ELECTRO-MOTIVE DIVISION • GENERAL MOTORS CORPORATION
SERVICE DEPARTMENT

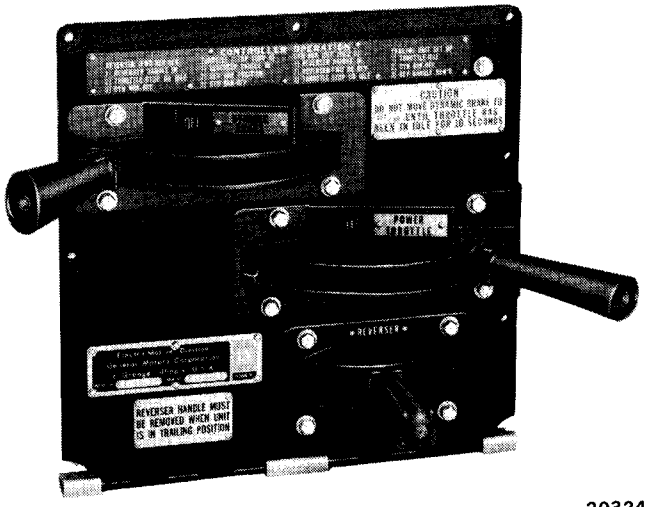
MAINTENANCE INSTRUCTION

LOCOMOTIVE CONTROLLER -- AAR -- ROLLER SWITCH TYPE (9093629 -- 9091052)

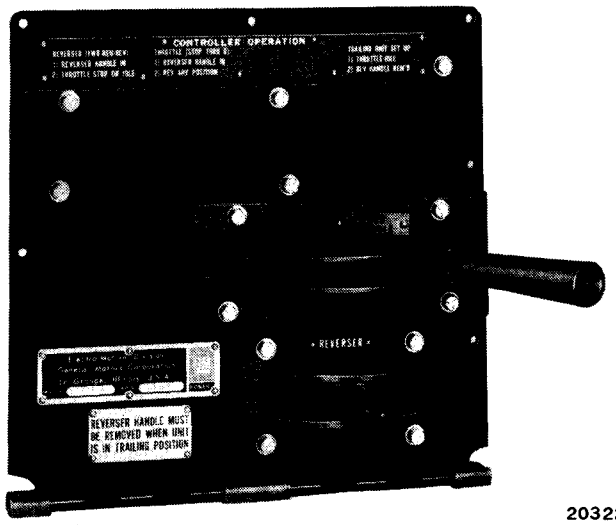
DESCRIPTION

The roller switch type of controller, Fig. 1, is a compact mechanism designed to energize the locomotive control circuits through cam operated roller switches.

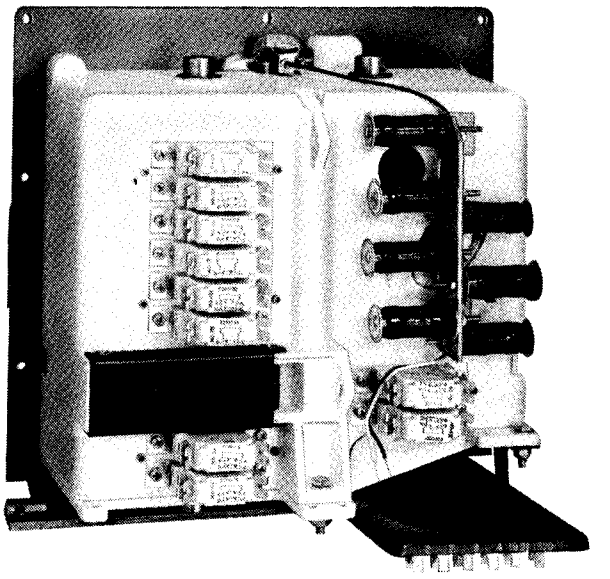
Two models of controllers are used, depending upon whether or not the locomotive is equipped with dynamic brakes. The two controllers differ only in the dynamic brake control mechansim, interlock mechanism, and the location, number, and type of roller switches used to provide the desired control.



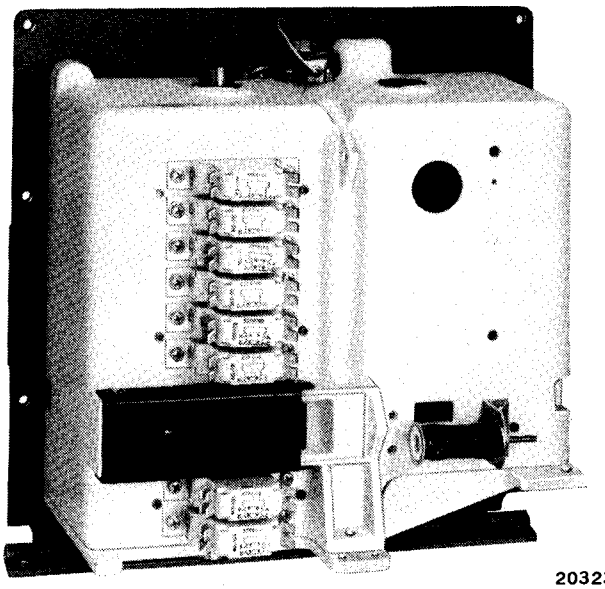
Dynamic Brake (Front)



Non-Dynamic Brake (Front)



Dynamic Brake (Rear)



Non-Dynamic Brake (Rear)

Fig. 1 – Controller Assembly

*Information contained herein is applicable to equipment being produced as of the date of publication and does not supersede previous issue.

The assembly is fastened on three sides by screws through the front mounting plate into a framed opening in the engineer's control stand. The bottom edge of the controller is hinge mounted to the control stand so that minor maintenance can be performed without removing the controller from the stand.

Depending upon the type of controller, either two or three handles protrude from the face of the controller to operate the mechanism. The following is a brief description of each handle and its associated mechanism.

DYNAMIC BRAKE HANDLE

On units so equipped, the dynamic brake handle is located in the upper portion of the controller panel. The position of the dynamic brake handle determines the amount of braking effort applied to the locomotive through the traction motors. With the directional handle in either forward or reverse position and the throttle in IDLE, the dynamic brake can be positioned from the OFF position to the "notched" SETUP position, and then to the "unnotched" positions of 1 through FULL 8 to control the braking rheostat. Each of the positions is shown in the illuminated indicator above the brake handle.

THROTTLE HANDLE

The throttle handle is located in the center portion of the controller panel. Movement of the throttle handle causes rotation of a cam drum which actuates roller switches to excite the main generator field and to establish low voltage circuits to the engine governor for the purpose of controlling engine speed and power.

The throttle has nine "notched" positions, from the far right position of IDLE through the running speeds of 1 through 8 at the far left position. There is also a STOP position which can be obtained by pulling the handle outward in the IDLE position and moving the handle to the full right position over the escutcheon detent. Placing the throttle in STOP shuts down all engines in a locomotive consist. Each of the positions is shown in the illuminated indicator above the throttle handle.

DIRECTIONAL HANDLE

The directional handle is located in the lower portion of the controller panel and controls the direction in which the locomotive moves. The handle has three positions: right of center, center position, and left of center. The locomotive will move in the direction in which the handle is positioned. With the handle in the center position, no tractive effort will be developed if the throttle is opened. The directional handle should be moved only when the locomotive is not in motion.

The directional handle on a locomotive controller also functions as a key to lock the mechanism when the handle is removed and to unlock it when the handle is inserted. The directional handle can be removed from the controller only when the handle is in the center position, the throttle is in IDLE, and the dynamic brake is in OFF.

Alteration of a directional handle to make the handle easier to insert or remove is a HIGHLY DANGEROUS practice. Such alteration can affect the ability of the handle to engage the locking mechanism of the controller.

For proper and safe operation, the directional handle must conform to specifications. Fig. 2 shows the correct dimensions of the directional handle as specified by the Association of American Railroads. Handles conforming to these specifications, even though well worn through many years of normal service, continue to function properly.

The design of the directional handle and controller is such that lubrication of the slot into which the handle is inserted is not necessary. Lubricant in this area can collect dust and dirt and cause the controller to malfunction.

INTERLOCK MECHANISM

The interlock mechanism is located in the lower portion of the controller. The throttle axle and dynamic brake axle each have a metal cam plate, the lobes and notches of which interact with pivoted rollers and the handle carrier cam plate to provide the necessary mechanical interlocking. This interlock inhibits the movement of an operating handle unless the other handles are in a position where the subject handle can be safely operated. An interlock override provision allows the throttle handle to be moved from IDLE to STOP position anytime the directional handle is inserted in the controller.

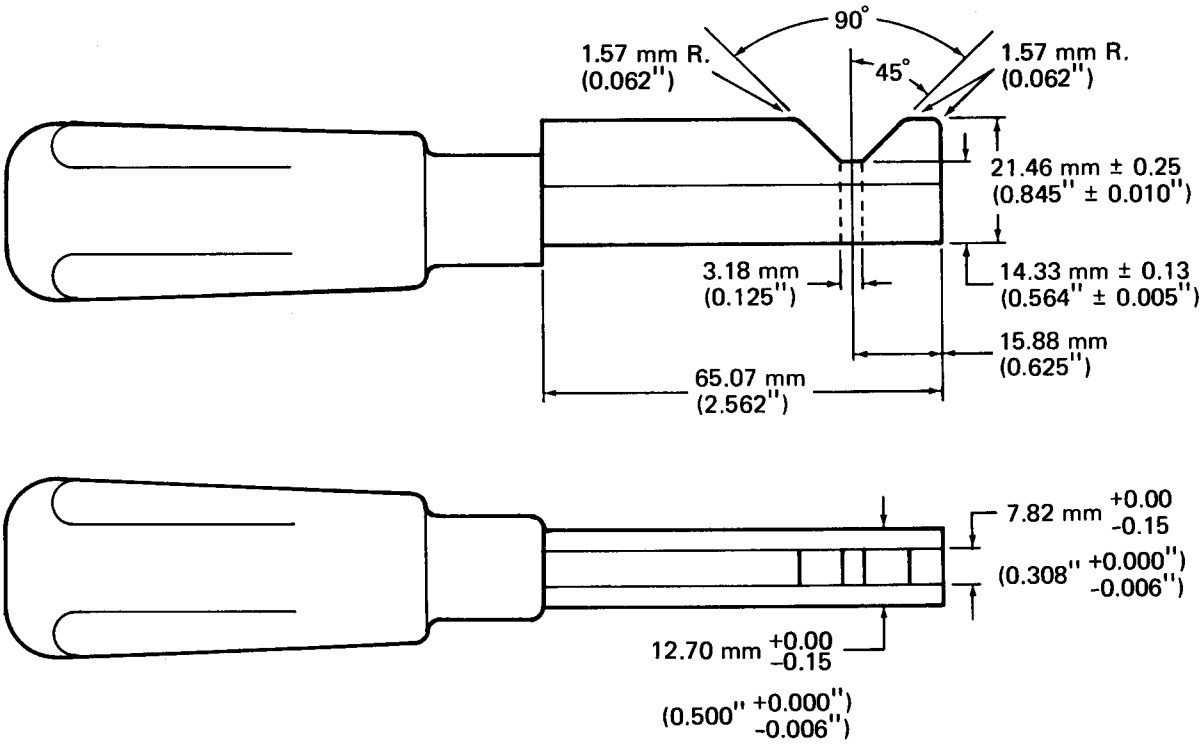


Fig. 2 – AAR Standard Control Stand Directional Handle

The throttle, dynamic brake, and directional handle carrier cam plates also have notches cut into their outer edges which contact spring loaded detent rollers to hold the carrier and axles in their selected positions. A moderate pull on the handles overcomes the detent pressure for movement to the next notch. Interlocking of the dynamic brake, throttle, and directional handles is provided in OPERATION section.

THROTTLE CAM DRUM

The cam drum is made of a molded material. Care should be taken to avoid chipping the cam drum surface.

The contours on the face of the drum are arranged to actuate the proper roller switches as dictated by the movement of the throttle handle. When the lobes of a cam are in contact with the roller switch, the switch plunger is fully depressed. When the cam depressions are in alignment with the switch, the switch roller drops into the depression and the switch contacts transfer. No switch contact adjustment is necessary or provided.

CONTROLLER HOUSING

The controller housing is a box shaped structure of molded polyester. The housing and the bottom plate contain bushings for the throttle and dynamic brake axles and for the interlocking mechanism. The roller switches are mounted on the back of the housing at locations which enable proper interface with the cam drum and handle carrier cam plate. The housing bottom plate is bolted to the main housing and positioned by two locating pins to provide support and alignment of the axles and the detent and interlock assemblies.

SWITCHES

Each roller switch consists of a two piece housing which encloses either one or two sets of contacts. A snap action mechanism provides positive making and breaking of switch contacts. Some switches are equipped with permanent magnet arc suppressors. Polarity must be observed when connecting these switches.

DYNAMIC BRAKE RHEOSTAT

A plate type rheostat is mounted on the bottom plate of the controller housing. The rheostat brush arm is attached to the dynamic brake axle and rotates through an angle of 90°.

The rheostat has 21 individual steps consisting of 35 contact bars. The first step consists of eight contact bars shorted together and the last step

consists of six contact bars shorted together. Steps four through eighteen contain an internal resistance of 308 ± 10% ohms. The remaining steps contain no internal resistance but are connected to externally mounted resistors.

Faston terminals are located on the base plate, and terminal identification is shown on the side of the plate. The brush is made of silver graphite and must make contact with each bar. The brush drive pin must contact all segments when the brush is removed.

OPERATION

Due to mechanization differences between dynamic and non-dynamic controllers, two separate lists of handle operation and interlocking are provided.

DYNAMIC CONTROLLERS

1. Directional handle removed.
   a. Throttle locked in IDLE.
   b. Dynamic brake locked in OFF.
2. Directional handle installed and centered.
   a. Throttle can be moved to any position.
   b. Dynamic brake locked in OFF.
3. Directional handle installed and in either forward or reverse.
   a. Dynamic brake in OFF.
      -- Throttle can be moved to any position.
   b. Dynamic brake in any position from SETUP to FULL 8.
      -- Throttle can be moved between IDLE and STOP only.
   c. Throttle in IDLE or STOP.
      -- Dynamic brake can be moved to any position.
   d. Throttle in any position from 1 to FULL 8.
      -- Dynamic brake locked in OFF.
4. Throttle handle in IDLE or STOP.
   a. Directional handle installed and centered.
      -- Dynamic brake locked in OFF.
   b. Directional handle installed and in either forward or reverse.
      -- Dynamic brake can be moved to any position.
   c. Dynamic brake in OFF.
      -- Directional handle can be moved to any position.
   d. Dynamic brake in any position from SETUP to FULL 8.
      -- Directional handle locked in either forward or reverse.
5. Throttle handle in any position from 1 to 8.
   a. Dynamic brake locked in OFF.
   b. Directional handle is locked in either forward, center, or reverse.
6. Dynamic brake handle in OFF.
   a. Directional handle installed and in forward, center, or reverse.
      -- Throttle can be moved to any position.
   b. Throttle in any position from 1 to 8.
      -- Directional handle locked in either forward, center, or reverse.
7. Dynamic brake in any position from SETUP to FULL 8.
   a. Throttle can be moved between IDLE and STOP only.
   b. Directional handle locked in either forward or reverse.

NON-DYNAMIC CONTROLLERS

1. Directional handle removed.
   -- Throttle locked in IDLE.
2. Directional handle installed and in either forward, center, or reverse.
   -- Throttle can be moved to any position.
3. Throttle in IDLE or STOP.
   -- Directional handle can be moved to any position.
4. Throttle in any position from 1 to 8.
   -- Directional handle locked in either forward, center, or reverse.

MAINTENANCE

Under extremely dusty or humid conditions, occasional inspection is advisable to determine if all components are functioning properly and efficiently. If sluggishness, tightness, or a gritty feeling is experienced; the controller should be disassembled, cleaned, and lubricated. After assembly, the controller should be thoroughly checked to qualify it for service. This work would be more conveniently performed on a bench.

NOTE: Maintenance or repair may be performed on the indicator lamp, switches, resistors, and the dynamic brake rheostat without removing the controller from the control stand.

INDICATOR LAMP

To replace a burned out indicator lamp, remove the back plate from the engineer's control stand which houses the controller. Slide lamp and socket off light transmitter mounting plate and remove lamp from socket. See Service Data for lamp part number.

SWITCHES AND RESISTORS

The switches and resistors are mounted on the rear of the controller housing and are made accessible by removing the back plate from the engineer's control stand which houses the controller. See Service Data for specifications on switches and resistors.

CAUTION: Polarity must be observed when installing switches equipped with permanent magnet arc suppressors.

DYNAMIC BRAKE RHEOSTAT

Remove the dynamic brake rheostat as follows:

1. Remove six mounting screws along the top and sides of the controller front panel, and tip the controller forward on the hinged bottom edge.

2. Identify, tag, and remove wires from terminals of rheostat.

3. With dynamic brake in OFF, loosen the 5/16"-18 hex head bolt which tightens C-clamp type adapter to dynamic brake axle, Fig. 3.

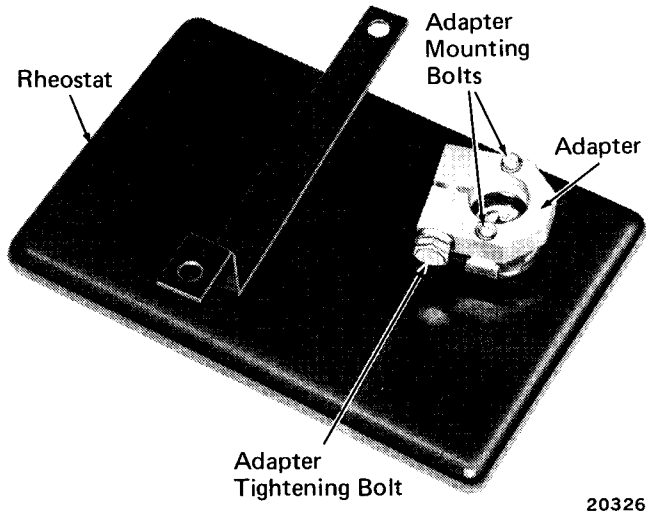


Fig. 3 – Dynamic Brake Rheostat And Adapter

4. Remove two 1/4"-20 mounting bolts which secure rheostat to housing.

5. Remove rheostat and adapter from dynamic brake axle.

6. Inspect contact brush for chips or excessive wear and replace if brush height is less than 5.5 mm (7/32").

7. Remove two 8-32 fillister head screws and lockwashers securing adapter to rheostat and remove adapter. See Service Data for specifications of rheostat.

NOTE: Replace contact brush at interval specified in Scheduled Maintenance Program.

The following procedure must be used for installing the dynamic brake rheostat to ensure proper angular movement of the rheostat.

1. Position adapter with 5/16"-18 bolt head closest to bent leg of rheostat with wiper positioned on contacts 1 and 2. Install two 8-32 fillister head screws and lockwashers to secure adapter to rheostat. Torque screws to 1.9 N·m (17 in.-lbs).

2. Install dynamic brake rheostat on bottom of dynamic brake rheostat axle. Do not tighten adapter screw at this time.

3. Rotate rheostat plate until mounting bracket holes are aligned with mounting holes in housing. Install 1/4"-20 x 1-1/4" mounting bolt with flat washer through housing, housing bottom plate, and rheostat mounting bracket. Apply self-locking nut torqued to 8.1 N·m (72 in.-lbs).

4. Install 1/4"-20 x 1" mounting bolt with flat washer through housing and rheostat mounting bracket and apply self-locking nut torqued to 8.1 N·m (72 in.-lbs).

5. Set throttle handle to IDLE, directional handle to either forward or reverse, and dynamic brake to OFF.

6. Press down on dynamic brake axle from the top of housing to remove any slack in bushings and rotate rheostat brush until it rests on the fourth and fifth bar as shown in Fig. 4.

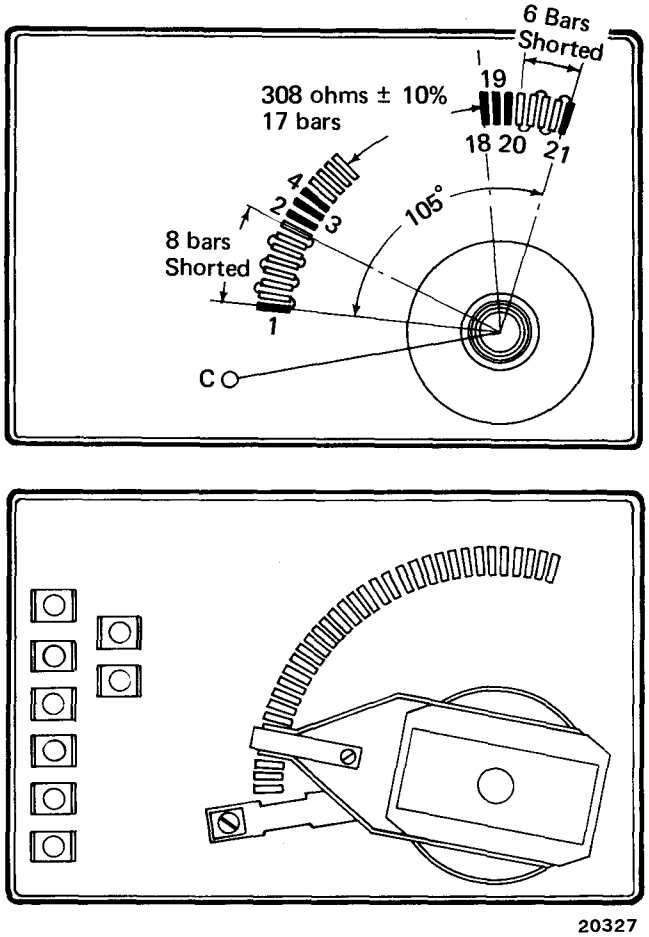


Fig. 4 – Dynamic Brake Rheostat Alignment

7. While holding rheostat brush in this position, carefully tighten the 5/16"-18 hex head bolt which tightens the C-clamp type adapter to the dynamic brake axle. Torque to 18 N·m (13 ft-lbs).

8. Move dynamic brake to FULL 8 position as indicated in window. Check that brush is positioned on any of the last six bars at the clockwise end of the rheostat. If not, loosen the C-clamp adapter and adjust rheostat until the brush contacts any of the first eight bars in OFF position and any of the last six bars in the FULL 8 position. Tighten 5/16"-18 hex head bolt to 18 N·m (13 ft-lbs).

9. Apply harness wiring to rheostat terminals.

CONTROLLER REMOVAL

1. Remove six mounting screws along top and sides of controller and tip controller forward on the hinged bottom edge.

2. Identify, tag, and disconnect all harness leads at the controller.

3. Remove three mounting screws from hinge securing controller to control stand.

4. Remove controller from control stand and place on work bench or other suitable work area.

DISASSEMBLY

This procedure describes the complete disassembly of both dynamic and non-dynamic controllers. Procedures in italics are applicable only to controllers equipped for dynamic braking. When working on non-dynamic controllers, disregard italicized text.

If controller needs only partial disassembly, use only the steps required to complete that portion of disassembly.

CONTROLLER

1. Identify, tag, and remove wiring jumpers from switches and resistors on rear of controller.

2. Disconnect black lead of indicator lamp from RE50 (300 Ω) and remove lamp and socket from light transmitter.

3. With dynamic brake in OFF, loosen 5/16"-18 hex head bolt which tightens dynamic brake rheostat C-clamp type adapter to dynamic brake axle.

4. *Remove two 1/4"-20 mounting bolts which secure rheostat to housing.*

5. *Remove rheostat and adapter from dynamic brake axle.*

6. *Inspect contact brush for chips or excessive wear and replace if brush height is less than 5.5 mm (7/32").*

NOTE: Replace contact brush at interval specified in Scheduled Maintenance Program.

7. Remove switches and resistor bracket from rear of controller housing.

8. Remove snap rings from throttle detent cover pin, Fig. 5, securing detent cover to housing.

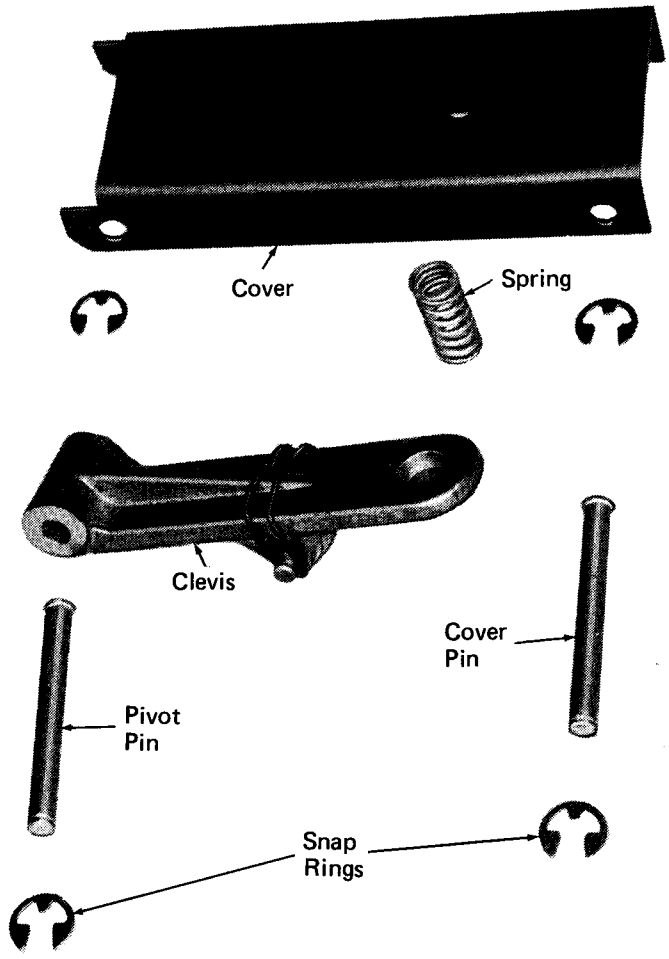


Fig. 5 – Throttle Detent Assembly

9. Apply pressure to detent cover and remove pin.

10. Slowly release pressure on cover to release spring pressure.

11. Remove detent pivot pin snap rings and slide pin out of cover, housing, and detent clevis holes.

12. Remove clevis, spring, and cover from housing closure.

13. *Remove 5/16"-24 self locking nut and flat washer securing handle, Fig. 6, to dynamic brake shaft. Nut and washer are recessed in end of handle.*

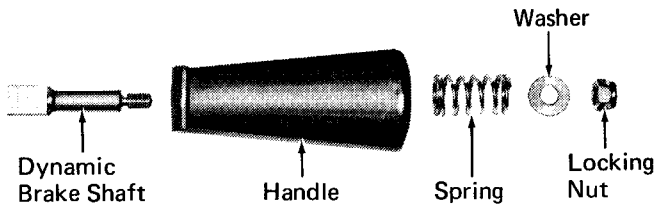


Fig. 6 -- Dynamic Brake Handle Removal

14. *Remove handle spring and handle from dynamic brake shaft.*

15. Remove 5/16"-24 self locking nut and flat washer securing handle to throttle shaft. Nut and washer are recessed in end of handle.

16. Remove handle spring and handle from throttle shaft.

17. Remove four 1/4"-20 bolts, lockwashers, and flat washers securing directional escutcheon to front panel, and remove escutcheon.

18. Insert directional handle into controller, and move handle to the left. Move *brake handle to OFF and* throttle handle to position 8.

19. Remove four 1/4"-20 front panel mounting screws, lockwashers, and flat washers at locations marked by X in Fig. 7, and remove front panel from controller.

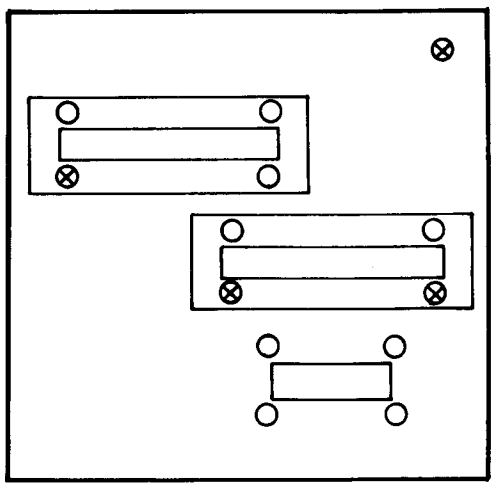


Fig. 7 – Front Panel Mounting Bolts

CAUTION: To avoid damage to throttle *and dynamic brake* guide-indicators, apply pressure to face of guide assemblies prior to rotation of the *dynamic brake and* throttle handles to ensure sufficient clearance between the guide-indicator and the controller housing.

20. Rotate throttle to IDLE position; center and remove directional handle.

21. Remove guide and spring from directional handle carrier, Fig. 8.

22. Remove two 10-32 screws securing light transmitter to housing and remove transmitter.

23. Insert directional handle into controller, and position to either forward or reverse.

24. Rotate dynamic brake axle until dynamic brake shaft is in line with round opening in rear of housing.

25. Remove guide-indicator assembly and spring from brake shaft.

26. Remove 3/8"-16 self locking shaft nut through round opening, place dynamic brake to OFF, and remove shaft from axle.

27. Center directional handle, and rotate throttle until shaft is in line with double switch opening at rear of housing.

28. Remove guide-indicator assembly and spring from throttle shaft.

29. Raise throttle cam drum on axle until it meets top of housing, and remove 3/8"-16 self locking nut from throttle shaft through double switch opening in rear of housing.

30. Lower throttle cam drum, and remove shaft from axle.

WARNING: Prior to removal of housing bottom plate, ensure that *dynamic brake and* directional detent torsion springs are properly seated in housing grooves.

31. Remove four 1/4"-20 bottom plate corner bolts, flat washers, and lockwashers and remove plate from main housing.

32. Remove directional detent roller assembly spring end, Fig. 9, from groove in housing, release spring tension, and remove spring from detent roller shaft.

33. Remove dynamic brake detent torsion spring end from housing groove, release spring tension, and remove spring from detent shaft.

34. Remove thrust washers and roller bearing from handle carrier stubshaft.

35. Remove handle carrier from end of throttle axle.

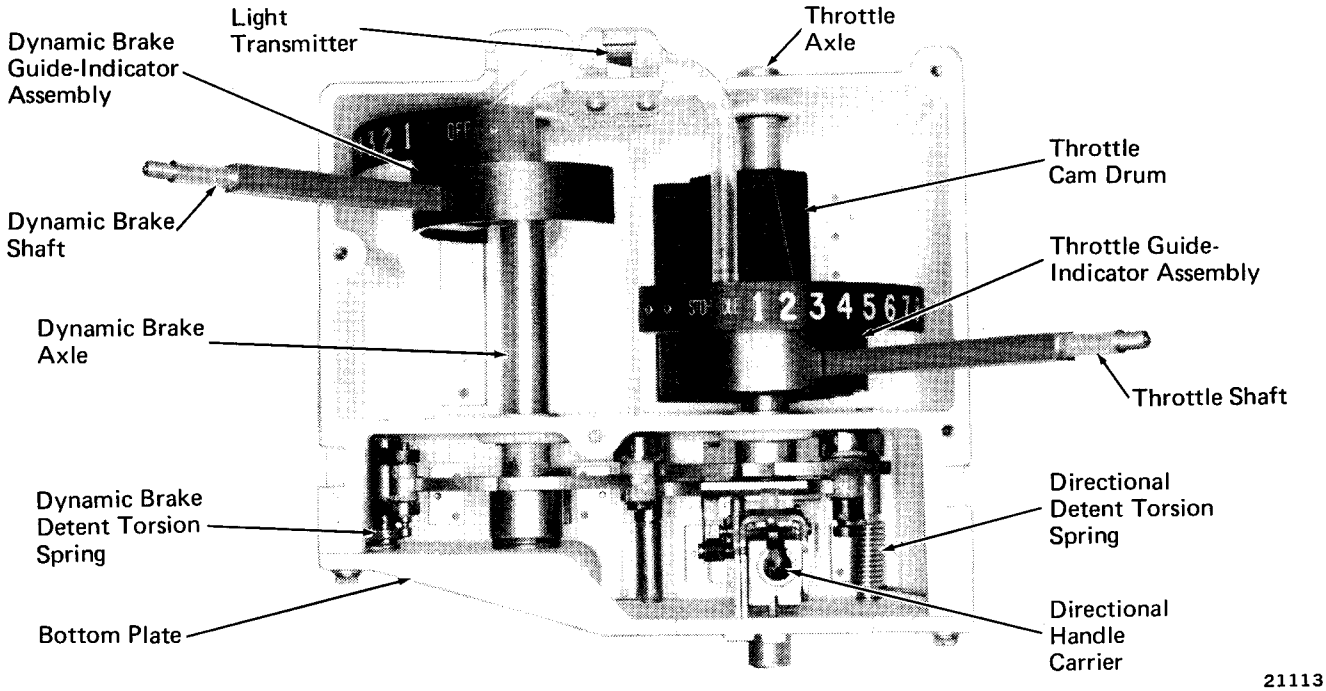


Fig. 8 – Controller With Front Panel Removed

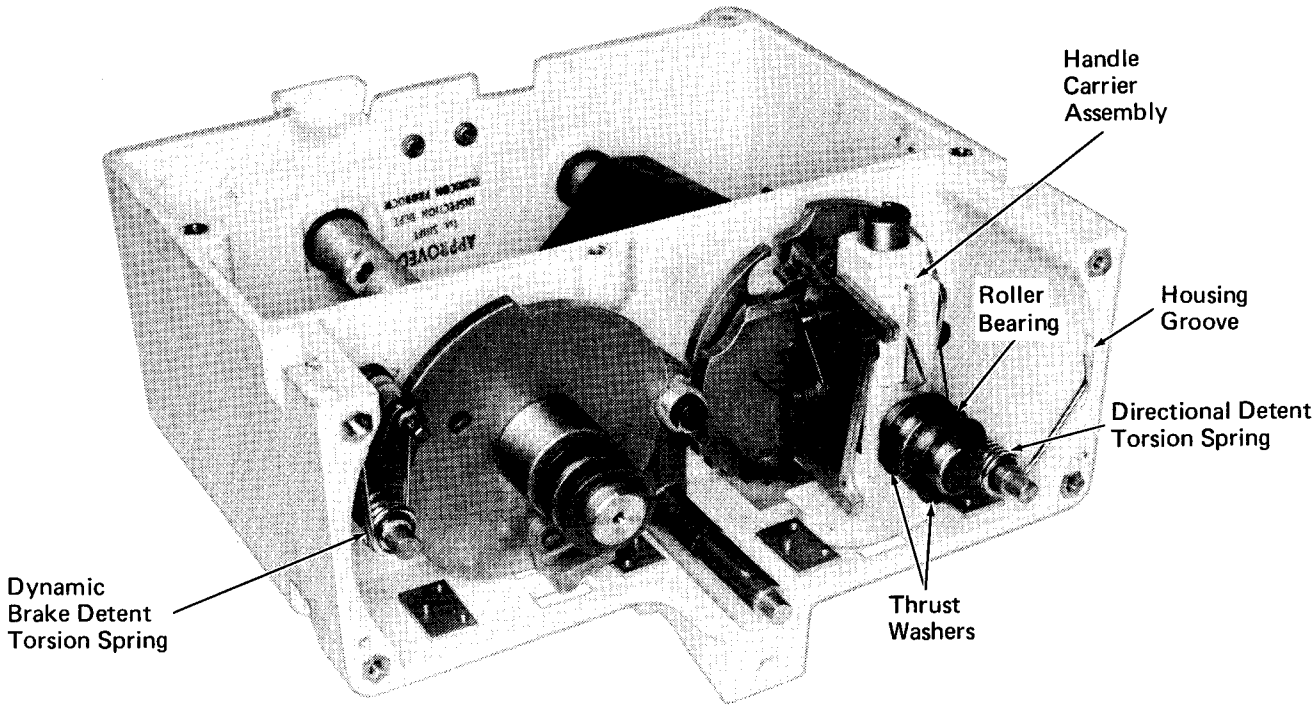


Fig. 9 – Controller With Bottom Plate Removed

36. Remove thrust washers and roller bearings from *dynamic brake and* throttle axles, Fig. 10.

37. Remove dynamic brake detent assembly from bushing in housing shelf.

38. Remove dynamic brake axle from housing.

39. Remove interlock roller assembly shaft from bushing in housing shelf.

40. Lower throttle axle to allow removal of directional detent roller support shaft from bushing in housing shelf.

41. While holding throttle cam drum in position, rotate throttle axle so interlock roller recess of throttle axle plate faces rear of housing, Fig. 11, and remove throttle axle from housing.

42. Remove throttle cam drum from housing.

43. Remove 6-32 socket head screws securing seven tapping pads to housing and remove tapping pads from housing. This completes disassembly of the controller. Proceed to sub-assembly disassembly.

SUB–ASSEMBLIES

1. Dynamic brake guide-indicator assembly – Remove two 10-24 self tapping screws securing indicator to guide.

2. Throttle guide-indicator assembly – Remove two 10-24 self tapping screws securing indicator to guide.

3. Dynamic brake detent assembly – Remove snap ring from roller pin and slide pin downward out of clevis, releasing the pin and the roller from the clevis.

4. Interlock roller assembly – Remove snap ring from roller support stubshaft and remove roller from stubshaft.

5. Directional detent roller assembly – Remove snap ring from roller support stubshaft and remove roller from stubshaft.

6. Throttle clevis assembly – Cut and remove locking wire securing roller pin. Remove roller pin and roller from clevis.

7. Front panel assembly – Remove bolts, washers, and lockwashers securing *dynamic brake and* throttle escutcheons to panel. Remove escutcheons from panel.

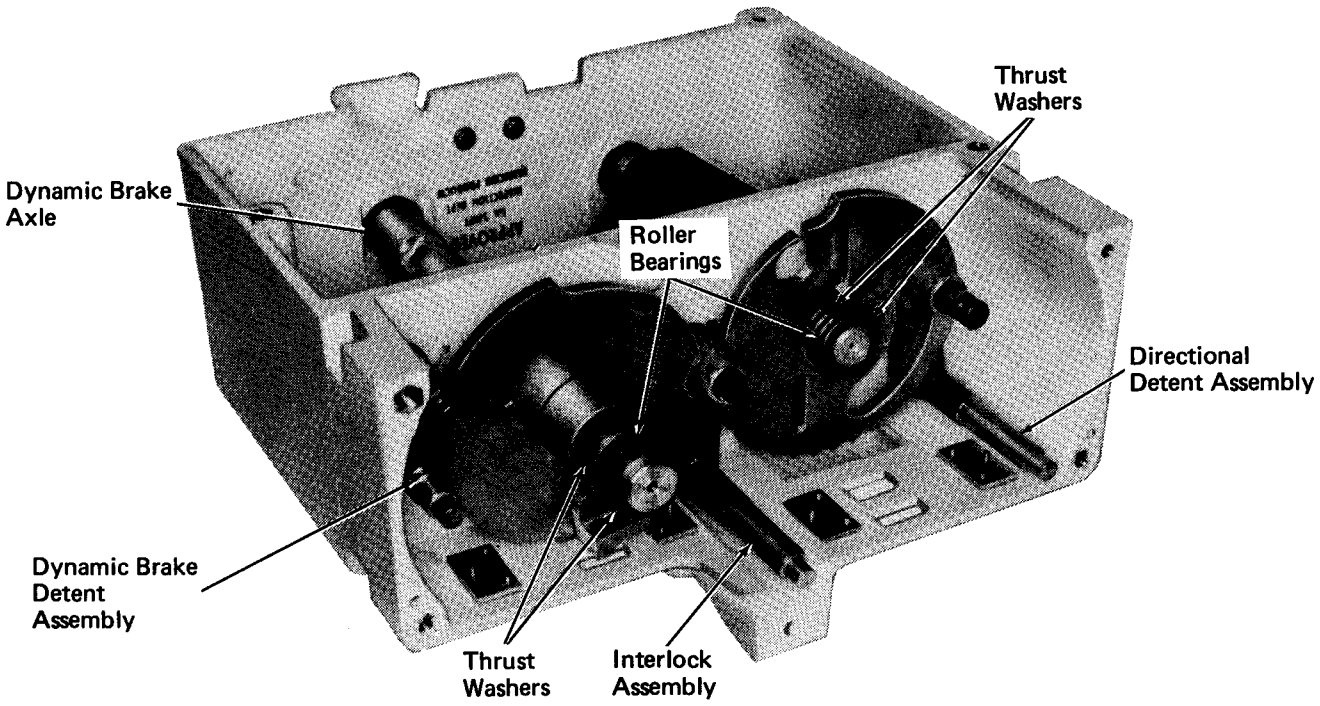


Fig. 10 – Detent And Interlock Removal

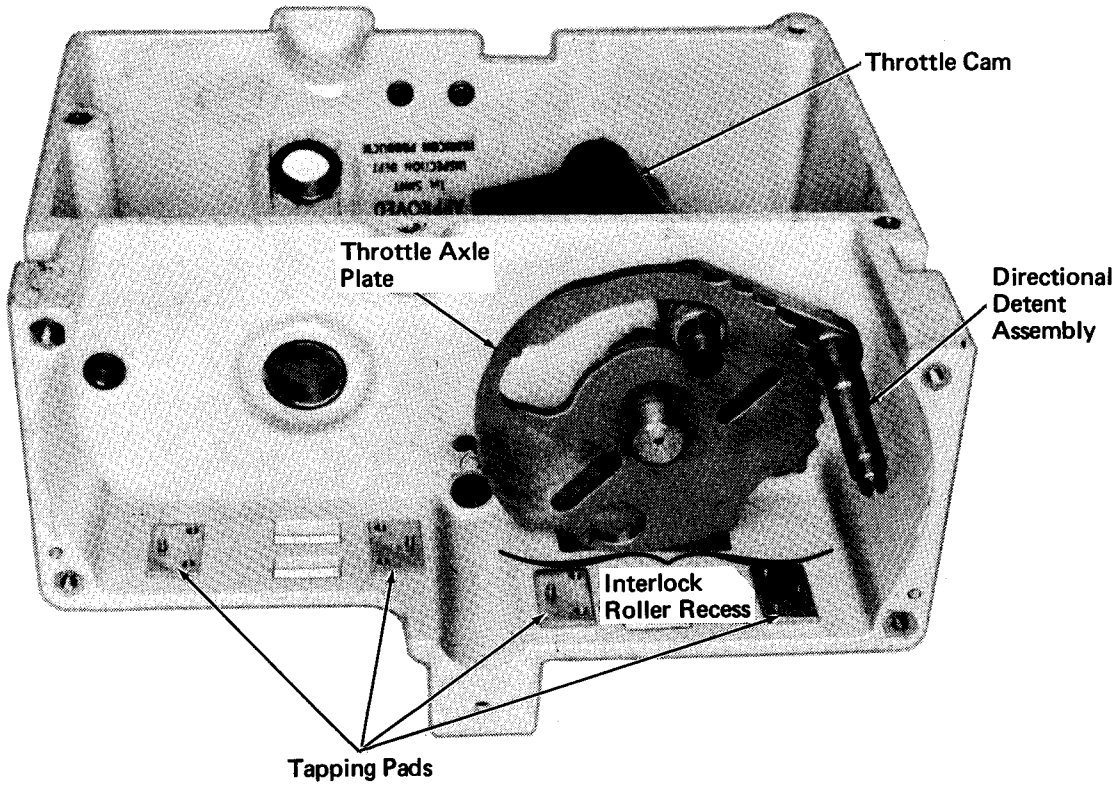
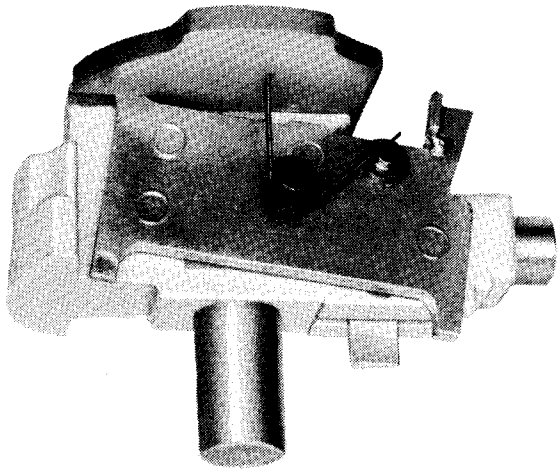


Fig. 11 – Throttle Axle Removal

8. Dynamic brake rheostat assembly – Remove two 8-32 fillister head screws and lockwashers securing adapter to rheostat. Remove adapter from rheostat.

9. Handle carrier assembly
   a. Release spring from groove in roller pin, Fig. 12.
   b. Remove retaining ring from locking bracket pivot pin on end opposite spring.
   c. Remove pivot pin from locking bracket, handle carrier, nylon washer, and spring.
   d. Remove locking bracket from carrier.
   e. Remove retaining ring from each end of roller pin.
   f. Remove pin and roller from locking bracket assembly.



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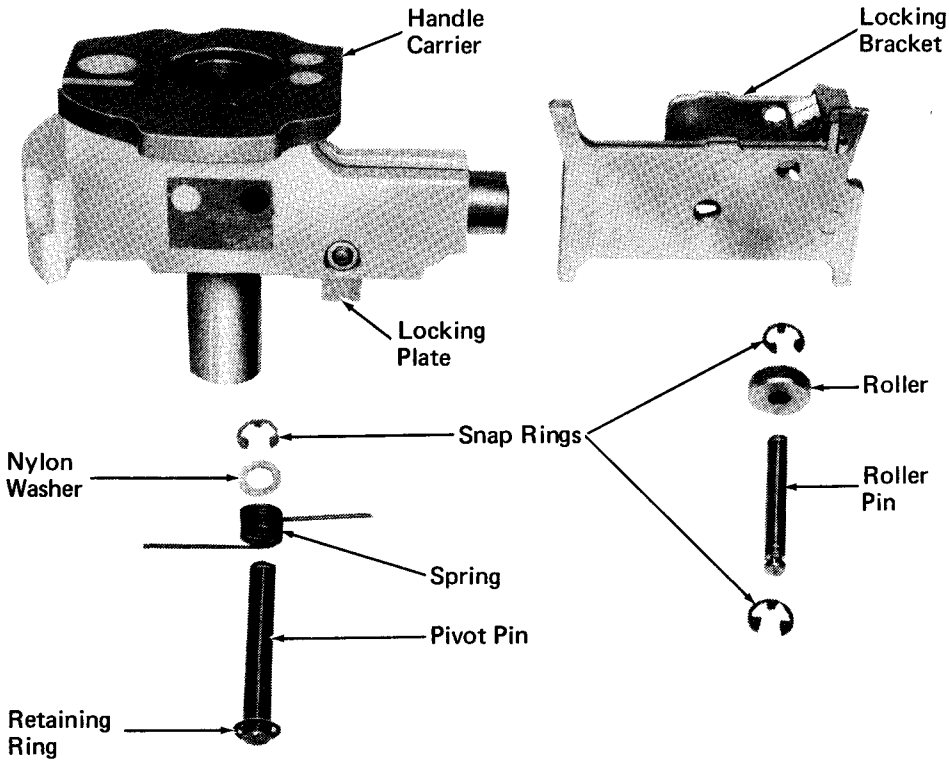

EXPLODED VIEW

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Fig. 12 – Handle Carrier Assembly

ASSEMBLY

This procedure describes the complete assembly of both dynamic and non-dynamic controllers. Procedures in italics are applicable only to controllers equipped for dynamic braking. When working on non-dynamic controllers, disregard italicized text. If a controller needs only partial assembly, use only the steps required to complete that portion of assembly.

To assemble the controller and its sub-assemblies, apply parts as described, making certain all parts operate freely with their mating parts. Lubricate parts and controls prior to assembly as described in LUBRICATION.

SUB-ASSEMBLIES

1. *Dynamic brake guide-indicator assembly – Assemble indicator to guide using two 10-24 self tapping screws. Torque to 2 N·m (18 in.-lbs).*

2. Throttle guide-indicator assembly -- Assemble indicator to guide using two 10-24 self tapping screws. Torque to 2 N·m (18 in.-lbs).

3. *Dynamic brake detent assembly – With the short stubshaft in up position align roller with holes in clevis arms. Insert snap ring groove end of roller pin through lower clevis arm, roller and upper clevis arm. Secure pin to clevis with snap ring at top of pin.*

4. *Interlock roller assembly – Slide roller on to roller support stubshaft and secure with snap ring.*

5. Directional detent roller assembly – Slide roller on to roller support stubshaft and secure with snap ring.

6. Throttle clevis assembly – Align roller with holes in clevis arms and insert roller pin through clevis arms and roller. Insert locking wire through one end of pin and run wire across back of clevis to other end of pin. Insert through hole in second end of pin and twist wire ends together on rear side of clevis. Wire must be tight enough to prevent pin rotation. Cut excess wire off so twisted portion is approximately 6.5 mm (1/4"). Fold twisted portion of wire flat against rear of clevis, Fig. 13.

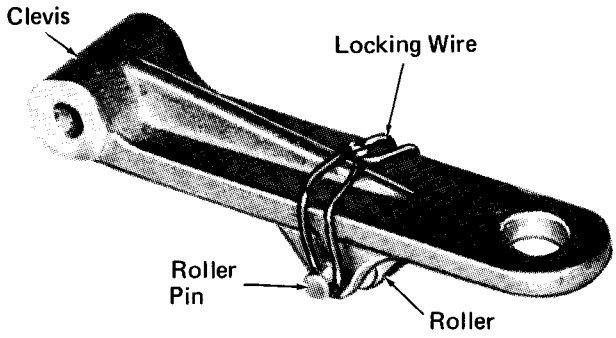

Fig. 13 -- Throttle Clevis Assembly

7. Front panel assembly – Mount *dynamic brake and* throttle escutcheons to front panel using flat washer, split lockwasher and 1/4"-20 x 1" bolts indicated by "X" in Fig. 14 and torque to 8.1 N·m (72 in.-lbs).

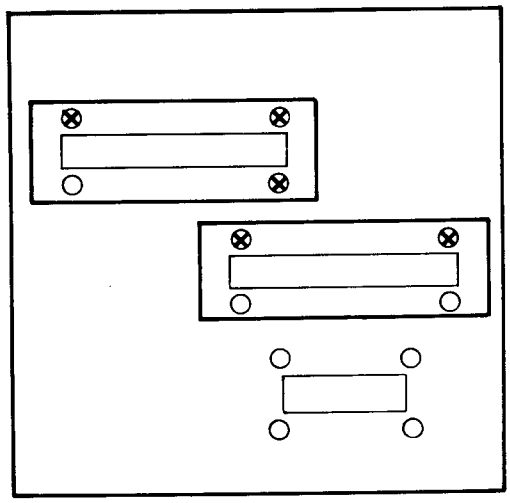

Fig. 14 – Escutcheon Mounting Bolts

8. *Dynamic brake rheostat assembly – Position adapter on rheostat with 5/16"-18 bolt head closest to bent leg of rheostat, Fig. 3, with wiper positioned on contacts 1 and 2. Install two 8-32 fillister head screws and lockwashers to secure adapter to rheostat. Torque to 1.9 N·m (17 in.-lbs).*

9. Handle carrier assembly.

   a. Install roller and roller pin in locking bracket and secure at each end with retaining ring.

   b. Place locking bracket over carrier with roller aligned with key slot.

   c. Align pivot pin holes of bracket with hole in carrier.

d. Insert nylon washer between bracket and carrier and align with pivot pin holes on spring side of carrier.

e. Insert one end of spring into hole in carrier top plate and align spring with pivot pin holes.

f. Insert pivot pin through spring, bracket, nylon washer, and carrier, and secure with retaining ring on end opposite spring.

g. Rotate free end of spring counter-clockwise and place in groove of roller pin.

CONTROLLER

1. If a new housing is being used for assembly, remove the bottom plate of the housing.

NOTE: Housing and bottom plates are matched sets. Do not interchange.

2. Install seven (7) tapping pads on inside of housing, Fig. 15, and secure with 6-32 hex head screws. Torque to 1 N·m (9 in.-lbs).

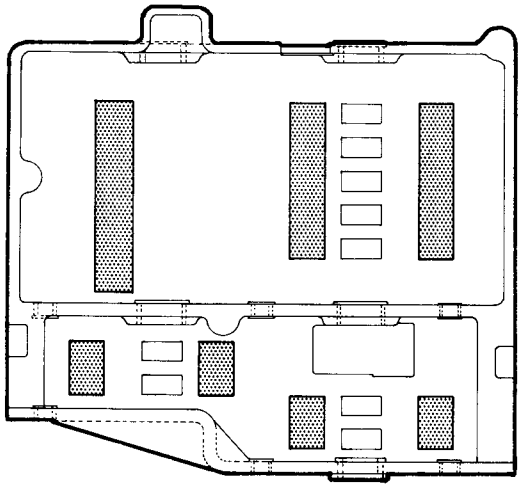

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Fig. 15 -- Tapping Pad Locations

3. With housing positioned on its back side on suitable work area, position throttle cam drum in upper housing and insert throttle axle through bushing in housing shelf. Insert axle with interlock roller recess of throttle axle plate facing rear of housing, Fig. 11.

4. Insert directional detent roller support assembly with arm above throttle axle plate and roller extending downward through large opening in throttle axle plate.

5. Move throttle axle inward until axle plate clears throttle clevis opening at rear of housing, Fig. 16.

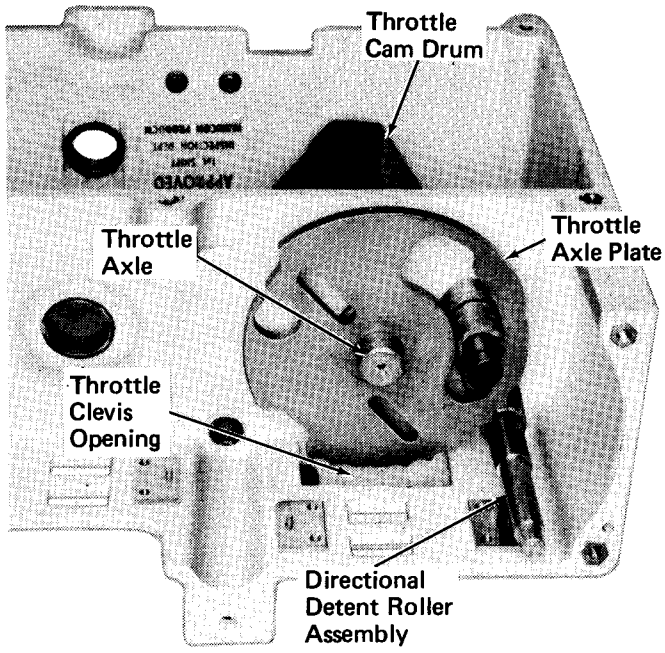


Fig. 16 -- Directional Detent Roller Assembly Installation

6. Rotate throttle axle plate to allow directional detent roller support shaft to be inserted into housing shelf bushing.

7. Move throttle axle up and insert axle into bushing in top of housing.

8. Insert interlock roller assembly short shaft end into housing shelf bushing, from bottom side of shelf, Fig. 10.

9. Rotate throttle axle so interlock roller fits into throttle plate interlock recess.

10. Insert dynamic brake axle through housing shelf bushing and push through housing into bushing in top of housing.

11. Install dynamic brake detent assembly short shaft into the housing shelf from bottom side of shelf.

12. Install thin thrust washer, roller bearing, and thick thrust washer on bottom of dynamic brake axle. The thick thrust washer must be on the bottom to contact the housing bottom plate.

13. Install thrust washer, roller bearing, and second thrust washer on bottom of throttle axle shaft.

14. Install handle carrier assembly on bottom of throttle axle.

15. Install thrust washer, roller bearing, and second thrust washer on stubshaft of handle carrier.

16. Install dynamic brake detent torsion spring over shaft and position one end in the spring groove of roller pin, and the other end in the housing groove, Fig. 9.

WARNING: Ensure that torsion spring end is firmly seated in housing groove.

17. Install directional detent roller assembly torsion spring over shaft, and position spring end with short bend in the stubshaft spring groove.

18. Rotate spring end with long bend in counterclockwise direction to apply tension until spring end can be fitted into housing groove.

WARNING: Ensure that torsion spring end is firmly seated in housing groove.

19. Place housing bottom plate over throttle and *dynamic brake* axles. Align *dynamic brake detent shaft, interlock roller assembly shaft, and* directional detent roller assembly shaft to the bushings in the housing bottom plate, Fig. 8.

20. Move housing bottom plate to housing being sure dowel pins mate with holes in housing.

21. Install four (4) 1/4"-20 x 7/8" corner bolts with flat washer and split ring lockwasher to secure housing bottom plate to housing. Torque bolts to 8.1 N·m (72 in.-lbs).

22. Slide throttle cam along axle until it meets top of housing. Insert directional handle to unlock throttle axle and rotate throttle axle until the throttle shaft hole is aligned with the double switch opening in the rear of housing.

23. Insert coarse threaded end of throttle shaft through throttle axle and secure shaft to axle using 3/8"-16 self locking nut applied through double switch opening in rear of housing. Torque to 33 N·m (24 ft-lbs).

24. Slide guide spring and guide-indicator assembly onto throttle shaft with indicator numbers facing toward handle end of shaft. Ensure that spring is seated on flat surface of axle.

CAUTION: To avoid damage to throttle *and dynamic brake* guide-indicators, apply pressure to face of guide assemblies prior to rotation of the *dynamic brake and* throttle handles to ensure sufficient clearance between the guide assembly and the controller housing.

25. With cams facing rear of housing, lower cam drum assembly to interface with throttle guide-indicator assembly.

26. With throttle handle in IDLE, position directional handle to either forward or reverse and rotate dynamic brake axle until brake shaft hole is aligned with round opening in rear of housing.

27. Insert coarse threaded end of dynamic brake shaft through dynamic brake axle and secure with 3/8"-16 self locking nut through round opening in rear of housing. Torque to 33 N·m (24 ft-lbs).

28. Slide guide spring and guide-indicator assembly on to brake shaft with indicator numbers facing toward handle end of shaft. Ensure that spring is seated on flat surface of axle.

29. Place controller on its back, *set dynamic brake to OFF position,* center directional handle, and remove directional handle from controller.

30. Install light transmitter with arms positioned so *short arm is located behind the dynamic brake indicator and* long arm is located behind throttle indicator, Fig. 8. Secure transmitter to housing with two 10-32 screws torqued to 2.5 N·m (22 in.-lbs).

31. Apply directional guide spring on directional handle carrier with handle slot toward the top and spring arms forward.

32. Slide directional guide onto handle carrier.

33. Insert directional handle into controller, and move handle to the left. *Move brake handle to OFF,* and throttle handle to position 8.

34. Apply front panel to controller housing and secure with four 1/4"-20 x 1-1/4" screws, lockwasher, and flat washers at locations marked by "X" in Fig. 7. Torque bolts to 8.1 N·m (72 in.-lbs).

35. Rotate throttle to IDLE position, center and remove directional handle from controller.

36. Install directional escutcheon to front panel and secure with two 1/4"-20 x 1" bolts in the upper mounting holes and two 1/4"-20 x 7/8" bolts in the lower mounting holes. Torque bolts to 8.1 N·m (72 in.-lbs).

37. Slide handle onto dynamic brake shaft with major axis of handle oval in vertical position as shown in Fig. 1.

38. Install handle spring over shaft and apply flat washer and 5/16"-24 self locking nut to secure handle to shaft, Fig. 6. Tighten until washer bottoms out on shaft shoulder.

39. Slide throttle handle over shaft with major axis of handle oval in the horizontal position. *(Handle rotated 90° from dynamic brake handle.)*

40. Install handle spring over shaft and apply flat washer and 5/16"-24 self locking nut to secure handle to shaft. Tighten until washer bottoms out on shaft shoulder.

41. Place throttle detent clevis, Fig. 5, in housing opening so roller will engage detents on throttle axle plate.

42. Place cover over housing so the cutout (notched) end is located toward the center of the housing.

43. Align cover, housing, and clevis bore holes, and insert detent pivot pin.

44. Secure pin with snap ring at each end of pin.

45. Insert screwdriver blade between coils of detent spring and align spring between depression on rear of detent and depression in detent cover.

46. Pivot cover toward housing until pressure is felt between detent plate and detent cover. Remove screwdriver from between spring coils and continue to pivot cover toward housing until holes in cover align with holes in detent closure portion of housing.

47. Insert cover pin through holes of detent cover and hole in housing and secure on each end with snap ring in ring groove of pin.

48. Install dynamic brake rheostat and adapter to bottom of dynamic brake axle. Do not tighten adapter screw at this time.

49. Rotate rheostat plate until mounting bracket holes are aligned with mounting holes in housing. Install 1/4"-20 x 1-1/4" mounting bolt with flat washer through housing, housing bottom plate, and rheostat mounting bracket. Apply self locking nut torqued to 8.1 N·m (72 in.-lbs).

50. Install 1/4"-20 x 1" mounting bolt with flat washer through housing and rheostat mounting bracket and apply self locking nut torqued to 8.1 N·m (72 in.-lbs).

51. Set throttle handle to IDLE, directional handle to either forward or reverse and dynamic brake to OFF.

52. Press down on dynamic brake axle from the top to remove any slack in bushings and rotate rheostat brush until it rests on the fourth and fifth bar as shown in Fig. 4.

53. While holding rheostat brush in this position, carefully tighten the 5/16"-18 hex head bolt which tightens C-clamp type adapter to the dynamic brake axle. Torque to 18 N·m (13 ft-lbs).

54. Move dynamic brake to FULL 8 position as indicated in window. Check that brush is positioned on any of the last six bars at the clockwise end of the rheostat. If not, loosen the C-clamp adapter and adjust rheostat until the brush contacts any of the first eight bars in OFF position and any of the last six bars in the FULL 8 position. Torque 5/16"-18 hex head bolt to 18 N·m (13 ft-lbs).

55. Mount resistor bracket, resistors and switches as shown in Fig. 1. Torque resistor mounting bracket screws to 8.1 N·m (72 in.-lbs), resistors to bracket to 1.8 N·m (16 in.-lbs) and switch mounting screws to 2.5 N·m (22 in.-lbs).

56. Install indicator lamp and socket in light transmitter and connect black lead to right side terminal of RE50 (300 Ω).

57. Install wiring jumpers on switches and resistors.

LUBRICATION

Apply lubricant to contact (wear) surfaces of all moving metal parts mentioned below:

CAUTION: Do not lubricate directional key slot of the handle carrier.

Handle carrier stubshaft, thrust washers, and roller bearing.

Directional detent roller assembly stubshaft, spring groove on stubshaft, roller, and spring shaft.

Interlock roller assembly stubshaft and roller.

Dynamic brake detent assembly pin, roller, and spring shaft.

Throttle clevis pin and roller, and clevis pivot pin.

Throttle axle thrust washers and roller bearing.

Dynamic brake axle thrust washers and roller bearing.

Bushings in bottom plate, shelf, and top of controller housing.

Interlock and notched surfaces of all cam plates.

MECHANICAL INSPECTION

The following mechanical checks should be made to qualify the controller for trouble-free operation:

1. Check the indicators to see that
   a. The proper position is indicated for each throttle and brake position.
   b. The numbers or designations are reasonably lined up in the center of the opening.
2. Check to see that the handles are tight on their respective axles or shafts, and that they move freely enough so that the spring-loaded detent action on the respective axle segment plates can "center" each position as follows:
   a. Directional Handle

      As the handle approaches the forward, center, or reverse positions a slight pull aiding the movement to the final position should be experienced. This is due to spring action of the directional detent roller assembly.

   b. Throttle Handle

      Full movement of the throttle handle from one notch to the next is 10° with one-half of this movement being required to get out of the previous notch. The throttle handle should automatically fall into the next position as the roller detent passes over the hump between position.

   c. Dynamic Brake Handle

      The dynamic brake handle has two "notched" positions and a free sliding position. Full movement of the handle from OFF to SETUP is approximately 10°, and from SETUP through FULL 8 is approximately 80°. Movement of the handle through the free sliding position requires a smooth, steady force with no rough spots or binding.

ELECTRICAL INSPECTION

In order to check the electrical operation of the controller, or to validate repairs which have been made, make the following tests:

1. Operate controller handles through their entire range, checking to see if the proper switches are energized for each position. Refer to switch sequence charts, Fig. 17, for switch identification and contact functions.

NOTE: Polarity must be observed when installing switches equipped with permanent magnet arc suppressors. See Service Data for proper switch part numbers.

2. Check dynamic brake rheostat to ensure electrical contact is made from "C" terminal on rheostat through the brush, contact bars, and to each terminal. The first eight bars are connected to terminal 1 and the last six bars are connected to terminal 21. The remaining terminals are connected to contact bars as shown in Fig. 4.

3. Check voltage on the indicating dial lamp. It should be 6-8 volts with 74 volts applied to the series circuit of the lamp and resistor.

THROTTLE HANDLE

SWS		POSITION									
		STOP	IDLE	1	2	3	4	5	6	7	8
1 THRU 8	A-B			●	●	●	●	●	●	●	●
IDLE	C-D		●								
STOP, 5 & 6	A-B	●						●	●		
	C-D	●						●	●		
3 THRU 8	C-D					●	●	●	●	●	●
5 THRU 8	A-B	●	●	●	●	●	●				
	C-D							●	●	●	●
2,4,6,8	C-D				●		●		●		●

DIRECTIONAL HANDLE

SW	CONTACT	FWD	CEN	REV
RH-R	A-B			●
	C-D			●
RH-F	A-B	●		
	C-D	●		

THROTTLE HANDLE

SWS		POSITION									
		STOP	IDLE	1	2	3	4	5	6	7	8
1 THRU 8	A-B			●	●	●	●	●	●	●	●
IDLE	A-B		●								
	C-D		●								
STOP, 5 & 6	A-B	●						●	●		
	C-D	●						●	●		
3 THRU 8	C-D					●	●	●	●	●	●
5 THRU 8	A-B	●	●	●	●	●	●				
	C-D							●	●	●	●
2,4,6,8	C-D				●		●		●		●

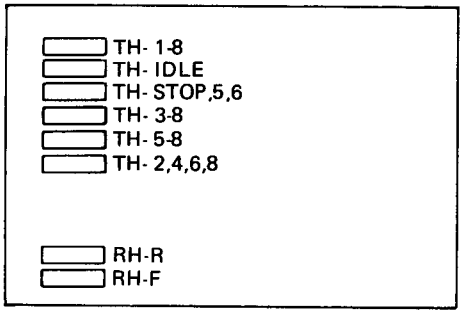
DIRECTIONAL HANDLE

SW	CONTACT	FWD	CEN	REV
RH-R	A-B			●
	C-D			●
RH-F	A-B	●		
	C-D	●		

DYNAMIC BRAKE HANDLE

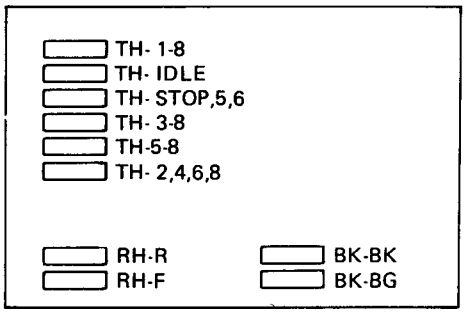
SWITCH	CONTACT	OFF	SET-UP	MIN-MAX BRK
BK-B	A-B	●		
	C-D		●	●
BK-BG	A-B			●
	C-D			●

SWITCH ARRANGEMENT
(BACK VIEW OF MECHANISM)



NON–DYNAMIC BRAKE

SWITCH ARRANGEMENT
(BACK VIEW OF MECHANISM)



DYNAMIC BRAKE

SWITCH IDENTIFICATION

PART NUMBER	CIRCUIT (PLUNGER EXTENDED)		COMMENTS
	A-B	C-D	
8296748		NC	
8296750	NO	NC	
8296752	NC		Magnetic blowouts A(+), B(–) Located in C-D position
8298178	NC	NC	

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Fig. 17 – Controller Sequence Charts

SERVICE DATA

SWITCH ASSEMBLY

1 contact - N.C.	8296748
2 contacts - 1 N.O. - 1 N.C.	8296750
1 contact - N.C. with arc suppressor (permanent magnet)	8296752
2 contacts - N.C.	8298178
2 contacts - N.O.	8299162

RESISTORS

25 Ohms ± 10%, 25 Watts	8318101
8 Ohms ± 10%, 25 Watts	8357919
5 Ohms ± 10%, 25 Watts	8357920
300 Ohms ± 5%, 25 Watts	8382293

DYNAMIC BRAKE RHEOSTAT

Contact Bars	35
Backlash	2.5° Max.
Brush (silver graphite)	8355907
Hi-Pot Terminals to ground	600 V RMS 60 cycles AC for one min.

DIAL LAMP	8140357
GREASE (non flow-hi melt)	(14 oz. can) 8196886

TOOLS

Cross-recess screwdriver No. 2
Flat blade screwdriver with 1/4" blade
7/16", 1/2", 9/16" sockets (Note: 1/2" socket to have max. O.D. of 3/4")
Socket extension 3" or longer
7/16" open end wrench
External snap ring pliers (8228031)
7/64" hex wrench
Standard pliers

Litho In U.S.A.