

## PILOT WIRE MASTER FLAT GAIN CONTROLLER KS-7664 REQUIREMENTS AND ADJUSTING PROCEDURES

### 1. GENERAL

1.01 This section covers the Pilot Wire Master Flat Gain Controller KS-7664 for flat gain regulation of type K1 carrier telephone systems.

1.02 This section is reissued to incorporate material from the addendum in its

proper location. In this process marginal arrows have been omitted.

1.03 Reference shall be made to Section 020-010-711 covering General Requirements and Definitions, for additional information necessary for the proper application of the requirements listed herein.

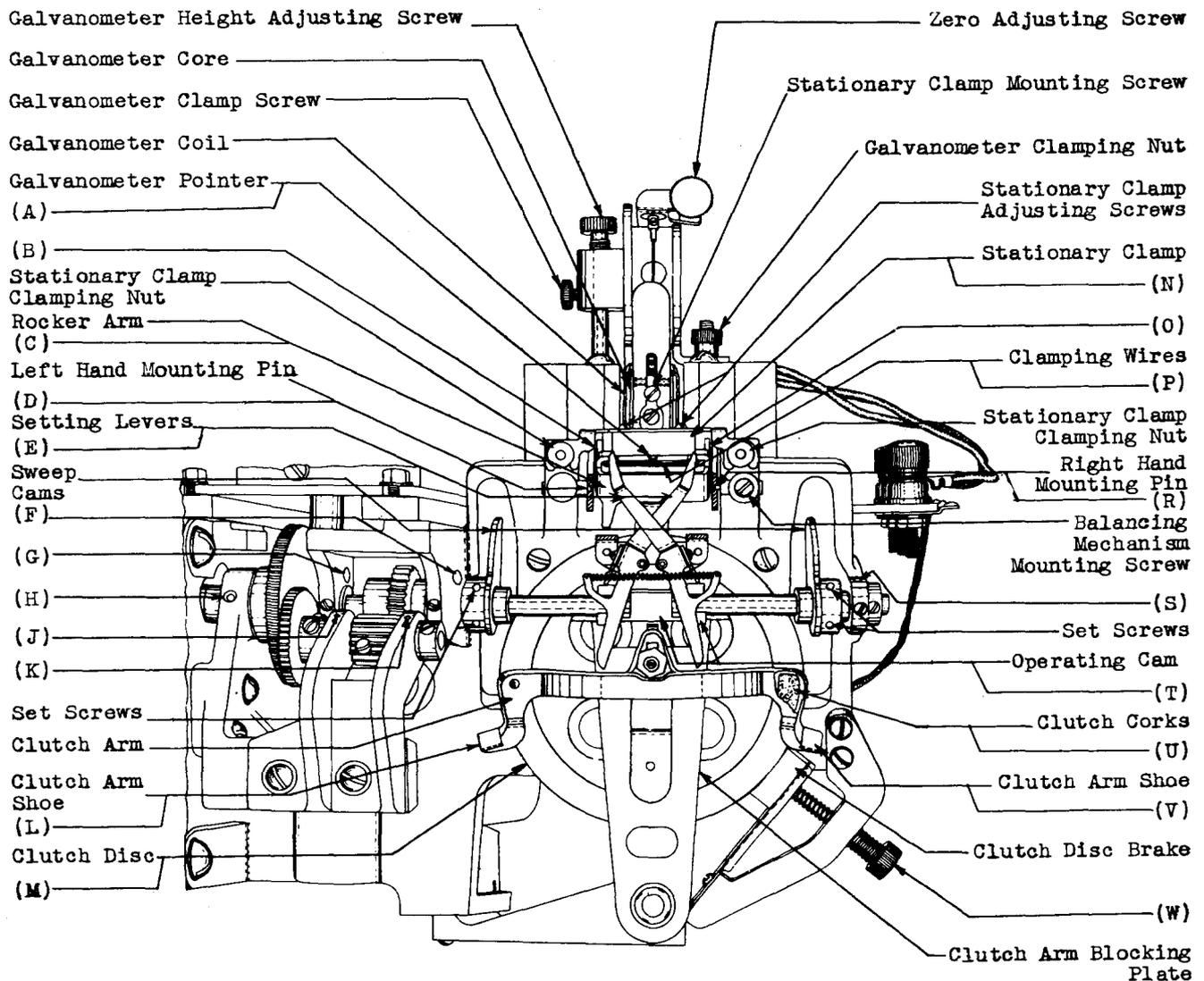


Fig. 1 - Controller Mechanism

\*1.04 Asterisk: Requirements are marked with an asterisk(\*) when to check for them would necessitate the dismantling or dismounting of apparatus or would affect the adjustment involved or other adjustments. No check need be made for these requirements unless the apparatus or part is made accessible for other reasons or its performance indicates that such a check is advisable.

†1.05 Double Dagger: The equipment shall be considered satisfactory for service when it has met all the requirements marked with a double dagger (†).

1.06 Hunting may be defined as a continuous succession of rebalancing movements of equal amplitude, first in one direction and then in the other, caused by an over-sensitive galvanometer.

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

1.08 Removing the master controller from service is described in Par. 3.002. This will allow the master controller to be operated for purposes of checking requirements and performing adjusting procedures without affecting the dial settings of the associated 100A regulators. The master controller should not be removed from service during periods of large variations in attenuation nor for an extended period of time. Placing the master controller back in service is described in Par. 3.003.

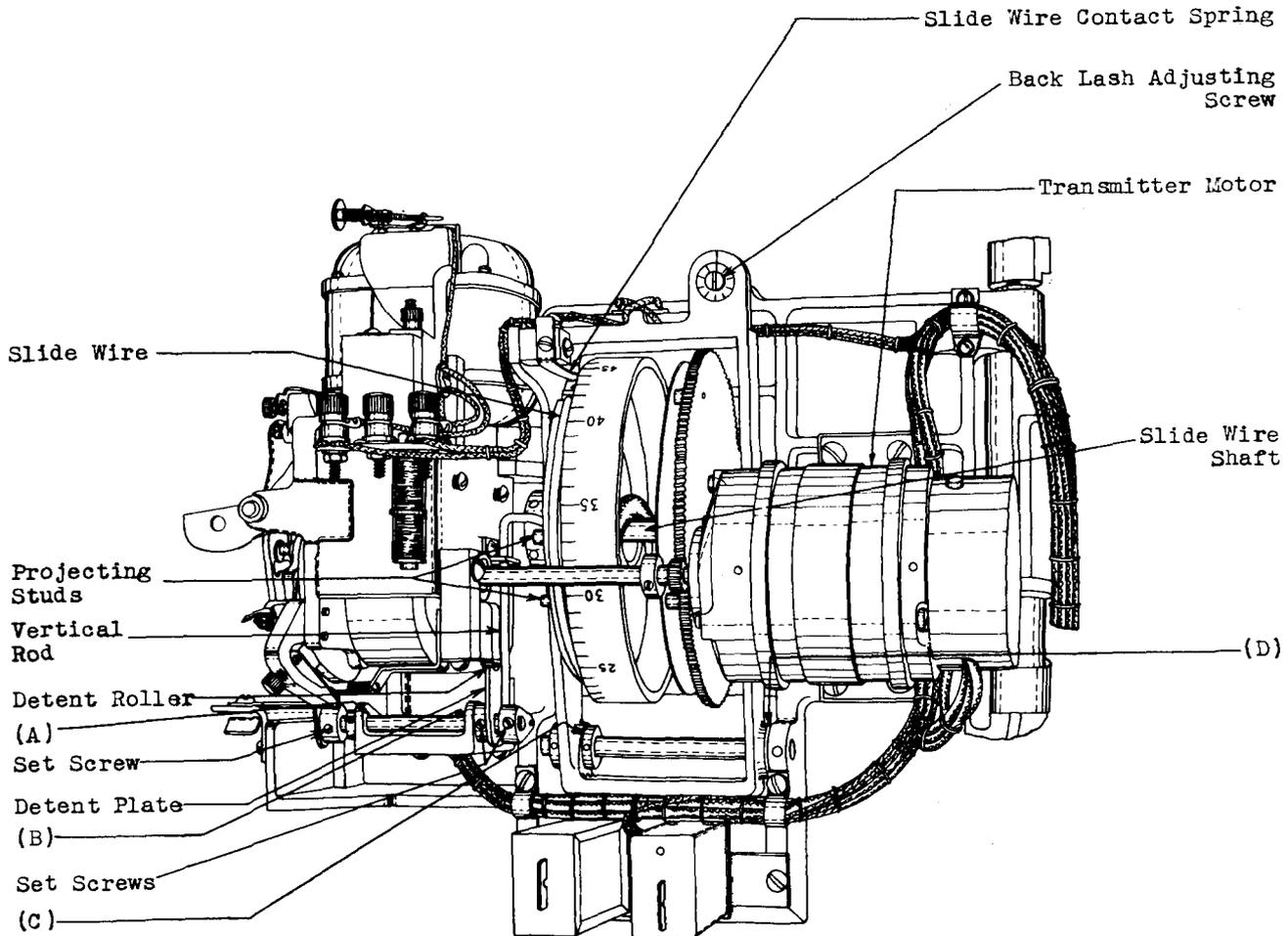


Fig. 2 - Controller Mechanism  
Side View

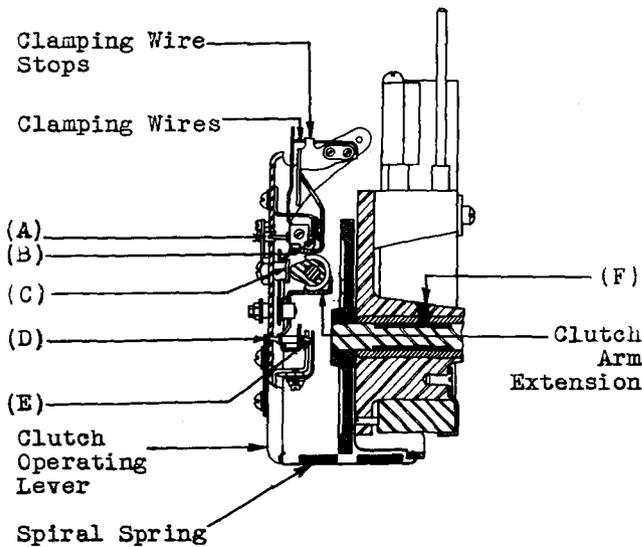


Fig. 3 - Cross Section of Balancing Mechanism and Clutch

## 2. REQUIREMENTS

### 2.01 Cleaning

(a) The following parts shall be cleaned when necessary.

- (1) Clutch disc Fig. 1 (M).
- (2) Clutch corks Fig. 1 (U).
- (3) Galvanometer pointer Fig. 1 (A).
- (4) Stationary clamp Fig. 1 (N).
- (5) Clamping wires Fig. 1 (P).
- (6) Setting levers Fig. 1 (E).
- (7) Shaft bearings Fig. 1 (F),(G),(H),(J),(K),(S) Fig. 2 (A),(B),(C),(D).
- (8) Bearings for shaft on which slide wire and dial are mounted.
- (9) Worm gear Fig. 7.
- (10) Clutch arm shoes Fig.1(L) and (V).
- (11) Relay contacts shall be cleaned in accordance with the section covering the cleaning of relay contacts and parts.

(b) The following parts shall be cleaned at 6 month intervals.

- (1) Operating cam Fig. 1 (T).
- (2) Slide wire Fig. 2.
- (3) Balancing mechanism Fig. 3.

2.02 Lubrication: Lubrication has been provided by the manufacturer on the following parts. Additional lubrication

shall be provided only after cleaning and at the intervals indicated in this section.

(a) The following parts shall be adequately lubricated with KS-2245 oil.

- (1) Shaft bearings, Fig. 1 (F),(G),(H),(J),(K),(S).
- (2) Bearings for shaft on which slide wire and dial are mounted.
- (3) Shaft bearings Fig.2 (A),(B),(C),(D).
- (4) Shaft bearing Fig. 3 (F).
- (5) Socket and pivot bearings Fig. 1 (B),(D),(O),(R).
- (6) Socket and pivot bearings Fig. 3 (A),(B),(D),(E).
- (7) Reduction gears Fig. 1 and 7.
- (8) Dial drive gears Fig. 2.
- (9) Clutch arm shoes Fig.1 (L) and (V).
- (10) Fibre contact buttons Fig.3 (C).
- (11) Operating cam Fig. 1 (T).

(b) Lubrication Interval: After turnover the following lubrication intervals are recommended. These intervals may be extended if periodic inspections have indicated that local conditions are such as to insure that the requirements will be met during the extended interval.

- 2 Months - Items 1, 2, 5, 6, 9 and 11
- 6 Months - Items 3, 4, 7, 8 and 10.

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

### 2.04 Rocker Arm

(a) Clamping Wires: Fig. 1 and Fig. 3 - The clamping wires shall be straight and parallel to each other. Gauge by eye.

\* (b) Clamping Wire Pressure: Fig.3 - The pressure of each clamping wire on the clamping wire stops shall be:  
 Minimum - 50 grams  
 Maximum - 150 grams  
 Use the 62B gauge and measure at a point in front of the clamping wire stops.

(c) The rocker arm shall move freely in its bearings with only a minimum amount of side play. Gauge by feel.

†2.05 Setting Levers - Fig. 4

(a) Balance: With the controller in operation and the galvanometer removed, the clutch disc shall not move. Gauge by eye.

(b) Clearance: With the galvanometer mounted and its pointer in the center of the space between the setting levers, there shall be no clearance between the levers and the pointer or between the levers and the clutch arm split collar, when the setting levers are free from the operating cam. Gauge by eye.

(c) Pressure: The pressure of the setting levers on the split collar when the clutch is disengaged shall be:

Minimum - 20 grams

Maximum - 50 grams

Use the 68B gauge and measure at a point on the levers as close as possible to the split collar. The clutch arm is to be held steady in its horizontal position while making this measurement.

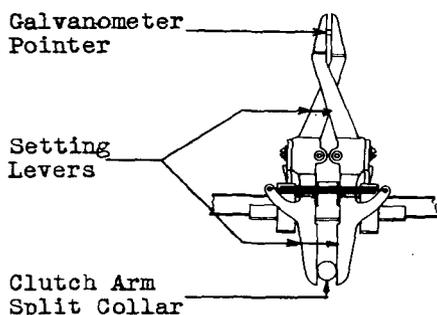


Fig. 4 - Setting Levers

2.06 Galvanometer

†(a) Coil Position: The galvanometer coil Fig. 1 shall be centrally located vertically and horizontally with respect to the galvanometer core, its front edge shall be approximately flush with the front face of the core, and it shall swing freely in both directions. Gauge by eye.

\*(b) Suspension Tension: Fig. 5 - There shall be no appreciable sag in the galvanometer suspension, when the galvanometer system is laid in a horizontal position. Gauge by eye.

(c) Suspension Torsion: Fig. 5 - With the galvanometer system in a vertical position and the zero adjusting screw near its center of travel, the pointer shall come to rest at right angles to the face of the core. Gauge by eye.

\*(d) Balance: The end of the galvanometer pointer shall not move when

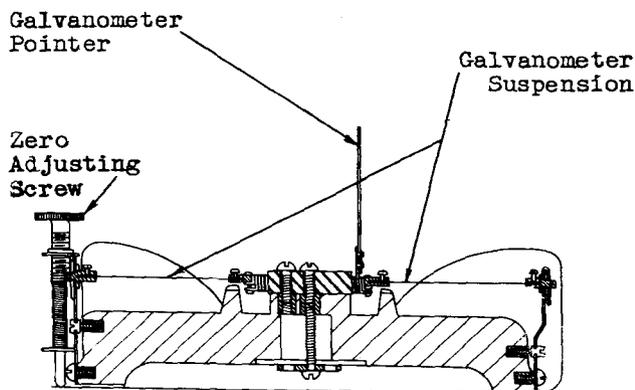


Fig. 5 - Cross Section of Galvanometer

the galvanometer system is tilted in any direction  $10^\circ$  or  $15^\circ$  from the vertical. Gauge by eye.

\*(e) Front and Rear Balance: The pointer shall remain horizontal when the galvanometer is held with the suspension horizontal and the pointer horizontal to the left or right. Gauge by eye.

\*(f) Lateral Balance: The pointer shall remain vertical when the galvanometer is held with the suspension horizontal and the pointer vertical downward. Gauge by eye.

†(g) Galvanometer Clamping Nut: Fig. 1 - The galvanometer clamping nut shall be turned down until it just touches the lug but shall not be tightened. Gauge by feel and eye.

Caution: Care shall be taken that this nut is not tightened against the lug since this may throw the galvanometer system out of alignment and affect the zero adjustment.

†(h) Pointer - Fig. 1(A)

(1) With the galvanometer winding connected to the test resistance, the galvanometer pointer shall be centered between the stationary clamp (N) and the clamping wires (P) (Fig. 1), when the straight edges of the sweep cams extend vertically upward. Gauge by eye.

(2) The upper and lower faces of the galvanometer pointer shall be parallel to the horizontal planes of the stationary clamp and rocker arm clamping wires. Gauge by eye.

(3) The pointer shall not stick to the stationary clamp, the rocker arm clamping wires or the setting levers. Gauge by eye.

†(j) Zero Adjustment: With the galvanometer winding connected to the test resistance and with the controller in operation, the galvanometer pointer shall remain steady in its zero position and the clutch disc shall not move. Gauge by eye.

## 2.07 Clutch

(a) Clutch Disc: The clutch disc Fig. 1(M) shall be tight on its shaft. Gauge by feel.

(b) Torque: With the clutch arm engaging the clutch disc, the force required to turn the clutch disc shall be:  
Minimum - 50 grams  
Maximum - 100 grams  
Use the 70E gauge applied at the clutch arm shoe.

(c) Clutch Corks: Both clutch corks Fig. 1(U) shall engage the clutch disc simultaneously and their surfaces shall be parallel to the plane of the disc. Gauge by mechanical test.

(d) Pressure of Clutch Operating Lever: The pressure of the clutch operating lever when the clutch is engaged shall be:  
Minimum - 560 grams or 1-1/4 lbs.  
Maximum - 760 grams or 1-3/4 lbs.  
Use the 79E gauge and measure at the bottom of the clutch operating lever.

†(e) Clutch Slip: The clutch arm shall turn the clutch disc without slipping. Gauge by eye.

(f) Clutch Arm Bearing: The clutch arm, when disengaged, shall be just tight enough in its bearings to remain in any position to which it is tilted. Gauge by eye.

2.08 Cams - General: All cams shall be tight on their shafts. Gauge by feel.

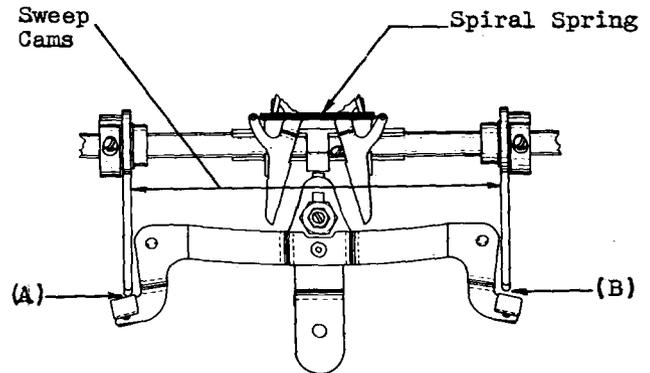
## 2.09 Sweep Cams

(a) Angular Relation to Operating Cam: Fig. 1 - The sweep cams shall be in such a position relative to the operating cam Fig. 1(T), that when the operating cam just begins to move the clutch operating lever, Fig. 3, the straight edges of the sweep cams shall extend horizontally back into the casting. Gauge by eye.

(b) Angular Relation to Each Other: The sweep cams shall be in the same angular position relative to each other. Gauge by eye.

†(c) Linear Position: Fig. 6 - The linear location of the sweep cams on

the cam shaft shall be such that both cams shall clear the clutch disc by the same amount, and when the high point of the cam is resting on a clutch arm shoe, the high point of the other cam shall clear its associated clutch arm shoe by  
Maximum - .002 inch  
Use the 75F gauge.



Touching at (A) Clearance at (B)  
(or vice versa)

Fig. 6 - Sweep Cams

2.10 Slide Wire Contact Spring: The pressure of the contact spring on the slide wire shall be:  
Minimum - 135 grams  
Maximum - 190 grams  
Use the 79C gauge.

## 2.11 Reduction Gears - Fig. 7

- (a) Worm (A) shall be lined up to center with gear (B). Gauge by eye.  
(b) There shall be no bind or appreciable backlash between the gear and the worm. Gauge by feel.

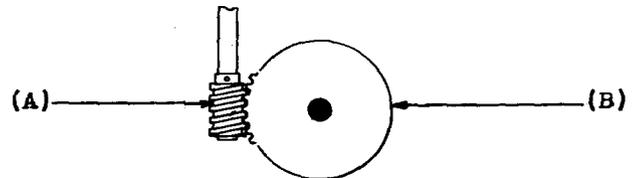


Fig. 7 - Driving Worm and Gear

2.12 Galvanometer Sensitivity Control: With the bridge circuit resistance values as in the accompanying table and with the controller in operation, the setting of the galvanometer sensitivity control shall be such that:

- (a) There shall be no hunting. Gauge by electrical test.
- (b) Each rebalancing movement of the controller mechanism shall cause a subsequent pointer deflection of 1/2 to 3/4 of the previous deflection and in the opposite direction. Gauge by electrical test.

Bridge Circuit Resistance Values

Note: At points where there is a twist controller in the same office as the flat gain controller, a varying amount of resistance is automatically inserted between terminals (TW) and (R) on the flat gain controller panel by means of regulator switches operating in association with the twist controller. In such cases for the purpose of checking this requirement the R2A resistance shall be set at zero and the resistance box shall be set at 2280 ohms for a pilot wire length of 0 to 27.0 miles (or at 4267 ohms for 27.0 to 50.3 miles, or at 6449 ohms for over 50.3 miles). Terminals (TW) and (R) shall be short circuited. For other cases the value of R2A shall be as given in the tables.

For Pilot Wire Length 0 to 27.0 Miles

Resistance	Resistances Strapped Out	Total
		Res. Value Remaining
R3B	640,80,20 and 5 ohms	535 ohms
R4A	1800 and 1640 ohms	1860 ohms
R6A	1000 ohms	500 ohms
Resistance box connected in place of pilot wire		84xM ohms
R2A		2280 minus (84xM) ohms

Note: M is the pilot wire length in miles. Where value of M is not known R2A shall be set at zero and the resistance box shall be set at 2280 ohms.

For Pilot Wire Length 27.0 to 50.3 Miles

Resistance	Resistances Strapped Out	Total
		Res. Value Remaining
R3B	640,80,20 and 5 ohms	535 ohms
R4A	1800 ohms	3500 ohms
R6A	1000 and 500 ohms	0 ohms
Resistance box connected in place of pilot wire		84xM ohms
R2A		4267 minus (84xM) ohms

Note: M is the pilot wire length in miles. Where value of M is not

known R2A shall be set at zero and the resistance box shall be set at 4267 ohms.

For Pilot Wire Length Over 50.3 Miles

Resistance	Resistances Strapped Out	Total
		Res. Value Remaining
R3B	640,80,20 and 5 ohms	535 ohms
R4A	None	5300 ohms
R6A	1000 and 500 ohms	0 ohms
Resistance box connected in place of pilot wire		84xM ohms
R2A		6449 minus (84xM) ohms

Note: M is the pilot wire length in miles. Where value of M is not known R2A shall be set at zero and the resistance box shall be set at 6449 ohms.

2.13 Bridge Balance: With the bridge circuit resistance values as in the table for paragraph 2.12 and with the controller in operation, the controller shall come to a balance so that the dial reading is  $30 \pm 1$ . Gauge by electrical test.

2.14 Slide Wire Resistance: With the bridge circuit resistance values as in the table for paragraph 2.12 and with the controller in operation and at a balance so that the dial reading is at mid-scale, the change in pilot wire resistance which will cause an increase of 25 divisions from the mid-scale reading of the controller dial and the change which will cause a decrease of 25 divisions from the mid-scale reading shall be within 3 ohms of each other. Gauge by electrical test.

2.15 Clutch Arm Block - Fig. 8

(a) With the clutch arm disengaged and in a horizontal position, the left prong of the clutch arm blocking plate shall be against the clutch arm extension when the dial reading is between 1.9 and 2.1. Gauge by eye.

(b) With the clutch arm disengaged and in a horizontal position, the right prong of the clutch arm blocking plate shall be against the clutch arm extension when the dial reading is between 57.9 and 58.1. Gauge by eye.

2.16 Limit Alarm: The limit alarm shall operate just before the clutch arm blocking plate touches the clutch arm extension. Check for both the left and right prongs of the clutch arm blocking plate.



Materials

- D-98063 Cloth
- KS-2245 Oil
- KS-8372 Trichloroethylene

Test Apparatus

- Leeds & Northrup Dial Decade Resistance Box 4780, 4746B or the Electrical Equivalent

3.002 To remove the master controller from service proceed as follows. Remove the 55 volt power by removing the PW REG line fuse. Remove the following fuses in the order named; TRS MOT PRI, REC PRI and REC SEC. Remount the PW REG line fuse.

3.003 To place master controller back in service proceed as follows. Remove 55-volt power by removing PW REG line fuse. Check that dial of master controller reads the same as associated 100A regulators. Remount following fuses in order named; REC PRI, REC SEC, TRS MOT PRI and PW REG line fuse.

3.004 In order to make mechanical adjustments on the controller mechanism, the controller should be stopped in the position in which the clutch arm is disengaged from the clutch disc and the straight edges of the sweep cams extend vertically upward. In this position all pressure is released from the clutch, and the sweep cams will not interfere with removal of the balancing mechanism and the galvanometer. To stop the controller, block the BF relay in its non-operated position and insulate the alarm contacts on it.

3.005 Care shall be taken to avoid touching or handling the front rim of the clutch disc as any slight trace of oil will collect dust and dirt and will cause the clutch to slip. It is also important to keep any trace of oil from the outside edge or rim of the clutch disc as this would interfere with the action of the brake on the clutch disc.

3.006 In the following procedures D-98063 cloth is referred to as cloth.

3.01 Cleaning (Rq.2.01)

(1) Stop the controller as covered in paragraph 3.004.

(2) Clutch Disc and Clutch Corks: Wipe the engaging surface of the clutch disc and of the clutch corks with a clean cloth moistened with trichloroethylene to be sure that they are free from oil. All of the engaging surface of the clutch disc can be made accessible for cleaning by turning the gear wheel associated with the slide wire.

(3) Galvanometer Pointer - Stationary Clamp - Clamping Wires - Setting Levers: Carefully clean the galvanometer pointer, the stationary clamp, the clamping wires and the setting levers

with trichloroethylene applied with a toothpick at the various points where these parts touch each other. Rub the toothpick lightly along the surface to be cleaned in order to loosen and remove any dirt or grease.

(4) Bearings and Gears: Wipe off any dust or dirt that may have accumulated around shaft bearings, socket and pivot bearings and gears, using a clean dry cloth.

(5) Clutch Arm Shoes: Wipe off any dust or dirt that may have accumulated on the clutch arm shoes, using a clean dry cloth.

(6) Contacts: All relay contacts shall be cleaned in accordance with the section covering the cleaning of relay contacts.

(7) Operating Cam and Balancing Mechanism: In order to clean the operating cam and the balancing mechanism it is necessary to remove the balancing mechanism. This is done as follows: Loosen the stationary clamp clamping nuts (Fig. 1) until the stationary clamp is free, then unhook the spiral spring (Fig. 3) from the clutch operating lever and loosen the balancing mechanism mounting screw (Fig. 1), using the 3-1/2 inch cabinet screwdriver. Move the balancing mechanism to the right thus pushing the right hand mounting pin out far enough to permit the clutch operating lever to clear the left hand mounting pin, and lift the balancing mechanism clear of the frame.

(8) To clean the operating cam, wipe off all accumulated oil and dirt with a clean dry cloth.

(9) Thoroughly clean the balancing mechanism by wiping with a clean dry cloth.

(10) Remounting Balancing Mechanism: To remount the balancing mechanism slide it into position so that the bearing in the left side of the clutch operating lever fits on the left hand mounting pin. Then, holding the balancing mechanism so that the bearing in the right hand side of the clutch operating lever is in line with the mounting pin, push the mounting pin into its bearing. Do not push too hard on the pin after it is fully in its bearing as this may cause the pin to exert sufficient pressure against the bracket in which the rocker arm is mounted to prevent the rocker arm from moving freely and may even cause it to stick. If the pin is not moved in far enough there will be some lost motion to the left or right between the bearings and the mounting pin. Tighten the balancing mechanism mounting screw. Hook the spiral spring

into place again. Push the stationary clamp down as far as it will go and tighten the stationary clamp clamping nuts.

(11) Slide Wire: When cleaning the slide wire, clean only the actual path of contact with the slide wire contact arm. The whole path of contact can be reached by rotating the gear wheel associated with the slide wire. Clean and lubricate in accordance with the section covering cleaning and lubricating of slide wire apparatus.

### 3.02 Lubrication (Rq.2.02)

(1) Attention is called to the fact that too much lubricant, as well as too little, may cause trouble. Too little lubricant may result in sticking and a tendency to bind. On the other hand an excess of lubricant is to be avoided as it will collect dust or dirt and interfere with satisfactory operation. Care shall be taken that no lubricant gets on the insulation.

(2) Stop the controller as covered in paragraph 3.004.

(3) When lubricating worm gears, shaft bearings, operating cams, clutch arm shoes and fibre contact buttons apply the oil with the 486A oil can. Wipe off all excess oil with a clean dry cloth. To gain access to the oil hole (F) in Fig. 9 it is necessary to remove the galvanometer.

(4) Removing Galvanometer: Disconnect the galvanometer leads (Fig. 1) at their screw terminals. Remove the galvanometer clamping nut. Loosen the galvanometer clamp screw and also the stationary clamp clamping nuts. Slowly lift out the galvanometer by the lug on the left hand side.

(5) Remounting Galvanometer: Be sure that the sweep cams extend vertically upward so that they will be out of the way while the galvanometer is being remounted. Turn the galvanometer height adjusting screw (Fig. 1) in as far as it will go. Slide the galvanometer down along its guide rods. Unscrew the galvanometer height adjusting screw until the galvanometer pointer just clears the rocker arm clamping wires for a full deflection in either direction. Push the stationary clamp down as far as it will go and secure it in this position by tightening the stationary clamp clamping nuts. Raise or lower the galvanometer system by means of the galvanometer height adjusting screw until the pointer is centered between the stationary clamp and the clamping wires. Tighten the galvanometer clamp screw and remount the galvanometer clamping nut turning it down until it just touches the lug. Care shall be taken that this nut is not

tightened against the lug as this will throw the galvanometer system out of alignment and will affect requirement 2.06(j) Zero Adjustment. Connect the galvanometer leads to their proper terminals. If the leads are reversed the controller will work away from balance instead of toward it.

(6) In order to lubricate that section of the operating cam which lifts the rocker arm, place the spout of the 486A oil can at the lower edge of the slot (A) of Fig. 9, and allow the oil to run down the inside of the arm (D), so that the oil will flow through the hole (E) to the cam underneath this hole.

(7) When lubricating socket and pivot bearings apply the oil with the 486A oil can and wipe off all excess oil with a clean dry cloth. To gain access to the sockets and pivot bearings in the balancing mechanism Figs. 3(A) and (B) it is necessary to remove the balancing mechanism as described in paragraph 3.01(7). After lubricating remount the balancing mechanism as described in paragraph 3.01(10). Start the controller by releasing the BF relay.

### 3.03 Record of Lubrication (Rq.2.03)

No procedure.

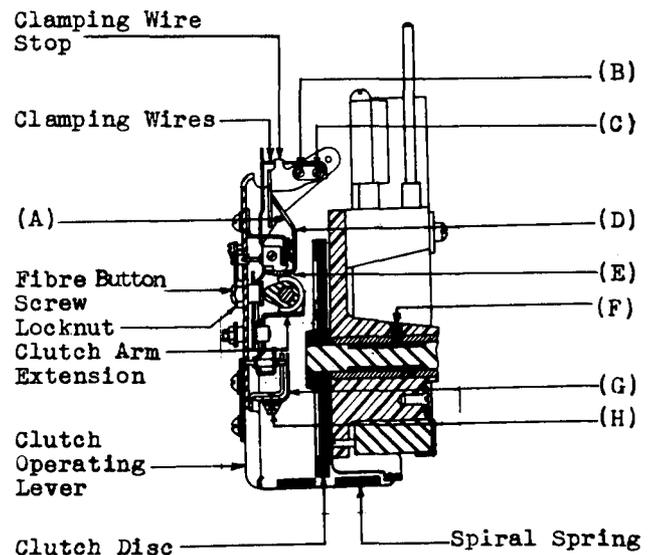


Fig. 9 - Cross Section of Balancing Mechanism

### 3.04 Rocker Arm (Rq.2.04)

(1) Stop the controller as covered in paragraph 3.004. Remove the galvanometer as covered in paragraph 3.02(4).

(2) Remove the balancing mechanism as covered in paragraph 3.01(7). Measure the pressure of the clamping wires against the clamping wire stops (Fig. 9). If necessary to adjust the pressure proceed as follows: Loosen screws (B) and (C) (Fig. 9), using the KS-6854 screwdriver. To increase the pressure, push the adjusting bar up under screw (B) and tighten screws (B) and (C). To decrease the pressure, allow the adjusting bar to slip down under screw (B) and tighten screws (B) and (C). Repeat until the requirement is met.

(3) If the clamping wires become bent, straighten them using a pair of duck-bill pliers. Recheck the pressure of the wires.

(4) Remount the balancing mechanism as covered in paragraph 3.01(10). Remount the galvanometer as covered in paragraph 3.02(5). Start the controller by releasing the BF relay.

(5) If the rocker arm does not move freely in its bearings the trouble may be caused by the right hand mounting pin (Fig. 1(R)) having been pushed in too far so that it exerts pressure against the bracket in which the rocker arm is mounted. To overcome this loosen the balancing mechanism mounting screw (Fig. 1) using the 3-1/2 inch cabinet screwdriver, thus freeing the pin so that it can move back into a position in which its pressure against the rocker arm mounting bracket is relieved, and then retighten the screw. If the rocker arm still does not move freely in its bearings remove the balancing mechanism as described in 3.01(7). Spread the arms of the rocker arm mounting bracket away from each other a very slight amount by exerting pressure on them with the fingers exercising care in doing this so as not to spring them too far apart. Remount the balancing mechanism as described in 3.01(10).

### 3.05 Setting Levers (Rq.2.05)

(1) Balance: Stop the controller as covered in paragraph 3.004. Remove the galvanometer as covered in paragraph 3.02 (4). With the galvanometer removed start the controller by releasing the BF relay. Observe the operation of the controller to see if the clutch disc moves. If there is any movement of the clutch disc proceed as follows: Stop the controller as covered in paragraph 3.004. Loosen screw (A) (Fig. 10) a slight amount using the KS-6854 screwdriver. If the clutch disc moved in a clockwise direction (dial moving toward zero) turn screw B a very slight amount in a counterclockwise direction and turn screw C the same amount in a clockwise direction. If the clutch disc moved counterclock-

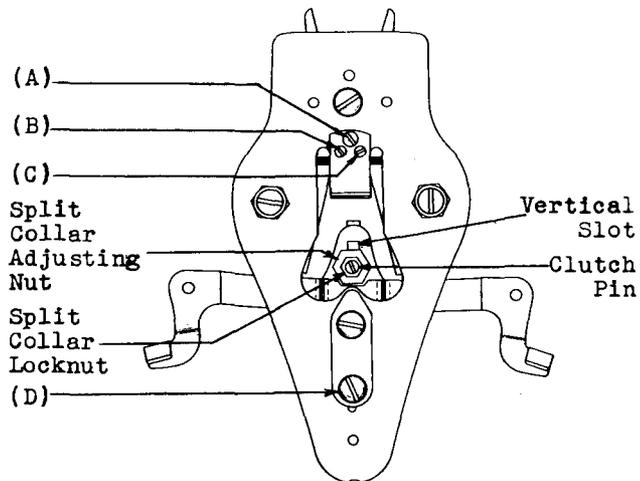


Fig. 10 - Balancing Mechanism

wise (dial toward 60) turn screw B clockwise and screw C the same amount counterclockwise. Tighten screw A. Start the controller and repeat the test for balance. Repeat the adjustments as directed until the requirement is met. In making the final adjustment, it may be found necessary to turn only one of the screws B or C, as turning both of them may cause too great a change.

(2) Clearance: Remount the galvanometer as covered in paragraph 3.02(5). Start the controller and then stop it so that the straight edges of the sweep cams extend vertically upward. By means of the zero adjusting screw (Fig. 1) set the galvanometer pointer in the center of the space between the setting levers. Start the controller and stop it when the setting levers are free from the operating cam. Observe if there is any clearance between the pointer and the setting levers or between the clutch arm split collar and the setting levers. If there is any clearance, loosen the split collar locknut (Fig. 10) using the 43 tool and turn the split collar adjusting nut using the 418A tool until there is no clearance. Tighten the locknut. After this adjustment repeat the test for balance as covered in paragraph 3.05(1). If balance readjustments were necessary then recheck for clearance. If while making the adjustment for clearance the clutch pin should inadvertently become loosened in its vertical slot so that its position is shifted, it should be repositioned at the center of the vertical slot.

(3) Pressure: If the setting levers fail to meet the pressure requirements, remove the balancing mechanism as covered in paragraph 3.01(7) and with the aid of the tweezers replace the spiral

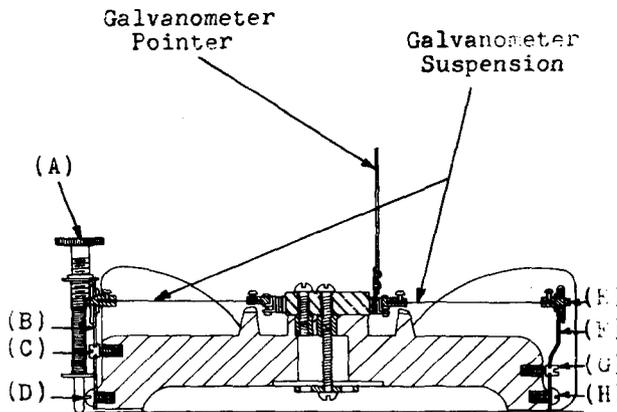


Fig. 11 - Cross Section of Galvanometer

spring (Fig. 4). Remount the balancing mechanism as covered in paragraph 3.01(10). Start the controller by releasing the BF relay.

### 3.06 Galvanometer (Rq.2.06)

(1) Care should be taken in working with the galvanometer to insure that the small parts are not strained and that everything is kept clean.

(2) Removing Galvanometer: Stop the controller as covered in paragraph 3.004. Remove the galvanometer as covered in paragraph 3.02(4). Loosen the stationary clamp mounting screw (Fig. 1) using the 3-1/2 inch cabinet screwdriver, and remove the stationary clamp from the galvanometer.

(3) Coil Position: Fig. 11 - If the galvanometer coil is not vertically central with respect to the core, the coil may be lowered by turning the tension screw (C) in a clockwise direction and screw (G) in a counterclockwise direction, using the size 3 watchmakers screwdriver. The screws should be turned in the reverse direction to raise the coil. If the coil is not horizontally central with respect to the core use the 3-1/2 inch cabinet screwdriver and loosen (very slightly) the screws (D) and (H) which hold the flat springs (B) and (F), and shift the position of these flat springs sufficiently to bring the coil into the desired position. Tighten the screws, being careful not to let this affect the position of the flat springs. If the front edge of the coil is not approximately flush with the front face of the core, loosen (very slightly) the screws (D)

and (H) and shift the zero adjusting screw (A) and the flat springs (B) and (F) either backward or forward as required. Retighten the screws, being careful not to let this affect the position of the flat springs.

(4) Suspension Tension: Fig. 11 - The tension in the galvanometer suspension should be such that there is no appreciable sag in it, when the galvanometer is laid in a horizontal position. The tension is increased by turning the tension screws (C) and (G) in a counterclockwise direction, using the size 3 watchmakers screwdriver, and is decreased by turning the screws in a clockwise direction. A very fine adjustment is required as one-eighth of a turn causes a large change in tension when the suspension is nearly taut. Care should be taken that the tension put on the system is not too great as this will break the suspension strip. If the suspension tension is not correct the pointer may vibrate excessively when the galvanometer system is in place in the controller. Usually the remedy for this is to increase the tension slightly.

(5) Suspension Torsion: Fig. 11 - If the pointer does not come to rest at right angles to the face of the core when the galvanometer is held in a vertical position proceed as follows: Set the zero adjusting screw (A) near its center of travel. Set the galvanometer on a flat surface so that the suspensions are approximately vertical. If the pointer is not approximately at right angles to the face of the core after it comes to rest, turn the suspension binding post by pin (E) until it comes to rest in this position.

(6) Balance: Tilt the galvanometer 10 or 15 degrees in all directions. If this does not cause the pointer to move, the galvanometer shall be considered as sufficiently balanced. If tilting the galvanometer 10 or 15 degrees causes the pointer to move, tests shall be made for front and rear balance and for lateral balance.

(7) Front and Rear Balance: Hold the galvanometer with the suspensions horizontal and the pointer to the left or right. If the tip of the pointer falls below or rises above the horizontal, the front and rear of the galvanometer system do not balance each other. Hold the galvanometer with the flat back of the moulding against the palm of one hand. Extend the thumb and fingers around the moulding and hold the coil. If the pointer tip moved downward during the test, turn each screw (A) (Fig. 12) an equal amount

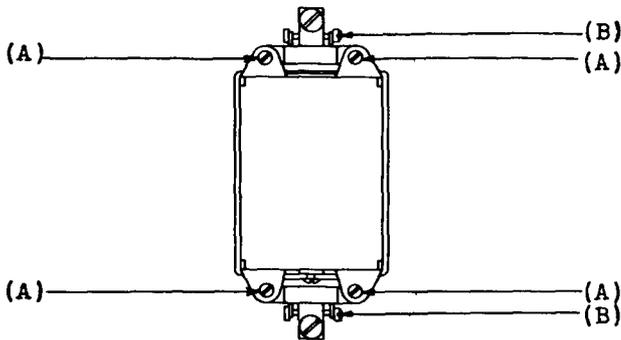


Fig. 12 - Galvanometer Coil Assembly

in a clockwise direction using the size 5 watchmakers screwdriver. If the pointer tip moved upward during the test, turn each screw (A) (Fig. 12) an equal amount in a counterclockwise direction. Several attempts may be necessary before a balance is obtained.

(8) Lateral Balance: Hold the galvanometer with the suspensions horizontal and the pointer downward. If the pointer moves to either side of the vertical, the left and right sides of the galvanometer system do not balance each other. Hold the galvanometer with the flat back of the moulding against the palm of one hand. Extend the thumb and fingers around the moulding and hold the coil. If the pointer moved to one side of the vertical during the test, the galvanometer system is heavier on the opposite side. If the galvanometer system is heavier on the side where the screw heads (B) (Fig. 12) are located, turn each of these screws an equal amount in a clockwise direction using the size 5 watchmakers screwdriver. If the galvanometer system is heavier on the opposite side, turn each screw (B) an equal amount in a counterclockwise direction. Several attempts may be necessary before a balance is obtained.

(9) Remounting Galvanometer: Fig. 1 - Before remounting the galvanometer the stationary clamp should be remounted. Place the support for the clamp on the galvanometer core and tighten the stationary clamp mounting screw so that the edges of the support clamped under the screw are parallel to the edges of the galvanometer moulding. Remount the galvanometer as described in paragraph 3.02(5).

(10) Pointer: Fig. 1 - The vertical position of the galvanometer pointer in the space between the stationary clamp and the clamping wires should be located as follows: Remove galvanometer lead + from its binding post and clamp it under binding post 0. Remove the galvanometer clamping nut and loosen the galvanometer clamp screw. Turn the height adjusting screw slowly until the pointer is centered between the stationary clamp and the clamping wires. Tighten the galvanometer clamp screw and remount the galvanometer clamping nut turning it down until it just touches the lug. Care shall be taken that this nut is not tightened against the lug as this will throw the galvanometer system out of alignment. To make certain that it is not out of alignment check the zero adjustment as in paragraph 3.06(13). After this adjustment, remove galvanometer lead + from binding post 0 and clamp it under binding post +.

(11) If the horizontal planes of the upper and lower faces of the pointer are not parallel to the horizontal planes of the stationary clamp and the rocker arm clamping wires, this may cause the pointer to deflect or to vibrate as the clamping wires leave it. To correct this replace the pointer as covered in Section 024-330-801.

(12) If the pointer sticks to the stationary clamp, to the rocker arm clamping wires or to the setting levers, the cause usually is dirt or oil on the pointer or on the parts which the pointer touches. To remedy this, carefully clean the different parts as covered in paragraph 3.01(3).

(13) Zero Adjustment: Remove galvanometer lead + from its binding post and clamp it under binding post 0. Start the controller by releasing the BF relay. Turn the zero adjusting screw slowly to move the pointer to its zero position. A satisfactory preliminary adjustment is obtained when three successive revolutions of the sweep cams do not cause the clutch arm to move. Since the galvanometer is very sensitive to air currents the final adjustment should be made with the controller case closed. If there is no movement of the controller dial for an interval of 2 minutes with the case closed the adjustment is satisfactory. If the pointer cannot be brought to the zero position in this way it will be necessary to remove the galvanometer and to turn the lower suspension binding post by pin (E) (Fig. 11) a small amount so that when the galvanometer is remounted the final adjustment can

be made by means of the zero adjusting screw. After this adjustment, remove galvanometer lead + from binding post 0 and clamp it under binding post +.

### 3.07 Clutch (Rq.2.07)

(1) Clutch Disc: Stop the controller as covered in paragraph 3.004. Turn the clutch disc a small amount in each direction being careful not to touch the engaging face of the disc with the hands. Observe if the clutch disc is loose on its shaft. If the disc is loose on the shaft tighten the clutch disc set screws (Fig. 1), using the 3-1/2 inch cabinet screwdriver.

(2) Torque: If the torque is outside the limits given, adjust the pressure of the mechanical brake by turning screw (W), Fig. 1 until the requirement is met.

(3) Clutch Corks: To check if the two clutch corks engage the clutch disc simultaneously start the controller and then stop it so that the clutch corks are almost touching the clutch disc. Insert a piece of paper between each cork and the clutch disc and start and stop the motor until the corks begin to tighten up against the paper. By moving the pieces of paper up and down carefully, it is possible to determine, after each starting and stopping of the motor, the exact instant when each cork engages the clutch disc and it is also possible to determine if the two corks engage the clutch disc simultaneously. If the corks do not engage simultaneously, the high cork should be refaced with fine sandpaper. To reface the corks use two strips of No. 00 sandpaper 1 inch wide and about 5 inches long. Insert the sandpaper between the corks and the clutch disc with the rough side of the sandpaper toward the corks and move the sandpaper up and down until the corks meet the requirement.

(4) Pressure of Clutch Operating Lever: If the pressure needs to be increased it will be necessary to replace the spiral spring (Fig. 9).

(5) Clutch Slip: If the clutch corks slip on the clutch disc check that the clutch operating lever pressure is met and if that is satisfactory clean the clutch disc and clutch corks as covered in paragraph 3.01(2).

(6) Clutch Arm Bearing: If the clutch arm is too tight or too loose in its bearings, remove the balancing mechanism as described in paragraph 3.01(7). Loosen screw (H) (Fig. 9) using the 3-1/2 inch cabinet screwdriver. Push the flat spring (G)

farther under screw (H) and tighten the screw to increase the pressure on the shaft. Remount the balancing mechanism as described in paragraph 3.01(10).

(7) If the corks on the clutch arm become so worn or oil soaked that they slip on the clutch disc and cannot be adjusted, the clutch arm should be replaced as covered in Section 024-330-801. After replacement of a new clutch arm make a check in accordance with procedures 3.05(1) and (2), 3.07(3) and (6) and 3.09(1).

(8) Start the controller by releasing the BF relay.

### 3.08 Cams - General (Rq.2.08)

(1) If the cams are loose on the shaft they can be tightened by means of the set screw holding them to their shaft. Care should be exercised that the cams are not shifted from their correct position while doing this.

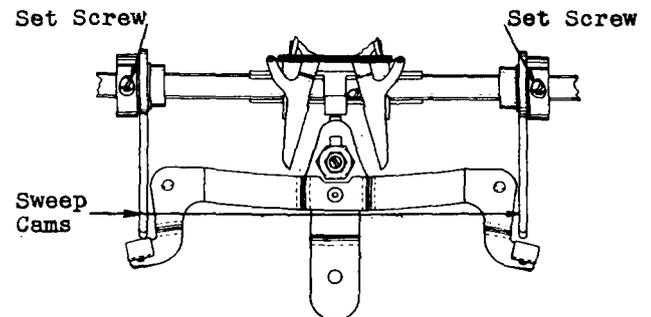


Fig. 13 - Sweep Cams

### 3.09 Sweep Cams (Rq. 2.09)

(1) If the sweep cams do not have the correct angular position relative to each other, or to the operating cam, or if their linear position on the shaft needs correcting proceed as follows: Stop the controller as covered in paragraph 3.004. Loosen the set screws (Fig. 1 and 13) holding the cams to the shaft, using the KS-6854 screwdriver. Then shift the cam to its correct position and tighten the set screws. Care shall be taken while correcting the position of a cam in one respect that the position of the cam in other respects is not disturbed. The sweep cams are in the correct position relative to each other when both cams leave the clutch arm shoes at exactly the same time. Special attention

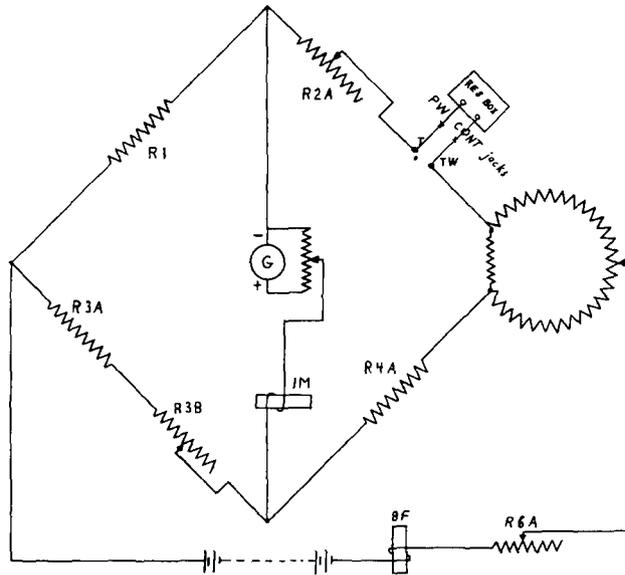


Fig. 14 - Bridge Circuit

is called to the fact that the highest point on the cam with respect to its own center is not only at the end point of the cam but extends back about 1/4 inch from the end point.

Note: The blade of the KS-6854 screwdriver is too wide for the sweep cam set screws. Modify this screwdriver locally by grinding until the end of the blade is 7/64 inch wide, tapering off gradually to the original width of the blade.

- (2) Start the controller by releasing the BF relay.

### 3.10 Slide Wire Contact Spring (Rq.2.10)

- (1) If the pressure of the slide wire contact spring is not within its requirements, the pressure may be adjusted by turning the adjusting screw in the contact spring mounting until the requirement is met.

### 3.11 Reduction Gears (Rq. 2.11)

- (1) If the worm on the motor shaft is not in correct alignment with respect to the gear which it drives, or if there is appreciable backlash between the gear and the worm, or if they bind, loosen the motor mounting screws with either the 4 inch regular screwdriver or the 129B tool and shift the position of the motor so as to realign

the worm gear to meet the requirement.

### 3.12 Galvanometer Sensitivity Control (Rq.2.12)

- (1) Stop the controller as described in paragraph 3.004. Connect the resistance box to the PW CONT jacks (Fig. 14). Strap the bridge circuit resistances to obtain the values given in the requirement table.
- (2) Start the controller and allow it to come to a balance. Increase the resistance in the resistance box by 2 ohms and closely observe the swing of the pointer immediately before and immediately after the rebalancing action. Adjust the galvanometer sensitivity control so that immediately after each rebalancing movement due to a 2 ohm increase the pointer will swing through zero to a distance equal to 1/2 to 3/4 of the immediately preceding deflection.
- (3) If difficulty is experienced or if it is not possible to obtain this condition by adjustment of the galvanometer sensitivity control it may be necessary to change the position of the clutch pin (Fig. 10) in its vertical slot. To do this stop the controller and holding the split collar adjusting nut steady with the 418A tool, loosen the split collar locknut with the 43 tool and remove this locknut. With the KS-6854 screwdriver loosen the clutch

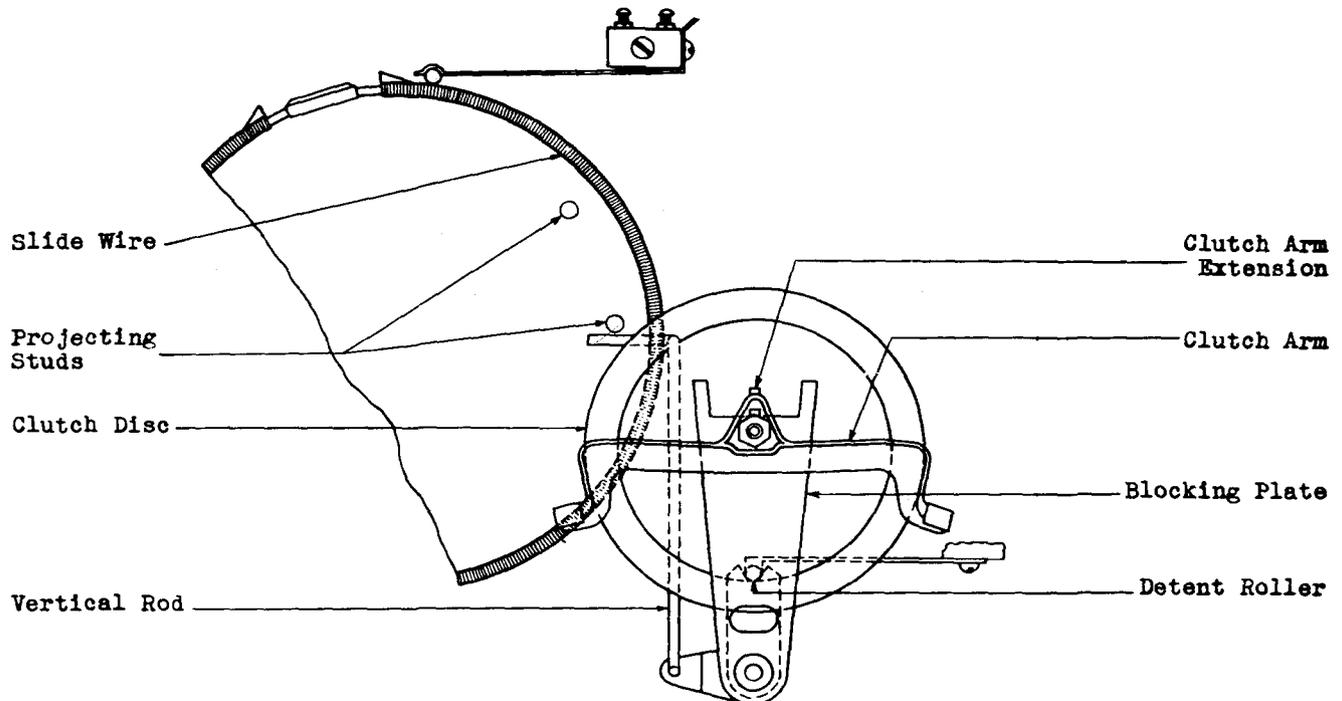


Fig. 15 - Clutch Arm Block Mechanism

pin. If the pointer deflection was less than the required amount the clutch pin should be lowered. If the deflection was greater than the required amount the clutch pin should be raised. Tighten the clutch pin in the new position and remount the split collar locknut. Holding the split collar adjusting nut steady with the 418A tool tighten the locknut with the 43 tool. After changing the clutch pin position recheck the clearance requirement for the setting levers 2.05(b) and adjust if found necessary.

(4) Stop the controller and remove the resistance box from the circuit. Start the controller by releasing the BF relay. (If proceeding with paragraph 3.13 and 3.14 it will not be necessary to disconnect the resistance box, as the same circuit arrangement will be used.)

### 3.13 Bridge Balance (Rq.2.13)

(1) Stop the controller as described in paragraph 3.004. Connect the resistance box to the PW CONT jacks (Fig. 14). Strap the bridge circuit resistances to obtain the values given in the requirement table.

(2) Start the controller and allow it to come to a balance. The dial reading should be  $30 \pm 1$ .

(3) If the requirement is not met it means that the angular relation between the slide wire and the dial needs adjustment. Make certain that the clutch is disengaged and then rotate the slide wire an amount sufficient to make accessible one of the screws which mount the dial on the slide wire. Loosen this screw a trifle and then rotate the slide wire so as to make the other mounting screw accessible. Loosen this second mounting screw also and shift the angular position of the dial with respect to the slide wire a sufficient amount to meet the requirement. Tighten the mounting screws securely and recheck the requirement.

Caution: To avoid electrical shock while making this adjustment disconnect the power from the controller circuit.

(4) Start the controller by releasing the BF relay.

### 3.14 Slide Wire Resistance (Rq.2.14)

(1) Stop the controller as described in paragraph 3.004. Connect the resistance box to the PW CONT jacks (Fig. 14). Strap the bridge circuit resistances to obtain the values given in the requirement table.

(2) Start the controller and adjust the resistance in the resistance box until the controller balances at a dial reading of 30. Note the value of the resistance box setting.

(3) Stop the controller. Make certain that the clutch is disengaged, then turn the controller dial until its reading is 5. Start the controller and adjust the resistance box so that the controller comes to a balance with a dial reading of 5. Note the difference between the resistance box setting for the controller dial reading of 5 and for the reading of 30.

(4) Stop the controller. Make certain that the clutch is disengaged, then turn the controller dial until its reading is 55. Start the controller and adjust the resistance box so that the controller comes to a balance with a dial reading of 55. Note the difference between the resistance box setting for the dial reading of 30 and the reading of 55. This difference should be within 3 ohms of the difference obtained in paragraph (3).

### 3.15 Clutch Arm Block (Rq.2.15)

(1) Stop the controller as described in paragraph 3.004. If this requirement is not met check the requirement in regard to bridge balance (Rq.2.13) to determine if the slide wire and the dial have the correct angular alignment with respect to each other. If their angular alignment is satisfactory then check whether the blocking plate Fig. 15 is correctly centered. To do this, it will be necessary to remove the balancing mechanism as described in paragraph 3.01 (7). The prongs of the blocking plate should be equidistant from the clutch arm extension when the clutch arm is horizontal and when the roller detent is in its notch. If the blocking plate is off center in this respect loosen the two screws in the hub of the blocking plate using the KS-6854 screwdriver and recenter the blocking plate. Tighten the two set screws securely and remount the balancing mechanism as described in paragraph 3.01(10).

(2) If the requirement still is not met after the above adjustment the trouble may be due to the vertical rod being either too high or too low. Turn the dial to the low end of its scale first making certain that the clutch is disengaged and observe the dial reading when the stud just touches the vertical rod. Turn the dial to the high end of the scale and observe the dial reading when the other stud just touches the

vertical rod. These two dial readings should be the same number of scale divisions on either side of the center point of the dial. If the two dial readings are not equidistant from the center point adjust the position of the vertical rod. Loosen the two set screws of the arm connected to the lower end of the vertical rod. By shifting the angular position of this arm on its shaft it is possible to raise or lower the vertical rod so that the above condition is obtained. Tighten the two set screws of the arm securely.

(3) Start the controller by releasing the BF relay.

### 3.16 Limit Alarm (Rq.2.16)

(1) Stop the controller as described in paragraph 3.004. If this requirement is not met check the requirement in regard to bridge balance (Rq.2.13) to determine if the slide wire and the dial have the correct angular alignment with respect to each other. If their angular alignment is satisfactory then proceed as follows: With the KS-6854 screwdriver loosen the set screw which holds the limit alarm cam on the slide wire shaft and change the angular position of the cam so that the requirement is met. Tighten the set screw securely. Start the controller by releasing the BF relay.

### 3.17 Motor Bearings (Rq.2.17)

(1) The bearings of a new driving motor should require no attention for at least a year and possibly two years. When these bearings become objectionably noisy they should be replaced by new ones. Detailed instructions for removal of old bearings and replacing them with new ones are covered in Section 024-330-801.

(2) When placing a spare controller in service it may happen that the driving motor sticks. This is due to the grease in the bearings having dried out and hardened. To overcome this condition, turn the motor shaft manually to break it loose from the hardened grease. After the motor has been in operation for a short while its operating temperature will bring about softening and melting of the grease.

### 3.18 Backlash (Rq.2.18)

(1) By means of the 4 inch regular screwdriver adjust the backlash in the manner specified in the requirement.