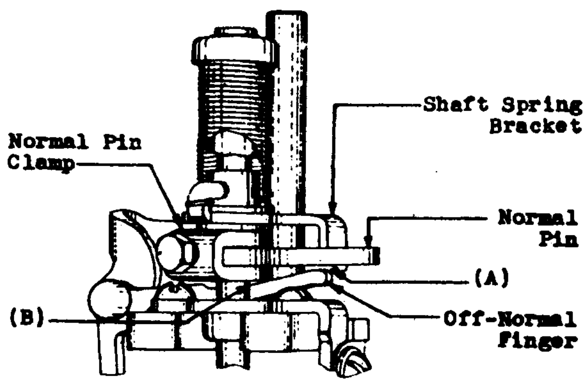

FIGURE 1

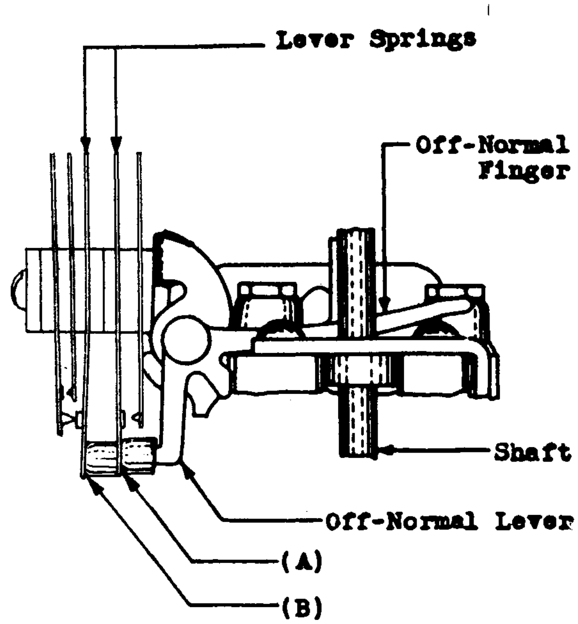

FIGURE 2

This Training Outline includes material from BSP A477.002, Issue 4-D and Addendum A477.002, Issue 2-D

6. CONTACT PRESSURE

(a) Requirement: The contact pressure shall be:

Test Min. 25 grams
Readjust - Min. 30 grams

(b) Checking Procedure: Use the number 70D gauge. The combined tension of the springs shall not be sufficient to prevent the shaft from restoring to its normal position, from any rotary level.

J. P. Kelly,

Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 305
PART 2
ADJUSTING PROCEDURE FOR SPRING ASSEMBLIES
197 TYPE SWITCHES

VERTICAL OFF-NORMAL SPRINGS

1. CLEARANCE BETWEEN NORMAL PIN AND OFF-NORMAL FINGER ON FIRST ROTARY STEP

2. CLEARANCE BETWEEN NORMAL PIN CLAMP AND OFF-NORMAL FINGER ON LAST ROTARY STEP

(c) Adjusting Procedure:

(1) If either of these clearance requirements are not met check to see that the first lever spring is approximately parallel to the shaft. If it is not, adjust it as necessary with the KS-7782 pliers.

(2) If the first lever spring is approximately parallel to the shaft and there is insufficient clearance between the normal pin and the off-normal finger on the first rotary step or between the normal pin clamp and the off-normal finger on the tenth or eleventh rotary steps, adjust the off-normal finger downward with the KS-7782 pliers as shown in Figure 1. Do not adjust the off-normal finger more than is necessary to insure adequate clearance, since the adjustment of this finger affects the contact separation, contact pressure and clearance requirements for the off-normal spring.

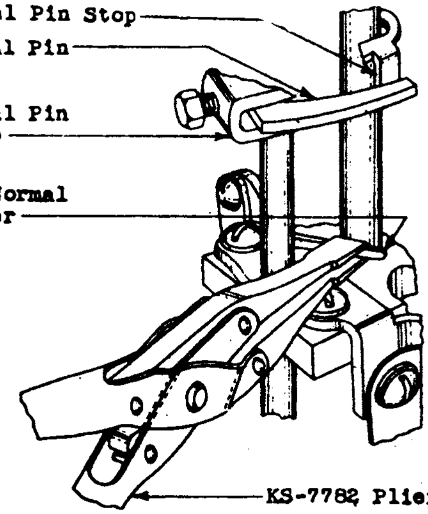

FIGURE 1

3. CONTACT SEPARATION
4. CLEARANCE BETWEEN STUD ON OFF-NORMAL LEVER AND FIRST LEVER SPRING
5. CLEARANCE BETWEEN LEVER SPRING AND STUD OF NEXT LEVER SPRING
6. CONTACT PRESSURE

(c) Adjusting Procedure

(1) Check to see that the first lever spring is approximately parallel to the shaft and if necessary adjust it with the KS-7782 pliers.

(2) If these requirements are met and if the off-normal finger in its highest position interferes with the restoration of the switch when it is released from the third contact of the first level, loosen the vertical off-normal spring assembly mounting screws with the Nos. 563A and 564A offset screwdrivers and shift the spring assembly in the direction to decrease the clearance between the off-normal lever and the casting. However, do not move the assembly so far in this direction as to prevent proper operation of the spring assembly. If the off-normal finger still interferes with the restoration of the switch, adjust the off-normal finger downward with the KS-7782 pliers as shown in Figure 1.

This Training Outline includes material from BSP A477.002, Issue 4D and Addendum A477.002, Issue 2D

3, 4, 5 AND 6 CONTINUED

(3) To change the contact separation, the clearance between the stud on the off-normal lever and the first lever spring or the clearance between the first lever spring and the stud of the next lever spring, adjust the stationary springs toward or away from their respective lever springs as required using the KS-7782 pliers applied near the insulators.

(4) If the contact separation, the clearance between the stud on the off-normal lever and the first lever spring or the clearance between the first lever spring and stud of the next lever spring, cannot be met by adjusting the individual springs, shift the off-normal spring assembly slightly as outlined in (2).

(5) Change the contact pressure or follow by increasing or decreasing the tension of the associated lever springs. In certain cases it also may be necessary to change the position of the stationary springs. Exercise care when adjusting the springs that the contact separation is not below the specified minimum and that the combined tension of the springs is not so great as to prevent the shaft from returning to vertical normal. If the contact pressure or follow requirements cannot be met it will be necessary to shift the off-normal spring assembly slightly.

(6) If the shaft of switches equipped with vertical off-normal springs per Figure 2 is moved by hand from its vertical normal position, permit it to drop by its own weight from at least the first level to insure that it will return to its vertical normal position.

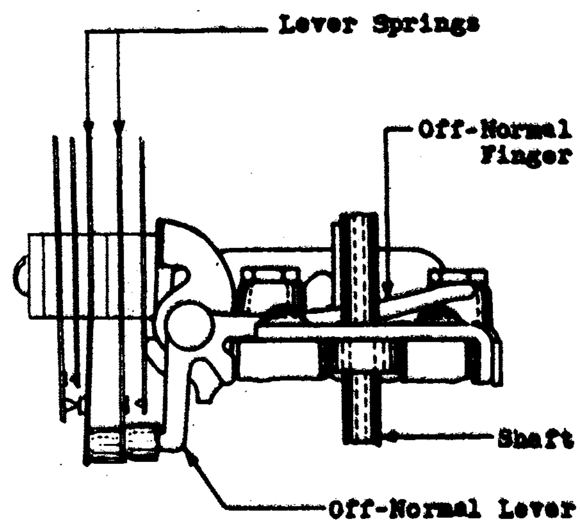

FIGURE 2

J. P. Kelly,

Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 306
PART 1
REQUIREMENTS AND CHECKING PROCEDURES FOR BANKS AND WIPERS
197 TYPE SWITCHES

BANK AND BANK WIPERS

1. POSITION OF BANKS

(a) Requirement: The bank rod collars shall secure all banks firmly and the topmost bank shall be in contact with at least one of the two bank rod assembly locating shoulders.

(b) Checking Procedure: Gauge by eye and feel.

2. WIPER ASSEMBLY POSITION

(a) Requirement: Wiper assemblies shall set at approximately right angles to the shaft.

(b) Checking Procedure: Gauge by eye.

3. ALIGNMENT OF WIPER SPRINGS

(a) Requirement: The wiper springs shall be in approximate vertical alignment at their tip ends and shall be tight on the wiper hub. Figure 1(A).

(b) Checking Procedure: Gauge by eye and feel.

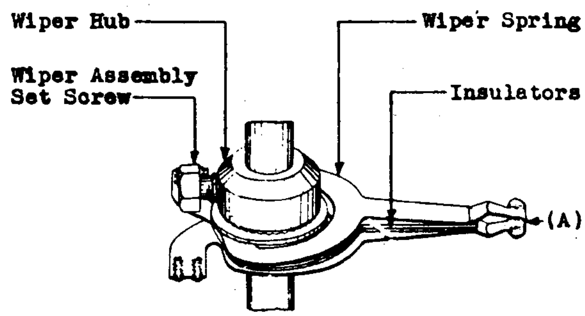

FIGURE 1

4. POSITION OF WIPER TIPS ON THE BANK CONTACTS

(a) Requirement

(1) The wipers shall rest on the bank contacts on their tips only and the upper and lower wiper tips shall rest on the bank contacts at approximately equal angles. Figure 2(A).

(2) The bank wipers shall overlap the end of each associated bank contact by at least 3/64". Figure 2(B).

(b) Checking Procedure

(1) Gauge by eye.

(2) This requirement shall be gauged by eye on the first and tenth contacts of the lowest bank level with which the wiper makes contact.

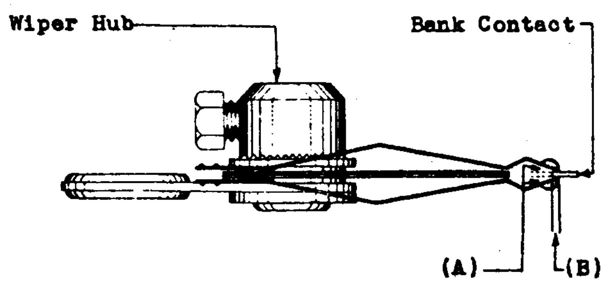

FIGURE 2

5. NORMAL POSITION OF WIPER TIPS

(a) Requirement

Single Conductor Wipers - Figure 3(A).

(1) The springs of all single conductor wipers shall touch at their tip ends.

(2) Wipers Having One Insulator: There shall be a clearance between at least one wiper spring and the end of the insulator.

Two Conductor Wipers - Figure 3(A): The separation between the tip ends of the springs of all two conductor wipers when not contacting the bank terminals shall be:
Min. .010"
Max. .020"

(b) Checking Procedure:

Wipers Having One Insulator: There shall be a clearance between at least one wiper spring and the end of the insulator. This requirement is met if with the insulator pressed lightly against one spring, there is a clearance between the other spring and the free end of the insulator.

Wipers Having Two Insulators: There shall be a clearance between at least one wiper spring and the ends of the insulators with the insulators held together. This requirement is met if with the insulators pressed lightly against one spring, there is a clearance between the other spring and the free end of the insulators. Use the KS-6909 Gauge and gauge by eye.

6. WIPER SPRING TENSION

(a) Requirement: The wiper springs shall have enough tension so that when the pressure of one spring in the pair is removed its mate will follow approximately the distance between two adjacent bank levels.

(b) Checking Procedure: Gauge by eye.

7. ALIGNMENT OF WIPERS WITH THE BANK LEVELS

(a) Requirement

(1) With the play between the shaft spring bracket and the left side of the normal post taken up by applying a light pressure to the shaft spring bracket near the normal post, the wipers shall not touch the banks when moving vertically. See Figure 4.

(2) The centerline between the tips of the wiper springs shall coincide with the centerline of the bank contact levels within ±1/64" when the wiper is about to cut in on the bank.

(b) Checking Procedure: Check requirements on contact 1 at the fifth level. Gauge by eye.

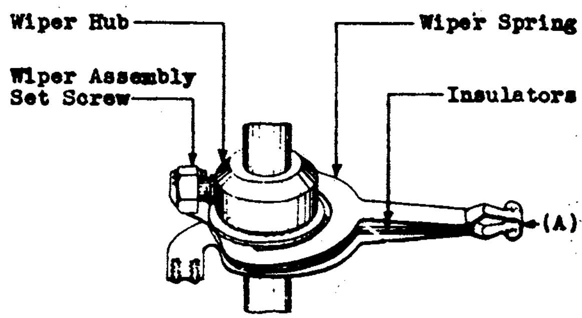

FIGURE 3

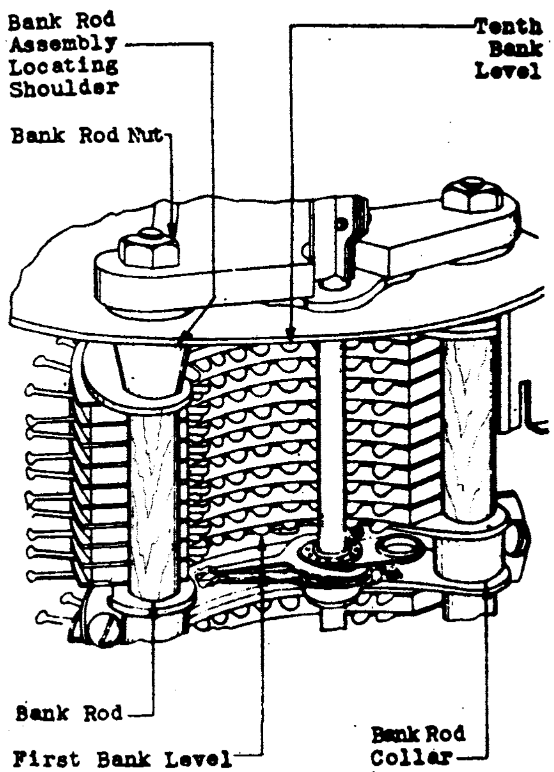

FIGURE 4

8. CENTERING OF WIPERS ON THE BANK CONTACTS

(a) Requirement

(1) The wipers shall center on the sixth contact of the first and tenth levels. Figure 5(A).

(2) If, when placed on the first and tenth contacts of these levels, the wipers do not center approximately, they shall rest either as far to the right of the center on the tenth as they are to the left of the center on the first, or as far to the left of the center on the tenth as to the right of the center on the first.

(b) Checking Procedure: Gauge by eye.

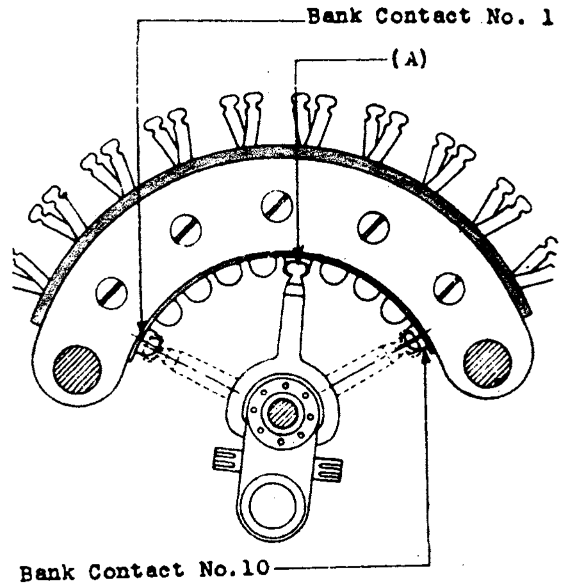

FIGURE 5

Rot. 10T Cont Pr. 1+2 – 150-300

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OPERATION TRAINING OUTLINE NO. 306
PART 2
ADJUSTING PROCEDURE FOR BANKS AND WIPERS
197 TYPE SWITCHES

BANK AND BANK WIPERS

1. POSITION OF BANKS

(c) Adjusting Procedure: To change the position of the banks, loosen the clamping screws in the bank rod collars with the R-2443 screwdriver and shift the banks on the bank rods as required. Then tighten the clamping screws securely, observing that the bank rod collars are turned on the bank rods as far as possible in a direction away from the wipers, so that each bank rod collar engages with the bank above and below it.

2. WIPER ASSEMBLY POSITION

(c) Adjusting Procedure: If the wiper assembly does not set at approximately right angles to the shaft, adjust the springs by placing the index finger against one spring as near to the hub as possible and pressing upward or downward as required until the springs set at approximately right angles to the shaft. Exercise care when alighing the springs in this manner not to introduce sharp bends into the springs.

3. ALIGNMENT OF WIPER SPRINGS

(c) Adjusting Procedure: Where the wiper springs are not in proper vertical alignment, the wiper assembly should be replaced with one that meets the requirements.

4. POSITION OF WIPER TIPS ON BANK CONTACTS
5. NORMAL POSITION OF WIPER TIPS
6. WIPER SPRING TENSION

(c) Adjusting Procedure

(1) If the wiper assembly position or wiper spring forming requirements are not met readjust the wiper springs as required with the 363 Adjuster, applied as shown in Figure 1.

(2) If the position of the wiper tips on the bank contacts, or the separation between the wiper tips is not satisfactory, adjust the tips of the springs with the No. 363 spring adjusters as shown in Figure 2.

(3) To increase the tension of the wiper springs, apply the KS-7782 pliers to the circular part of the spring first on one side, as shown in Figure 3 and then on the opposite side, with the shaft rotated to the tenth rotary step. Twist the pliers in a direction to force the wiper spring toward its opposing spring. Repeat this operation on the other spring of the pair, equalizing the adjustment so that the follow on both springs of the pair will be approximately the same.

(4) If the bank wipers do not overlap the bank contacts as specified, loosen the bank rod nuts with the R-2743 wrench, shift the banks toward the front of the switch and tighten the bank rod nuts securely.

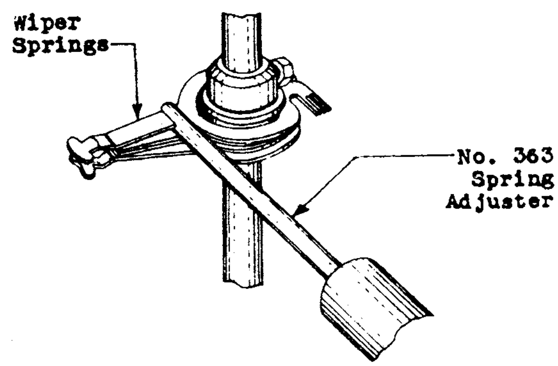

FIGURE 1

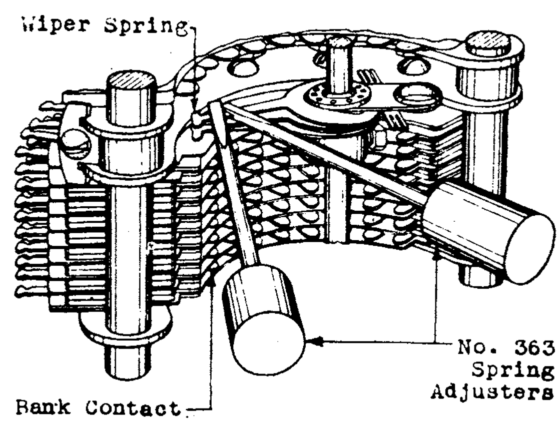

FIGURE 2

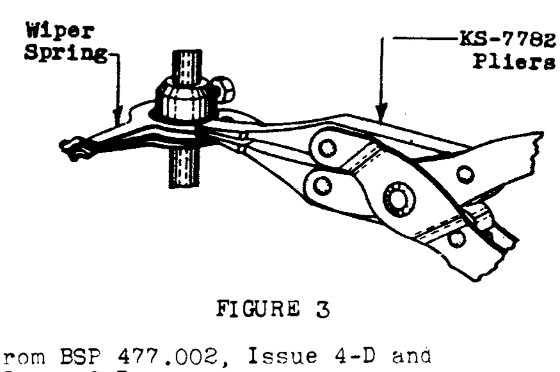

FIGURE 3

7. ALIGNMENT OF WIPERS WITH THE BANK LEVELS
8. CENTERING OF WIPERS ON THE BANK CONTACTS

(c) Adjusting Procedure

(1) Loosen the set screw in the wiper hub with the 555A wrench. Raise the shaft to the required level and raise or lower the assembly until the wipers center with the bank level. Tighten the set screw finger tight and then rotate the shaft to the sixth contact. Note that both blades of the wiper rest on the bank contacts at equal angles. If necessary, raise or lower the assembly slightly to obtain this condition.

(2) Center the wipers on the sixth contact. To do this loosen the set screw in the wiper hub and turn the wiper to the right or left as required. It is advisable to support the shaft and hold the wiper assembly firmly while loosening or tightening the wiper set screws. After the wipers have been centered properly, carefully restore the shaft to rotary normal and see that the vertical alignment has not changed. If any change is required in the vertical alignment exercise care not to disturb the horizontal alignment. Tighten the wiper set screw. Take care when using the offset wrench not to tighten the screw too securely as this may cause bending of the shaft.

(3) After aligning an upper wiper whose hub is turned up, operate the switch to the tenth level and note whether or not the wiper strikes against the lower shaft bearing. If the wiper strikes against the bearing, it will be necessary to invert the upper wiper so that the hub will be below the springs.

(4) Where wipers cannot be centered properly, it may be necessary to loosen the bank nuts and shift the bank slightly to meet these requirements.

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OPERATION TRAINING OUTLINE NO. 307
PART 1

REQUIREMENTS AND CHECKING PROCEDURES FOR
221, 222, 224 AND 248 RELAYS

1. RELAY MOUNTING

(a) Requirement: Relays shall be fastened securely to the mounting plate.

(b) Checking Procedure: Gauge by feel.

2. VERTICAL CLEARANCE BETWEEN RELAYS

(a) Requirement

(1) There shall be a clearance between the armature or springs of any relay and the armature, springs or heelpiece of the relay above or below it of Min. 1/32".

(2) There shall be a clearance between the armature back stop and the heelpiece of the relay above it.

(b) Checking Procedure: Gauge by eye.

3. CONTACT ALIGNMENT

(a) Requirement: Contacts shall not be out of alignment more than 40% of their base diameter. Figure 1(A).

(b) Checking Procedure: Gauge by eye.

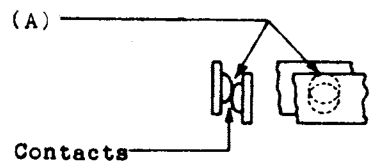

FIGURE 1

4. STRAIGHTNESS OF SPRINGS

(a) Requirement: All springs, from the point where they leave the assembly clamping plates and insulators, to the ends of the springs, shall be free of sharp bends or kinks due to adjustment, but a Max. 1/32" bow in the springs is permissible.

(b) Checking Procedure: Gauge by eye.

5. ARMATURE MOVEMENT

(a) Requirement: The armature shall move freely in its bearings and the end play when measured in line with the axis of the bearings shall be Max. .020". Figures 2(A) and 3(A).

(b) Checking Procedure: Use the KS-6909 gauge.

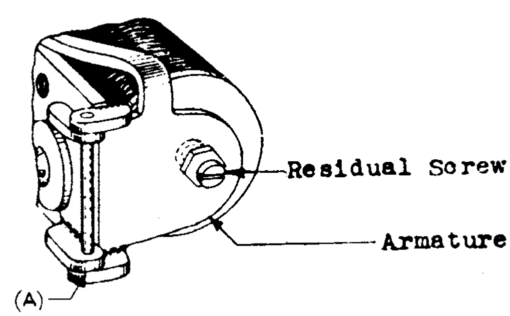

FIGURE 2

6. RESIDUAL AIR-GAP

(a) Requirement: The relays shall meet the residual air-gap requirement specified on the Circuit Requirement Table. Figure 4(A).

(1) Where the letter "S" is specified in the residual column on the Circuit Requirement Table, this shall be interpreted to mean that the armature shall not touch the core when the relay is electrically energized.

Type of Relay	Residual Air-Gap
(A) 221-A	7-11
(B) 248-D	1.5-4
(C) 221-CL	S-4
(D) 222-KM	S-4
(E) 221-DU	0
(F) 222-J	S-4
(G) 221-T	S-4
(K) 224-D	S-4

NOTE: Information in this requirement table for "Residual Air Gap" taken from Circuit Requirement Table on associated drawing.

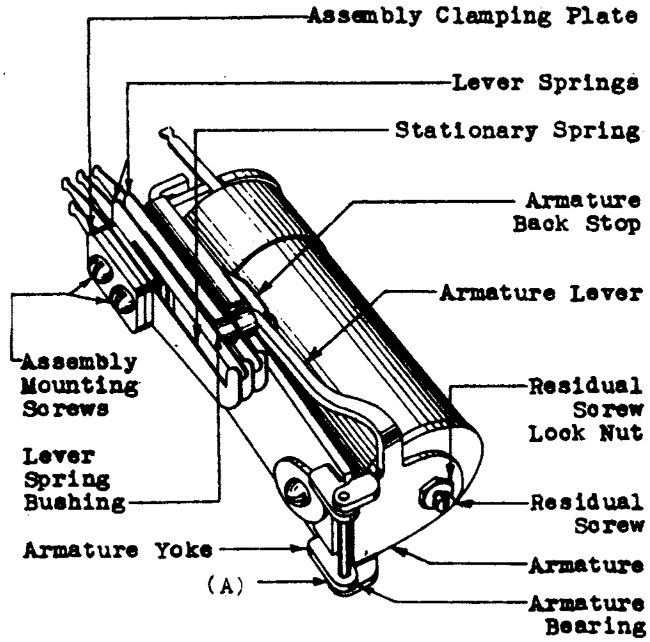

FIGURE 3

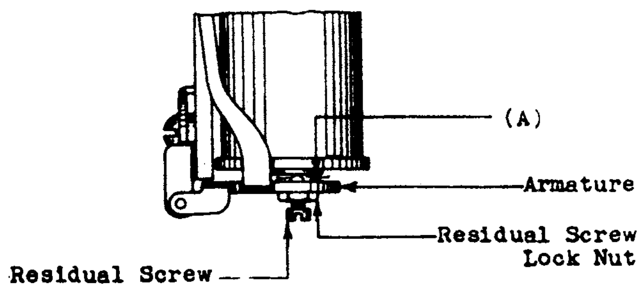

FIGURE 4

(b) Checking Procedure

(1) Where "0" (zero) residual is specified it shall be checked by inserting a piece of 1/2" wide x 2-1/2" Bond Paper between the armature and core and electrically energizing the relay. In some cases it may be necessary to supplement the energizing force of the relay by pressing the armature toward the core sufficiently to cause a dot or impression to appear on the paper if residual is present. Then release the relay and withdraw the paper. Absence of a "dot" or impression on the paper is an indication of "0" (zero) residual.

(2) Where "S" meaning some residual is specified it shall be checked as outlined in (1) above for the "0" residual except that the appearance of a "dot" or impression on the paper is an indication of some residual.

6. RESIDUAL AIR-GAP (CONT'D)

(3) Where the minimum or maximum value specified is .0015", .002" or .003", the maximum limit shall be measured by inserting the .002" KS-6909 gauge between the armature and core as shown in Figure 5, so that the residual screw is free to touch the core through the hole in the end of the gauge and then inserting a piece of 1/2" wide x 2-1/2" Bond Paper between the gauge and the core so that the paper is in back of the hole in the gauge as viewed from the front of the relay. Electrically energize the relay and where necessary supplement the energizing force by pressing the armature toward the core by hand with sufficient force to cause a dot or impression to appear on the paper if the residual is greater than .002". Allow the relay to release and then withdraw the paper and gauge. Absence of a "dot" or impression on the paper is an indication that the residual is less than the maximum specified value.

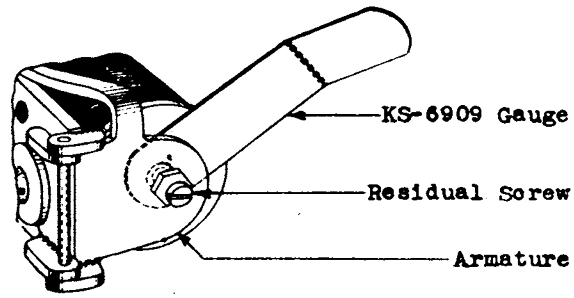

FIGURE 5

(4) Where the value specified is .004" or more these values shall be checked by placing the proper KS-6909 gauge between the armature and the core, as shown in Figure 5, so that the residual screw is free to touch the core through the hole in the end of the gauge. Electrically energize the relay and judge the residual air-gap by the "tightness" of the gauge or by placing a piece of white paper beneath the armature and observing the clearance between the armature and the core when the relay is electrically operated. When checking the minimum limit with the gauge, the gauge should not be tight. When checking the maximum limit the gauge should be tight.

Examples

In the case of the relay where the specified residual air-gap is "S-4", the appearance of a "dot" on the paper is an indication of some residual; but a .004" gauge placed between the armature and the core as shown in Figure 5 should be tight. Where the specified residual is "7-11", the .007" gauge placed between the armature and the core should not be tight and .011" gauge should be tight.

NOTE: For method of operating relays electrically, see Table No. 1.

7. HEELPIECE AIR-GAP

(a) Requirement

Heelpiece Air-Gap

(1) All Relays Except 248 Types: With the relay electrically operated, the armature shall be parallel to the heelpiece but shall not make contact with the heelpiece nor clear it by more than .004" at the closest point. Figure 6(A).

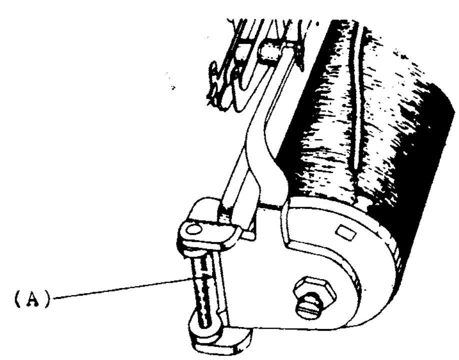

FIGURE 6

7. HEELPIECE AIR-GAP (CONT'D)

(2) 248 Type Relay - Figure 7(A): With the relay electrically operated the armature shall be parallel to the heelpiece but shall not make contact with the heelpiece or yoke nor clear the heelpiece at the closest point by more than:

Test - .007" (With the relay adjusted to specified residual)
Readjust - .004" (With the armature touching the core)

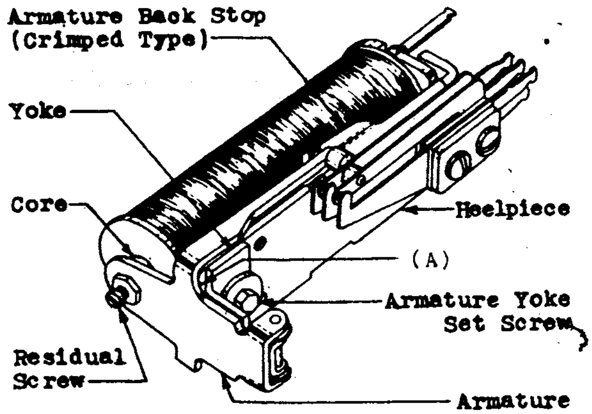

FIGURE 7

(b) Checking Procedure

(1) Checking the Maximum Limit on 221, 222, and 224 Type Relays: Insert the .004" blade of the KS-6909 gauge between the armature and the heelpiece and electrically operate the relay. The gauge should be tight. Check first as shown in Position No. 1 on Figure 8 and then as shown in Position No. 2 so as to check the gap over the entire width of the heelpiece.

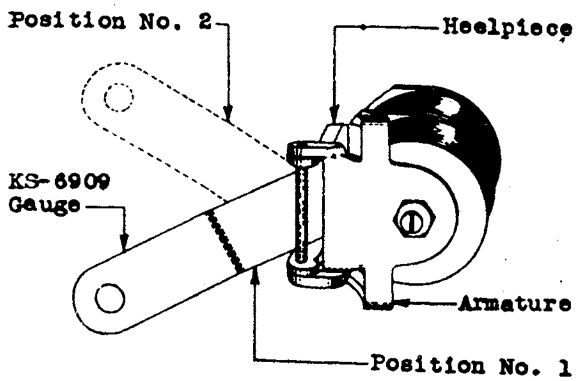

FIGURE 8

(2) Checking the Minimum Limit on 221 and 222 Type Relays: Insert the .0015" blade of the KS-6909 gauge and electrically operate the relay. The requirement is met if the gauge is loose. Exercise care not to extend the gauge between the armature and core or beyond the edge of the heelpiece adjacent to the yoke as this may result in an improper check. The minimum limit is also met if light can be observed between the armature and heelpiece throughout its entire length.

(3) Checking the Minimum Limit on 224 Type Relays: Check the minimum limit in the same manner as described above for the maximum limit. The minimum limit is also met if light can be observed between the armature and heelpiece throughout its entire length. Use the 376A mirror to observe the air-gap.

(4) Checking the Maximum Test Limit on 248 Type Relays: Insert the .007" blade of the KS-6909 gauge between the heelpiece and armature from the armature side as shown in Figure 9 and electrically operate the relay.

(5) Checking the Maximum Readjust Limit: Insert the .004" blade of the KS-6909 gauge between the heelpiece and armature from the armature side and electrically operate the relay. Check first as shown in Position No. 1 and then as shown in Position No. 2 on Figure 9, so as to check the gap over the entire width of the heelpiece. Exercise care not to extend the gauge between the armature and core or beyond the edge of the heelpiece.

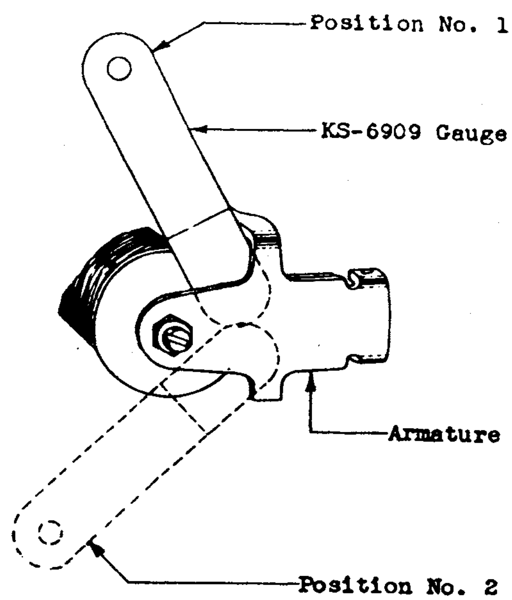

FIGURE 9

7. HEELPIECE AIR GAP (CONT'D)

(6) Checking the Minimum Limit: Insert the .0015" blade of the KS-6909 gauge between the heelpiece and armature from the bottom as shown in Figure 10 and operate the relay electrically. Exercise care not to extend the gauge between the armature and core or beyond the edge of the heelpiece adjacent to the yoke as this may result in an improper check. Use the KS-6909 gauge and No. 376A mirror.

NOTE: For method of operating relays electrically see Table 1.

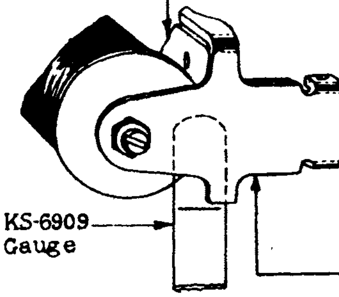

FIGURE 10

8. ARMATURE TRAVEL

(a) Requirement

221, 222 and 248 Type Relays Where the First Contact is a Break Contact and

224 Type Relays Where the First Contact of Both Assemblies is a Break Contact

Armature travel is the gap between the core and the armature, or core and residual screw where residual is specified, with the relay in the normal (unoperated) position.

(1) Where the first contact is a make contact, or in the case of 224 type relays where the first contact of one or both spring assemblies is a make contact the value specified in the "ARM TRVL" column of the Requirement Table is the test armature travel.

(2) Where the first contact is a break contact, or in the case of 224 type relays where the first contact of both assemblies are break contacts, the value specified in the "ARM TRVL" column of the Requirement Table is the test value on which the first contact (or these contacts) should not break.

Test The first contact (or contacts) shall not break when the relay is electrically energized against a gauge of the value specified in the armature travel column on the Requirement Table.

REQUIREMENT TABLE FOR 221, 222, 224 AND 248 TYPE RELAYS

Relays	Arm. Travel
A-221-A	8
B-248-D	27
C-221-CL	12
D-222-KM	15
E-221-DU	13
F-222-J	25
G-221-T	13
K-224-D	31

NOTE: Information in this Requirement Table for "Armature Travel" taken from Circuit Requirement Table on associated drawing.

8. ARMATURE TRAVEL (CONT'D)

Example: In the case of a spring combination similar to that shown in Figure 11 the armature must not leave the stop when electrically energized against a gauge of .015", but it must leave the armature stop when the relay is electrically energized against a gauge of .011".

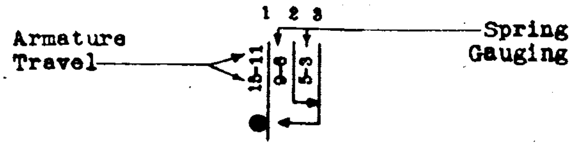

FIGURE 11

(b) Checking Procedure: Use the KS-6909 and KS-6938 gauges as required for measuring the armature travel. Check the opening or closing of contacts visually by directing light through a piece of Bond Paper inserted beneath the spring assembly of the relay.

9. POSITION OF FIRST LEVER SPRING WITH RESPECT TO THE ARMATURE LEVER STUD

(a) Requirement: The position of the first lever spring with respect to the armature lever stud, Figure 12(A), shall be as indicated in the following table.

NOTE: No Stud Gap: The first lever spring or balancing spring shall rest against its associated armature stud with sufficient tension to hold the armature against the back stop or back stop screw.

Type of Relay	First Contact of Assembly	Stud Gap
221, 222,	Make or Balancing Spring	None - See Note.
248	Break	.008"
224 Type	Make on Both Assemblies	None - each assembly shall meet Note.

(b) Checking Procedure Use KS-6909 gauge and also gauge by eye.

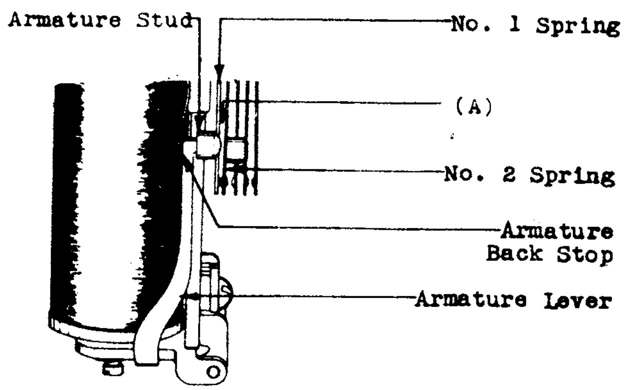

FIGURE 12

10. CONTACT SEPARATION

(a) Requirement

Test: The contact separation, measured at the contacts, between all break contacts with the relay electrically operated and between all make contacts with the relay in the unoperated position shall be Min. .005".

(b) Checking Procedure: Use the KS-6909 gauge.

NOTE: For method of operating relays electrically, see Table 1.

11. CONTACT SEQUENCE

(a) Requirement

(1) Test and Readjust: All break contacts except the break contacts of standard make before break contacts of each spring assembly considered separately shall break in sequence, beginning with the first break contact.

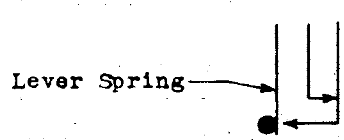

FIGURE 13

11. CONTACT SEQUENCE (CONT'D)

(2) Test: Unless otherwise specified all break contacts of each spring assembly considered separately, except the break contact of make before break springs, shall break before any make contact makes.

Standard make before break contact springs are an arrangement of springs where the lever spring makes contact when the relay is operated. See Figure 13.

(b) Checking Procedure: Gauge by eye.

NOTE: For method of operating relays electrically, see Table No. 1.

12. CONTACT PRESSURE

(a) Requirement: (Make Before Break Contacts Only)

Test: The pressure on the break contacts of make before break springs per Figure 14 with the armature operated, shall be Min. 25 grams.

(b) Checking Procedure: Use the No. 68C gauge as shown in Figure 14.

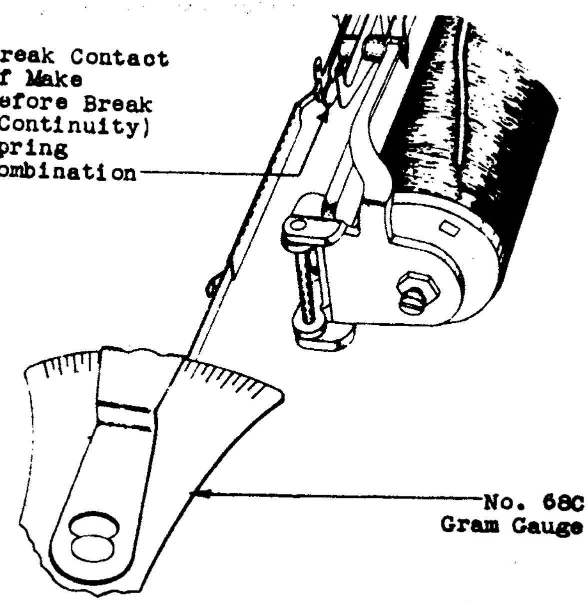

FIGURE 14

13. CONTACT FOLLOW

(a) Requirement

(1) Make Contacts

Test: The contact follow of all make contacts shall be Min. .010" - (at the contacts). Operate the relay manually.

(2) Break Contacts

Test and Readjust: There shall be follow on each break contact, except on the extra thick back contact springs such as are provided on pulsing "A" relays. The follow of back contacts may be checked by manually operating the relay and gauging the follow.

(b) Checking Procedure: Use the KS-6909 gauge, placing between armature and core of the relay.

14. SPRING GAUGING (READJUST ONLY)

(a) Requirement: All spring gauging limits as specified on spring gauging table part (2) shall be met. In the case of make and break contacts, the make contacts shall not make and the break contacts shall not break when the relay is electrically energized against the gauge equal to the greater specified value placed between the armature and the core at the closest point, but make contacts shall make and break contacts shall break when a gauge of smaller value is used.

(b) Checking Procedure: Use the KS-6909 gauge, placing between armature and core of the relay.

TABLE 1

METHOD OF OPERATING CONNECTOR RELAYS FOR MECHANICAL ADJUSTMENTS

Relay	Code	Circuit Preparation
A	221-A	Relay may be operated by blocking (B) relay non-operated and placing a make busy tool KS-477-A in the test jack.
B	248-D	Relay may be operated by insulating spring No. 1 of the (A) relay with KS-7187 Bond Paper and grounding spring No. 3 of the (A) relay.
C	221-CL	Relay may be operated by grounding the spring No. 3 of the (B) relay.
D	222-KM	Relay may be operated by blocking the relay non-operated and by shorting springs Nos. 5 and 8 of the (F) relay.
E	221-DU	Relay may be operated by insulating spring 4T of the (K) relay with KS-7178 Bond Paper and grounding No. 2 of the (G) relay.
F	222-J	Relay may be operated by placing ground on spring No. 2 of the (F) relay.
G	221-T	Relay may be operated by blocking the (K) relay operated and grounding spring No. 5B of the (K) relay.
K	224-D	Relay may be operated by grounding spring No. 2B of the (K) relay.

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Superintendent of Installation Engineering.

OPERATION TRAINING OUTLINE NO. 307
PART 2
ADJUSTING PROCEDURES FOR RELAYS
221, 222, 224 AND 248

1. RELAY MOUNTING
2. VERTICAL CLEARANCE BETWEEN RELAYS

(c) Adjusting Procedure: Realign the relays when necessary by loosening the mounting screws with the R-2443 screwdriver and shifting the relay as required, and retighten mounting screws.

3. CONTACT ALIGNMENT
4. STRAIGHTNESS OF SPRINGS

(c) Adjusting Procedure

(1) If contacts are out of alignment more than 40% of their diameter, as shown in Figure 1(A), loosen spring assembly mounting screws with R-2443 screwdriver or with the 563A and 564A offset screwdrivers, shift springs as required and tighten the assembly screws securely.

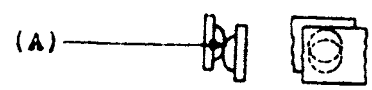


FIGURE 1

(2) If the spring is excessively bowed or bent or if there is not sufficient clearance between springs, straighten the spring using the 415A or 416A spring adjusters as indicated in Figure 2. Draw the adjuster forward the length of the spring meanwhile applying pressure as required so that the spring is formed into a slight gradual bow with the concave surface facing the heelpiece. Do not straighten kinked springs unless the kink interferes with proper adjustment of spring assembly. Removing kinks tends to weaken and shorten life of spring. A gradual bow, however, is permissible.

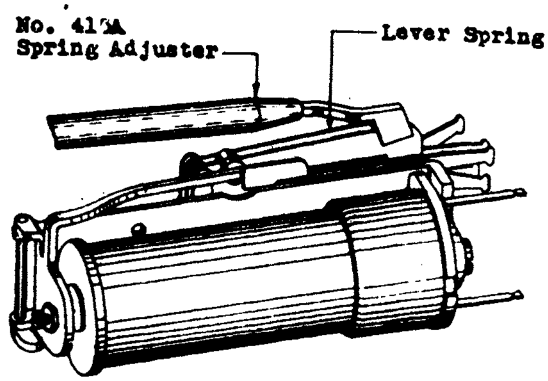


FIGURE 2

5. ARMATURE MOVEMENT

(c) Adjusting Procedure: To check the maximum vertical play of the armature hold the armature against one of the yoke bearing lugs and check the gap between the armature and yoke bearing lugs at the closest point on the other side of the armature. If the armature binds at the bearings or if the .020" gauge enters between the armature and yoke bearing lugs, the armature should be replaced. See Figure 3(A).

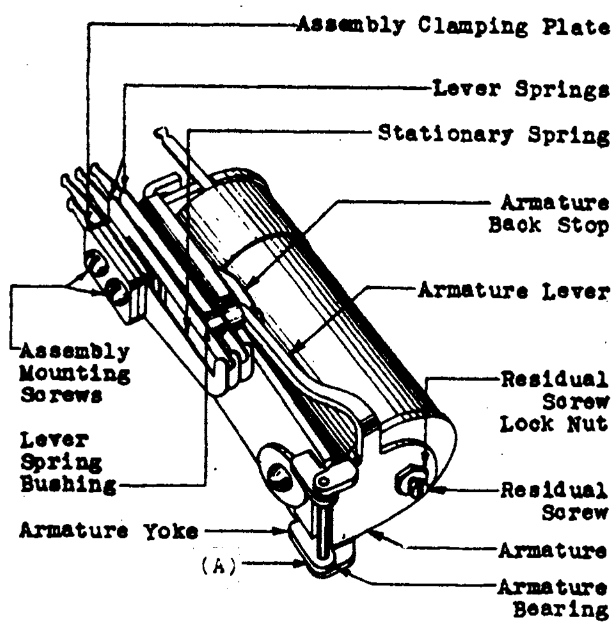


FIGURE 3

6. RESIDUAL AIR GAP
7. HEELPIECE AIR GAP

(c) Adjusting Procedure

NOTE: The procedures outlined below provide for setting up the residual air-gap followed by the setting of the heelpiece. This is the sequence of operation to be followed in adjusting all relays except 248 types. For this type, follow the reverse procedure.

(1) To change the residual air-gap, loosen the residual screw lock nut with the socket wrench of the 48 combination wrench and screwdriver and turn the residual screw in a clockwise direction with the screwdriver portion to increase the gap and in a counter-clockwise direction to decrease the gap.

(2) Readjust the heelpiece air-gap as follows. Loosen the armature yoke set screw with the 476A wrench in the case of 248 type relays or with the 563A and 564A offset screwdrivers for the other types of relays and set the armature so that there is a gap between it and the heelpiece of approximately .025" as gauged by eye. Then tighten the armature yoke set screw so as to hold the armature temporarily in this position. Insert the KS-6909 gauge between the armature and the heelpiece for the various types of relays. Operate the relay electrically. Loosen the armature yoke set screw about 1/8 turn and tap the armature lightly toward the heelpiece with the handle of a screwdriver until the air-gap spacer binds. Exercise care not to tap the yoke. The purpose of tapping the armature is to take up all the play in the heelpiece. If the yoke is tapped rather than the armature, the play will be taken up in the opposite direction. Hold the armature in this position with the fingers and tighten the armature yoke set screw securely. It is necessary to recheck the heelpiece air-gap since the tightening of the screw may change this gap.

(b) In certain cases changing the residual air-gap or heelpiece air-gap on relays known to have the proper spring gauging limits may necessitate a readjustment of these springs. This may readily be corrected by adjusting the armature lever slightly with the 14768 armature adjuster as shown in Figure 4. If this is done exercise care that the first lever spring is parallel to the heelpiece when the armature is in the unoperated position.

NOTE: For method of operating relays relays electrically, see Table 1.

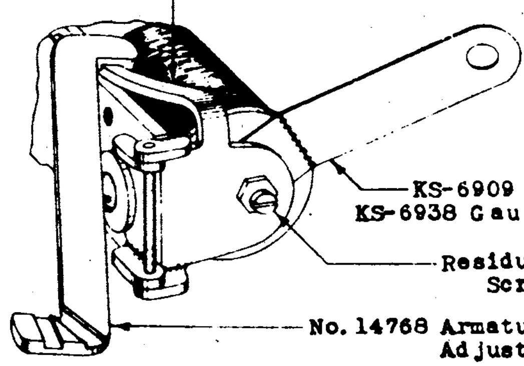


FIGURE 4

8. ARMATURE TRAVEL
9. POSITION OF FIRST LEVER SPRING WITH RESPECT TO THE ARMATURE LEVER STUD

(c) Adjusting Procedure

(1) Observe that the first lever spring of 221 and 222 type relays and the first lever spring of both spring assemblies of 224 type relays are approximately parallel to the heelpiece If they are not, adjust the armature lever, or levers with the 14768 armature adjuster applied as shown in Figure 5.

(2) After adjusting the armature lever as described in (1), readjust the armature back stop within the limits specified, with the 14769 armature back stop adjuster as shown in Figure 6.

(3) To change the stud gap or clearance between the armature stud and the first lever spring, adjust the end of the armature back stop with the 14769 adjuster away from the armature stud to increase the gap, and toward the stud to decrease the gap.

(4) To reduce contact chatter adjust the clearance between the armature stud and the first lever spring so that it is as large as possible consistent with meeting the other requirements.

10. CONTACT SEPARATION
11. CONTACT SEQUENCE
12. CONTACT PRESSURE
13. CONTACT FOLLOW
14. SPRING GAUGING

(a) Requirements: All the spring gauging limits as specified on the individual figure of the spring combination figures or on the requirement table shall be met. In the case of make and break contacts, the make contacts shall not make and the break contacts shall not break when the relay is electrically energized against the gauge equal to the greater specified value placed between the armature and core at the closest point, but make contacts shall make and break contacts shall break when a gauge of the smaller value is used.

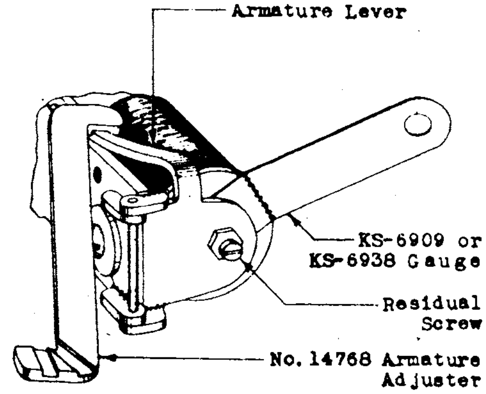


FIGURE 5

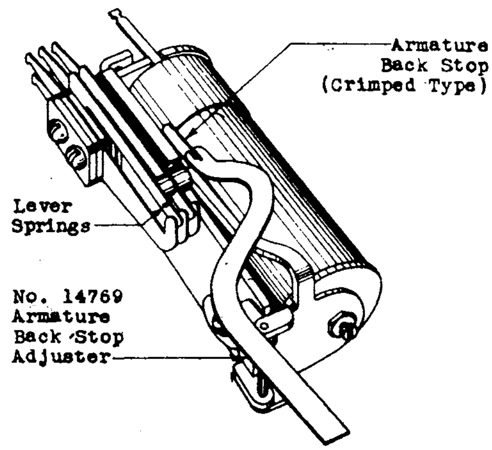
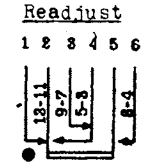
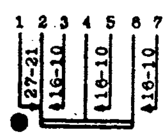
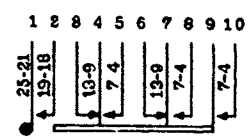
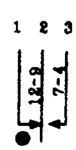
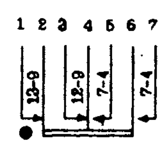
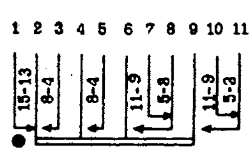
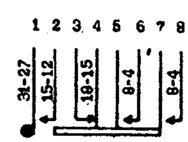
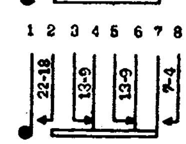


FIGURE 6

SPRING GAUGING TABLE

Relay	Readjust	Relay	Readjust
(A) 221A		(E) 221DU	
(B) 248D		(F) 222J	
(C) 221CL		(G) 221T	
(D) 221KM		(K) 224D	 

10, 11, 12, 13, 14 (Continued)

(c) Checking Procedure: Use KS-6909 or KS-6938 Gauge and place between the armature and core of the relay. See Figure 7. Check the opening or closing of contacts visually be directing light through a piece of Bond Paper inserted beneath the spring assembly of the relay.

(1) Adjust the break contacts (except the break contacts of make before break spring assemblies) so that they just break with a gauge of minimum value inserted, making due allowances for the sequence of break contacts and make contacts.

(2) Adjust the break contacts of make before break assemblies so that they break as near the specified maximum gauging value as possible.

(3) Adjust make contacts so that they just fail to make with a gauge of the maximum value inserted.

(4) Use the 415A or 416A spring adjusters to adjust the springs. Apply the spring adjuster to the stationary spring near the point where the springs leave the assembly clamping plates and the insulators as shown in Figures 8 and 9. Adjust the springs to the right or left as required. After making these adjustments check that the springs break in the proper sequence.

NOTE: For method of operating relays electrically see Table 1.

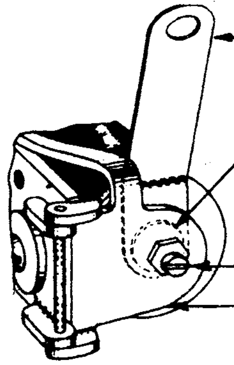


FIGURE 7

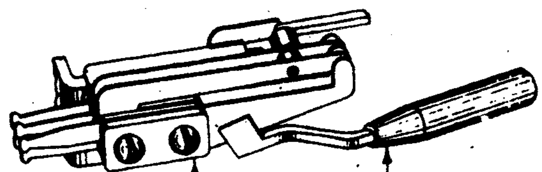


FIGURE 8

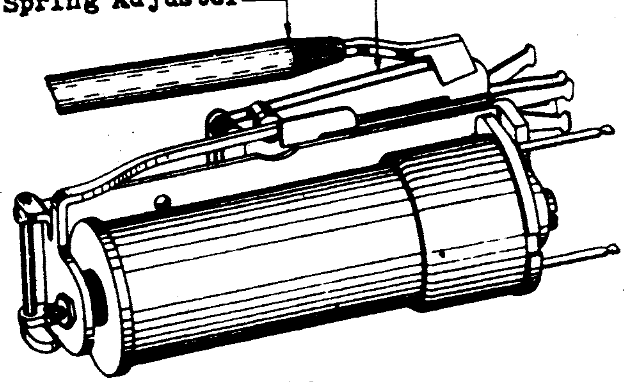


FIGURE 9

METHOD OF OPERATING CONNECTOR RELAYS FOR MECHANICAL ADJUSTMENTS

Table 1 - Circuit Preparation

Relay	Code	
A	221-A	Relay may be operated by blocking (B) relay non-operated and placing a make busy tool No. 477-A in the test jack.
B	248-D	Relay may be operated by insulating spring No. 1 of the (A) relay with KS-7187 Bond Paper and grounding spring No. 3 of the (A) relay.
C	221-CL	Relay may be operated by grounding spring No. 3 of the (B) relay.
D	222-KM	Relay may be operated by blocking the (B) relay non-operated and by shorting springs No. 5 and 8 of (F) relay.
E	221-DU	Relay may be operated by insulating spring 4T of the (K) relay with KS-7187 Bond Paper and grounding spring No. 2 of the (G) relay.
F	222-J	Relay may be operated by placing ground on spring No.2 of the (F) relay.
G	221-T	Relay may be operated by blocking the (K) relay operated and grounding spring No. 5B of the (K) relay.
K	224-D	Relay may be operated by grounding spring No. 2B of the (K) relay.

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OPERATION TRAINING OUTLINE NO. 308

DESCRIPTION OF STEP-BY-STEP SYSTEM OPERATIONS

CONTENTS

1. GENERAL

1.1 This section describes the general operation of the step-by-step dial system which is in common use by the Bell System.

1.2 The circuit fundamentals described herein and the conventions shown in the associated figures should be understood by the step-by-step apparatus or relay adjuster.

2. PRELIMINARY DESCRIPTION

2.1 The Step-by-Step System is a dial system, one in which the usual operations of the operator are performed by switches, magnets, relays, etc.

2.11 By the operation of his dial, the subscriber causes the mechanisms to set up the desired connection without the services of an operator.

2.12 The dial is a mechanical device for making and breaking the circuit to the central office a number of times, corresponding to the digit the subscriber desires.

2.2 A brief description of the path of a subscriber to subscriber call through the various elements of the Step-by-Step System illustrated in Figure 1 is as follows:

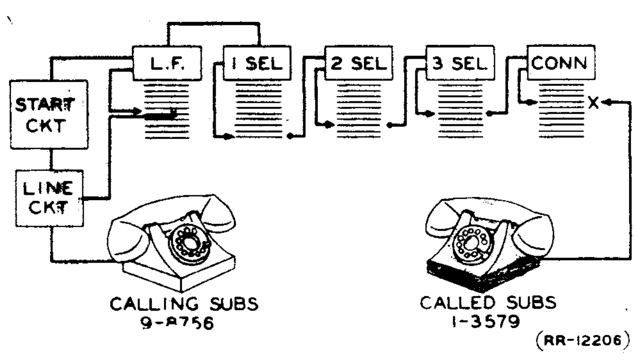

FIG. 1 SUBSCRIBER TO SUBSCRIBER CALL THRU STEP-BY-STEP SYSTEM

2.21 The calling subscriber removes his receiver. The operation of his line circuit actuates a line finder switch directly connected to a first selector, which sends dial tone to the calling subscriber. The subscriber then dials the first digit of the called number. As the dial returns to normal, the electrical impulses, consisting of breaks in the line current corresponding in number to the digit dialed, cause the first selector to raise its shaft one vertical step for each impulse. When the desired level is reached, the shaft rotates automatically, and carries the wipers attached to the shaft over the bank terminals. When an idle terminal is reached this rotary action ceases and the wipers come to rest on contacts leading to a second selector.

2.22 The second selector, responding to the impulses caused by the second digit dialed by the subscriber, steps its shaft up to the desired row of terminals and automatically selects a trunk to a third selector. The third selector, responding to the third digit dialed, steps its shaft up in the same manner as the first and second selectors except that it selects a trunk to a connector. The last two digits dialed cause the connector to step its shaft vertically and horizontally to complete the call by selecting the called number.

3. LINE, START AND LINE FINDER CIRCUIT OPERATION

3.1 Line and Start Circuit

3.11 The fundamental line and start circuit is shown in Figure 2. When the subscriber removes his receiver the L relay in the line circuit operates. The L relay operated, brings up the G relay in the start circuit and places battery thru the CO relay on the S terminal of the particular line on the line finder bank.

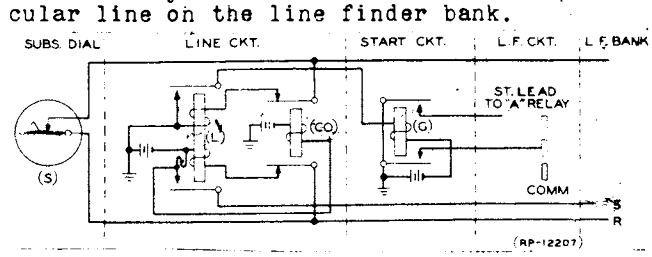

FIG. 2 LINE AND START CIRCUIT

3.12 The G relay in the start circuit operated, grounds the commutator segment in the line finder corresponding to the bank level on which the line appears. It also grounds the start lead to the line finder to actuate the vertical stepping circuit of the line finder.

3.2 Line Finder Vertical Stepping Circuit

3.21 The fundamental line finder vertical stepping circuit is shown in Figure 3. The G relay in the start circuit operates the A relay. The A relay, when operated, in turn operates the C relay, closes a circuit to operate magnet VERT, raising the shaft and wipers.

3.22 Relay C and magnet VERT will continue to operate and release as long as relay A is operated and the commutator brush does not reach a grounded segment. When the commutator brush contacts the segment grounded by the G relay in the start circuit relay E operates and opens the circuit to magnet VERT, which stops the vertical stepping of the line finder.

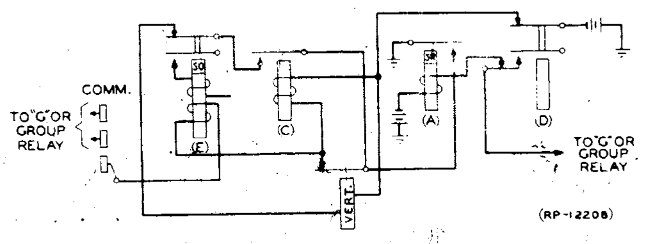

FIG. 3 LINE FINDER VERTICAL STEPPING CIRCUIT

3.3 Line Finder Rotary Stepping Circuit

3.31 The fundamental line finder rotary stepping circuit is shown in Figure 4. When the vertical stepping described above has been stopped by the operation of relay E, a circuit is closed which causes magnet ROT and relay C to operate and release, thus stepping the switch until the terminals of the calling line are found.

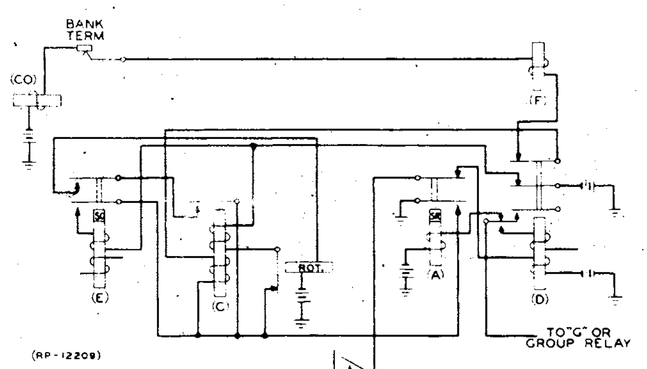

FIG. 4 LINE FINDER ROTARY STEPPING CIRCUIT

4. SELECTOR CIRCUIT OPERATION

4.1 Selector Pulsing and Releasing Circuit

4.11 The fundamental selector pulsing and releasing circuit is shown in Figure 5. When the switch is connected to the loop, either directly or through line finders and other selectors, relay A is energized and operates relay B. At the first interruption of the loop at dial S, relay A releases and energizes relay C and vertical magnet VERT. Relay B is a slow release relay and does not release during the pulsing due to the heavy copper collar on the end of its core. During the succeeding impulses, relay C also stays in the operated position for the same reason.

4.12 After the last impulse of the digit has been transmitted, the loop circuit remains closed for a sufficient length of time for relay C to release. This operates the hunting circuit as outlined in Paragraph 4.2.

4.13 It is apparent that if the loop remains open long enough for relay B to release (about 0.5 seconds or longer) the release magnet RLSE will be energized, restoring the switch to normal.

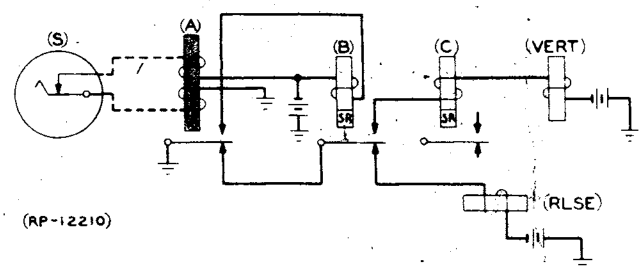

FIG. 5 SEL. PULSING AND RELEASING CIRCUIT

4.2 Selector Rotary Hunting Circuit

4.21 A simplified selector rotary hunting circuit is shown in Figure 6. After the last impulse of the digit has been received and selector relay C releases as described above, the rotary magnet operates and causes the switch to take one rotary step, placing the wipers on the first terminal of the level to which they have been raised. The ROT magnet also opens the circuit of relay E and this relay releases.

4.22 If the first trunk is idle, relay D will operate, cutting the tip and ring contacts through to the line wipers. If the first trunk is busy, ground is found on the sleeve (S) bank terminal. This ground reoperates relay E which causes the rotary magnet to step the wipers to trunk No. 2.

4.23 This operation is repeated until an idle trunk is found or until the switch passes to the 11th position, in which case it is arranged to send back a distinctive tone to the calling subscriber or operator.

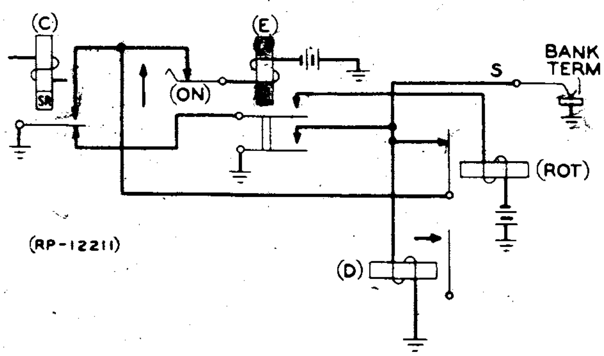

FIG. 6 SEL. ROTARY HUNTING CIRCUIT

5. CONNECTOR CIRCUIT OPERATION

5.1 Connector Pulsing and Releasing Circuit

5.11 The fundamental connector pulsing and releasing circuit is shown in Figure 7. When the switch is connected to the calling loop through the selectors, relays A and B operate. At the first interruption of the loop at the dial, relay A releases, operates relay C and causes the vertical magnet to step the wipers to the first level. The B relay is of the slow release type so that it holds up during the pulsing. The C relay is also slow releasing and stays operated until the last pulse of the digit has been received.

5.12 After the last pulse, relay C releases and prepares the circuit through the rotary magnet ROT which responds to the next series of pulses and steps the wipers around to the called terminals. If at any time the loop remains open long enough for both relays A and B to release, the release magnet RLSE is energized and the switch restores to normal.

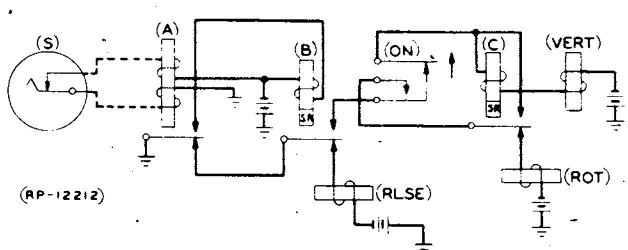

FIG. 7 CONN. PULSING AND RELEASING CIRCUIT

5.2 Connector Busy Test Circuit

5.21 The features of the connector busy test circuit are shown in Figure 8. It will be noted that relay E, due to its slow release feature will remain up for a moment after the last rotary pulses have been received and if the called line is busy, relay G will operate. After relay E releases, relay G will remain operated and connect busy tone to the tip side of the line. This tone is transmitted to the calling subscriber.

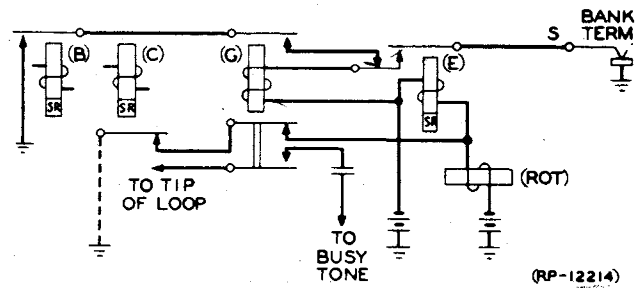

FIG. 8 CONN. BUSY TEST CIRCUIT

5.3 Connector Ringing Circuit

5.31 The fundamental ringing circuit for individual line connectors is shown in Figure 9. When the tip and ring conductors are cut through to the line wipers, interrupted ringing current is applied to the line. It will be noted that 48 volt battery is superimposed on the ringing current and is also applied to the line during the silent interval.

5.32 When the receiver at the called station is removed, relay F operates, cuts off the ringing current and also closes the tip and ring through the 2 MF talking condensers. During the ringing period a slight amount of ringing current is passed back to the calling subscriber through 0.04 MF condensers as a signal that the called station is being rung.

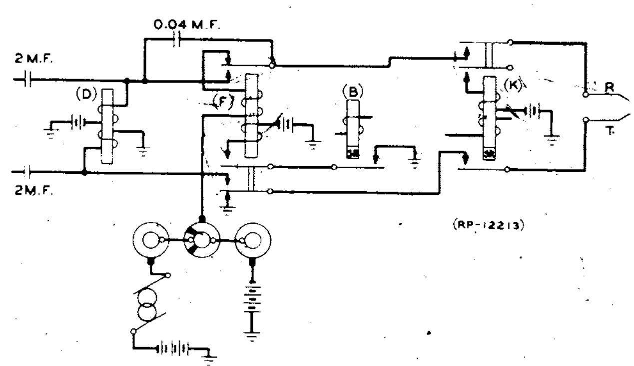

FIG. 9 CONN. RINGING CIRCUIT

5.4 Connector Transmission Circuit

5.41 The connector transmission circuit is shown in Figure 10. When the called loop, which is fed through the windings of relay D, is completed by the removal of the receiver, relay D operates and reverses the polarity of battery supply to the calling line. It is this reversal which is utilized to operate the message register or coin collect equipment associated with the calling loop.

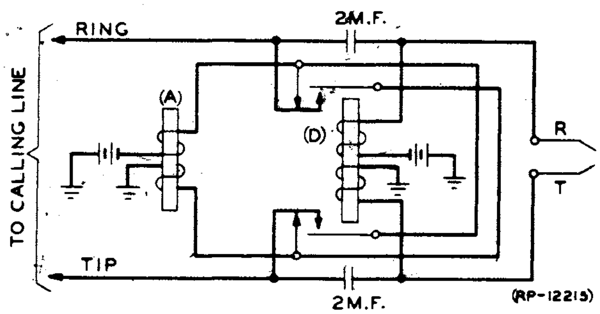

FIG. 10 CONN. TRANSMISSION CIRCUIT

6. REVIEW QUESTIONS

6.1 Check the correct answers to these questions.

1. In a step-by-step system, the assistance of an operator is needed to complete some calls. (Yes - No)

2. The number of digits dialed determines the number of switches used. (Yes - No)

3. The line finder is under control of the subscribers dial. (Yes - No)

4. To how many switches is the calling party connected when he hears dial tone? (1 - 2 - 3 - 4)

5. The "B" relay in the selector follows the dial pulses. (Yes - No)

6. The number of rotary steps taken by the selector is controlled by the dial. (Yes - No)

7. If all trunks are busy the selector releases. (Yes - No)

8. The C relay in the connector releases before the last digit is dialed. (Yes - No)

9. If the dial return is greatly retarded manually, the switches will release. (Yes - No)

10. The connector signals the calling party that the line is busy or that it is ringing the called party. (Yes - No)

11. The operation of the D relay in the connector determines whether or not the subscriber is charged for a call. (Yes - No)

12. When the called party hangs up the receiver, the switches release. (Yes - No)

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OPERATION TRAINING OUTLINE 309

ELECTRICITY AND MAGNETISM

CONTENTS

1. GENERAL

1.1 This section contains a simple, short description of the fundamentals of direct current electricity and magnetism. It has been included in this apparatus adjustment training manual in order to clarify the electrical and magnetic behavior of step-by-step relays and switches to a degree consistent with an adjusting course.

1.2 Accordingly reference has not been made to modern electron theory of current flow since the commonly used water flow analogy gives a clear conception of this phenomenon. Alternating currents have also not been discussed since they are normally not used when adjusting this apparatus.

2. FUNDAMENTALS OF DIRECT CURRENTS

2.1 A current of electricity is a flow of electrons thru an electric circuit which may be likened to a current of water thru a pipe. This electric current may flow continuously in one direction or may change in direction periodically, that is, flow first in one direction in the circuit and then in the other, reversing at regular intervals. These two types of electric currents are called DIRECT or DC CURRENT, and ALTERNATING or AC CURRENT, respectively.

2.2 This discussion is confined to DC currents only as some knowledge of their behavior will aid in the understanding of step-by-step apparatus adjustment. A convenient source of DC current is the dry cells used in flashlights, etc, which generate electricity chemically. Electricity is considered to flow from the center or positive pole of the dry cell, thru the external circuit, and back to the outer case of the cell which is its negative pole.

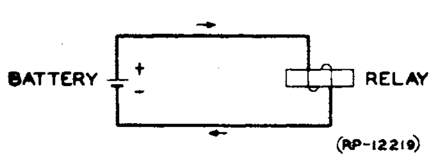

FIG. 1 TYPICAL BATTERY CIRCUIT

Figure 1 shows schematically such a cell or battery and the arrows indicate the direction of current flow thru an external circuit, in this case a relay. Although electronic theory has shown that electron flow or current is from negative to positive poles, it is generally assumed in telephone switching circuits that the current flows from positive to negative as shown in Figure 1.

2.3 In telephone circuits, one side of the battery is usually connected to what is known as a ground bar. If one end of the relay winding is also connected to this common ground bar, current will flow thru the relay as shown in Figure 2.

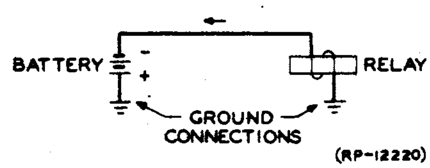

FIG. 2 TYPICAL GROUNDED BATTERY CIRCUIT

With the positive pole of the battery grounded, as shown, the relay is said to be operating from NEGATIVE BATTERY. If the ground connection to the battery was reversed, the relay would be operating from POSITIVE BATTERY.

2.4 To understand the behavior of DC Current, comparison may be made to water flow thru a pipe system as shown in Figure 3. The pump provides the pressure

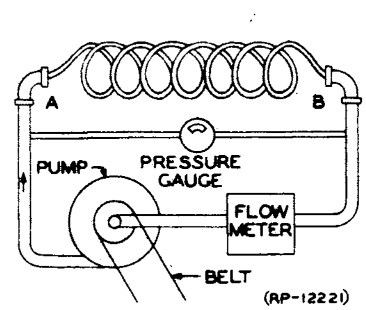

FIG. 3 SIMPLE WATER SYSTEM

to start and maintain the flow of water thru the system. The amount of water flowing thru the system will depend upon the amount of pressure generated by the pump and the resistance of the system to the flow due to the size of the pipe, friction of its walls, etc.

2.5 In an electrical system or circuit as shown in Figure 4 the battery provides

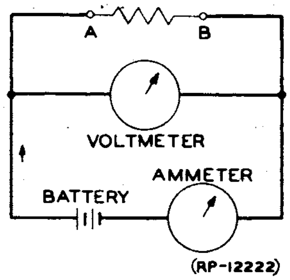

FIG. 4 SIMPLE ELECTRICAL CIRCUIT

the pressure to start and maintain the flow of electricity thru the circuit. The amount of current flowing thru the circuit will depend upon the pressure produced by the battery and the resistance of the circuit to current flow due to size, length and type of conductors and apparatus.

2.6 In the pipe system, the pressure provided to cause the flow of water from A to B is measured on the pressure gauge in pounds per square inch. In the electrical system, the battery supplies the pressure or electro-motive force (EMF) which is measured in volts using a voltmeter connected as shown in Figure 4.

2.7 The water flowing in the pipe system would be measured by the flow meter in gallons. In the electrical system, the current is measured by the ammeter in amperes. For convenience in communications work where quantities of current to be measured are ordinarily small, current flow is usually expressed in milliamperes, abbreviated mils. One mil equals $\frac{1}{1000}$ ampere, or .001 ampere.

2.8 In the pipe system the pump not only starts the flow of water but overcomes the friction of the walls of the pipe. In the electrical system, the voltage of the battery starts the electric current and also overcomes the inherent resistance to its flow of the wire and apparatus in the circuit. Electrical resistance is expressed in ohms and may be calculated for any particular circuit by using Ohm's Law.

3. OHM'S LAW

3.1 As stated in the pipe system analogy, a definite relation exists between pressure, resistance and amount of water flowing in the system. This relation can be expressed mathematically.

3.2 Exactly the same relation exists in the electrical system between voltage, resistance and current. The units which are described above, are so related that an EMF of one volt applied to a circuit with one ohm resistance will cause a current of one ampere to flow. Expressed mathematically, current equals voltage divided by resistance, or

$$I \text{ (Current in Amperes)} = \frac{E \text{ (EMF in Volts)}}{R \text{ (Resistance in Ohms)}}$$

3.3 This formula is known as Ohm's Law. Expressed in another way, resistance is equal to voltage divided by current, or

$$R = \frac{E}{I}$$

A third way of expressing this relationship is that voltage equals current times resistance, or $E = I \times R$

By this law, given any two components of an electric circuit, the value of the other can be computed.

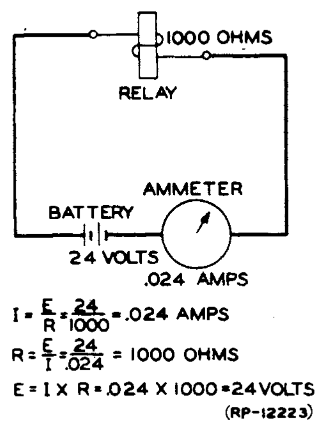

FIG. 5 ILLUSTRATION OF OHM'S LAW

3.4 It is obvious from the example above that the amount of current flowing in the circuit may be easily regulated by varying either the voltage or the resistance. This will be made use of in relay adjusting practices where it is desired to cause a certain amount of current to flow thru a relay winding. By changing the variable resistances in the adjusting set placed in the circuit with a relay winding, the total resistance of the circuit can be made such that the desired current will flow thru the relay winding. Figure 6 shows this arrangement schematically for a typical series circuit. The resistance of V may be computed from

$$I = \frac{E}{V+R}$$

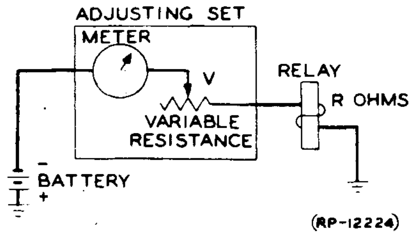

FIG. 6 TYPICAL ADJUSTING ARRANGEMENT OF SERIES CIRCUIT

3.5 A parallel circuit as shown in Figure 7 presents a different condition as the current measured by the ammeter will be the total current drawn from the battery.

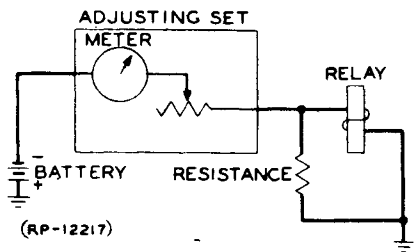

FIG. 7 TYPICAL PARALLEL CIRCUIT

The actual current in the relay will not be indicated with the setup shown, as the total current will divide between the resistance and the relay depending upon their resistance. Reference to the A. T. & T. Co. pamphlet "Principles of Electricity Applied to Telephone and Telegraph Work" should be made if further information on parallel circuits is desired. When adjusting relays in such circuits, specific information is given in each case so that the parallel paths are either opened or otherwise made ineffective, or are allowed for in the current values set up on the adjusting set meter.

4. PERMANENT MAGNETS

4.1 General

It is necessary to obtain a good working knowledge of magnets and magnetism since it is this property of metals upon which most of the mechanical operations performed in a dial telephone system depends. Permanent magnets are made of steel or some alloy of steel. They are called permanent magnets because with proper treatment they retain their magnetic properties indefinitely.

4.2 Polarity of Magnets

Magnets possess the property of attracting iron or ferrous alloys to themselves. The two ends of a magnet over which the magnetic force is most pronounced are called the poles. If a bar magnet is freely suspended it will align itself in a north-south direction like a compass needle. The pole which points north is called a north or positive pole and that which points south, a south or negative pole.

4.3 Attraction and Repulsion

If we place the north pole of one magnet adjacent to the south pole of another magnet, we find that they attract each other, but two similar poles placed together repel each other. This is a fundamental law of magnetic action and should be remembered.

4.4 Magnetic Fields

Any region in which a magnetic force acts is called a magnetic field. The field about a bar magnet is shown in Figure 8.

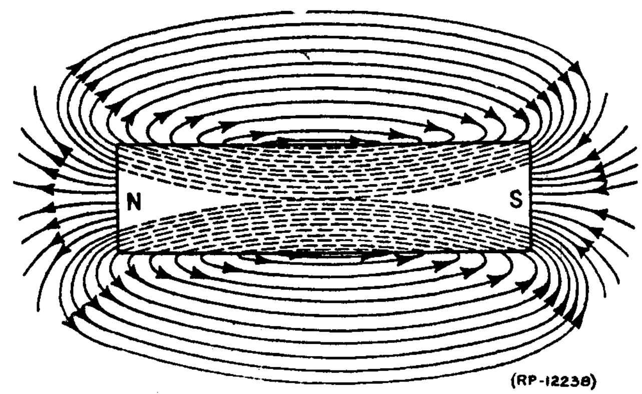

FIG. 8 MAGNETIC FIELD OF A BAR MAGNET

4.5 Lines of Force

The curved lines shown in Figure 8 are called "lines of force" and represent both the direction of the magnetic forces in the field and the strength of the field. These lines are always closed loops and are considered to leave the magnet at the north pole, looping around to enter the magnet at the south pole and pass thru the magnet to the point of origin. We may think of each line of force as a stretched rubber band in that it always tends to shorten itself as much as possible. Each line of force has another property of repelling all other lines of force, tending to spread them apart. Figure 9 indicates the action of two magnets when brought together and illustrates how the behavior of magnets can be explained in terms of the above attributes of the lines of force.

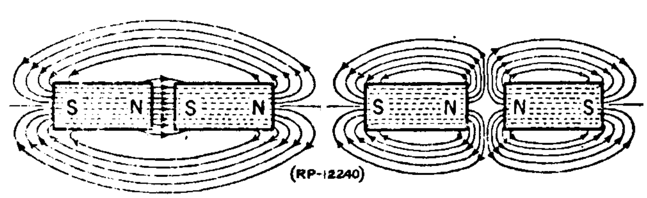

FIG. 9 MAGNETIC FIELDS OF ADJACENT MAGNETS

When the adjacent poles are unlike as in the left hand diagram, the lines between them tend to form closed loops thru the two magnets and their tendency to shorten themselves causes the attraction between the poles. On the other hand, when the adjacent poles are alike as in the right hand diagram, the relative direction of the two sets of lines are such that the tendency of the lines to spread apart accounts for the repulsion between the like poles.

4.6 Magnetic Circuits

The path which the magnetic field or "flux" takes is called the magnetic circuit. The amount of flux depends upon the opposition to its flow which is set up by the various parts making up the magnetic circuit. Iron forms an easy path for its flow, while substances such as air, copper, glass, etc., form a difficult path. The magnetic circuits of relays, switch magnets, and similar apparatus is designed to consist mostly of iron, the air gaps being made as short as possible.

4.7 Flux Density and Field Strength

The opposition which a magnetic circuit offers to the flux is called "reluctance." It controls the amount of flux in the same manner as that in which resistance controls the amount of current in an electric circuit. We may look upon the lines of force as representing not only the direction of the magnetic forces in the field but the strength of the field as well. In considering field strength, we can again use the water analogy, in that where the stream is confined to a narrow channel, the current is strong and where the stream spreads out the current is weak. It is easily proven that the magnetic forces increase as we approach the magnet poles and decrease as we recede from them. This is illustrated by the lines of force at one pole of a magnet as shown in Figure 10. As we approach the pole the flux density increases but as we move away the lines spread out in all directions and the density decreases.

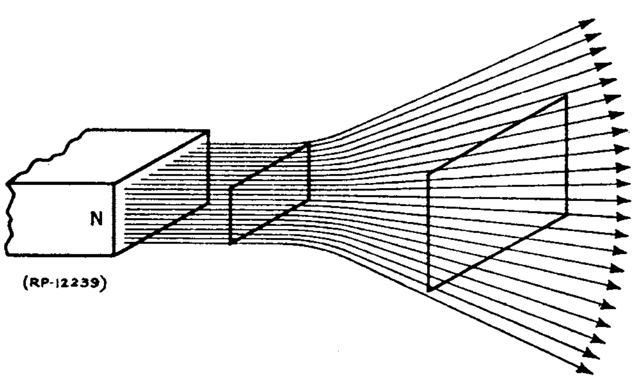

FIG. 10 FLUX DENSITY AT A MAGNET POLE

Thus the field strength and flux density vary together. When the path of the flux is confined to a small area the density is high and the field strong; where it is spread out the density is low and the field weak. These principles must all be taken into consideration when designing equipment such as relays in which we expect the magnetic fields to do mechanical work for us.

5. ELECTRO-MAGNETS

5.1 Relation Between Magnetism and Electricity

Magnetism and electricity are so inter-related that magnetism can be created and controlled by an electric current. This enables us to make electricity perform a great amount of useful mechanical work. Wherever an electric current flows, a magnetic field is set up around the conductor carrying the current. The lines of force in this field are circular loops lying in planes at right angles to the conductor as shown in Figure 11.

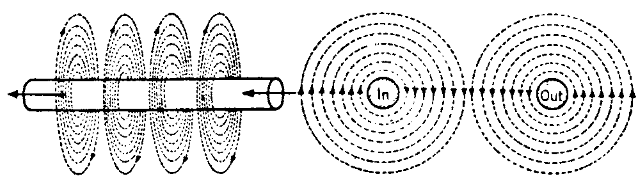

FIG. 11 MAGNETIC FIELD AROUND A CURRENT CARRYING CONDUCTOR

5.2 Magnetic Field Around Current Carrying Coils

The magnetic field set up around a single turn of wire carrying a current is shown in Figure 12. We can see that all the lines of force encircle the wire in the same direction.

Figure 13 shows what happens to the magnetic field when we place a number of turns of current carrying wire together. The effect of the several turns combines to set up lines of force, a small proportion of which encircle the individual turns, but most of which link themselves together thru the whole group of turns. We can immediately recognize the field setup as similar to that of a bar magnet and can conclude that when current passes thru a coil it acquires the properties of a magnet. Such a coil is called an "Electro-Magnet."

5.3 Relation Between Magnetic and Electric Circuits

We have seen by "Ohm's Law" how the current, resistance and electro-motive force in an electric circuit are related. In a magnetic circuit there is an analogous relation between the flux, the reluctance and the force which sets up the flux which is called the "Magneto-Motive Force" (abbreviated MMF): the flux equals the MMF divided by the reluctance.

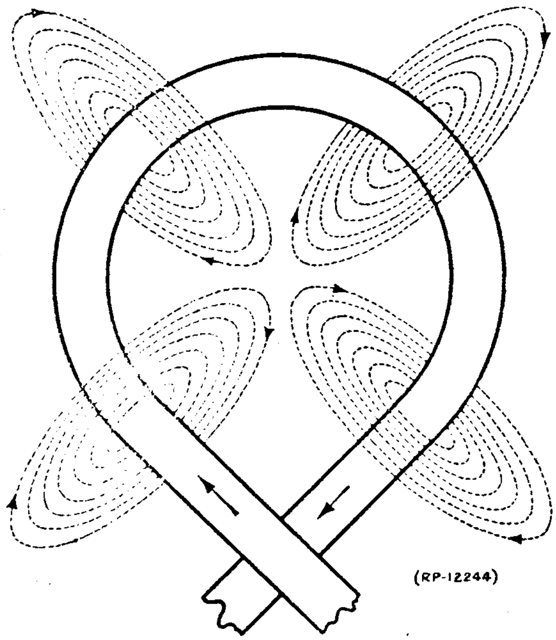

FIG. 12 MAGNETIC FIELD AROUND A SINGLE TURN OF WIRE

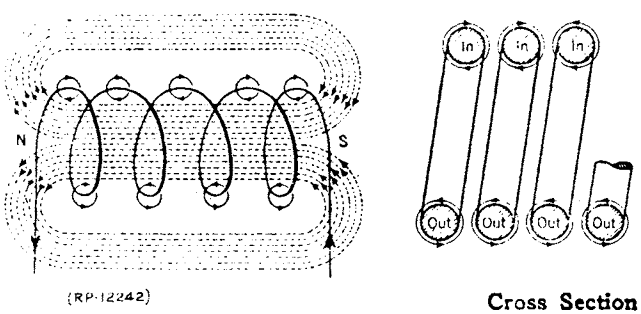

FIG. 13 MAGNETIC FIELD AROUND A COIL OF WIRE

This force due to an electric current flowing around a coil is directly proportional both to the number of turns in the coil and the number of amperes in the current; in other words, the MFF depends upon the number of amperes multiplied by the number of turns. Consequently, magneto-motive force is commonly expressed in "ampere turns".

5.4 Design of Electromagnets

The reluctance of a magnetic circuit in which the path of the flux is thru air or non-magnetic substances is a constant. No matter how the MMF is varied, the flux varies in direct proportion. This is not true, however, when the path of the flux is partly or entirely thru magnetic substances. By experiment we can determine that the magnetic effect of a given current flowing thru a coil can be increased in two ways; (1) by increasing the number of turns in the coil, thereby increasing the MFF, and (2) by winding the coil on an iron core, thereby greatly reducing the reluctance of the magnetic circuit. A very strong electromagnet can therefore be made by passing a current thru a coil of many turns wound on an iron core. The core of such magnets is usually made of a special soft iron which has been treated so that it magnetizes easily and will give up its magnetism as completely as possible immediately after the energizing current ceases to flow thru the winding.

5.5 Residual Magnetism

It should be borne in mind, however, that a small amount of magnetism, called "residual magnetism", is normally retained in the core of electromagnets. The effect of this in a relay would be to prevent the immediate release of the armature when the current stops flowing. This is overcome by slightly increasing the reluctance of the magnetic circuit by placing stop pins or "non-freezing" discs of a non-magnetic material in the path of the armature travel to prevent the armature from striking the core, thereby decreasing the flux density caused by the residual magnetism.

5.6 Relay Design

A simple relay is shown in Figure 14.

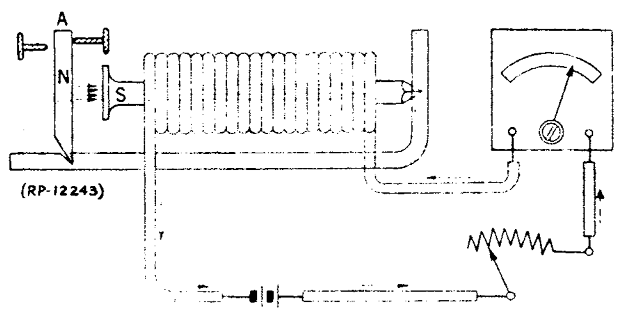

FIG. 14 SIMPLE RELAY

When the electric circuit is closed, the current thru the coil sets up a magnetic flux, making the core a magnet. The flux passes out at the north pole of the core, thru the air gap into the armature, and then thru the rest of the relay structure (made of iron) to the opposite pole of the core and back to the starting point. As the lines of force tend to shorten themselves, the armature will be attracted to the core. Thus the electric current is made to perform the mechanical work of moving the armature.

From the discussion of magneto-motive force it will be appreciated that the determination of the proper number of ampere turns in the coil is an important factor in relay design. They must be figured out to meet the requirements imposed by the load to be placed on the armature, the length of the air gap, the distance thru which the load must be operated, etc. The load may be a single armature, or it may be a group or "pile-up" of springs whose tension must be overcome.

It should therefore be clear why we use current flow test sets in installation adjusting work and why we adjust relays to operate on a given amount of current.

The very basis of relay design is such that the relay must receive a proper amount of current in order to do its work, and conversely, that it must be so adjusted as to do its designed work when the proper amount of current passes thru its winding.

6. REVIEW QUESTIONS

6.1 Place a check mark in the box beside each question which will give a correct answer to the question.

1. Is a flashlight battery a source of AC CURRENT. Yes [ ] No [X]

2. Is  this the symbol for NEGATIVE BATTERY. Yes [X] No [ ]

3. In what units are the following measured:

	Amperes	Volts	Ohms
(a) Current	[X]	[ ]	[ ]
(b) Voltage	[ ]	[X]	[ ]
(c) Resistance	[ ]	[ ]	[X]

4. Does 35 mils equal - 3.5 amps [ ]
   0.35 amps [ ]
   0.035 amps [X]

5. In a circuit with a 48 volt battery operating a relay having 1200 ohms, will the current be:
   48 mils [ ]
   .240 amperes [ ]
   .24 mils [ ]
   40 mils [X]

6. A relay of 1300 ohm resistance requires a current of 24 mils when being adjusted. If a 48 volt battery is used, will the variable resistance in the adjusting set of Figure 6 supply an additional resistance of:
   700 ohms [X]
   1700 ohms [ ]

NOTE: In determining this answer, first figure the total resistance required to obtain 24 mils.

7. Is a mariner's compass needle a permanent magnet. Yes [X] No [ ]

8. If a permanent magnet is cut in half, will the newly formed ends be:
   both positive poles [ ]
   both negative poles [ ]
   one positive and one negative [X]

9. When two permanent magnets are placed positive end to positive end, they will have a tendency to attract one another. Yes [ ] No [X]

10. A strong permanent magnet can be made of:
    Copper [ ] Glass [ ]
    Lead [ ] Steel [X]

11. The magnetic strength of a relay having 20,000 turns and drawing 5 mils of current is approximately the same as a relay of 10,000 turns drawing 10 mils of current. Yes [X] No [ ]

12. The core of a relay is made of a material which is easily magnetized when the relay coil is carrying a current and which will give up its magnetism as completely as possible when the current stops flowing. Yes [X] No [ ]

13. Assuming other things equal, the shorter the gap between armature and pole piece of a relay, the faster it will pull up when its coil is energized. Yes [X] No [ ]

14. The direction of the DC current thru a relay winding makes no difference in its operation. Yes [X] No [ ]

NOTE: This applies to relays of the type described in this section.

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Superintendent of Installation Engineering.

Training Manual 16
Western Electric Company, Incorporated
Installation Department

2-11-46

OPERATION TRAINING OUTLINE NO. 310
METHOD OF OPERATION
D-C ADJUSTING SET, ITE-4040

1. GENERAL

1.1 Purpose and Use

This set may be used when checking and adjusting apparatus on direct current to current flow requirements.

1.2 Description

This is a portable set approximately 11-3/4" x 12-3/4" x 6" overall. It is assembled on a metal chassis (see Figure 1) and housed in a sheet steel box. A compartment is provided in the bottom of the box for cord and accessory equipment

1.3 Cords and Accessories

Some of the cords and accessories furnished with this set are shown in Figure 2. The quantities of the various items are given on the "Cord and Accessory Label" which is mounted in a card holder on the cord compartment cover. The ITE-4088 Case is furnished for use as a container for the small loose equipment items. The 4-P-353450 screws used to secure the chassis in the box for shipment should be removed and placed in this case when the set is in use. While the set is in use the case may be attached to the front end of the box.

FIG. 1 ITE-4040 CHASSIS

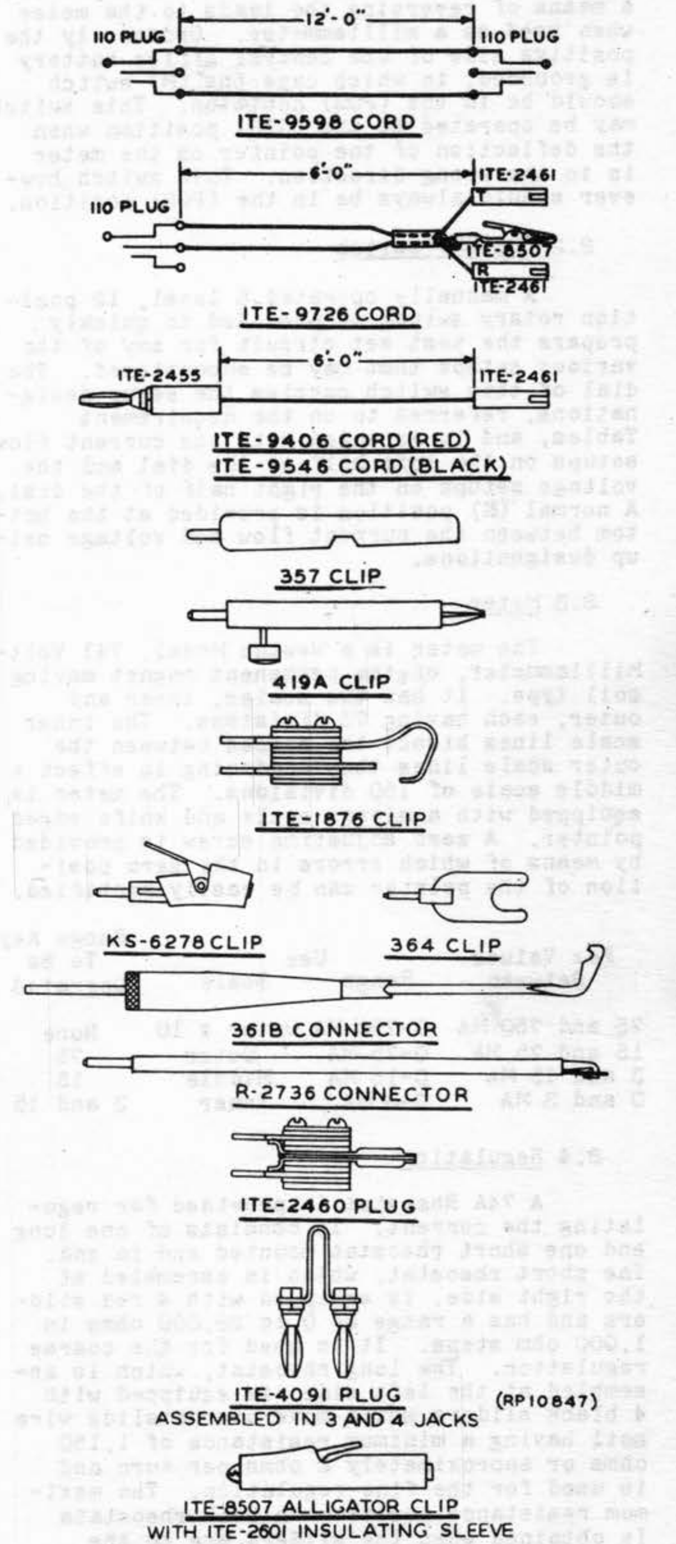

FIG. 2 SOME OF THE CORDS AND ACCESSORIES FURNISHED WITH ITE-4040

2. APPARATUS AND CIRCUIT FUNCTIONS

2.1 (M) Switch

This is a toggle switch which provides a means of reversing the leads to the meter when used as a milliammeter. Ordinarily the positive side of the central office battery is grounded, in which case the (M) switch should be in the (POS) position. This switch may be operated to the (NEG) position when the deflection of the pointer on the meter is in the wrong direction. This switch however should always be in the (POS) position.

2.2 (SETUP) Switch

A manually operated 6 level, 12 position rotary switch is provided to quickly prepare the test set circuit for any of the various setups that may be encountered. The dial of this switch carries the setup designations, referred to on the Requirement Tables, and is arranged with the current flow setups on the left half of the dial and the voltage setups on the right half of the dial. A normal (N) position is provided at the bottom between the current flow and voltage setup designations.

2.3 Meter

The meter is a Weston Model, 741 Volt-Milliammeter, of the permanent magnet moving coil type. It has two scales, inner and outer, each having 75 divisions. The inner scale lines bisect the spaces between the outer scale lines thus producing in effect a middle scale of 150 divisions. The meter is equipped with a mirror scale and knife edged pointer. A zero adjusting screw is provided by means of which errors in the zero position of the pointer can be easily rectified.

For Values Between	Use Range	Use Scale	Range Key To Be Operated
75 and 750 MA	0-750 MA	Outer x 10	None
15 and 75 MA	0-75 MA	Outer	75
3 and 15 MA	0-15 MA	Middle	15
0 and 3 MA	0-3 MA	Inner	3 and 15

2.4 Regulation

A 74A Rheostat is provided for regulating the current. It consists of one long and one short rheostat mounted end to end. The short rheostat, which is assembled at the right side, is equipped with 4 red sliders and has a range of 0 to 28,000 ohms in 1,000 ohm steps. It is used for the coarse regulation. The long rheostat, which is assembled at the left side, is equipped with 4 black sliders which move over a slide wire coil having a minimum resistance of 1,150 ohms or approximately 2 ohms per turn and is used for the fine regulation. The maximum resistance position on both rheostats is obtained when the sliders are to the extreme right. The 2 sets of sliders are numbered 1, 2, 3 and 4 and are associated with 4 similarly numbered miniature telegraph keys which may be either locked operated or momentarily operated to close the circuit through the set. The 4 miniature telegraph keys and the 4 sets of red and black sliders provide 4 different resistance circuits so that 4 different and independent values may be set up at one time. Further regulation may be required in the case of extremely low current flow or voltage values and provision for inserting additional resistances is made in the Nos. 3 and 4 circuits. The (3) and (4) switches each provide an additional resistance of 500,000 ohms in 25,000 ohm steps for this purpose. They are manually operated 2 level switches. This resistance is not ordinarily required and when the switches are in the normal (N) position, the above resistance is taken out of the circuit.

2.5 Protection

The set is fused with a (3/4 AMP) 24D fuse. Spare fuses are furnished with the set.

CAUTION: This fuse adequately protects only the high range of the meter. It is, therefore, necessary before using any of the lower ranges to make sure that the current is regulated so that the meter reading will be within the limits of the range to be used. This is accomplished either by placing all sliders to the extreme right or by approximating the desired meter reading on the highest range before depressing any of the range keys.

The circuit is arranged so that connection is made to the 0-75 MA range with the (SETUP) switch in any of the current flow setup positions and the 0-300V range with the (SETUP) switch in any of the voltage setup positions. With the (SETUP) switch in any of the current flow setup positions, the operation of the (3 and 15), (15) or (75) range keys transfers the circuit to the 3, 15 and 75 milliampere ranges. In a like manner with the (SETUP) switch in any of the voltage setup positions the operation of the (3), (15) or (75) range keys transfers the circuit to corresponding voltage ranges. The range keys are non-locking so that they will restore the circuit to the high range when not held operated. This arrangement is intended to protect the lower meter ranges.

3. OPERATION

The steps normally followed in using this set are listed below.

(1) Place all red and black sliders to the extreme right.

(2) Set the (3) and (4) switches in the (N) normal position and patch the (3) and (4) single conductor jacks using 2 ITE-4091 twin plugs.

(3) Make sure that none of the miniature telegraph keys are operated.

(4) The (REV) key should be in the unoperated (UP) position.

(5) Ascertain from the "Test Set Prep." column on the Circuit Requirement Table the application to be used and then refer to the particular figures illustrating this application. Set the (SETUP) switch and connect the cords accordingly making the connection to the apparatus under test at the points listed under the "Test Clip Data" columns on the Circuit Requirement Table. If the deflection of the pointer on the meter is in the wrong direction operate the (M) switch to the (NEG) position.

(6) Determine from the Circuit Requirement Table the electrical requirements to be applied to the particular piece of apparatus under test and then refer to the table under Paragraph 2.3 for information concerning the proper scales and ranges to be used and the range keys to be operated.

(7) Lock one of the telegraph keys operated and proceed to set up one of the electrical values using the correspondingly numbered red and black sliders. Move the red sliders to the left until the meter reading is just below the required value and then obtain the exact value by moving the black slider as required. In the same manner set up the other electrical requirements using the other telegraph keys and their associated red and black sliders.

(8) When a soak value is called for on the Circuit Requirement Table the soak current shall be applied preceding each of the other test conditions. The soak current shall be applied for at least one second and the other test conditions shall be applied within two or three seconds after releasing the key that applies the soak value.

4. TYPICAL TESTING ARRANGEMENTS

4.1 The following information covers the various setups that are to be used. The figures are simplified schematics showing only the essential parts of the circuit. The heavy arrows in these illustrations show the position of the (SETUP) switch rotor rather than the direction of the current flow. They are based on the various positions of the (SETUP) switch and show the external connections as well as the used portion of the circuit within the set.

(a) Figure 3 (BG) Battery Ground Application. The application is used where neither battery nor ground is supplied by the apparatus under test. The setup as shown in Figure 3 is used for checking the (F) relay. See Requirement Table for Test Clip Preparation.

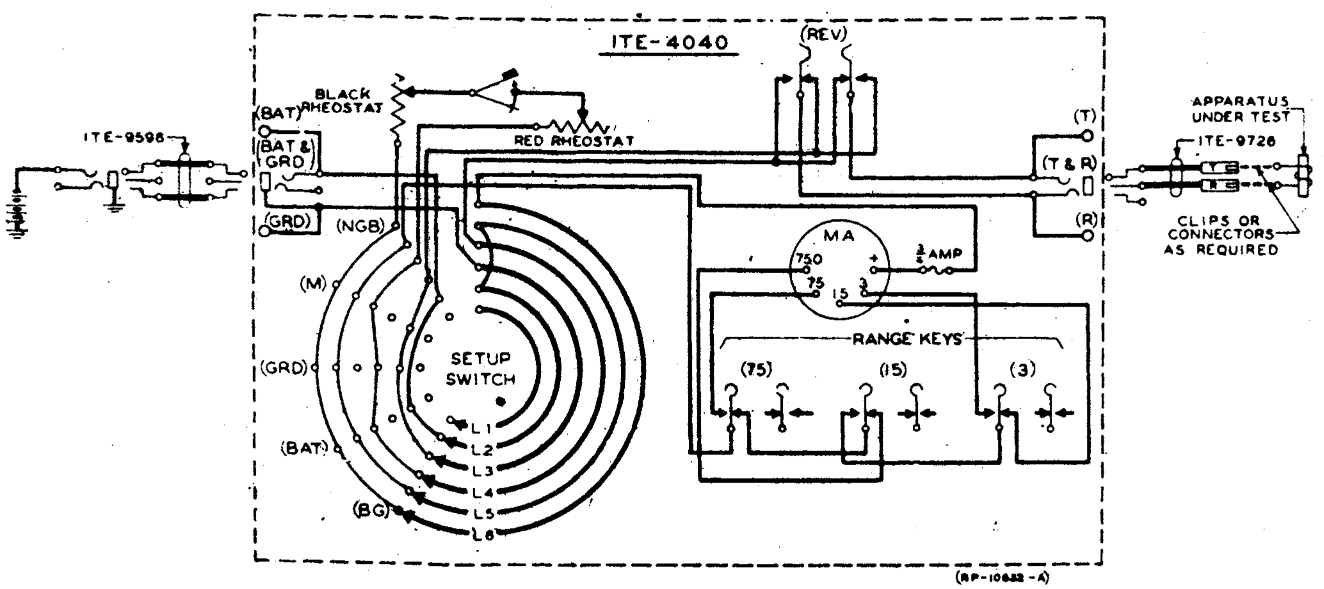

FIG. 3 (BG) BATTERY GROUND APPLICATION

(b) Figure 4 (BAT) Battery Application. This application is used where ground is supplied by the apparatus under test. The setup as shown in Figure 4 is used for checking the (K) relay. See Requirement Table for Test Clip Preparation.

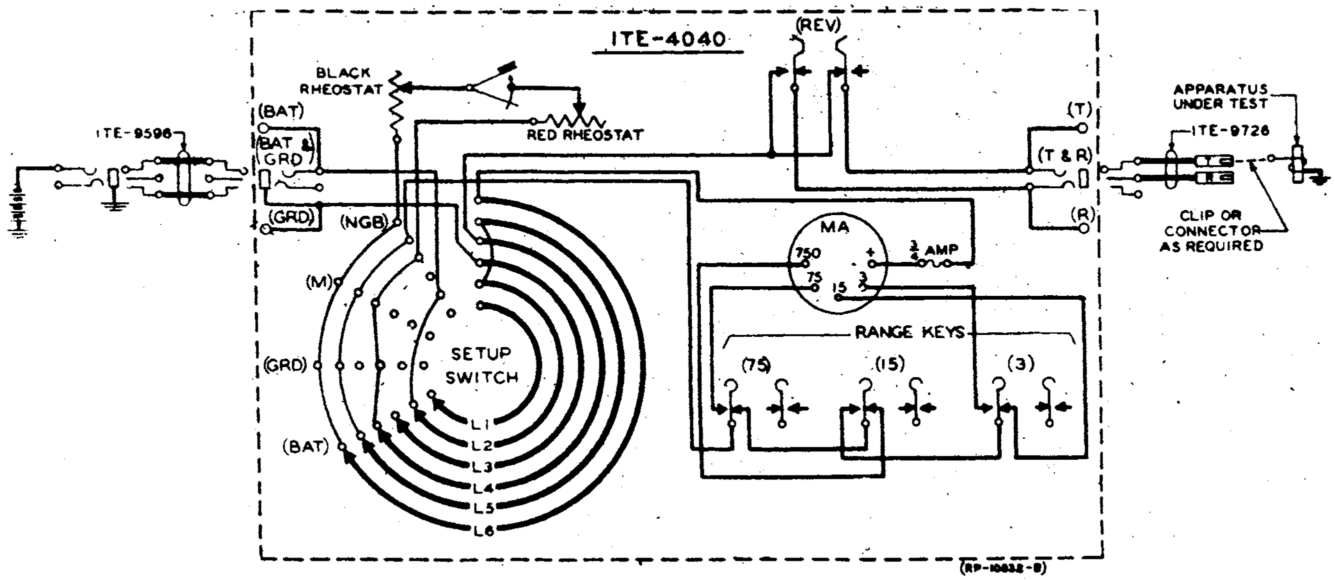

FIG. 4 (BAT) BATTERY APPLICATION

(c) Figure 5 (GRD) Ground Application. This application is used where battery is supplied by the apparatus under test. The setup as shown in Figure 5 is used for checking the (B), (C), (E) and (G) relays. See Requirement Table for Test Clip Preparation.

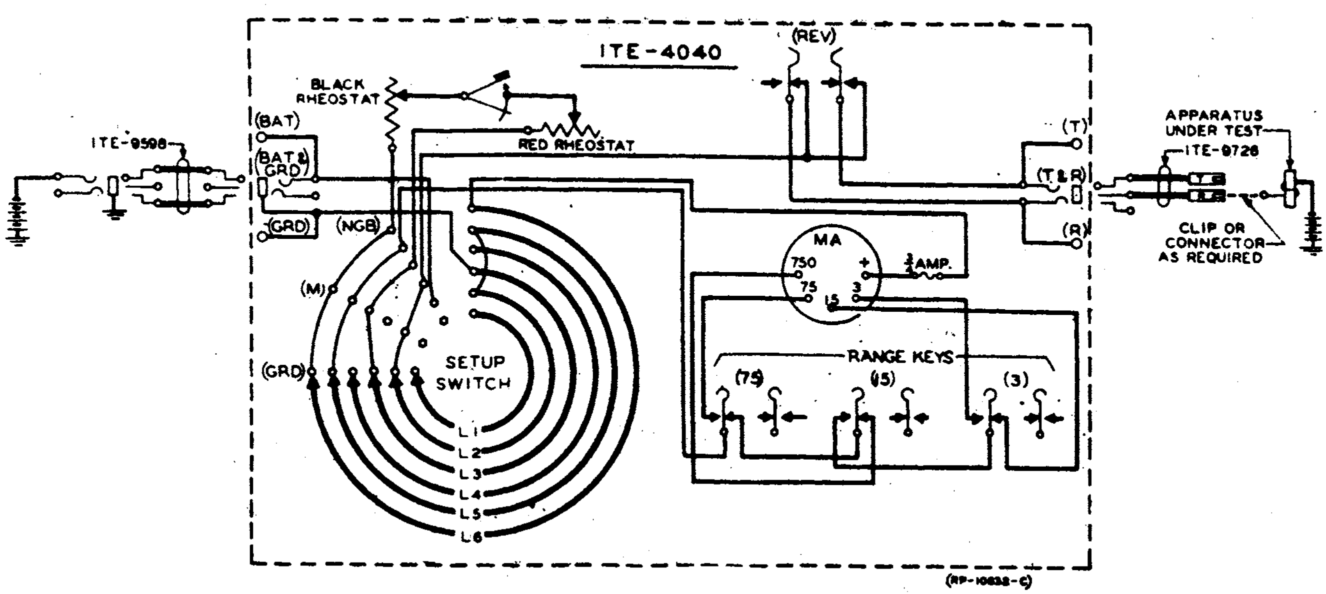

FIG. 5 (GRD) GROUND APPLICATION

(d) Figure 6 (M) Metallic Application. This application is used where both battery and ground is supplied by the apparatus under test. The setup as shown in Figure 6 is used for checking the (D) relay. See Requirement Table for Test Clip Preparation.

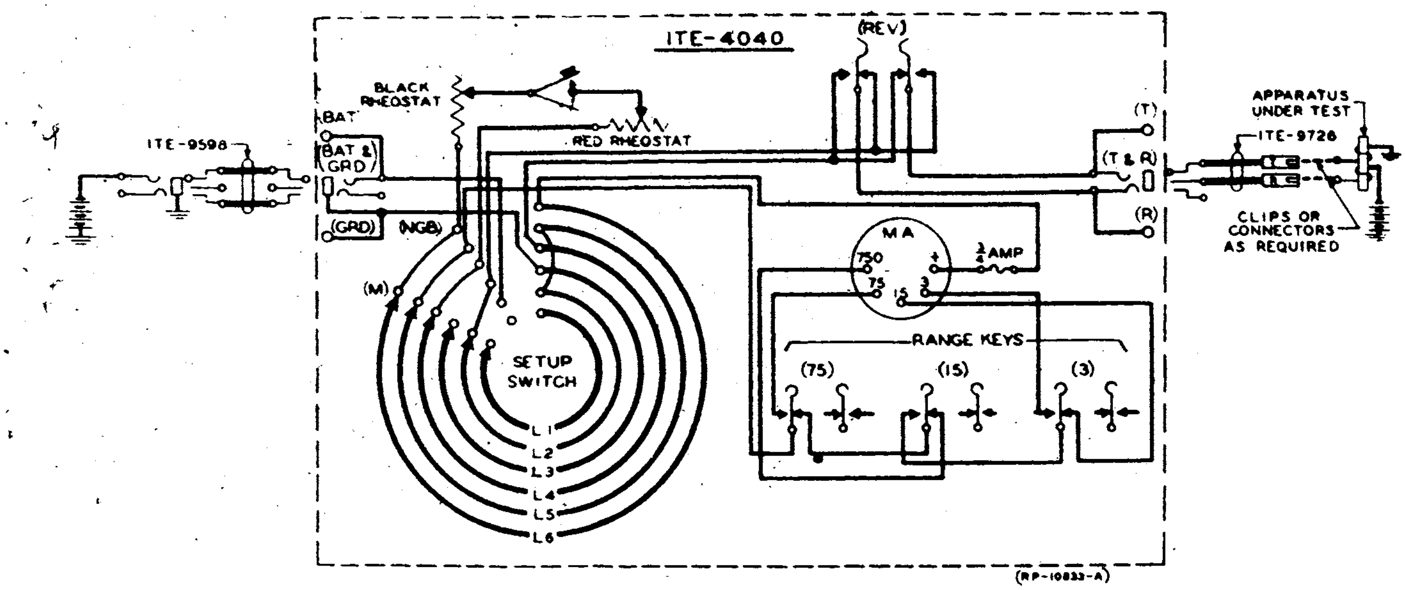

FIG. 6 (M) METALLIC APPLICATION

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OPERATION TRAINING OUTLINE NO. 311
PART 1
ELECTRICAL REQUIREMENTS AND CHECKING PROCEDURES FOR STEP-BY-STEP RELAYS

1. ELECTRICAL REQUIREMENTS

(a) Requirement

(1) A relay shall meet the electrical requirements specified on the Circuit Requirement Table.

Operate: A relay is said to operate if, when current is connected to its winding, the armature moves all the way up to the core, except where a residual is specified in which case the residual screw (adjustable stop pin) touches the core, and all back contacts break and all front contacts make.

Non-operate: A relay is said to non-operate, if, when current is connected to its winding, the armature does not move sufficiently to close any make contacts or to reduce the back contact pressure enough to cause an unreliable contact.

Soak: The soak value specified on the Circuit Requirement Table shall be applied. The relay shall be soaked before applying the electrical test or readjust requirements by passing through the winding or windings under test the maximum current (not to exceed .500 amp.) permitted by the specified test clip data with minimum resistance in the relay adjusting set.

The soak current shall be applied for an interval of minimum 1 second. The other electrical requirements shall be applied within a minimum of 1 second, maximum 3 seconds after the soak has been disconnected.

CIRCUIT REQUIREMENT TABLE

197H CONNECTOR SWITCH

Apparatus		Circuit Preparation			Test Set Prep.	See Test Note No.	Direct Current Flow Req.					Remarks
Desig.	Code	Block or Insulate	Test Clip Data Conn.Batt.	Test Clip Data Conn.Grd.			Test WDG.	Test For	After Soak MA.	Test MA.	Readj. MA.	
Relays												
A	221-A	(B)NO (B)NO	Test Jk.2 Test Jk.2	Test Jk.1 Test Jk.1	M M	1 1	F/R or P/S	O NO	100 100	15.1 13.9	14.8 14.4	Test Cont.Separation Min.3 Cont. Follow on make Min. 8
B	248-D	1(A) 1(A)		3(A) 3(A)	GRD GRD			O NO	50 50	10.5 8.5	10 9	
C	221-GL			3(B) 3(B)	GRD GRD			O NO	500 500	90 62	85 69	
D	222-KM	(B)NO (B)NO	5(F) 5(F)	8(F) 8(F)	M M		F/R or P/S	O NO	100 100	28.5 19	27 21	Test Min.Cont.Press 35 Grams on Spring 7-8 and 10-11
E	221-DU	4T(K) 4T(K)		2(G) 2(G)	GRD GRD			O NO	110 110	15.5 10.6	14.7 11.2	Cont.Pressure Springs 3 & 4 Min. 15 Grams.
F	222-J		8T(K) 8T(K)	6T(K) 6T(K) 2(F) 2(F)	B/G B/G GRD GRD	2	P P S S	O NO O NO	 30 30	30 23 27 20	27 25.5 24 22	Springs 1 & 2 may make
G	221-T	(K)O (K)O		5B(K) 5B(K)	GRD GRD			O NO	30 30	14.4 11	12.8 12.1	
K	224-D	(E)O(G)NO (E)O(G)NO	1(E) 1(E)	 2B(K) 2B(K)	BATT BATT GRD GRD	3/4	P P S S	O NO O O	 35 35	29.5 23.5 22.5 32.5	28 25 21 31.5	Only Conts.1B & 2B need make 3T and 4T shall Break, 1T & 2T may make

TEST NOTES:

1. Armature need not touch core on operate current.
2. Req. for springs 1 and 2, contacts shall make before spring 1 strikes the bushing on spring 4.
3. Test 1B and 2B shall make before 1T and 2T make and 3T and 4T break.
   3T and 4T shall break before 3B and 4B break.
   1T and 2T shall make before 5B and 6B break.
4. 1B and 2B contacts shall make before spring 1B strikes the bushing on spring 4B.

(b) Checking Procedure

To check the specified operate and non-operate values of relays given in the Circuit Requirement Table, use the ITE-4040 Adjusting Set as covered in Operation Training Outline No. 310.

221,222, 224 and 248 Type Relays: Block relays non-operated by inserting a toothpick or KS-6320 orange stick for relays having a large armature travel, between the armature and the core. Block relays operated by inserting a toothpick or KS-6320 orange stick between the armature and the armature stop. Due to the construction of the relay, manually operate the relay before inserting the toothpick, or orange stick. See Figure 1.

Blocking tools, toothpicks and paper used in insulating contacts, should be removed after checking relay requirements.

Insulating With Bond Paper: In general, when it is necessary to insulate contacts, use KS-7187 bond paper. Before removing the paper, relieve the tension of the springs against the paper. After using paper for insulating contacts, burnish the contacts with the proper burnishing tool as a further precaution against trouble from paper lint. Relays other than the one under test may ordinarily be blocked operated or non-operated or the contact springs be separated by means of toothpicks. In a few cases it may be necessary to insulate one contact without affecting the rest of the spring assembly, as illustrated in Figure 2.

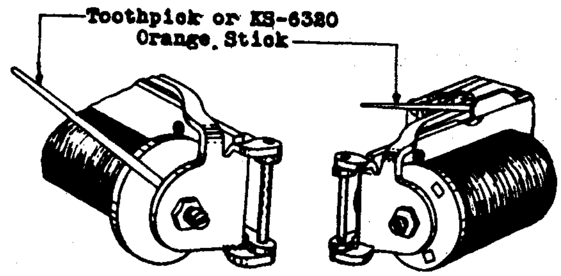

FIG. 1 NON-OPERATED FIG. 1 OPERATED

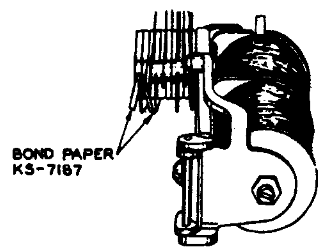

FIG. 2

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OPERATION REQUIREMENTS OUTLINE NO. 311
PART 2
ELECTRICAL ADJUSTING PROCEDURES FOR STEP-BY-STEP RELAYS

1. ELECTRICAL REQUIREMENTS

(c) Adjusting Procedure

(1) If a relay meets all other requirements which are applicable, but fails to meet the operate test requirement, reduce the tension of the lever springs so that unless otherwise specified the relay will operate all springs on the specified readjust operate current.

(2) If a relay meets all other requirements which are applicable, but fails to meet the non-operate test requirement, increase the tension of the lever springs so that the relay will not open any break contacts or close any make contacts on the non-operate readjust requirement, except as permitted in the notes and remarks on the Circuit Requirement Table.

(3) On spring assemblies having more than one lever spring, it is advisable to tension the lever springs against their associated break contacts approximately equal. In the case of lever springs associated with make contacts only, the tension of the lever springs shall be distributed uniformly.

(4) To change the relative position of the springs, place the adjuster on the front ends of the springs but back of the armature stud and then slide it back to a point about 1/4" from where the spring leaves the insulators as shown in Figures 1 and 2. Increase or decrease the tension of the lever springs by applying a slight twist of the spring adjuster to the right or left as required, exercising care not to disturb adjacent springs. In adjusting the springs exercise care to adjust them in line with their movement so as not to twist them off center.

(5) If a satisfactory position of the springs can not be obtained by adjusting as outlined in (4) without bowing the spring beyond its permissible limit apply the spring adjuster to the spring just back of the stud and slide it back to the base of the spring, as indicated in Figures 1 and 2. Draw the adjuster forward the length of the spring meanwhile applying pressure as required so that the spring is formed into a slight gradual bow with the concave surface facing the heelpiece. The magnitude of the bow to be formed in the spring must be learned by experience and should be such that when the final tension adjustment is made at the base, the spring will be approximately straight. Move the adjuster to the base of the spring and adjust as covered in (4).

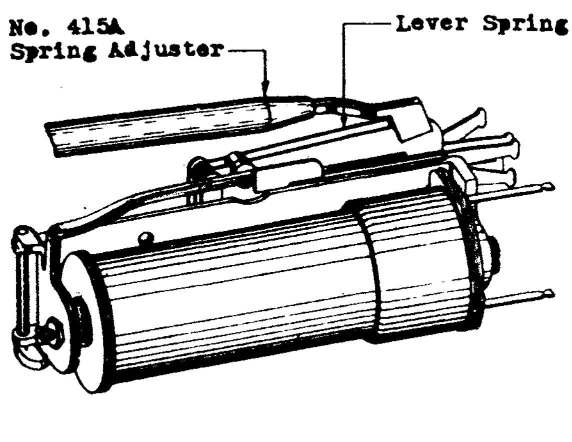

FIGURE 1

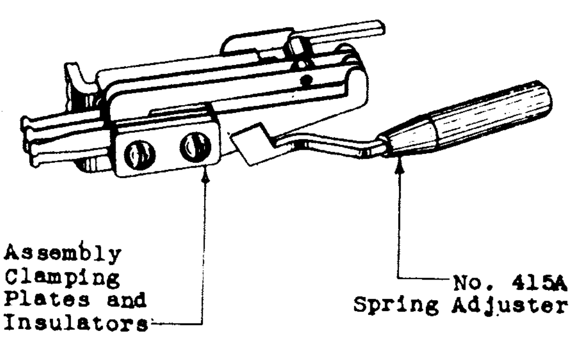

FIGURE 2

(c) Adjusting Procedure (Continued)

(6) If the spring combination has more than one break contact, make sure that the tension against each break contact is approximately equal. Check this with the KS-6320 orange stick, first releasing the tension of the springs which press against the springs being checked. In the case of lever springs associated with make contacts only, make sure that there is uniform distribution of tension.

(7) Apparatus which fails to meet one or more of the test requirements seldom requires a complete readjustment. Any part found out of adjustment should be readjusted (to the readjust value when one is specified) and any other parts which, because of their close association with this adjustment, may have been disturbed should then be checked and readjusted if necessary.

(8) Mean Readjustment: Unless otherwise specified, where there is a maximum and a minimum limit for the requirement an effort should be made in readjusting a piece of apparatus to work to the mean of the limits.

(9) Associated Readjust Requirements: After any readjustment has been made associated adjustments which may have been affected shall be checked to their readjust requirements and readjustments shall be made if necessary.

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